# Automotive Technologie in Bavaria +e-Car

GLOBAL PARTNER

# Dear Readers,

Electromobility is currently the subject of intense activity in the automotive industry. We expect the beginning of the next decade to mark a turning point: Starting then, we will experience more sales stimulus from electric cars than from combustion engines.

Our roadmap for electrification is in place. In 2018 we will launch the Audi e-tron, our first fully electric SUV. With a range of more than 500 kilometers, it is completely suitable for everyday driving. By 2020 we will offer three fully electric cars and starting in 2021 we will be successively electrifying one model in each of our key model lines.

Yet the success of electromobility is not solely dependent on attractive and practical products. Its success or failure will depend on whether the underlying conditions are suitable for customers. As a manufacturer, we are asking for support from public policymakers so that the infrastructure and legal framework will facilitate the changeover.

To accelerate the transformation to emission-free mobility, we are currently taking on an infrastructure-related task that is unusual for a carmaker. In Europe, the Volkswagen Group with Porsche and Audi plans to establish a joint venture in cooperation with BMW, Daimler and Ford. Together, we want to set up high-performance charging points with up to 350 kW for fast charging when on long journeys on the main highway routes in Europe.

For electromobility to achieve the breakthrough, it is also important to ensure that electric cars are cost-effective. Our customers are not prepared to pay more for an electric car than for a comparable one with a combustion engine. The value analysis helps us as well as our partners to optimize concepts at an early stage, so that we can meet this expectation. In coming years, the cost of batteries will drop significantly while they become more efficient at the same time.

For this reason, we are confident enough to predict that by 2025, one third of the Audi brand cars we deliver will be electrically driven. Until then, we are developing the qualifications of our employees for the upcoming transition. As a result, 6,000 employees have already trained as electric specialists and advanced training for powertrain developers has been set up in partnership with the Technical University of Ingolstadt (THI). Qualification for the wide-ranging transformation is an important and responsible undertaking that we share with our partner suppliers. In this way, we are getting ourselves ready for the emission-free future of mobility.

Dr. Bernd Martens

Member of the Board
of Management
of AUDI AG,
Procurement

# Automobiltechnikum Bayern GmbH in Hof

Founded by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology, the test laboratory is accredited according to EN 17025 and situated within the Automobilzulieferpark (= Automotive Supplier´s Park) Pole Position at Hof-Gattendorf. It performs tests and experiments in accordance with customerspecific test instructions and requirements. As regards concepts, the tests are supervised by competent staff. Engineering services and solutions to problems as well as constructional adjustments are offered individually.

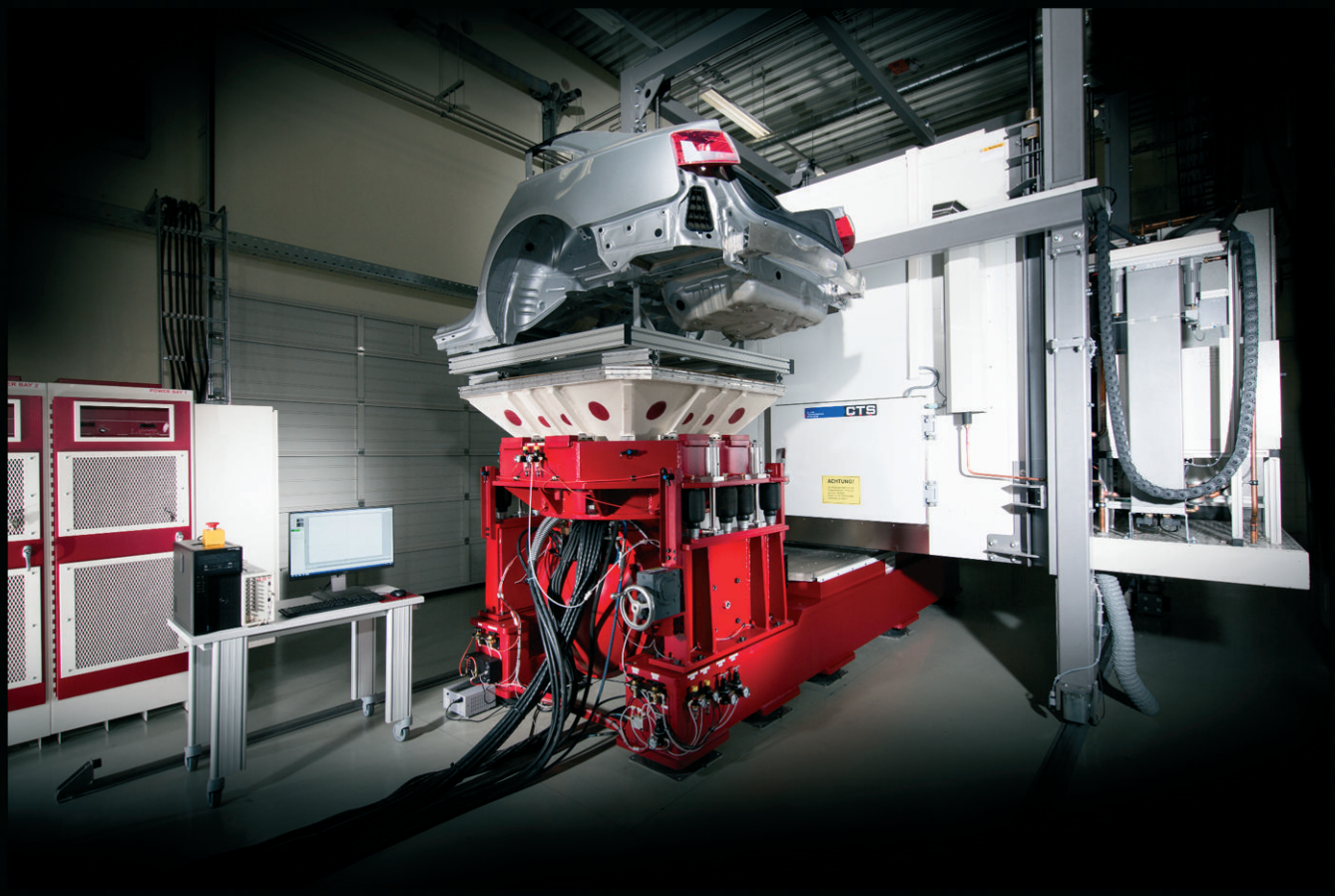
Concerning service strength, three Occubot seat test robots made by KUKA are available at ATB. Using a system for changing test dummies does not only provide an automated programme process, but a continuous picture documentation as well. At the same time the test loads are constantly observed and readjusted. The area of service strength comprises as well four spring testing machines, versions "Schenck" and "Reicherter Short and Long Stroke".

The servo-hydraulic testsystem with a total of 8 hydro-pulse cylinders operates with loads of up to 40 kN and mximum strokes of 400 mm.

Two electric stroke cylinders with loads of up to 20 kN and maximum strokes of up to 350 mm can also be operated in connection with a climate chamber of 1,5 $m^3$. Tests with lower loads may be run by using various pneumatic stroke cylinders.

The area environmental simulation disposes of 14 climate chambers with sizes ranging from 240 litres to 30 m3, the latter being accessible by vehicles. Temperature ranges lie between -70 °C and 180 °C, the relative humidity can be programmed continuously between 10 % and 97 %.

Forschung und Entwicklung



The two heating furnaces with a volume of up to 720 litres allow tests up to 300 °C. The salt spray fog chamber with a test volume of 2 $m^3$ complies with all established test standards, also for condensation tests.

The measuring laboratory contains a material testing machine for tensile and pressure tests, several digital tracers by HBM with up to 8 measuring channels per system, an infrared camera and a digital light optical microscope with up to twohundredfold enlargement.
Furthermore, photogrammetric surveys are offered, thereby using a system produced by AICON respectively a stripe light scanner produced by Steinbichler.
The 90 kN shaker is fitted with a Head expander measuring 150 cm x 150 cm. The frequency range goes from 5 Hz to 3000 Hz. Maximum acceleration is achieved at 150 g. In addition, the control system enables tests in multisinus mode.
In addition, a climate chamber of 15 $m^3$ may be positioned over the support plates.

For further informations please see our homepage:

www.atbayern.de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# Bavaria is still the master of invention

The third CCI report from the Bavarian Chambers of Commerce and Industry, "Patents in Bavaria 2017", proves: Bavaria is the land of inventions! In 2015, Bavaria produced around 29 percent of the German patents published by the European Patent Office and the German Patent and Trade Mark Office. This was an increase of 3 percent compared to 2012. The technological innovation performance in Bavaria correlates with the high rates of investment in research and development (R&D).

With expenditure for R&D at 3.26 percent of gross domestic product (GDP), Bavaria remains one of the forerunners in Germany. In 2013, around 2.84 per cent (80.4 billion euros) of Germany's entire gross domestic product was spent on R&D. Around 55 billion euros of this came from the business sector and 22 percent thereof came from Bavaria.

On the one hand, industrial property rights lay the foundation for recouping investments in new products, new processes and market launches. On the other hand, published property rights such as patents provide a comprehensive insight into the current status of technology. It is therefore advisable to intensively investigate the state of the art of global competitors in advance of and alongside new developments. Patents also provide effective protection for your own technology expertise and the exclusive right to its use. The latter forms the basis of our present culture of innovation. By systematically using patent literature, companies and regions can check and compare their technology profiles against their competitors. The CCI report "Patents in Bavaria 2016/2017" breaks down the core technologies not only for Bavaria, but also for each of the individual CCI regions. It thus provides decision-makers in economy, science, politics and management with valuable information. ■

## *Patent publications as early indicators of innovative performance*

The CCI report "Patents in Bavaria 2016/2017" notes the fields of technology in which Bavarian economy and science actively generate innovation. The analysis is based on published patent applications (= patent publications) that were examined according to regional origin. Furthermore, the analysis was based upon two criteria: firstly according to proportions of technology areas that are recorded following the International Patent Classification (IPC), and secondly according to the application activity of companies and research institutes.

The technology segments that were assessed according to the IPC were put into a German and European context in order to map out the strengths and weaknesses of Bavaria and its regions. 141,529 European and 47,907 German patent publications were evaluated to this end. Here, the qualitative considerations of patent publications are particularly valuable. The object of the analysis is not only the number of patent applications, which is significant in its own right due to its sheer scope, but also their technical content. This allows for the interpretation and assessment of Bavaria's innovative strength in research and development efforts in core technologies.

