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CENTER OF AUTOMOTIVE MANAGEMENT – The automotive institute of Bergisch Gladbach University of Applied Sciences

The future of mobility

Future trends in the areas of e-mobility, connected cars and mobility services

Paper by the Center of Automotive Management | November 2022

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Study of the Center of Automotive Management (CAM) for BNP Paribas Cardif – November 2022

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Executive Summary

Future trends in the areas of e-mobility, connected cars and mobility services

- The study investigates future trends in mobility in a compact and focused format. The aim is to analyse the current transformation in automotive mobility and the development of innovations in the most important areas, and draw conclusions about the future of mobility. It identifies innovation trends in the areas of electric vehicles, autonomous driving and interconnectivity. It also focuses on new mobility services and forms of mobility (mobility solutions) and how they are being received by consumers.
- In the area of e-mobility, the number of new registrations has grown significantly in recent years. In Germany alone, the number of electric passenger vehicles more than doubled between 2020 and 2021, from almost 600,000 to 1.27 million. This represents around 2.6 percent of total passenger vehicles. This growth is expected to continue in the coming years. In a scenario described in this study, in 2030 there will be more than 11 million battery electric vehicles (BEVs) on German roads. This represents almost a quarter of the total number of passenger vehicles. New registrations of plug-in hybrid electric vehicles will total almost 4.8 million in 2030, representing a market share of around 10 percent. This will bring the share of electric vehicles (battery electric and plug-in hybrid vehicles) as a proportion of the total to 34 percent, or around 15 million passenger vehicles.
- The number of innovations in relation to connected cars has also increased sharply in recent years, enabling the networking of services. This will offer car manufacturers considerable sales potential. This is less about one-off revenues from sales of vehicles or hardware features than recurring software-based digital services for manufacturers' entire fleets of networked or autonomous vehicles. Based on the use cases for connected services presented in the study, sales potential of around EUR 900 to EUR 1,000 per vehicle per year could potentially be realised in 2030. Taking into account the number of networked and autonomous cars produced by original equipment manufacturers (OEMs), this will result in a high share of global sales in 2030, which could contribute a total market volume of more than EUR 200 billion globally.
- Another trend area is mobility services. CAM and YouGov conducted a survey on mobility behaviour and consumer views in Germany in June 2022. A similar survey in 2018 enables longitudinal comparisons to be made. The survey found that the importance of cars in Germany has declined only slightly. Sixty-nine percent of Germans state that a car is important for them owing to their current mobility situation. Of these, 42 percent say that they are actually dependent on their own car. In 2018, having a car of their own was important for 73 percent of survey participants. What is striking is that significantly more young city dwellers now say they rely on their car than four years ago. People living in rural areas are more heavily dependent on their cars in any case.
- Car sharing is one of the most common mobility services in Germany. However, a longitudinal comparison shows a decline in people's willingness to use car sharing between 2018 and 2022. Only 26 percent said they *would definitely or might* consider using free-floating car sharing in 2022. This compares with 34 percent in 2018. In addition to the linkage of different modes of transport in a booking, prepayment for travel in the form of a flat rate is possible. Despite the current small offering, the survey shows that at least in urban areas and among younger customers there is great willingness to use car sharing. Almost fifty-eight percent of city dwellers aged between 18 and 34 would (probably) consider using car sharing, while in the middle age group a good 40 percent would consider it.

Content of the study

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1.

Introduction

Introduction

Analysis of future trends is the central focus, along with customer surveys

- The study investigates future trends in mobility. The aim is to analyse the current transformation in automotive mobility and the development of innovations in the most important areas, and draw conclusions about the future of mobility. The key questions are as follows: What are the innovation trends in the fields of e-mobility, autonomous driving and networking? What new mobility services and forms of mobility (mobility solutions) are emerging?
- The study focuses on Germany, as an important European market. Based on a status quo examination, the year 2030 is taken as a medium-term time horizon.
- In terms of methodology, this study is based partly on analyses of trends in the innovations of 28 global automotive manufacturers on the basis of the CAM AutomotiveINNOVATIONS database. It also involved carrying out meta-analyses of current studies by the Center of Automotive Management (see annex). Additionally, consumer views on mobility are obtained by means of a quantitative survey, partly building on the 2018 BNP study. In particular, some trends in mobility behaviour in Germany are presented.
- Future trends in key technological and service areas are central to the innovation analysis:
 - **E-mobility** – One of the most important megatrends is the revolution that is taking us away from internal combustion engines towards electric motors. The goal is to move towards fully electric vehicles in the form of battery electric vehicles, and possibly, for niche applications, the hydrogen fuel-cell engine. A combustion engine can be used as an additional source of propulsion by way of transition (plug-in hybrid).
 - **Connected car (connectivity, autonomous driving, interface)** – Connecting the passenger vehicle with its surroundings makes new vehicle functions possible, up to and including fully autonomous driving. This is not achieved in one go, but through various levels of driver assistance. Networking also enables new comfort and safety features, such as warning functions. Connected cars are operated using new interfaces, speech and gestures.
 - **Mobility services** – Mobility is often considered not as a hardware function (one's own car), but as a service – hence the term mobility as a service (MaaS), which can take many different forms depending on distance to destination and comfort needs.



2.

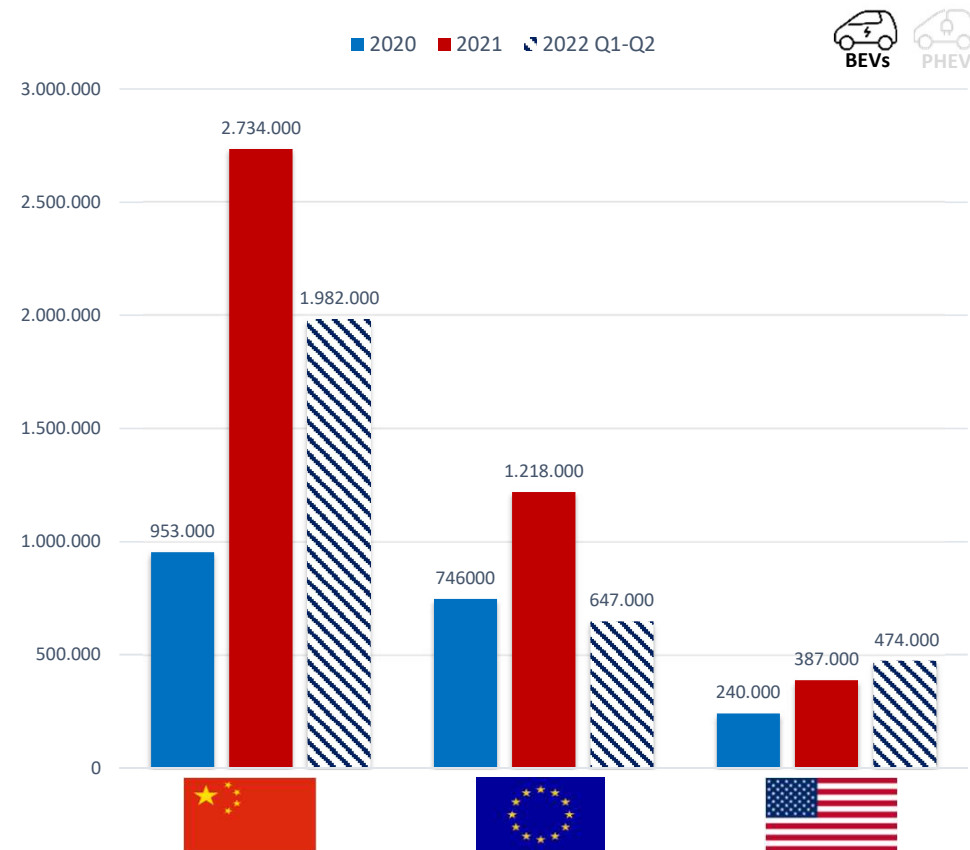
Future trend: e-mobility

E-mobility as a future trend

With its strong growth, China remains the leading market for e-mobility, followed by Europe