Patent publications not only reflect the results of technical development efforts, but also document the patent applicant's commercial interest in a certain market segment. Targeted patent analysis can thus be used to derive information about future technical trends and market development. The observation of patent publications and the identification of the "technology pigeonholes" pursuant to the IPC have proven to be output-oriented indicators for detecting technological trends. One limiting factor that must be noted is that each region's strength of innovation is only reflected by the number of patent publications, which means the total innovative performance of each region is not comprehensively represented. This would require the consideration of other innovation indicators (e.g. levels of investment in research and

development, university density, number of students, concentration of engineers, etc.). ■

## Core technologies in Bavaria

In 2015, the EPO and DPMA analyzed around 13,744 published patent applications from Bavarian applicants. This makes up a proportion of around 29 per cent of all patent applications published in Germany. In addition to considering this one year, the development of the most important fields of technology was also examined for the period spanning 2011 to 2015. To this end, the first top 20 technology classifications according to the IPC were used to analyse changes in applicant behaviour in the leading technology segments. As previously outlined, the "technology pigeonholes" are determined by the selection of the IPC. Every patent publication can contain one or more IPC mentions, applicants or inventors. In 2015, up to 535 technology entries (number of different IPC mentions) were named in published patent applications by Bavarian applicants. To be able to assess the significance of the Bavarian top 20 technologies on a Germany-wide scale, the German and European rankings of these technologies have been listed as comparative figures. Population, gross domestic product and companies were used as reference values. Bavaria accounts for 15.6 percent of the population, 18.1 percent of gross domestic product and 18.5 percent of companies in Germany. The proportion of patent publications lies at 29 percent for 2015 and is therefore 1.7 times higher than the average. The Bavarian proportion of IPC technology mentions in Germany represents the strength of application activity in Bavaria in the relevant technological fields. This high proportion, with regard to all German patent publications in these technology segments, documents the particular strength of research and development in these fields of technology.

Even in the German and European rankings, the majority of these technologies can be found in the highest positions. As such, these areas also exhibit high application impetus and significant innovation potential in an European context. In other words: Bavaria leads in defined technology segments that are of high significance with regard to innovation at a national and international level. For example, economic and R&D institutes invested heavily and documented

| IPC (classification) | IPC (text) | Ranking Europe | Ranking Germany | Ranking Bavaria | Proportion [%] made up by Bavaria in Germany |
|---|---|---|---|---|---|
| H01L | Semiconductor devices | 8 | 2 | 1 | 47.7 |
| B60R | Vehicles, vehicle fittings or vehicle parts | 37 | 1 | 2 | 38.2 |
| A61B | Diagnosis; surgery; identification | 5 | 5 | 3 | 46.1 |
| F16H | Gearing | 42 | 7 | 4 | 38.1 |
| B29C | Shaping or joining of plastics | 19 | 6 | 5 | 35.6 |
| G01R | Measuring electric variables; measuring magnetic variables | 39 | 13 | 6 | 45.1 |
| G06F | Electrical digital data processing | 2 | 8 | 7 | 38.0 |
| F16C | Shafts; elements of crankshaft mechanisms; bearings | 75 | 23 | 8 | 53.4 |
| B60W | Control of vehicle sub-units, including hybrid vehicles | 67 | 14 | 9 | 38.6 |
| G01N | Investigating or analysing materials by determining their chemical or physical properties | 6 | 3 | 10 | 23.7 |
| B62D | Motor vehicles; trailers | 73 | 9 | 11 | 33.6 |
| B60K | Arrangement or mounting of propulsion units or transmissions in vehicles | 54 | 11 | 12 | 34.9 |
| H01M | Processes or means, e.g. batteries, for the direct conversion of chemical energy into electrical energy | 13 | 4 | 13 | 22.4 |
| H02K | Dynamo-electric machines | 47 | 16 | 14 | 32.1 |
| H04L | Transmission of digital information | 4 | 20 | 15 | 35.8 |
| F16D | Couplings for transmitting rotation; brakes | 71 | 12 | 16 | 24.1 |
| F01L | Valves for machines or engines | 231 | 51 | 17 | 60.5 |
| H05K | Printed circuits; casings or constructional details of electrical apparatus | 38 | 27 | 18 | 38.7 |
| H02J | Systems for supplying or distributing electric power; systems for storing electric energy | 26 | 19 | 19 | 31.4 |
| G01B | Measuring length, thickness or similar linear dimensions; measuring angles | 86 | 18 | 20 | 29.9 |

Data source: EPA and German Patent and Trade Mark Office (DPMA)

Fig. 1: *Ranking of the top 20 Technologies in Bavaria as compar with Germany and Europe, and the proportion they make up of German patent publications (2015)*

high levels of development expertise in the form of patent applications in "semiconductor devices", "diagnosis; surgery; identification" and "shafts; elements of crankshaft mechanisms; bearings". In this way, competitive advantages are systematically secured in these future-oriented fields of technology.

Furthermore, Bavaria's proportion of technology fields such as "gearings" (IPC = F16H), "vehicles; vehicle fittings or vehicle parts" (IPC = B60R), "Electrical digital data processing" (IPC = G06F) and "shaping or joining of plastics" (IPC = B29C) is extremely significant *(figure 1)*. These also take the top ranking positions in Germany and are thus decisive in setting technology trends.

*Figure 2* shows the development of the top 20 technologies from 2011 to 2015. The field of technology concerning "vehicles, vehicle fittings or vehicle parts" (IPC = B60R) is in first place in Ger-

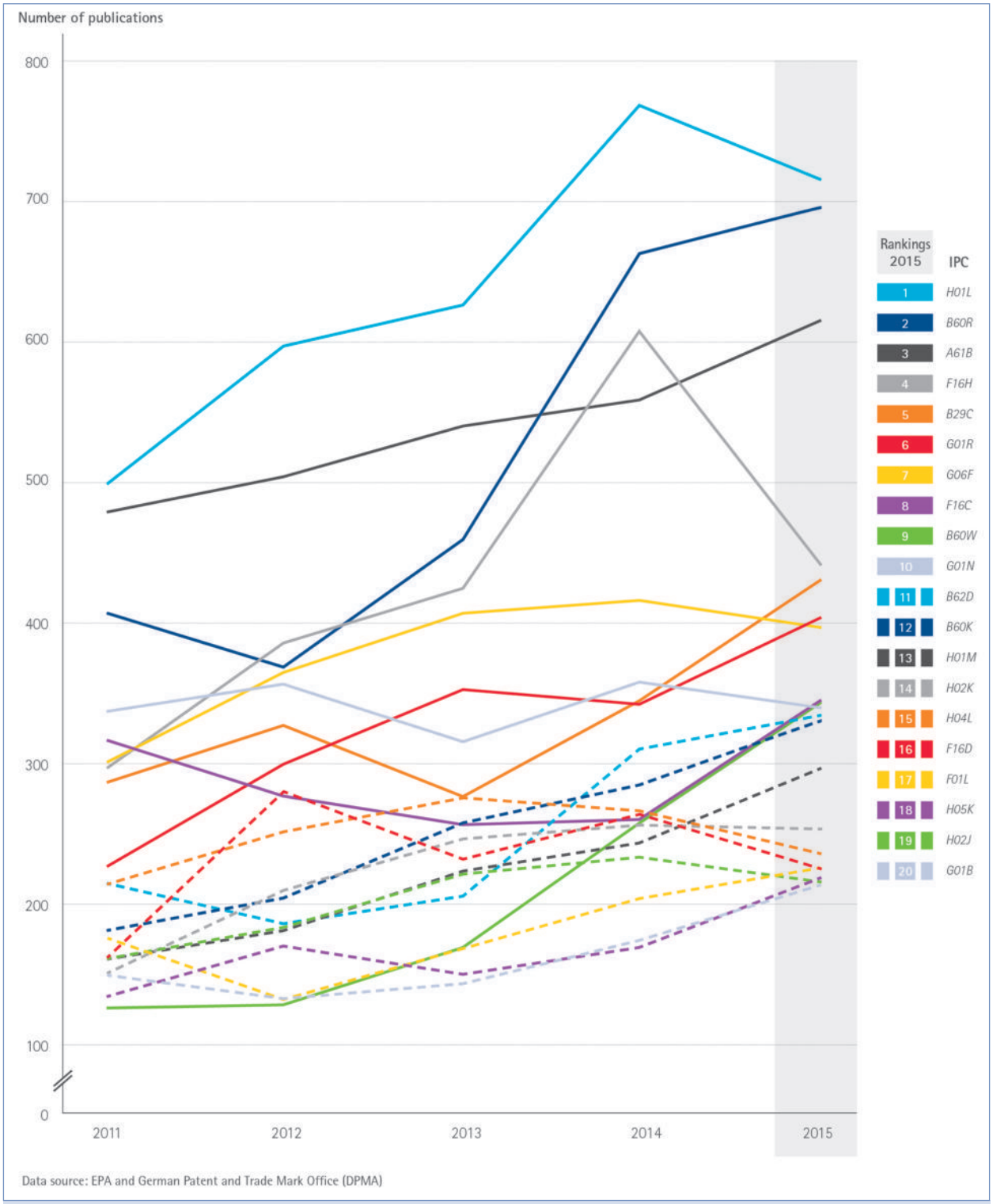


Fig. 2: *„Top 20"-technologies in Bavaria between 2011 and 2015* ■

many, 38.2 per cent of which is made up by Bavaria. This technology has been showing enormous positive development since 2011. Automobile manufacturers in Bavaria dominate with their development efforts, making up around two fifths of this field of innovation. ■

## *Patent applicants from Bavaria*

Patent applications were used to identify the top 50 patent applicants for 2015. This circle of companies and institutes was the source of the patent applications that make up the majority of the top 20 technologies list.

It should be noted that one or – in the case of collaborations – several applicants/inventors can be named in patent publications. Here, the joint patent applications are clear proof of collaborative research efforts. In 2015, a total of 2,364 applicants were registered in

| Rang | Anmelder | Nennungen der Anmelder in Patenterstpublikationen |
|---|---|---|
| 1 | Siemens AG | 1.621 |
| 2 | Bayerische Motoren Werke AG | 1301 |
| 3 | Schaeffler Technologies GmbH & Co. KG (296); Schaeffler Technologies AG & Co. KG (612) | 908 |
| 4 | Audi AG | 776 |
| 5 | Robert Bosch GmbH | 471 |
| 6 | Osram Opto Semiconductors GmbH/Osram GmbH/Osram OLED GmbH | 384 |
| 7 | Infineon Technologies AG | 367 |
| 8 | BSH Bosch und Siemens Hausgeräte GmbH | 351 |
| 9 | Continental Automotive GmbH | 320 |
| 10 | ZF Friedrichshafen AG | 303 |
| 11 | Krones AG | 221 |
| 12 | Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e. V. | 204 |
| 13 | MAN (Diesel\|Turbo und Trucks\|Bus) | 184 |
| 14 | Conti Temic Microelektronic GmbH | 164 |
| 15 | Airbus Defence and Space GmbH/Airbus Helicopters Dt. GmbH/Airbus Operations GmbH | 162 |
| 16 | Daimler AG | 154 |
| 17 | Giesecke & Devrient GmbH | 148 |
| 18 | Brose Fahrzeugteile GmbH & Co. Kommanditgesellschaft | 136 |
| 19 | MTU Aero Engines GmbH | 129 |
| 20 | Linde AG | 128 |
| 21 | BASF SE | 104 |
| 22 | Knorr-Bremse Systeme für Nutzfahrzeuge GmbH | 95 |
| 23 | Wacker Chemie AG | 88 |
| 24 | Lisa Dräxlmaier GmbH | 68 |
| 25 | Deutsches Zentrum für Luft- und Raumfahrt e. V. | 66 |
| 26 | Carl Zeiss GmbH | 64 |
| 27 | Diehl Stiftung & Co. KG | 64 |
| 28 | Linde Material Handling GmbH | 60 |
| 29 | Friedrich-Alexander-Universität Erlangen-Nürnberg | 55 |
| 30 | Roche Diagnostics GmbH | 52 |
| 31 | Volkswagen AG | 48 |
| 32 | Mann + Hummel GmbH | 47 |
| 33 | Technische Universität München | 47 |
| 34 | Rohde & Schwarz GmbH | 46 |
| 35 | Koenig & Bauer AG | 45 |
| 36 | KUKA Systems GmbH | 40 |
| 37 | Rational AG | 37 |
| 38 | Maschinenfabrik Reinhausen GmbH | 35 |
| 39 | Evonik DEGUSSA GmbH | 34 |
| 40 | OCE Printing Systems GmbH | 33 |
| 41 | Brainlab AG | 31 |
| 42 | Leoni Bordnetz System GmbH (18); Leoni Kabel Holding GmbH (13) | 31 |
| 43 | Dr. Johannes Heidenhain GmbH | 28 |
| 44 | Grammer AG | 28 |
| 45 | Henkel AG & Co.KG | 26 |
| 46 | Max-Planck-Gesellschaft zur Förderung d. Wissenschaften e.V. | 26 |
| 47 | Voith Patent GmbH | 26 |
| 48 | Rehau AG & Co. | 24 |
| 49 | Semikron Elektronik GmbH & Co. KG | 24 |
| 50 | Endress + Hauser Wetzer GmbH & Co. KG | 23 |

Datenquelle: EPA und DPMA

Fig. 3: *Top 50 patent applicants from Bavaria: Metions of company in patent publications* ■

| CCI region | Inhabitants [%] | Gross domestic product [%] | Company [%] | Patent publications [%] | Patent innovation index* |
|---|---|---|---|---|---|
| Aschaffenburg | 3.0% | 2.6% | 3.1% | 2.6% | 0.9 |
| Coburg | 1.0% | 0.6% | 0.9% | 0.9% | 1.1 |
| Munich and Upper Bavaria | 36.7% | 44.0% | 42.7% | 44.3% | 1.1 |
| Lower Bavaria in Passau | 8.7% | 7.4% | 8.3% | 5.1% | 0.6 |
| Nuremberg for Central Franconia | 13.7% | 12.7% | 15.1% | 21.2% | 1.5 |
| Upper Franconia in Bayreuth | 8.5% | 6.0% | 5.2% | 8.0% | 1.2 |
| Regensburg for Upper Palatinate / Kelheim | 9.7% | 8.3% | 8.4% | 11.3% | 1.3 |
| Swabia | 14.4% | 12.3% | 15.4% | 9.9% | 0.7 |
| Würzburg-Schweinfurt | 7.5% | 6.2% | 6.6% | 6.6% | 1.0 |

Source: CCI Nuremberg; *for the calculation of the patent innovation index, see "methodology and data collection" section

Fig. 4: *Proportion of Bavarian reference values in CCI regions (reference year: 2015 / GDP 2014)* ■

13,744 patent publications. The 50 most active patent applicants in Bavaria are responsible for over 70 per cent of all applications. In other words: 2.1 per cent of applicants based in Bavaria placed more than two thirds of the patent applications at the DPMA and EPO.

As positive as this accumulation may seem from the view of these companies, it does involve a substantial risk when it comes to research strategy. The multitude of small and medium-sized enterprises is underrepresented in this consideration. Nevertheless, SMEs are currently the innovation drivers when it comes to the development of new technologies and products. This link cannot be conclusively proved using the patent analysis. Many SMEs do not submit patent applications for financial or secrecy reasons. ■

## The patent innovation index (PII):

In the following, the proportion of individual CCI regions in Bavaria is assessed in comparison to patent publications made in Bavaria and Germany as a whole and in relation to reference values (population, gross domestic product, companies). In *figures 4 and 5*, the proportion of patent applications in Bavaria and Germany for each region is given as a percentage. ■

## The strength of CCI regions in Bavaria

According to this evaluation, over two fifths of patent publications come from the region of Munich and Upper Bavaria. A further fifth can be attributed to the CCI region of Nuremberg for Central Franconia. The patent innovation index (PII) implemented here provides a quick overview of regional innovative performance, measured using patent publications and reference values. If the PII is less/more than one, then the innovative performance of that region is lower/higher than average.

With regard to reference values, population, GDP, companies and patent publications, the current distribution of innovative performance across Bavaria is predominantly even. The region of Munich and Upper Bavaria presents the highest patent activity in Bavaria. Nevertheless, the

| CCI region | Inhabitants [%] | Gross domestic product [%] | Company [%] | Patent publications [%] | Patent innovation index* |
|---|---|---|---|---|---|
| Bavaria | 15.6% | 18.1% | 18.5% | 28.9% | 1.7 |
| Aschaffenburg | 0.5% | 0.5% | 0.6% | 0.7% | 1.5 |
| Coburg | 0.2% | 0.1% | 0.2% | 0.3% | 1.9 |
| Munich and Upper Bavaria | 5.6% | 8.0% | 7.9% | 12.8% | 1.8 |
| Lower Bavaria in Passau | 1.3% | 1.3% | 1.5% | 1.5% | 1.1 |
| Nuremberg for Central Franconia | 2.1% | 2.3% | 2.8% | 6.1% | 2.6 |
| Upper Franconia in Bayreuth | 1.3% | 1.1% | 1.0% | 2.3% | 2.1 |
| Regensburg for Upper Palatinate / Kelheim | 1.5% | 1.5% | 1.6% | 3.3% | 2.2 |
| Swabia | 2.2% | 2.2% | 2.9% | 2.9% | 1.2 |
| Würzburg-Schweinfurt | 1.1% | 1.1% | 1.2% | 1.9% | 1.6 |

Source: CCI Nuremberg; *for the calculation of the patent innovation index, see "methodology and data collection" section

Fig. 5: *Proportion of German reference values in CCI regions and Bavaria (reference year: 2015 / GDP 2014)* ■

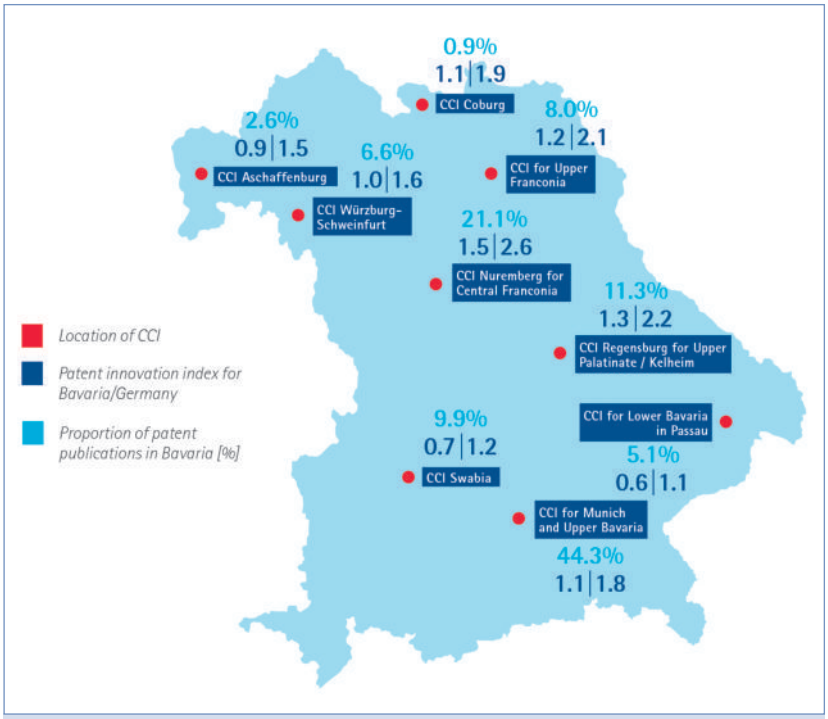


Fig. 6: *Regional proportion of published patents in Bavaria according to CCI region; Patent innovation index for the Bavarian CCI regions* ■

PII of 1.1 speaks of innovative performance that is only slightly above average. Bavaria's positive results in innovative performance are essentially based upon the outstanding position of the CCI regions Nuremberg for Central Franconia, Upper Palatinate/Kelheim and Upper Franconia Bayreuth. ■

## The innovative strength of Bavaria and the CCI regions in Germany

The Bavarian CCI regions performed very well in comparison with the total German average. Seen in terms of Germany as a whole, The PII of Bavaria PII (PII = 1.7) and the individual CCI regions is altogether more positive (*figure 6*). This result illustrates Bavaria's high innovative strength, which is spread across several regions. The CCI regions of Upper Franconia Bayreuth (PII = 2.1), Nuremberg for Central Franconia (PII = 2.6) and Regensburg for Upper Palatinate / Kelheim (PII = 2.2) are particularly noteworthy centres of innovation. ■

## Conclusion

Patents generally document the spirit of innovation and research findings even before a product has been launched on the market. This information helps to accelerate proprietary development projects. This includes halting projects if the state of the art has already been achieved by competitors. Bavaria covers seven of Germany's top 10 fields of technology. With regard to population, gross domestic product and companies, the percentage of German technology entries made up by Bavaria is far above average. Bavaria's top 20 also cover five of the ten technologies in a Europe-wide comparison. The patent indicators bring to light a region's key areas of innovation, which could also be found in clusters such as "medicine" or "mechatronics and automation". In this respect, patent indicators can be used to support arguments for strategic, technology-oriented innovation, economy and cluster policies. ■

*Data source: EPO and German Patent and Trade Mark Office (DPMA)*
*Data collection: Hamburg Chamber of Commerce*
*Data analysis: CCI Nuremberg for Central Franconia*
*Download:*
*https://www.bihk.de/bihk/bihk/Nachrichten/bayern-ist-erfinderland.html*

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# The second generation of the Audi Q5 – even sportier and more multifaceted

*Audi presents another successful model: The SUV with the four rings combines the sportiness of an Audi saloon with a multifaceted character and a highly flexible interior. Whether in its connectivity, efficiency or driver assistance systems – the new Audi Q5 once again sets standards in its segment.*



"The first Audi Q5 was for many years the world's best-selling SUV in its class. It was no easy task to design its successor, but that is precisely why it is so very exciting," says Rupert Stadler, Chairman of the Board of Management at AUDI AG.