- The market growth trajectory of e-mobility as the most important trend in the field of passenger vehicle propulsion is continuing to accelerate in the most important market regions, despite the coronavirus and microchip crises. Electric vehicles include pure battery electric vehicles and plug-in hybrid vehicles. The widening of the range of battery electric vehicles and the grant schemes in place in core regions are increasing the acceptance rate of battery electric vehicles among the population and giving rise to a huge increase in registrations.
- China remains the leading market for pure electric transport solutions in the first half of 2022. At around 2 million, the figure for new registrations of battery electric vehicles has quadrupled in comparison with 2021 (0.6 million). As a result, the share of battery electric vehicles in the total number of new registrations has increased by 11.6 percentage points to 19.2 percent.
- On the European market, sales of battery electric vehicles increased to around 0.6 million in the first half of 2022, in contrast to the overall decline in the private passenger vehicle market. The share of battery electric vehicles as a proportion of the total has increased to 12 percent, up 4 percentage points on the first half of 2021. This continuous upward trend is attributable both to the buyer's subsidy and tax advantages in place in many European countries and to the widening range of battery electric vehicles available, although the growth has currently weakened somewhat owing to supply shortages.
- In the United States, new registrations of battery electric vehicles grew faster than in the markets in China and Europe, to a level of around 474,000 units. Despite an increase in their market share from 3 percent over the whole year in 2021 to 4.8 percent in the first half of 2022, battery electric vehicles still have a low profile apart from Tesla. However, the US federal government has now launched a subsidy programme for electric vehicles.
- At the same time, traditional US automotive manufacturers are currently electrifying their ranges at a high development cost.

Battery electric vehicle registrations in the core markets



Source: CAM, KBA, CAAM; note: *EU-27 + EFTA + UK (All figures in German data format.)

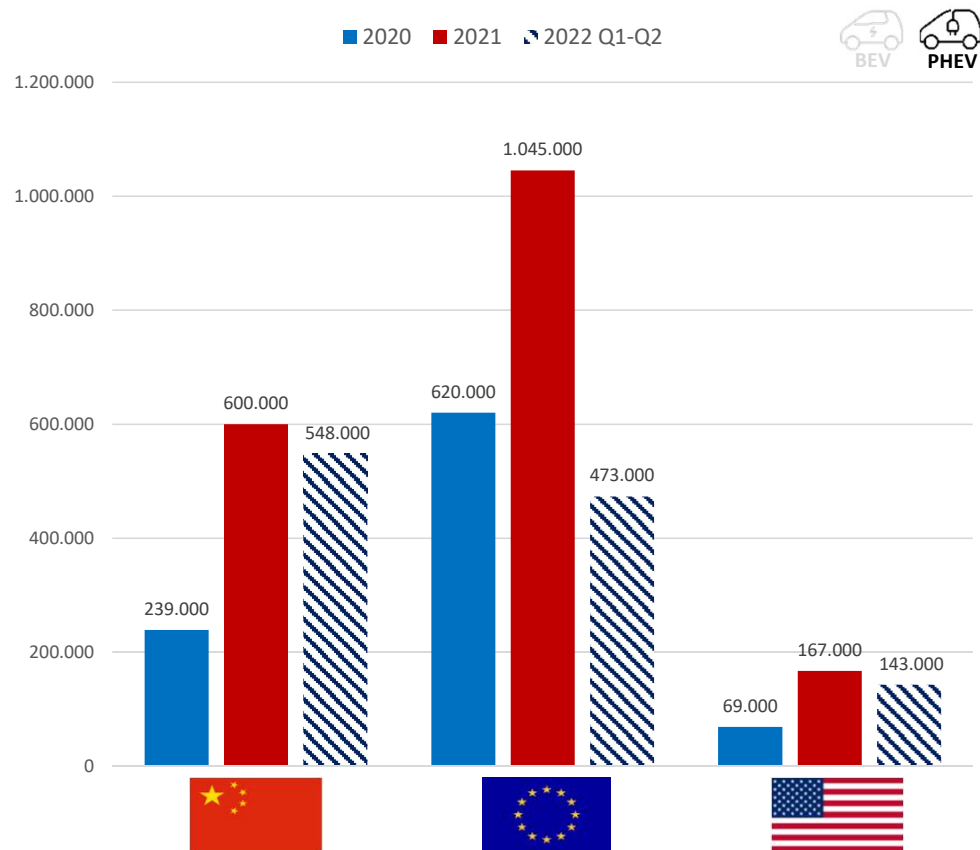
Situation as of July 2022

E-mobility as a future trend

China overtakes Europe in the first half of 2022 as the most important market for plug-in hybrid vehicles

- Trends and developments in the market for plug-in hybrid vehicles continue to vary greatly between the different e-mobility core regions. While demand for plug-in hybrid electric vehicles in Europe remains high, in the two other leading markets this form of propulsion plays a minor role, as measured by the total number of registrations.
- Europe lost its position as the leading market for plug-in hybrid vehicles to China in the first half of 2022. New registrations in the first half of the year were down from 537,000 in 2021 to 473,000 in 2022. Despite the wide range of plug-in hybrid vehicles offered by automotive manufacturers, the European market is stagnating, and the share of plug-in hybrid vehicle sales remains unchanged at 8 percent.
- In China, by contrast, new registrations of plug-in hybrid vehicles are increasing. There were 548,000 registrations in the first half of 2022 – almost as many as in the entire previous year, when the figure was 600,000. Despite their market share of around 5 percent, demand for plug-in hybrid vehicles in China remains low, especially in comparison with battery electric vehicles.
- The US automotive market recorded a similar trend to China's in the first half of 2022. There were 143,000 new registrations of plug-in hybrid vehicles in the first half of 2022, almost as many as in the entire previous year. However, with a total of around 15 million vehicles registered, plug-in hybrid vehicles technology does not play a significant role in the United States either.
- Overall, plug-in hybrid vehicles propulsion systems are basically considered a transitional technology. In Europe they are mostly used by German automotive manufacturers. In the view of the CAM, plug-in hybrid vehicles will become less important when the market for battery electric vehicles takes off at the end of the 2020s.