"With the new Q5 we are setting the bar a notch higher. Among the great innovations are the quattro drive system with ultra technology, highly efficient engines, the air suspension with damper control and a comprehensive line-up of infotainment and assistance systems."

The new SUV from Audi takes a sporty and taut stance on the street. A sculpturally flared Singleframe grille with a solid frame dominates its aerodynamically flat front end. It is available with headlights that are either in LED or high-resolution Matrix LED technology with dynamic turn lights. ■

*Audi Q5 – front view* ■

## Typically Audi: Reference to the quattro drive

A distinctively curved and strongly undercut shoulder line gives structure to the side view. The strongly emphasized wheel arches are a reference to the quattro permanent all-wheel drive system, and the low greenhouse tapers back down early. Just as at the front, horizontal lines at the rear convey an image of width and presence. The tail lights are also available with optional dynamic turn signals. The tailgate wraps around the C-pillars – a typical feature of the Q models from Audi. A diffuser insert integrates the exhaust tailpipes.

Audi is offering the new Q5 in 14 different exterior colors. Five newly configured equipment lines are available – sport and design, the S line sport package, design selection and the S line exterior package. They influence the overall appearance.

In the design line, contrasting gray add-on parts emphasize the rugged character of the new SUV, while the sport equipment line of the Audi Q5 has parts fully painted in the exterior color. ■

## Weight saved: up to 90 kg (198.4 lb) lighter than the previous model

4.66 meters (15.3 ft) long, 1.89 meters (6.2 ft) wide and 1.66 meters (5.4 ft) tall with a 2.82 meter (9.3 ft) wheelbase – compared to the previous model, the new Q5 has grown in nearly all of its dimensions. Consequently, the unladen weight was reduced – depending on the engine – by up to 90 kg (198.4 lb). Steels with maximum tensile strength and aluminum form an intelligent material mix in the body.

The new Q5 also stands at the top of its class in its aerodynamics. The four-cylinder versions attain a cd figure of 0.30 with the aerodynamically optimized roof. Wind noises are exceptionally low, and vibration comfort is high – the new SUV

from Audi indulges the driver and passengers with the best interior acoustics in its class. ■

## Spacious and wide: the interior

The interior offers a lot of space for five persons, and it surpasses the previous model and its competitors in key dimensions. Its horizontally oriented lines underscore the impression of width and comfort, and a three-dimensional trim strip runs across the entire width of the instrument panel. The new equipment lines concept offers customers a broad selection of colors and materials.

The new, high-efficiency air conditioner is available in two versions. A three-spoke multifunction steering wheel is standard; additional functions such as steering wheel heating are optional. Seat features range all the way to a pneumatic massage function. When it is dark, the optional ambient lighting (standard with design selection) creates an attractive atmosphere in 30 different colors. The workmanship quality in the new Q5 is uncompromising.

The rear seat back of the new Audi Q5 is split into three segments. Longitudinal and seat back angle adjustment are optional. Depending on the rear seat position, the basic volume of the luggage compartment ranges from 550 to 610 liters (19.4 to 21.5 cu ft), 10 liters (0.4 cu ft) more than in the previous model. When the rear bench is folded down, this volume grows to 1,550 liters (54.7 cu ft) . Cargo loading is simplified by intelligent solutions like a standard, variably folding mat, optional sensor control of the power tailgate and manual lowering of the body via the optional air suspension. ■

## Simply coherent: controls and displays

Operation of the new Audi SUV is intuitive and is marked by three great new features. The optional Audi virtual cockpit presents brilliant graphics on its high-resolution 12.3-inch screen. The driver can choose from two views – a classic view with large round instruments and a mode in which the navigation map or lists dominate. The also optional head-up display projects key information onto the windshield.

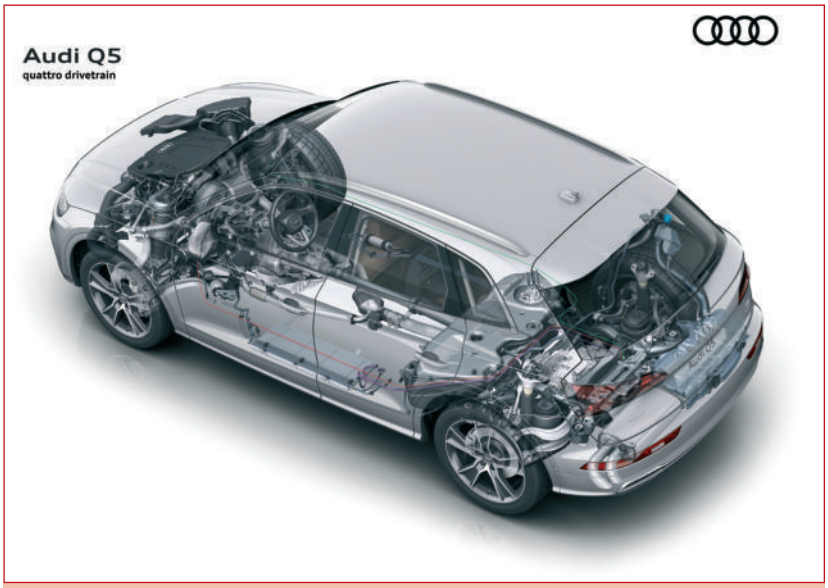
The MMI terminal in the center console acts as the main control element. In the top infotainment system, the MMI navigation plus with MMI touch and an 8.3-inch display, a touchpad is integrated into the rotary pushbutton. It recognizes handwritten entries as well as gestures familiar from consumer electronics such as zooming gestures. If the new Q5 has an automatic transmission, it also has the larger MMI all-in-touch including haptic feedback.

The MMI operating logic is based on the flat hierarchies used in today's smartphones, and it offers such features as intelligent free-text search. The new natural-language voice control function also recognizes inputs from everyday speech. Serving as an additional third operating level in the new Audi Q5 is the multifunction steering wheel plus. Audi can deliver a newly developed head-up display as an option. It projects relevant information onto the windshield – including from driver assistance systems – as symbols and numbers that can be perceived quickly. ■

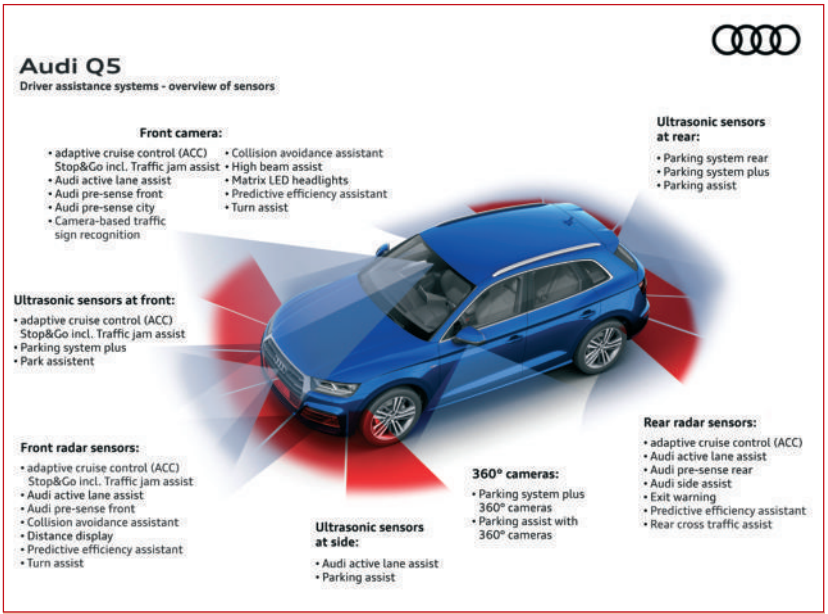
## Audi navigation: "Personal route assist"

The new Audi Q5, like the Q7 and the A4, has a self-learning "personal route assist" function. After activating this function, the navigation system learns the routes and destinations that the customer regularly selects, and it associates this information to the parked position and time of day.

For as long as it is active, the system therefore learns from the customer's behavior and uses this information to suggest optimized route planning for the next trip – even while navigation is inactive. The navigation system incorporates the three most likely destinations into the calculation, taking into consideration both the arrival time and current traffic levels. For instance, the system can suggest that the customer activate navigation to find out about potential alternative routes. The driver decides whether or not to activate the function. He also has the option of deleting saved destinations. If the function is deactivated, the system does not store the destinations and does not consider deleted destinations or the routes driven. ■




*Audi Q5 – quattro drivetrain* ■




*Audi Q5 – driver assistance systems – overview of sensors* ■

## Online via LTE: MMI navigation plus

MMI navigation plus utilizes the Audi connect module to integrate a LTE module and a Wi-Fi hotspot – this lets passengers go online with up to eight mobile devices.

Audi connect enables convenient roaming in Europe for many Audi connect services with its permanently installed SIM card – the Audi connect SIM with a flat data rate. If they wish, users can also book data packages for the Wi-Fi hotspot at attractive prices, which also include EU roaming.

The free Audi MMI connect app produces a close interconnection between the car and smartphone or a smartwatch and offers other services. They include remote checking of important vehicle states, online media streaming and transmission of a calendar from a smartphone to the MMI. ■

## High-end option: the infotainment modules

The Audi phone box connects smartphones to the vehicle's antenna for optimal reception quality; it also charges smartphones inductively according to the Qi standard. The Bang & Olufsen Sound System with innovative 3D sound introduces the spatial dimension of height. The Audi tablet, which is also new, serves as a flexible Rear Seat Entertainment device. The Audi smartphone interface also brings Apple CarPlay and Android Auto into the new Q5. ■

## Driver assistance and safety systems

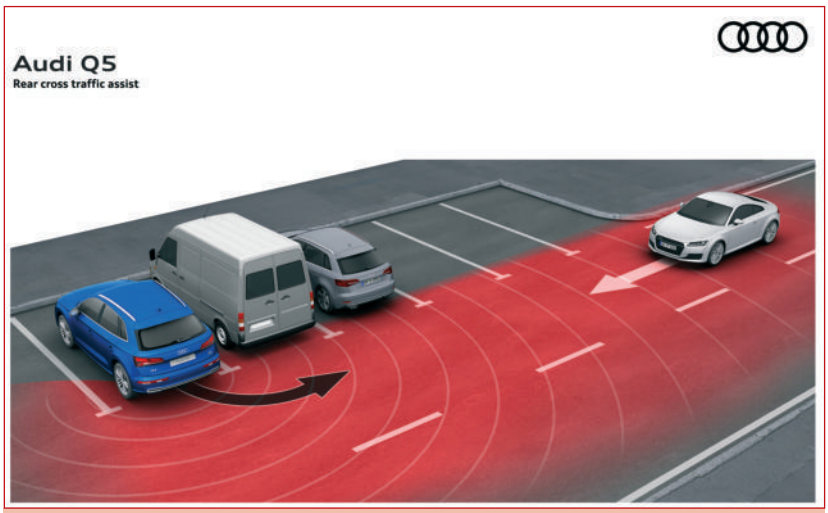
In its driver assistance systems, the new Audi Q5 also tops its segment with a broad range of high-tech options. In their intelligent interplay, the systems represent a next step towards piloted driving. They are bundled into three packages – Tour, City and Parking.

The predictive efficiency assistant helps the driver save fuel by specific information on the car's surroundings. Adaptive cruise control (ACC) including traffic jam assist can handle some of the steering work in slow-moving traffic. Audi active lane assist makes it easier to stay in lane. Distance warning alerts the driver when the distance to a vehicle drops below a safe distance.

Cross traffic assist rear, the exit warning system, collision avoidance assist and turn assist are other new features that perform excellently in pursuit of safety. The same applies to the pre sense systems – Audi pre sense city is a standard feature which warns of pedestrians and vehicles and may initiate automatic emergency braking within system limits. Park assist, the camera-based recognition of traffic signs and hill descent assist round out the features. ■

## Powerful quintet: TDI and TFSI engines

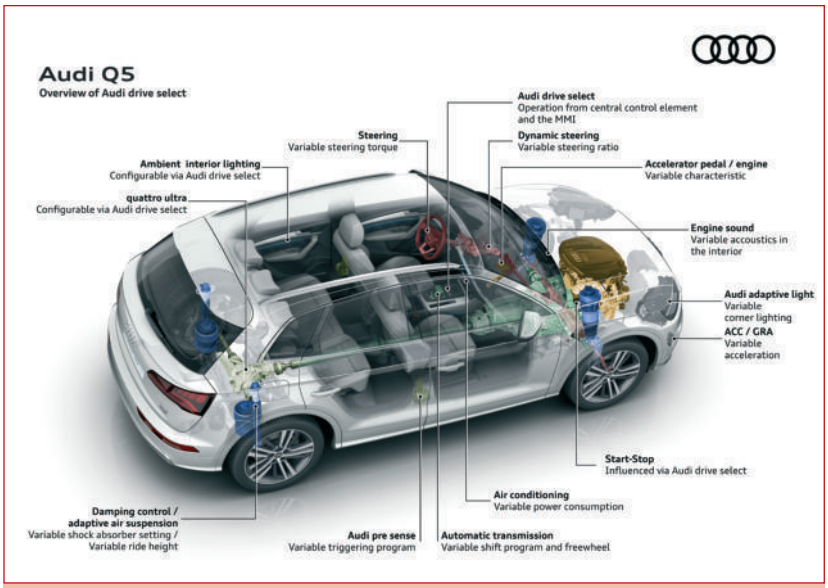
The new Audi Q5 is launching in Europe with five powerful and efficient engines: four TDI engines and one TFSI. They have added up to 20 kW (27 hp) of power, with fuel consumption however being significantly reduced. Particularly the 2.0 TDI engines in the new Q5, with outputs of 110 kW (150 hp), 120 kW




*Audi Q5 – rear cross traffic assist* ■

(163 hp) and 140 kW (190 hp), are highly efficient. The two-liter diesel is also a highly efficient engine in the version with 140 kW (190 hp).

The two top engines combine ample power with efficiency. The further developed 2.0 TFSI has an output of 185 kW (252 hp), yet it only consumes 6.8 liters of gasoline per 100 km (34.6 US mpg), which equates to 154 grams $CO_2$ per km (247.8 g/mi). The also intensively revised 3.0 TDI increases output to 210 kW (286 hp) with 620 Nm (457.3 lb ft) of torque. ■




*Audi Q5 – overview of Audi drive select* ■

## Versatile and efficient: drivetrain

The drivetrain of the mid-size SUV has been redeveloped from the ground up – this also applies to the six-speed manual transmission, seven-speed S tronic and eight-speed tiptronic (only with the 3.0 TDI). The automatic transmissions integrate a fuel-saving freewheel function. The driver controls it by a selection lever or by shift paddles on the steering wheel; in both cases, the control signals are transmitted electronically.

The new quattro drivetrain with ultra technology is standard equipment for the 2.0 TDI with 120 kW (163 hp) and 140 kW (190 hp), and for the 2.0 TFSI with 185 kW (252 hp). Audi can deliver it as an option for the entry-level diesel engine with 110 kW (150 hp). The quattro with ultra technology always disengages the rear-axle drive whenever it is not needed, and if necessary it can proactively re-engage it. The new concept boosts efficiency without reducing traction or driving dynamics.

In both the front-wheel drive and quattro drive versions, torque vectoring gives handling a refined touch. The intelligent software solution always delivers a dynamic, precise and controllable driving experience. For the V6 diesel, Audi can deliver an optional sport differential at the rear axle which distributes torque between the wheels as necessary and thereby provides a maximum of driving dynamics – this is another new feature in this model series and in the competitive field. ■

## Resolving contradictions: the chassis

The new Audi Q5 enables handling that combines very different strengths – it is sporty while being extremely comfortable. Creating the basis for this are the


newly developed five-link suspensions and also the new electromechanical power steering system. Dynamic steering is available as an option; it varies its gear ratio according to the driving speed and steering angle.

Customers can choose from two extension stages of springs and damping. The chassis with damper control offers a very wide spread between comfort and dynamics, which the driver can select via Audi drive select. In addition to adjusting damper control, the new adaptive air suspension can be used to vary the ride height of the car body over five stages. In the Audi Q5 3.0 TDI, these two systems and the sport differential are bundled into a new central chassis control unit.

In the standard system, Audi drive select, which accesses various technical modules, the driver can select one of as many as seven driving modes. The two new modes, lift/offroad and allroad, emphasize the offroad character of the Audi Q5 optimally.

The new Audi SUV comes from the factory with 17-inch alloy wheels. The design and sport equipment lines come with 18-inch wheels, and the S line sport package and Audi design selection come with 19-inch wheels. Wheels up to 21 inches in diameter are available as options. ■

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# New comfort functions with ADAS sensors

*As a result of autonomous driving, ADAS sensor systems will be standard in many of the next vehicle generations. They can also be used for functions beyond vehicle automation. Close collaboration between OEMs and suppliers will play a key role in this area.*

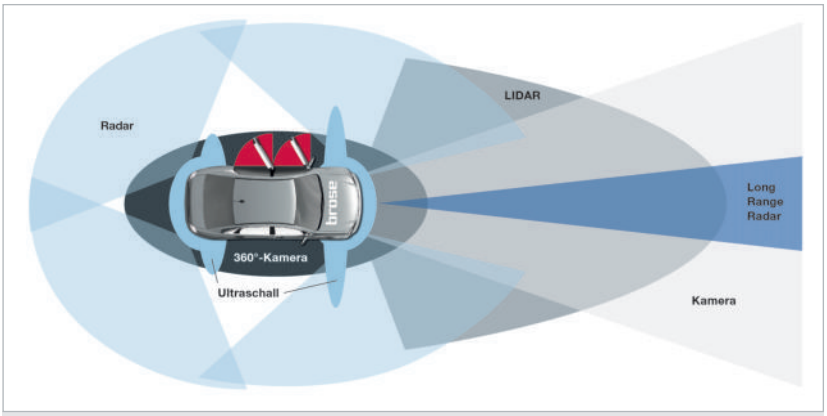
The automotive industry is undergoing radical change. Car connectivity, innovative solutions for human-machine interfaces, big data and, above all, autonomous driving will define individual mobility in the future. New players like Google and Tesla are accelerating the trends classic manufacturers started by more rapidly implementing features without the burden of fixed development processes, mature E/E architectures and modular systems with millions of identical parts. Established manufacturers are responding by building alliances with IT infrastructure providers and classic software companies to advance autonomous driving technologies as quickly as possible.

By 2020 we can expect autonomous driving to be implemented at level four (of five) in upper mid-range vehicles and luxury models. The vehicle is already fully automated at this stage, but the driver must take control as soon as the system can no longer handle these tasks. German OEMs have already defined most of the sensor systems necessary for this: LIDAR sensor technology, which monitors the space in front and behind the car, is supplemented by Short Range Radar, which also "looks" forward and back. A long-range radar sensor is added to the radiator grille, a high-resolution camera to the front along with four other cameras that enable a 360 view. The ultrasound technology commonly used today as a parking sensor will likely disappear altogether and be replaced by radar. One of the reasons for this is because system components for car-to-X communication, which also play an important role in autonomous driving, will need the space occupied by the ultrasonic sensors. It will be crucial for this sensor technology to become the standard as autonomous driving progresses. The corresponding E/E architectures and computer systems needed to process the resulting flood of data are already available.

*Systems for hands-free opening and closing of liftgates such as Brose's "Hands-Free Access" already demonstrate how sensor technology and mechatronic comfort features can work in unison* ■

Comparatively little attention has been paid so far to the possibility of also using the new ADAS sensor systems for functions outside of their primary range of tasks. This technology has untapped potential for other areas: complex and expensive ADAS sensor technologies ensure safety while driving, but they are not used when the car is stopped or parked. They could provide valuable services for mechatronic comfort features relevant to consumers here; the 360° cameras used today already create a kind of "cocoon" around the vehicle.

Sensor technology can also provide greater comfort, as systems for hands-free opening and closing of




*The opening area of the side doors is completely covered by the "sensor cocoon" around the vehicle* ■

liftgates show. Brose introduced this technology for the first time in 2009: a capacitive sensor under the bumper sends a signal to open and close the liftgate when it detects a foot movement. The keyless entry system verifies that the user is in possession of the key and then sends a command to the liftgate control unit. This function is practical for loading the trunk when your hands are full, for example.

Standard sensor technologies will also make new comfort features possible in the near future. Power opening and closing side doors are one example, as Brose presented at the last International Motor Show. In this case the "sensor cocoon" around the vehicle can be fitted with special sensors to detect an obstacle and reliably stop the door before it comes into contact with it. This would be extremely useful – especially in parking garages or when parking on the edge of the road – because the sensors can be used to monitor the blind spot and prevent collisions with cyclists, for example. The additional user benefits also extend to exiting the vehicle: for instance, the door swings open as far as possible and then locks in place thanks to the built-in door check enabling the door to be used as a support for more convenient exiting. Such features will become increasingly important in view of the expected demographic changes in society and the expectation of unchanged mobility regardless of age. This technology can also benefit families: for example, doors would stop automatically before a collision occurs when children swing them open. Comfort features like this are possible with the right ADAS sensor technology. However, some applications will require additional sensors such as opening doors when the car is parked and the assistance systems are not enabled. Developing such systems is one of the key activities of Brose electrical engineers.