New registrations of plug-in hybrid vehicles in the core markets



Source: CAM, KBA, CAAM. Note: *EU-27 + EFTA + UK (All figures in German data format.)

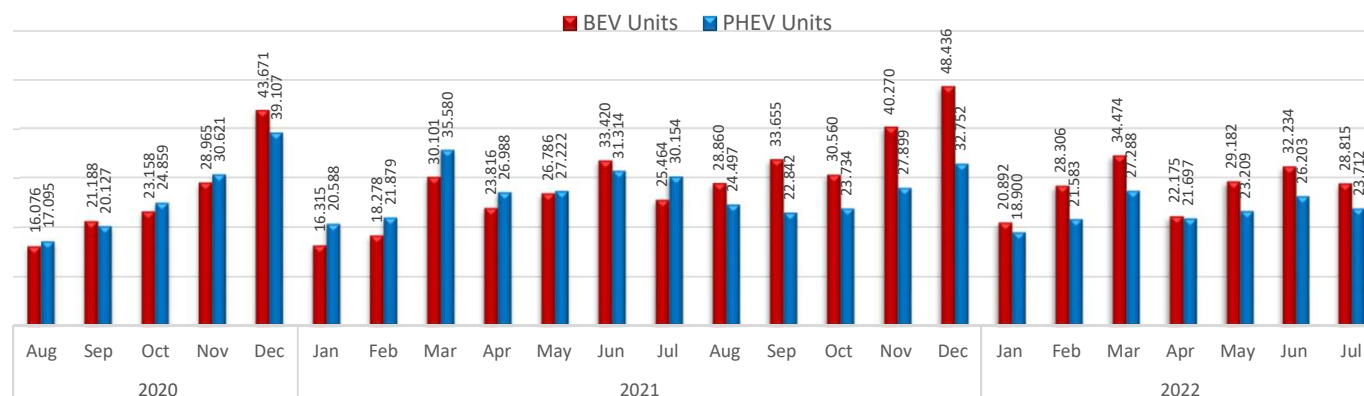
Situation as of July 2022

E-mobility as a future trend

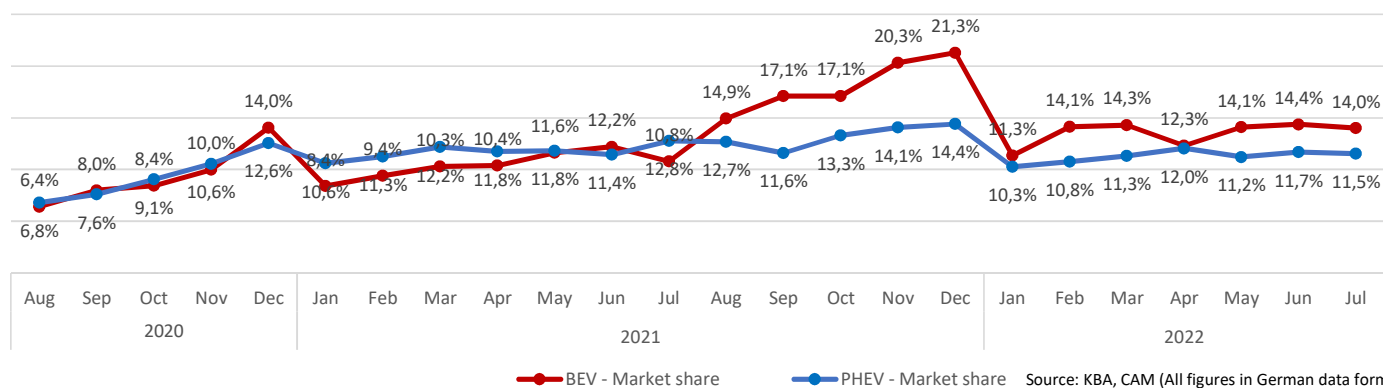
Germany: Chip shortage impacts new registrations of electric vehicles

- Monthly new registrations of electric vehicles in Germany are high but stagnating as a result of the chip shortage in the first seven months of 2022.
- The strong e-mobility dynamic is also reflected in the sharp increase in the share of new registrations. The battery electric vehicles share rose almost continuously from around 6.8 percent in August 2020 until it reached a new high at 21 percent in December 2021. In 2022, the battery electric vehicles share is around 14 percent.
- While the monthly volume of plug-in hybrid vehicle registrations was still higher than that of battery electric vehicles in 2020, since August 2021 the reverse has been true. In 2022, monthly new registrations of battery electric vehicles continue to outnumber those of plug-in hybrid vehicles.
- As in the first half of 2021, plug-in hybrid vehicle shares have plateaued and vary between 10 and 12 percent.

Monthly new registrations of battery electric and plug-in hybrid vehicles in Germany (August 2020 to July 2022)



Share of battery electric and plug-in hybrid vehicles per month as a percentage of all new registrations in Germany (August 2020 – July 2022)



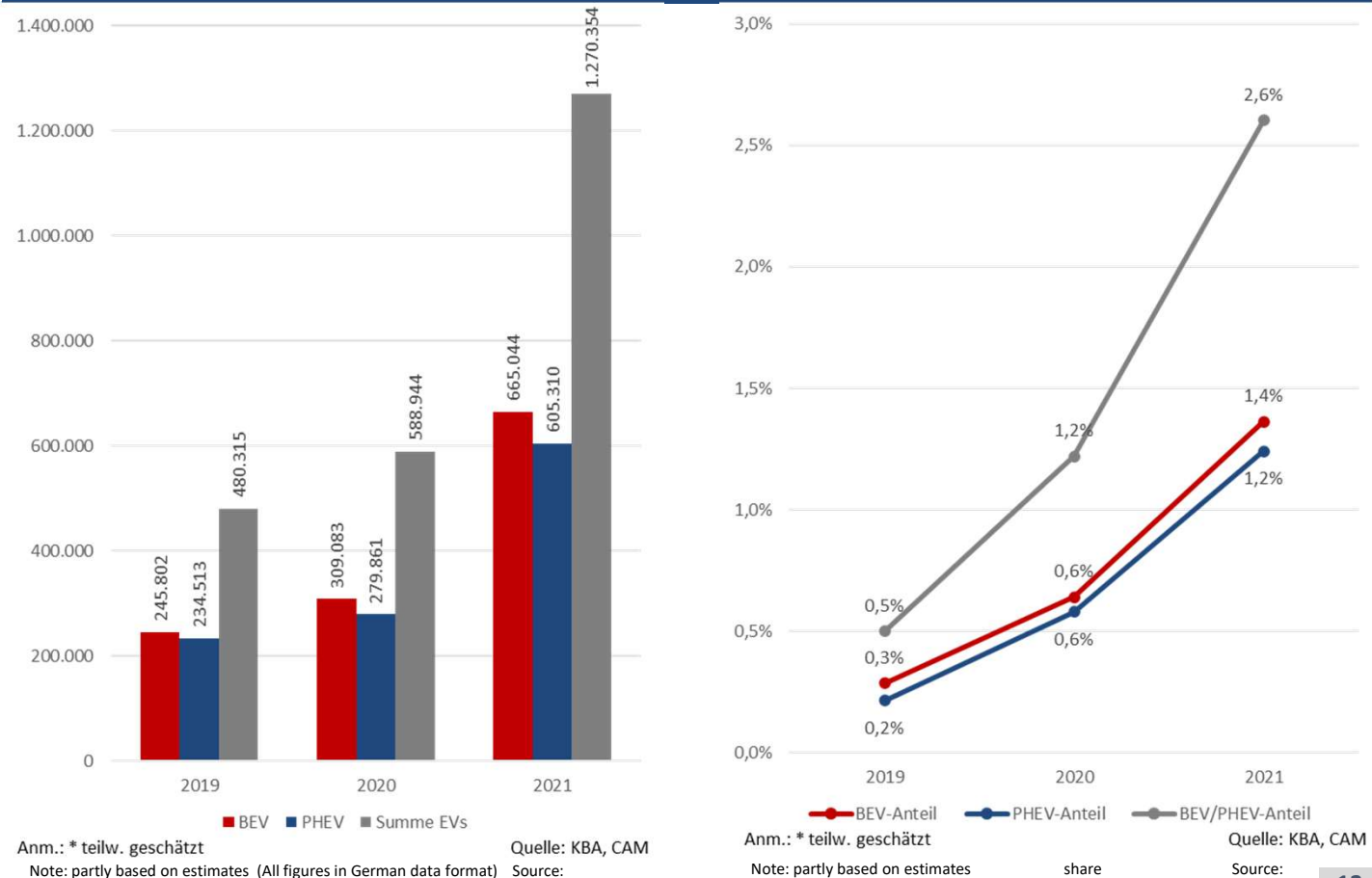
Source: KBA, CAM (All figures in German data format)