The scenario above is still a long way off; ADAS functionality drives sensor technology development at OEMs, not comfort. Collaboration with automotive suppliers in this area can help. Established system suppliers have experience with actuator systems in the field of comfort features and can offer the necessary mechatronics and sensor systems as a package solution from a single source. This requires intense exchange with OEMs. For example, none of the technologies available on the market today can offer sufficient environment recognition on its own. This calls for "sensor fusion" – the combination of various technologies. For instance, the combination of a radar system and complementary sensors for collision protection could be used to protect doors when they open. But for this to work, the vehicle's electronics architecture must be designed in a way that gives the comfort features corresponding access to the sensor data. Considerations must also be made of course with regard to aspects and obstacles of data security between different security levels. This kind of collaboration must be based on trust, but it is economically viable and worth the effort when it results in innovations: once established, the cooperation can lead to the cost-effective development of additional functions. ■

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# The future is connected – Audi is driving digitalization in the automobile

*Intelligent networking is a key for the future of the automobile. Already a leader in this area, Audi continues to expand its lead – with the first car-to-x services from Audi connect, with new infotainment modules and the high-precision digital map from HERE for piloted driving. Audi customers will enjoy even more comfortable, safe and efficient mobility in the connected cars of tomorrow.*

Intelligent networking

The term Audi connect covers all applications and developments that connect an Audi with its driver, the internet, the infrastructure and other automobiles. Audi is putting the pedal to the metal in this field of technology, completely integrating the car of tomorrow into the digital world of the customer. Audi launched its first digital information services, such as point-of-interest search or news, back in 2009. Numerous additional services have followed since then, including traffic information online and navigation with Google Earth and Google Street View. Remote functions used in combination with a smartphone or smartwatch have also been seamlessly integrated into the car for some time now. Audi developers are now working on the seamless connectivity between car and infrastructure as well as between the cars themselves. ■

## *Audi connect and swarm intelligence*

The new Audi connect SIM makes online access child's play. It includes a flat-rate data plan for the Audi connect services and saves roaming charges when traveling in other European countries. The connect services emergency call and online roadside assistance cover key emergency and assistance functions. The Audi MMI connect app brings the customer's smartphone and the car even closer together with services such as online media streaming, calendar linking and the remote control of certain functions.

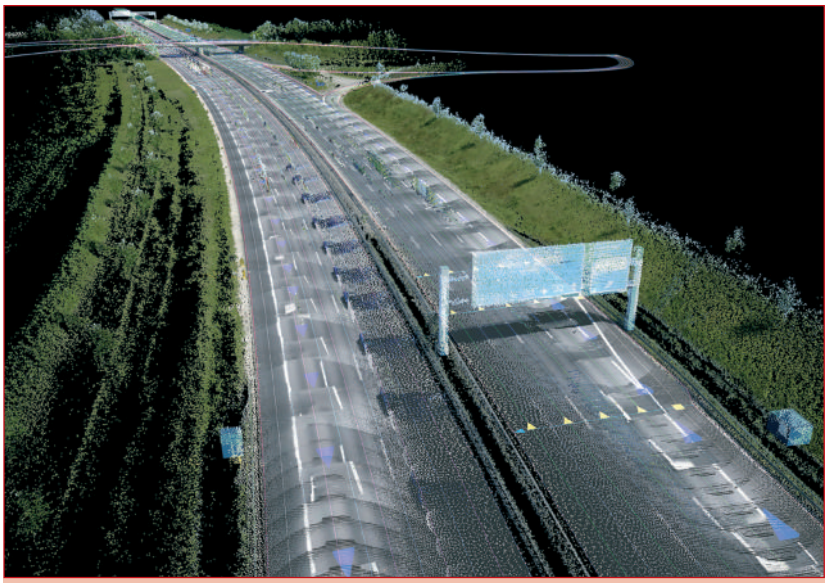
*Audi Smart Display - communicates via WLAN with the MMI Navigation plus and Audi connect.* ■

Now the company is launching the next stage of Audi connect. Since this year, the first car-to-x services are available to customers: traffic sign information and hazard information (for Europe) and traffic light information online (for the USA). The intelligent analysis of the data generated by the cars themselves gives rise step-by-step to a new form of swarm intelligence. With its help, Audi customers in the future will

spend less time waiting at red lights, be warned in advance of hazards and experience safe piloted driving.

To be able to process this quickly expanding volume of data, Audi is investing in new hardware technologies, in particular with the Modular Infotainment Platform (MIB). The next version, MIB2+, supports the LTE Advanced wireless communication standard, and Audi is also exploring the LTE-V automotive standard. Cars can use this to interconnect directly and spontaneously.

Another important foundation for piloted driving besides a perfect online connection is the HERE HD Live Map. The high-precision digital map is conceived as an independent, continuously extensible and updatable platform. Whether carmaker or supplier, municipal traffic manager or service provider: HERE is accessible to all. ■



*HERE HD Map - captures billions of 3D points to model the road surface* ■

## Controls and displays

Audi is also setting new standards for controls and displays with solutions such as the Audi virtual cockpit, MMI touch and the natural speech voice control system. In the future, the latter will tap into the boundless knowledge of the cloud. The cockpit is also getting a complete overhaul with the Audi virtual dashboard. In addition to the Audi virtual cockpit, it includes two touch displays with haptic feedback that can assume a variety of functions.

The fully digital implementation of the Audi control concept creates the foundation for a system that adapts ideally to the use patterns of individual customers. With intelligent messages and personalized content, it becomes a personal assistant in the car. ■

*Audi virtual engineering terminal* ■

## Virtual reality

Audi is increasingly turning to high-tech simulation tools. With the Audi VR experience, customers can now virtually experience the car of their choice at the dealership. In three dimensions and from a 360-degree perspective. The new high-tech tool uses the original design data from Technical Development, where VR tools are also becoming increasingly important. ■


*Audi TT Coupe - Audi virtual cockpit* ■

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# Quality – an often neglected key player



In times when products are becoming more and more complex coupled with rising cost pressure and increasing demands with regard to functionality, comfort and visual features, companies are having to work extremely hard to deliver adequate quality. Legal and normative guidelines also mean reduced room for maneuver. Nevertheless, customers still expect robust products, especially when longer term use is required.

A sign that these expectations are not being fulfilled, however, is that there has been a growing trend of product recalls over the last few years, particularly in the automotive industry. One of the main influences on this phenomenon is the increase of standardization in nearly all areas of product development. Without a doubt, such standardization is a fundamentally sensible, welcome and sustainable step in terms of quality assurance. A relapse towards high individualization would not be a suitable solution to reverse this trend. In reality, the solution lies in focusing on quality concerns. Some areas of activity are outlined briefly below.

Quality should be taken into account at an early stage of product development so as to avoid the enormous cost of subsequent corrections, which at the same time can also damage a company's reputation incredibly. Controlled design and development processes that are clearly and consistently documented also help to fulfill relevant normative and legal requirements.


Processes such as requirement and risk management should be worked through in a structured manner right from the start. The intelligent use of preventive quality methods can have a considerable influence here. This is because identifying and eliminating risks early on avoids problems that may later need to be solved through expensive reactive measures. This approach frees up human resources and also has financial and image-related advantages. Developers are also able to focus on their core business and do not have to constantly deal with old problems.

However, even the best-possible preventive methods will not avoid all problems. Despite careful avoid-

ance strategies, a number of problems remain – though these are manageable and can be specifically addressed. A fast and structured approach needs to be adopted, ideally in the form of a process. A root cause analysis should be carried out very early in the solution process to exclude conflicts of competence and ineffective measures from the very start. The more problem-solving activities are defined in a process and the more analytical and methodical expertise is applied, the quicker results will be generated and the more sustainable they will be. Chance-based „trial and error“ approaches often do not lead to the desired levels of success.

Another important factor in addition to preventive qualitative work and targeted problem-solving is preventing errors from being repeated. Here too, consistent process solutions that document important information as „lessons learned“ and make the right person available at the right time are essential. Ideally, there should be such a process that ensures uniform consistency across the company. Well-intended but ultimately misguided simultaneous activities are more of a hindrance than a help. If everyone would rather implement their own solution and bypasses existing processes, the whole thing will be doomed to fail.

Generally, it is becoming increasingly important to consistently and sustainably document all the activities involved in the value creation processes. In many cases, this has even become a legal or at least normative requirement. With regard to safety-related functions – a topic that is gaining more and more attention with the increasing degree of automation in nearly all product areas – there is a need to take this very seriously. Otherwise, companies will quickly be confronted with existential risks fueled by potential claims for compensation.

The aspects mentioned above are not rocket science and yet many companies, however innovative and modern they may be, struggle to manage these activities effectively. Practical experience shows that in many places, a good standard of quality is not a foregone conclusion. Often it's the simple framework conditions that turn out to be unsurmountable hurdles. In some cases, it can be seen that quality is implemented for no clear purpose just because it is a desirable concept. Clear authority and financing are often lacking. It can also often be seen that although sporadic measures to improve quality are sometimes taken as a means of expressing an understanding of their necessity, they fizzle out ineffectively within the overall context, due to a lack of any kind of system.

There is therefore a need for concepts which favor a pronounced culture of quality with regard to all framework conditions, such as the process landscape and the mind-set of the workforce, but which also permit a structured approach.

Here at ESG, we meet these challenges with a holistic approach. This way, we are able to react to problems in a targeted manner using our core elements of quality data analysis, operative quality management, quality method consultation and implementation. We constantly scrutinize our portfolio with regard to meaningfulness and completeness. We add new elements if need be and establish professionalism quickly. Professional, controlled action is an essential core element for managing a multitude of challenges. You can only operate successfully with the right specialist for the right task. We have recognized that a high level of professionalism, which is accepted in the development sector as a matter of course, also plays an extremely important role in quality management.

Quality requires specialists! As well as trained, experienced quality engineers who observe the classic quality assurance tasks, other specialists such as analysis experts, process consultants, facilitators and methodologists should also be deployed according to requirements. Only with their help can you obtain a complete and holistic overview, which enables quality to be targeted in a specific manner.

With this knowledge, you are well prepared for current and future challenges. It is true that this „professionalization“ of work quality is an additional investment – but it is one which pays for itself very quickly and offers both manufacturing companies and their customers attractive benefits. ■

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# acad group: Your expert for armrests and express injection moulding parts

## Flexible, faster, more economical

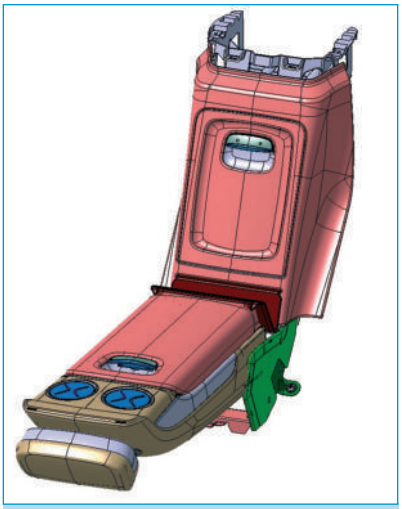
*As a specialized provider, the acad group has an excellent name in terms of protoyping, express injection molding and the development of armrests and head rests among automotive suppliers.*

‚By means of a special express injection molding process, we produce genuine and complex plastic parts in only 10 to 15 working days, thus saving the company considerable costs,' explains Alexander Kalusche. ■

### acad prototyping

Good prototypes save cash. Crash tests, installation tests and functional tests are very demanding for the parts. They should be serial quality in the original material but still be flexible to changes. With a standard procedure these requirements cannot be fulfilled. Due to a specially developed tool system acad prototyping copes with the balancing act. The high segmentation is a decisive advantage, especially for very complex parts. Also geometry changes are possible in a fast and cost-effective manner. Because risks can be minimized in advance the gained experiences are an advantage at latest when series tools are made. ■

*Console front armrest for VW Touran F. S. Fehrer Automotive GmbH* ■



*Daimler S-Klasse, Middle armrest SA back for F. S. Fehrer Automotive GmbH* ■

### Extended development department

The most important customers in this sector are system and component suppliers of the automotive manufacturers. ‚For these companies, we are the extended development department,' says Alexander Kalusche. ■

### acad engineering

In order to go the limits in of material usage a mature design that is suitable for plastics is essential. acad engineering provides this & can fall back on 25 years of experience in the field of automotive interior (armrests and headrests). Thanks to a well thought out process chain and high plastic knowhow we create innovative and trend-setting results. In order to minimize the development risk and to identify potential vulnerabilities acad counts on the FEM analysis as preliminary step to the prototype phase. ■

**acad engineering**
*driven by evolution*

- *25 years development experience with important OEMs*
- *Focus on automotive interior*
- *Cost-oriented development*
- *Functional models*

**acad prototyping**
*driven by improvement*

- *Express injection moulding parts in original serial quality*
- *High testing capability*
- *Early product confirmation*
- *very complex parts with various directions of remoulding*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acad group

# Special e-Car

# European Metropolitan Region of Nuremberg: strength in the automotive industry – e-mobility as a strategic driver of innovation

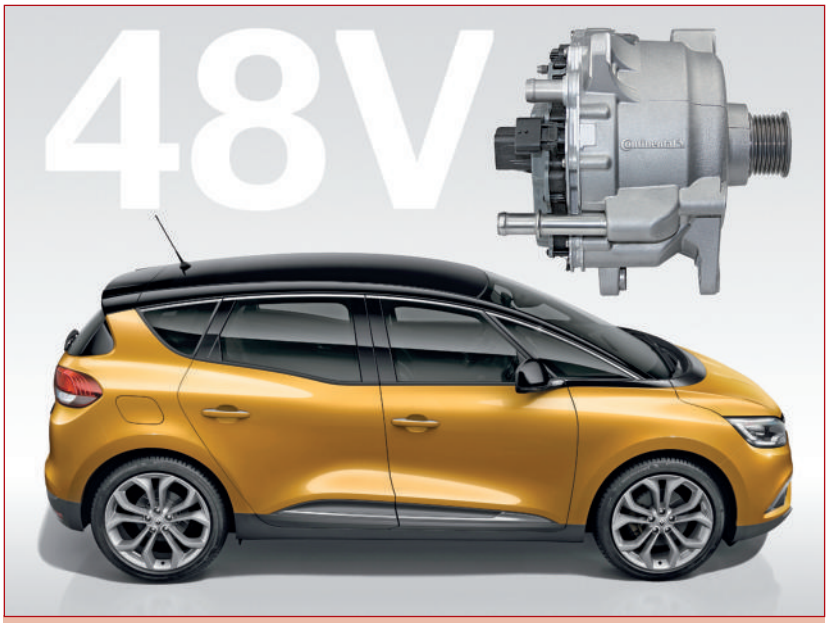
*Automobile suppliers form the industrial backbone of the European metropolitan region of Nuremberg (EMN). With around 88,000 employees and job growth of over ten per cent within the last six years, they represent a key industry. The EMN's corporate landscape is shaped mostly by medium-sized businesses. However, it is also home to global market leaders from various sectors. Its particular strengths lie in electrical and mechanical drive technology and mechatronic system solutions.*



It is therefore not without reason that the EMN's plans for development focus on the "automotive" technology-oriented field of expertise and the "intelligent mobility" action field. Key areas include: automated driving, environmental compatibility, intelligent networks, age-appropriate mobility and hybrid drive systems including e-mobility.

Efficient and electric mobility is gaining more and more importance and it seems only a question of time before it permanently replaces the classic combustion engine. With its mix of varied suppliers, the EMN is perfectly positioned to advance and decisively shape this and other issues.

One example is provided by Conti-Temic microelectronic GmbH in Nuremberg, where around 2,500 employees work on all aspects of electrification. The world's first 48-volt hybrid drive has been mass produced there since October 2016. The technology used is a particularly cost-efficient solution that significantly reduces fuel consumption and exhaust emissions. The 48-volt variant is an alternative to the considerably more complex 300 to 400 volt technology that has previously been the standard in hybrid vehicles. Since 2013, the engineers at Continental in Nuremberg have been developing this hybrid drive together with Renault and regional partners such as the Fraunhofer Institute for Integrated Systems and Device Technology (IISB) and the Bayerisches Laserzentrum (both based in Erlangen).




*The world's first hybrid drive, which works with a voltage of 48V, was developed by Conti in Nuremberg and continues to be mass produced there. Image: Continental* ■

Other companies and brands such as Siemens, Baumüller, Brose,

Semikron, Schaeffler, MAN and ABM Greiffenberger also stand for considerable global expertise in the field of electric and hybrid drive technology.

The region's other strengths include the provision of components and solutions for electronics, cables, wiring systems, and storage and charging systems. Examples of companies and brands in these sectors include Bosch, Leoni, Komax, FCI Connectors, ZF, Delphi, Diehl, Schlenk, Scherdel, E-T-A, ABL Sursum, TÜV Süd and TÜV Rheinland.


*Ladeverbund Franken: More than 30 local municipal utilities engage in a comprehensively expanded and unified public charging infrastructure. There are currently about 140 charging stations available. Another 100 are planned for 2017* ■

The Nuremberg metropolitan area is home to several research institutes and university departments specialising in electromobility. Examples include the above-mentioned Fraunhofer IISB (developing power electronics, designing and implementing storage systems and test centres for electric vehicles), the Fraunhofer Institute for Integrated Circuits IIS (e.g. information and communication technology for battery management, energy management, connection to smart grids, non-destructive material testing), Fraunhofer Institute for Silicate Research ISC (material development for fast, high-performance and secure energy storage) and the Fraunhofer UMSICHT Institute Branch Sulzbach-Rosenberg (centre for energy storage). Institutions such as the E|Drive Center at the Friedrich-Alexander Universität Erlangen-Nürnberg (production-related design, production technology and application development for electric drives), the Bayerische Polymer-Institut in three Universities based in Bayreuth, Fürth and Würzburg (development of fibre-reinforced composites such as CFRP) and the Technologie-Transfer-Zentrum-Elektromobilität (TTZ-EMO) at the University of Applied Sciences Würzburg-Schweinfurt (i.a. load management with electromobility and innovative charging technology) provide future-oriented solutions, as do the Institute for Power Electronic Systems (ELSYS) at the Technische Hochschule Nürnberg Georg Simon Ohm (network integration of electric vehicles i.a.), Automobiltechnikum Bayern in Hof (measurement and testing technology), the Ostbayerische Technische Hochschule Amberg-Weiden (integrated systems and real-time software for electromobility) and the Technologietransferzentrum Automotive of the Hochschule Coburg (TAC).

Since 2013, the Nuremberg Chamber of Commerce and Industry for Central Franconia has provided the CCI Innovation & User Club e-mobility (http://emobility-nordbayern.de) in cooperation with the chambers of commerce and industry based in Coburg, Bayreuth, Regensburg and Würzburg-Schweinfurt to create opportunities for regional providers, users and developers to cooperate and promote the

*Netherlands@Schaeffler: In April 2016, a Dutch economic delegation supported by the IHK visited Schaeffler AG in Herzogenaurach to discuss urban mobility and smart electric vehicles, among other things. Photo: Schaeffler*

*Netherlands@Schaeffler: The Schaeffler bio-hybrid combines benefits such as stability and weather protection with the energy consumption and space utilisation of a pedelec. Photo: Schaeffler* ■

exchange of knowledge. Examples of other regional clusters and networks advancing the issue of electronic mobility include Nuremberg-based Bayern Innovativ GmbH, and the competence initiatives EnergieRegion Nürnberg e.V. (project "CODIFeY"), Center for Transportation and Logistics Neuer Adler e.V. (CNA), European Center for Power Electronics e.V. (ECPE) and in Bayreuth the Automobilnetzwerk ofraCar-Automobilnetzwerk e.V. Fürth-based solid GmbH combines the electronic mobility activities of regional energy providers, for example in the "Ladeverbund Franken+" project, a charging network in and around Franconia. ■

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# Audi Q8 concept – full-size SUV in coupe design

- *Luxury lounge for four, new control concept with large touchscreens*
- *Plug-in hybrid with 330 kW system output and 700 Nm (516.3 lb-ft) of torque*
- *Production model based on concept to launch in 2018*

*Dynamic, highly efficient and extremely comfortable: Audi presented the Audi Q8 concept at the North American International Auto Show (NAIAS) 2017. With this model the premium manufacturer is tapping into a new segment for the full-size class – an elegant alternative to the robust presence of a classic sport utility vehicle. The Q8 concept stands for maximum prestige. It combines the spaciousness typical of an SUV with the emotional lines of a coupe. Propulsion is provided by a powerful, yet highly efficient plug-in hybrid with 330 kW of system output and 700 Nm (516.3 lb-ft) of torque. The concept car is the basis for a production model that Audi will launch on the market in 2018.*

Audi Q8 concept

At 5.02 meters (16.5 ft) long, the Audi Q8 concept is an impressive presence in the full-size class. Thanks to a wheelbase of three meters (9.8 ft), the show car offers plenty of space for passengers and luggage. Despite the sloping, coupe-like roofline, even the rear-seat passengers enjoy ample head and shoulder room. The control concept uses large touchscreens in the cockpit and is rounded out by an expanded version of the Audi virtual cockpit and a contact-analogue head-up display. The latter uses intelligent augmented reality technology that merges the real and the virtual worlds.