E-mobility as a future trend

Germany: highest growth in the number of electric vehicles (battery electric and plug-in hybrid vehicles)

- The number of electric cars more than doubled between 2020 and 2021, from almost 600,000 to 1.27 million. This represents a share of around 2.6 of the total number of cars.
- The continuous increase in the number of new registrations of electric vehicles has meant that the number of battery electric vehicles has grown from 0.25 million in 2019 to 0.67 million at the end of 2021. The resulting share of battery electric vehicles as a proportion of the total was around 1.4 percent in 2021.
- As a result of government grant schemes, the number of plug-in hybrid vehicles had also grown to more than 0.6 million by the end of 2021. This represents a share of 1.2 percent of the total number of cars in Germany. In the medium term, this number is expected to decline, as the expiry of the buyer's subsidy at the end of 2022 will curb future sales.

Number of electric vehicles (battery electric vehicles and plug-in hybrid vehicles) in Germany, 2019-2021 (absolute/relative)*



E-mobility as a future trend

Assumptions are also made for the scenario regarding costs, functionalities, infrastructure and regulation

- To estimate the market growth trajectory of e-mobility, a scenario analysis was conducted for the year 2030.
- The scenario analysis was based on assumptions regarding central e-mobility influencing factors: relative vehicle costs, functionality of vehicles, charging infrastructure and regulation. The medium (moderate) scenario for the market growth of e-mobility in Germany up to 2030 presented here is based on the assumptions shown on the right.
- It is assumed, for instance, that the relative vehicle costs, especially of battery electric vehicles, will fall significantly by 2030, mainly through lower battery costs. This will give battery electric vehicles an advantage in terms of costs (total cost of ownership – TCO) for battery electric vehicles as compared with internal combustion engine models.
- Work continues on the expansion of the private and, in particular, the public charging network up to the approximately 1 million charging points already being called for by policymakers. Charging is made very easy by the widespread use of a plug-and-charge function.
- An important regulatory condition is the reduction of fleet-wide CO2 emissions by 55 percent by 2030 in line with the European Green Deal (*Fit for 55*).

Assumptions regarding influencing factors for the moderate electric vehicle scenario up to 2030

Influencing factor	Measures/arrangements
Relative vehicle costs	<ul style="list-style-type: none"> Battery system costs gradually reduce from € 120 (2020) to € 80 (2025), and to around € 55/kWh by 2030 In terms of initial outlay, in 2030 battery electric vehicles are 1 percent below the cost of petrol models Trends in total cost of ownership (TCO) result in a cost advantage for battery electric vehicles of only around 20 percent by 2030 in comparison with petrol models
Functionality	<ul style="list-style-type: none"> Range: battery capacities of 150-200kWh from 2025 enable ranges of 450-700 km to be covered in high segments Charging speed: peak charging outputs of between 120 kW enable fast charging from 10 to 80 percent in 25 to 30 minutes Electricity consumption: 14-17 kWh as a segment average Full range of battery electric vehicles models in relevant segments
Charging infrastructure	<ul style="list-style-type: none"> Private charging network is expanded gradually; however, the demand for home charging is not yet fully met in cities, especially in apartment buildings. Of the total 8.8 million non-public charging points, 6.3 million are private and 2.5 million are workplace charging points. Public (fast) charging network is being expanded at a moderate rate; however, it is not much ahead of demand; slight shortages arise at peak times. Expansion of the public charging infrastructure to 957.000 charging points, of which 142,000 are fast-charging points. That is, at least a further 900,000 charging points would have to be created by 2030, of which more than 130,000 would have to be fast-charging points Good charging experience, since functions such as plug-and-charge have been implemented. Smart charging / bidirectional charging available in some places, but not yet standard.
Regulation and subsidies	<ul style="list-style-type: none"> Fleet-wide CO2 emission reduction targets in the EU: reduction to 43g CO2/km (= -55%) Buyer's subsidies for battery electric vehicles /electric vehicles expire in 2025; they are then replaced by a moderate arrangement of bonuses and disincentives to give priority to buying and using battery electric vehicles. Moderate restrictions imposed on combustion engine models, i.e. motorway tolls in (certain) conurbations and cities