"The Q8 concept is an Audi in peak form. It demonstrates the strengths of our brand in both technology and design while providing a glimpse at a future full-size, production SUV," said Dietmar Voggenreiter, Member of the Board of Management for Sales and Marketing at AUDI AG. "With its next-generation display and control solutions, we are enabling customers to experience connectivity in a whole new way." ■

*Audi Q8 concept – front view* ■

## Dynamic lines and digital Matrix laser technology: the front end

The silouhette of the Audi technology study also evokes tautness. The doors do not have window frames, thus contributing to the flat roofline. The Audi Q8 concept is 1.70 meters (5.6 ft) tall. All lines on the body climb upward dynamically toward the rear – the bottom edge of the side window, the shoulders, the dynamic line and the sill lines. The surfaces of the fenders, doors and side panels are athletically curved. The lower section of the doors form a deep fillet. Other design features are the quattro logo milled below the rear doors and also the exterior mirrors with their multifaceted edges. The doors are opened via

*Audi Q8 concept – side view* ■

touch sensors. As soon as the door detects hand contact, it opens easily and swings to a defined opening angle.
The extremely flat and very wide C-pillar is reminiscent of the Audi Ur-quattro from the 1980s, as are the strongly flared shoulders over the wheels. This places the concept car in a logical line with the show cars of the Audi Prologue series. The balanced proportions of the Audi Q8 concept emphasize the front and rear wheels equally – that too is typical quattro. The strongly accentuated wheel arches feature a double design. The sill region of the doors shines inbrushed aluminum for an intriguing contrast to the show car's Bombay blue paint finish. ■

## Athletic and powerful: the side view

The silouhette of the Audi technology study also evokes tautness. The doors do not have window frames, thus contributing to the flat roofline. The Audi Q8 concept is 1.70 meters (5.6 ft) tall. All lines on the body climb upward dynamically toward the rear – the bottom edge of the side window, the shoulders, the dynamic line and the sill lines. The surfaces of the fenders, doors and side panels are athletically curved. The lower section of the doors form a deep fillet. Other design features are the quattro logo milled below the rear doors and also the exterior mirrors with their multifaceted edges. The doors are opened via touch sensors. As soon as the door detects hand contact, it opens easily and swings to a defined opening angle.
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## Flat and compact: the rear

A long roof edge spoiler shades the extremely flat rear window of the Audi concept car. A double spoiler lip below the window forms a distinctive contour on the power luggage compartment hatch. The strip of lights extending over the entire width of the rear end is part of a distinctive e-tron light signature. It serves as both the tail and brake light as well as the dynamic turn signals. The four outer lighting elements are set in aluminum blades and reflect the semantics of the headlights. The individual elements of the tail lights are also open, and all lighting functions are dynamic.
The license plate of the Audi Q8 concept is located on a black trim strip between the lights – a typical feature of the Audi Ur-quattro. The diffuser is made of aluminum; its clasp of high-gloss Carbon Atlas. This combination of materials is also used around the headlights to demonstrate sportiness. ■

## Luxury lounge for four: the interior

The interior of the Audi Q8 concept offers opulent spaciousness for four persons and their large suitcases. The luggage compartment has a capacity of 630 liters (22.2 cu ft). Widely stretched lines lend the cockpit a sporty as well as elegant ambiance. Virtually floating above the center tunnel is a console for the shift-by-wire lever, with which the driver controls the eight-speed tiptronic transmission purely electronically. The console's appearance resembles the stern of a sailing yacht. The wrap-around begins in the front doors. This large, horizontal arc runs along the lower edge of the windshield and frames the driver's and front passenger's seats without hemming in the occupants. The sport seats as well as the two individual seats in the rear are made up of segments that appear to be separate geometric bodies, from the pronounced side bolsters to the head restraints. A horizontal aluminum clasp divides the backrests at the height of the window shoulder line.
The instrument panel with its distinctly horizontal character descends in steps toward the interior. The central control and display surfaces are integrated into the so-called "black panel" – a glossy black strip framed by an aluminum clasp. When switched off, the monitor is invisibly

*Audi Q8 concept – interior* ■

embedded in the surface and the lines flow harmoniously. When the display is in operation, it assimilates perfectly into the design line. In the front passenger area, the black panel encircles a graphical quattro badge. The arrow-shaped inlays in the doors pick up the expressive design. Filigree aluminum bars integrated into them serve as door openers. When dark, LED light guides illuminate the interior with white light.

The colors and materials in the Audi Q8 concept provide for a cool and sporty atmosphere. One highlight is the three-dimensional, engineered grain on the instrument panel, doors and floor. High-gloss carbon applications with a new, abstract fabric structure as well as aluminum strips and frames set accents. Their brushed finish is relatively dark. Brightness increases gradually from the headlining to the center console in graduated shades of gray from steel gray to pastel silver.

The technical materials in the Audi Q8 concept contrast with the soft surfaces. The seats are covered in a combination of Fine Nappa leather and Nubuk leather, both in pastel silver. The upholstery is pulled around the clasp that divides the backrests – the inside becomes the outside at this point. The head restraints are covered with a structured textile of a color similar to that of the leather elements. ■

## New ways: controls and displays

The elegant interior architecture of the Audi Q8 concept merges with a groundbreaking control and display concept. Information and commands are passed primarily through touch displays augmented by the Audi virtual cockpit and a contact analogue head-up display. All displays feature a new "digital design" that concentrates systematically on the most important things.

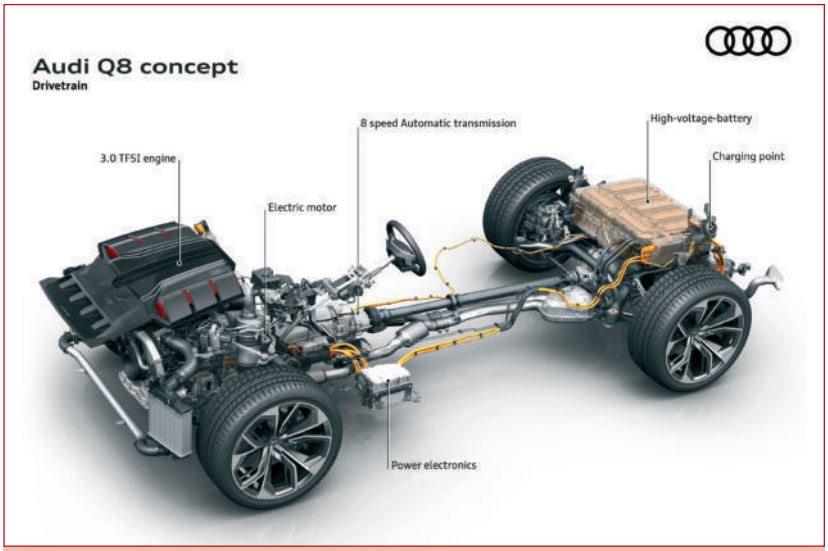
The contact analogue head-up display projects important displays onto the windshield in the driver's direct field of view, seemingly placing them in the real environment. A navigation arrow, for example, appears in the same position as an actual arrow on the road – an intelligent application of augmented reality. The notifications from the driver assistance systems also merge the virtual and physical worlds.

The Audi virtual cockpit future is even more dynamic thanks to new functions, and with a resolution of 1920 x 720 pixels displays graphics with more detail than ever before. In "auto" display mode, the 12.3-inch TFT display offers generous space for maps, lists and additional information. The top-down map view visualizes the selected route. When zooming in, the current position and surroundings are displayed in 3D. Through the buttons on the steering wheel, the driver can switch to "performance" mode. The needles of the speedometer and powermeter now appear in a foreshortened, three-dimensional display.

All other monitors in the Audi Q8 concept are touch displays. The great strength of this principle is the direct, fast and intuitive operation. Drivers select each function exactly where they see it. Audi was also able to reduce the number of buttons, switches and levers thanks to the touchscreens. The interior now appears even neater and cleaner.

The MMI monitor in center of the dashboard is used to control the infotainment system and for vehicle settings. A display for the climate control system is integrated into the diagonal section of the center console. The driver's wrist rests comfortably on the low selector lever of the eight-speed tiptronic while using this display. If the sensors in the seat detect a front-seat passenger, the touchscreen displays their climate control settings. This function is not available when the driver is traveling alone. Another touchscreen is reserved for the lighting functions. ■

*Audi Q8 concept – cockpit* ■




*Audi Q8 concept – drivetrain* ■

## Powerful and highly efficient: the drive system

The Audi Q8 concept uses production technologies for the drive system and suspension. Their use in the study demonstrates their importance once again. The plug-in hybrid combines sporty performance with high efficiency. The combustion engine is a 3.0 TFSI producing 245 kW (333 hp) and a maximum of 500 Nm (368.8 lb-ft) of torque. The electric motor generates 100 kW of power and 330 Nm (243.4 lb-ft). Together with a decoupler, it is integrated into the eight-speed tiptronic. The complete system produces 330 kW and 700 Nm (516.3 lb-ft) of torque. The Audi Q8 concept accelerates from 0 to 100 km/h (62.1 mph) in 5.4 seconds on its way to a top speed of 250 km/h (155.3 mph). According to the standard applicable for plug-in hybrids, it consumes just 2.3 liters of fuel (102.3 US mpg) per 100 kilometers (62.1 mi) in the NEDC, corresponding to 53 grams $CO_2$ per km (85.3 g/mi).

The lithium-ion battery located in the rear consists of 104 prismatic cells. With a capacity of17.9 kWh, it enables an electric range of 60 kilometers (37.3 mi), and the total range with the TFSI engine is up to 1,000 kilometers (621.4 mi). A full charge with 7.2 kW output takes about two and a half hours.

When driving, the hybrid management system controls the operating states of the Audi Q8 concept intelligently and flexibly. The full-size SUV can boost, coast and recuperate as appropriate for the situation. The predictive efficiency assistant, which in production models supports the driver, provides the hybrid management system with highly detailed information about the near surroundings for this purpose. Route data from the navigation system and Audi connect Car-to-X services are also considered.

The driver controls the Audi drive select system via a prismatic satellite button on the flat- bottomed steering wheel, just like the start-stop system. There is a choice of three driving modes: "EV" mode prioritizes electric driving, while in "hybrid" mode the decision regarding the drive type is left largely to the hybrid management system. In "battery hold" mode, it saves the available electric energy for a later time. ■

## High-tech from production models: drivetrain and suspension

In the Audi Q8 concept, the quattro permanent all-wheel drive system delivers the power of the hybrid drive to the road with supreme control. At the cornering limit, it works closely with the wheel-selective torque control. This minimally brakes the inside wheels, which further enhances dynamics and stability.

The technology study also uses high-end production solutions for its wide-track suspension. The adaptive air suspension sport – an air suspension system with controlled damping – allows a wide range from cushioned cruising to firm and tight handling. In addition, it sets the ground clearance in two levels, with 90 millimeters (3.5 in) height difference, to the ideal level in each case. The front and rear suspensions are engineered as lightweight five-link designs.

Audi mounts 305/35-series tires on the large 11J x 23 wheels. The five intertwining Y spokes project a filigreed, three-dimensional and powerful image. Ceramic brake discs measuring 20 inches in di-…ameter effortlessly decelerate the Audi Q8 concept. ■

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