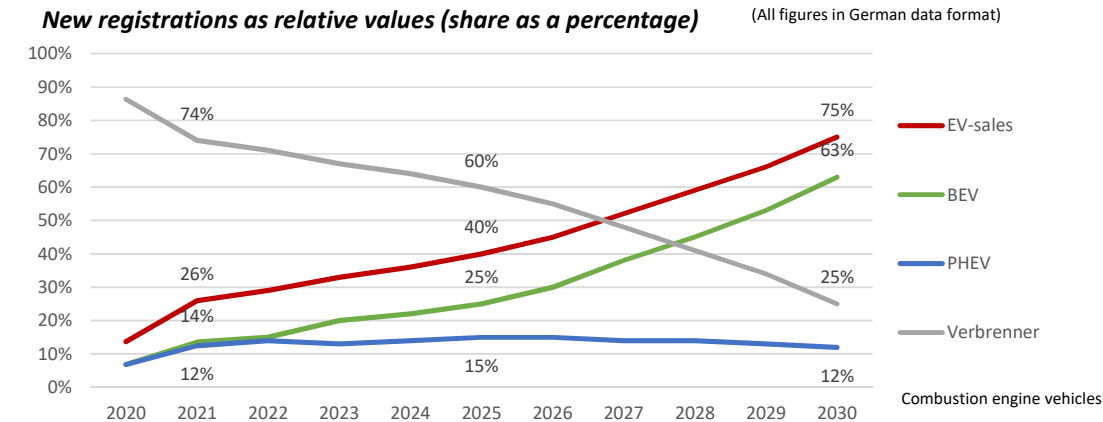
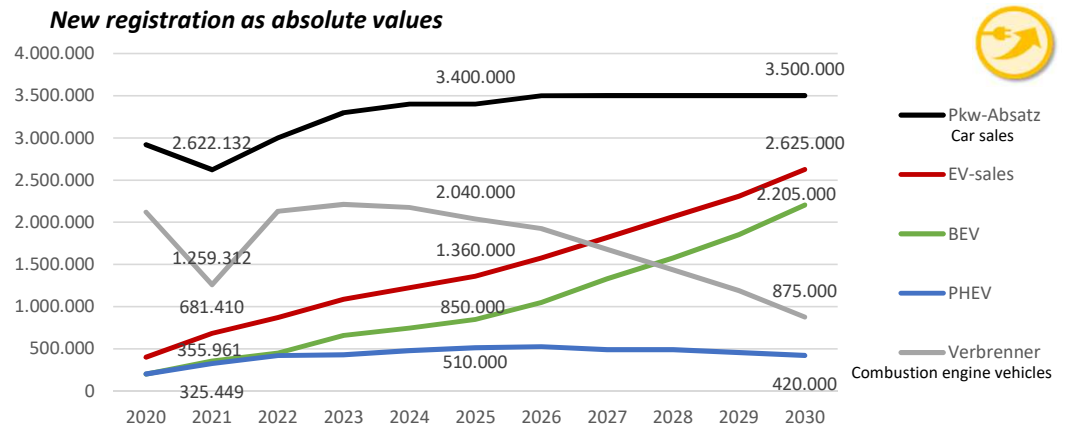
Source: CAM

E-mobility as a future trend

Germany: new registrations of private passenger vehicles in a moderate electric vehicles scenario up to 2030

- In a moderate scenario regarding the number of registrations of e-vehicles up to the year 2030, it is assumed that the trend in the key e-mobility influencing factors – especially in Germany – will be moderate. The total number of car registrations in the years 2021 to 2025 is between 2.6 million and 3.4 million and remains at this level thereafter.
- In this electric vehicles scenario the following new registration trends arise:
 - battery electric vehicles sales rise to 0.85 million in 2025, representing a share of 25 percent of the total number of new registrations; in 2030, 2.2 million newly registered cars, or 63 percent, will be fully electric;
 - new plug-in hybrid vehicle registrations play a significant role in this scenario up to 2025, with a share of 15 percent (0.51 million). By 2030, annual new registrations fall to 0.42 million, representing a share of 12 percent;
 - by 2030, altogether around 75 percent of new registrations are electric vehicles. The share of combustion engine vehicles (petrol, diesel including hybrid electric vehicles, others) in the total number of new registrations falls to 60 percent in 2025 (2 million), and to 25 percent in 2030 (0.875 million);
 - in total, 15.6 million new combustion engine vehicles are registered in the period from 2022 to 2030.

New registrations and market shares by propulsion system (moderate scenario)



Source: CAM

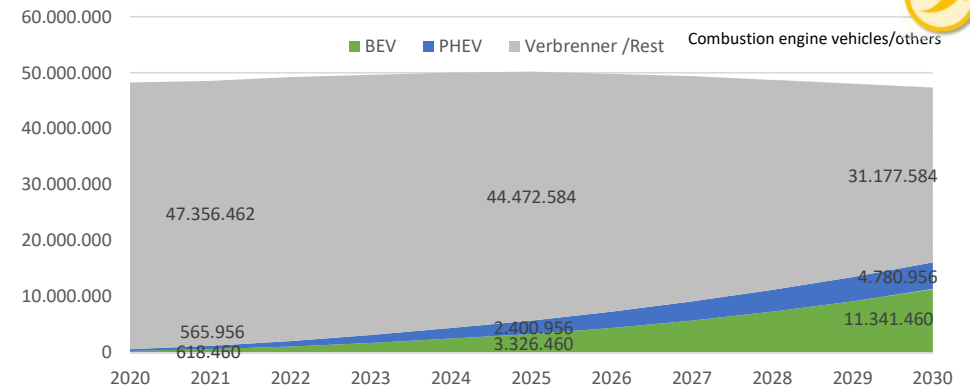
E-mobility as a future trend

Germany: car fleet in a moderate electric vehicles scenario up to 2030

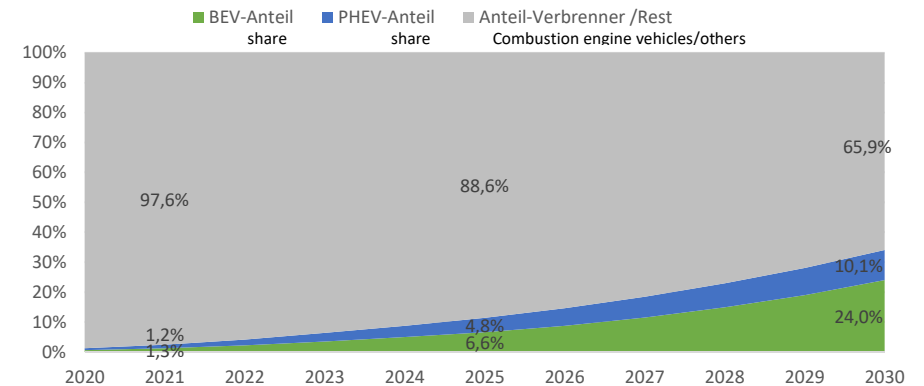
- In the moderate electric vehicles scenario, there are more than 11 million battery electric vehicles altogether on German roads in 2030. This represents almost a quarter of the total private passenger vehicle fleet.
- New plug-in hybrid vehicle registrations amount to almost 4.8 million in 2030, representing a market share of around 10 percent.
- The share of electric vehicles (battery electric and plug-in hybrid vehicles) as a proportion of the total fleet amounts to 34 percent, or around 15 million vehicles.
- In the moderate electric vehicles scenario, the fleet of petrol/diesel cars (including hybrid engine vehicles and others) reduces only gradually, owing to the high average age of the fleet, from 47.5 million in 2021 to 44.5 million in 2025.
- In 2030 more than 31 million private passenger vehicles are expected to have a petrol or diesel motor. This represents around 66 percent of the total fleet.
- The number of predominantly petrol and diesel vehicles thus falls by around 16.5 million between 2022 and 2030. The vehicles that are being replaced are mainly the roughly 10.4 million cars (21 percent of the fleet) that were between 10 and 14 years old at the end of 2021, and the around 10.5 million cars (22 percent) that were more than 15 years old.
- However, approximately 17 million of the combustion engine cars in the fleet in 2030 are less than 10 years old. Around 14 million combustion engine cars in the fleet are therefore already more than 10 years old.

Fleet (absolute and relative) by propulsion system (moderate scenario)

Absolute car fleet



New registrations as relative values (share as %)



Source: CAM (All figures in German data format)

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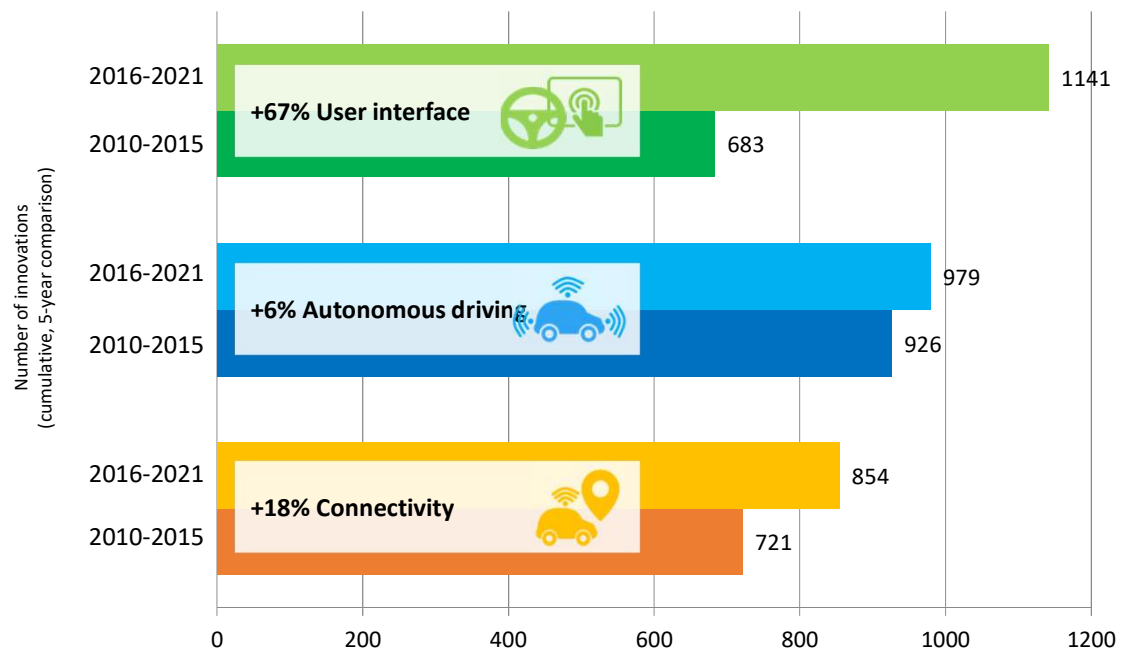
Future trend: connected car

Connected car as a future trend

Trends in the emerging areas of advanced driver-assistance systems, autonomous driving, and connectivity and interface

- The industry trends concerning connected cars can be seen from the innovations of the 28 global automotive manufacturers. Global original equipment manufacturers generated almost 3,000 innovations in the period from 2016 to 2021 in the three sub-areas of user interface, autonomous driving and connectivity. The periods 2010-2015 and 2016-2021 are compared here. The innovation performances were analysed using quantitative and qualitative criteria.
- User interface innovations make up the largest share quantitatively since 2015. The number of innovations in the area of operating and display concepts rose by 67 percent to 1,141 innovations between the two periods. In the last five years 979 innovations in relation to autonomous driving and driver assistance systems were identified (up 6 percent). In the area of connectivity, 854 innovations (2016-2021) were recorded, representing growth of 18 percent in comparison with the previous six-year period.
- The quantitative innovation trends among automotive manufacturers reflect the radical shifts in the emerging areas.
- A qualitative shift is also apparent, from hardware orientation – in which customers buy built-in features – towards increasing software and services orientation: vehicle hardware is increasingly being configured to enable the customer to be offered new on-demand functions and features by means of target group-specific and context-sensitive over-the-air software updates. New user interfaces (speech, gesture and touch) that can be controlled increasingly via Artificial Intelligence algorithms are being developed for this purpose. In the future, customers will be offered a broad digital ecosystem of services in vehicles – by manufacturers or in collaboration with big data players such as Alphabet/Google or Apple – ranging from ecommerce/infotainment and safety and comfort functions to autonomous driving functions (see examples of trends on the following page).

Comparison of cumulative number of innovations for 2010-2015 and 2016-2021







CCA034 Source: CAM

n = 5304

Connected car as a future trend

Hardware focus in vehicle manufacturing is changing to a software/service focus

Current developments and future trends in the technology fields

	2016 - 2021	2025/2030
Autonomous driving 	<ul style="list-style-type: none"> Level 2: automatic longitudinal and lateral control Level 2+: enhancements, e.g. traffic light recognition Level 3: traffic jam pilot (up to around 60 km/h, from 2021/22) 	<ul style="list-style-type: none"> Level 3: highway / traffic jam pilot (up to 120 km/h) Level 4: autonomous driving in specific zones, autonomous parking
Connectivity / connected services 	<ul style="list-style-type: none"> Launch of over-the-air updates (functions, operating system) Personalisation through apps: cloud connection, entertainment, personal assistant First V2X applications: charging stations, danger warnings Learning navigation Data-driven services, e.g. vehicle insurance 	<ul style="list-style-type: none"> Widespread use of V2V, V2I and V2H: complete networking of the vehicle with its surroundings, other road users and infrastructure, including situation-specific features, e.g. congestion avoidance, automatic right of way determination Apps that can be adapted to different needs (similar to smartphones), enhanced entertainment apps in autonomous vehicles E-commerce: offerings tailored to the driver or passengers, place, time of day, etc. Enhanced over-the-air updates: data and functions are continuously updated, demand-based function enabling, on-demand use
User interface 	<ul style="list-style-type: none"> Improved displays (curved, OLED) Voice control (Alexa integration) Control system concepts (touchscreens, Artificial Intelligence, driver identification) First forays into augmented reality (partly still with the aid of front-facing camera and display) 	<ul style="list-style-type: none"> Control system concepts: assignable control areas (<i>virtual buttons</i>) with touch ID (<i>minimalism</i>) Holographic controls simplify and enhance gesture control Interactive voice control: user enters into dialogue with Artificial Intelligence Recognition of facial expressions of passengers, taking these into account for voice control; driver observation as a component of assistance systems (command to take control) Anticipation: vehicle assists, guides and anticipates driver's wishes Augmented Reality: presentation of enhanced, dynamic content as a windscreen display, e.g. navigation, warnings, marking of dangerous objects, e-commerce (e.g. fuel prices)
	<p>Hardware focus: Customers buy vehicles and features</p> 	<p>Software/services focus: Customers use software and services and hardware as a <i>commodity</i></p>

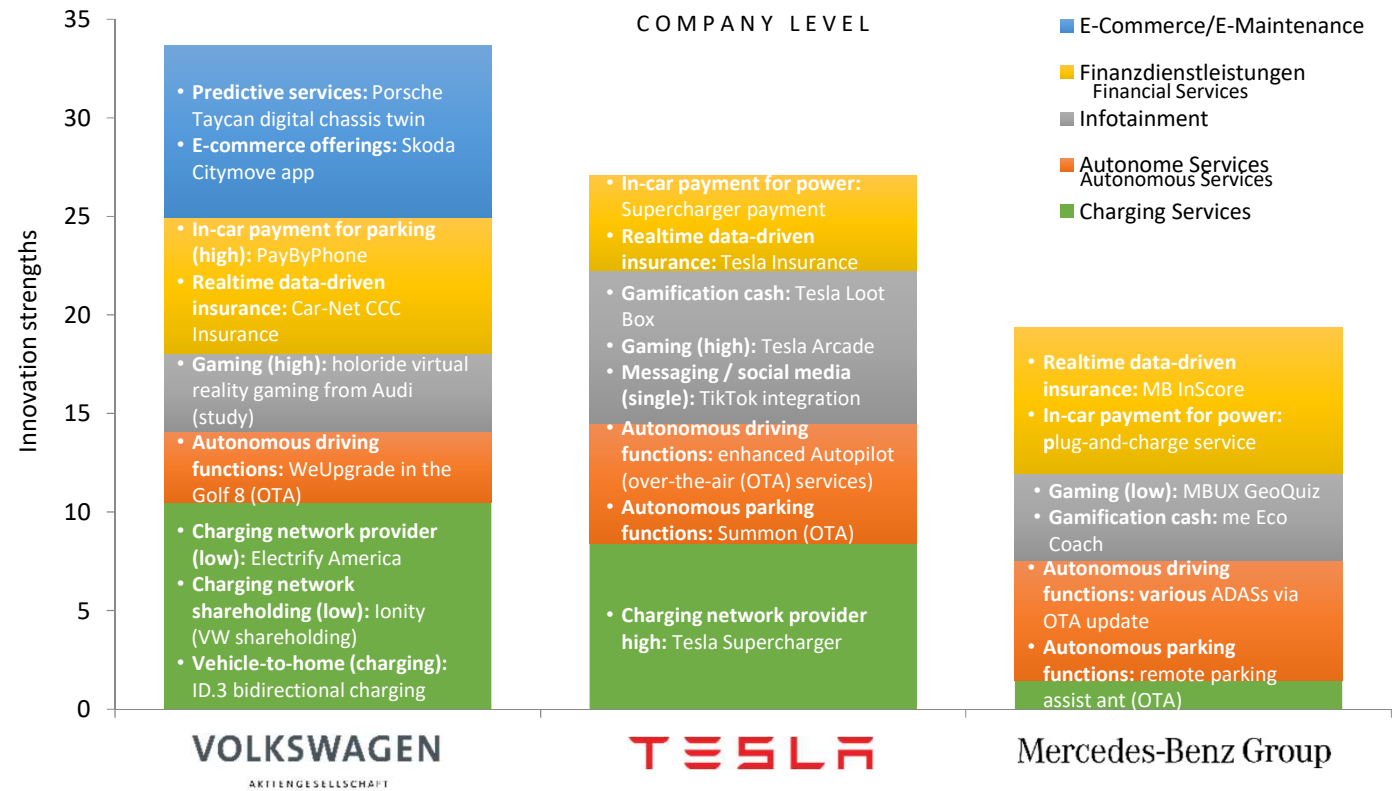
Source: CAM

Connected car as a future trend

The top automotive manufacturers will enhance their products by a large number of networked services

- In addition to innovations related to connected car technology, an increasingly important role will be played by digital ecosystems of networked services in the future. These trends are already apparent among the top automotive manufacturers.
- The comparison between Volkswagen, Tesla and Mercedes-Benz shows five service areas (e.g. e-commerce / e-maintenance) with examples of specific services (e.g. digital chassis twin in the VW Group's Porsche Taycan).
- Like Tesla and Mercedes-Benz, the Volkswagen Group already has a wide portfolio of services, particularly in the area of e-commerce/e-maintenance. In addition to chassis data as a digital twin, as mentioned above, it also includes Skoda's Citymove app (as a pilot project / pilot series respectively).
- Owing to its proprietary charging network (Electrify America), equity investments (Ionity) and charging services (bidirectional charging), VW is also well placed in the charging business. Tesla is also successful here (Supercharger) and with infotainment services (e.g. arcade games to play in the car), while Mercedes-Benz's main area is financial services.

Examples of the connected services offered by VW, MB and Tesla



CCA040b Source: CAM Situation as of February 2022

n = 144

Connected car as a future trend

In 2030, an original equipment manufacturer could generate income of up to EUR 1,100 per car on connected services

- Connected services will offer automotive manufacturers considerable potential for revenue generation in the future. The revenue potential was estimated for individual use case packages for the year 2030.
- The revenue potential of the individual use case packages for 2030 was estimated on the basis of assumptions including the following:
 - Highway pilot: leasing rates for current optional extras related to autonomous driving (Level 2), assumed take rate (*How often is the highway pilot used?*);
 - City pilot: the number of car journeys in the city (based on journeys shorter than 50 km), price per booking period (e.g. € 6 per day);
 - In-car e-commerce: revenue per person (e.g. food), share in car use, price or commission for original equipment manufacturers, take rate;
 - In-car entertainment: price of current in-car offerings (e.g. connectivity services from original equipment manufacturers) and home (e.g. Netflix, Spotify),
 - Vehicle-to-grid/home energy: number of e-vehicles, revenue potential based on external studies, commission for original equipment manufacturers, home electricity consumption.
- The take rate for all services is estimated, as only a fraction of customers who could theoretically use the services in cars will actually do so.
- Altogether, this results in a recurring revenue volume of around € 900 to € 1,100 per car per year. The spread results from variations in the pricing of brands and differences in the purchasing power of the main global markets.

Overview of the expected global revenue for an OEM per year

Use case packages	Expected revenue p.a. (per original equipment manufacturer and car)*
Highway pilot	€ 220 – 270
City pilot	€ 440 – 530
In-car e-commerce (mobility and non-mobility)	€ 60 – 100
Travel-related (e.g. electricity**, parking, tolls***)	€ 30 – 50
Not travel-related (e.g. food and other shopping, leisure)	€ 30 – 50
In-car entertainment	€ 15 – 30
Vehicle-to-grid/home energy	€ 150 – 180
Others (e.g. big data analysis / data sale)	€ 50 – 100
Potential volume of revenue	€ 890 – 1,120







Source: CAM. Note: *In the case of up-to-date prices (inflation), all values are rounded. **Only travel-related electricity sales, i.e. charging of electric vehicles on trips / on the road. *** Car toll (motorway/city) included as the study is international; Germany currently has no toll roads.

Connected car as a future trend

Global sales volume of more than € 200 billion possible in 2030

- A potential sales volume per use case is calculated on the basis of the car fleet and the proportion of vehicles that have the relevant capabilities. In the in-car e-commerce or vehicle-to-grid/home energy use case, for instance, the result is a possible value pool of up to € 98 billion or € 43 billion respectively.
- The global connected services market volume is estimated at more than € 200 billion in total in 2030.
- In addition to the five use cases considered, it is possible that there are others that could increase the market volume. Ultimately the services will not be tied to a car, but to the relevant customers, who identify themselves by their cloud ID. The advantage for customers is that they can use the booked services on any hardware (in any car), just as they are accustomed to using other services (Netflix etc.) on any device.

Calculation of the expected total market sales by connected services use cases globally

	Connected services uses cases*				
	Highway pilot (L3)	City pilot (L4)	In-car e-commerce	In-car entertainment	Vehicle-to-grid/home energy
					
Car fleet ^{23, 24}	1.5 billion	1.5 billion	1.5 billion	1.5 billion	0.3 billion
Proportion of vehicles with relevant capabilities	10%	2%	65%	80%	80%
Vehicles with relevant capabilities	150 million	30 million	975 million	1200 million	240 million
Expected revenue per vehicle	€ 220-270	€ 440-530	€ 60-100	€ 15-30	€ 150-180
Potential sales volume	€ 33-41 billion	€ 13-16 billion	€ 59-98 billion	€ 18-36 billion	€ 36-43 billion
... TOTAL	Σ € 159 - 234 billion				

Source: CAM. Note: all figures rounded. * Where applicable, in addition to other uses cases such as in-car office services, in-car wellbeing etc.

- For the original equipment manufacturer, this can mean additional revenue, as it creates a service ecosystem, thus tying customers to the brand. Linking the services to a person enables several subscriptions per vehicle to be sold, as, for instance, in car-sharing vehicles or family subscriptions. However, other market participants are also establishing a digital service ecosystem, especially big data players such as Alphabet/Google, Apple and Tencent, and Alibaba in China. These companies have an advantage in terms of their expertise and a competitive edge, because they already operate customer platforms consisting of a digital service ecosystem (e.g. Google, Apple etc.) and they want to broaden their services by venturing into the (automotive) mobility segment.

4.

Future trend: mobility services

Mobility services as a future trend

Importance of private cars in Germany declining only slightly


- Shared mobility services are already widely used. Services provided under the sharing model range from taxi portals, ride sharing, car sharing, micromobility and autonomous shuttles to robotaxis and, looking ahead, drone taxis. An important question in this regard is to what extent this is influencing the importance of private car ownership.
- CAM und YouGov conducted a survey on mobility behaviour and consumer views in Germany in June 2022. A similar survey in 2018 enables longitudinal comparisons to be made. The sample composition in both 2018 and 2022 is representative of the German population in age groups of 18 and older with regard to the most important demographic characteristics such as gender, place of residence (urban-rural distribution) and age composition.
- Of those surveyed, 69 percent stated that a private car is important to them owing to their current mobility situation; 42 percent of these stated that they actually depend on their cars. These figures show a slight decline in comparison with the survey conducted four years ago: 73 percent of those surveyed in 2018 said that having a car of their own was important (45 percent of these responded that they *depend on it*).
- What is striking is that the number of young city dwellers who say that they rely on their cars is now significantly higher than four years ago: In 2022 one in four young city dwellers aged between 18 and 34 years stated that they depended on their cars (26 percent), compared with 17 percent in 2018.
- In total, 57 percent of young city dwellers say a private car is currently very important or important (2018: 45 percent).
- On the other hand, almost a third of older city dwellers stated that they *don't really need* a car of their own, while in 2018 only 18 percent gave this answer.
- As expected, survey participants from rural areas are more dependent on their cars, e.g. almost two thirds in the 35 to 54 age group.


Survey: importance of private cars in Germany

How important is it for you to have a car of your own, given your current mobility situation?

	2018							2022						
	Stadtbewohner zwischen 18 bis 34 Jahre	Landbewohner zwischen 18 bis 34 Jahre	Stadtbewohner zwischen 35 bis 54 Jahre	Landbewohner zwischen 35 bis 54 Jahre	Stadtbewohner zwischen 55 Jahre und älter	Landbewohner zwischen 55 Jahre und älter	Gesamt	Stadtbewohner zwischen 18 bis 34 Jahre	Landbewohner zwischen 18 bis 34 Jahre	Stadtbewohner zwischen 35 bis 54 Jahre	Landbewohner zwischen 35 bis 54 Jahre	Stadtbewohner zwischen 55 Jahre und älter	Landbewohner zwischen 55 Jahre und älter	Gesamt
Sehr wichtig (bin darauf angewiesen)	17%	47%	37%	61%	34%	57%	45%	26%	47%	36%	65%	31%	61%	42%
Wichtig	28%	31%	27%	22%	31%	30%	28%	31%	21%	26%	19%	26%	24%	27%
Weniger wichtig	21%	13%	11%	7%	16%	5%	11%	17%	12%	11%	7%	11%	3%	11%
Unwichtig (brauche ihn eigentlich nicht)	32%	6%	25%	7%	18%	8%	15%	21%	12%	23%	5%	31%	10%	17%
weiß nicht / keine Angabe	2%	3%	1%	2%	1%	0%	1%	5%	8%	5%	4%	1%	2%	4%
Summe	115	128	169	182	165	243		115	128	169	182	165	243	

Source: CAM/YouGov.

if figure has grown by more than 5 percent between 2018 and 2022 = 

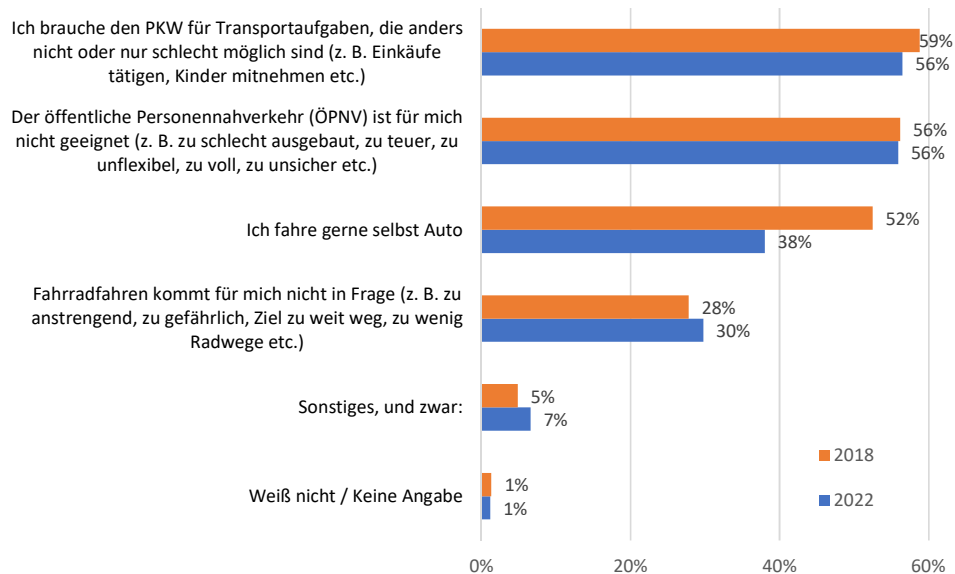
if figure has fallen by more than 5 percent between 2018 and 2022 = 

Mobility services as a future trend

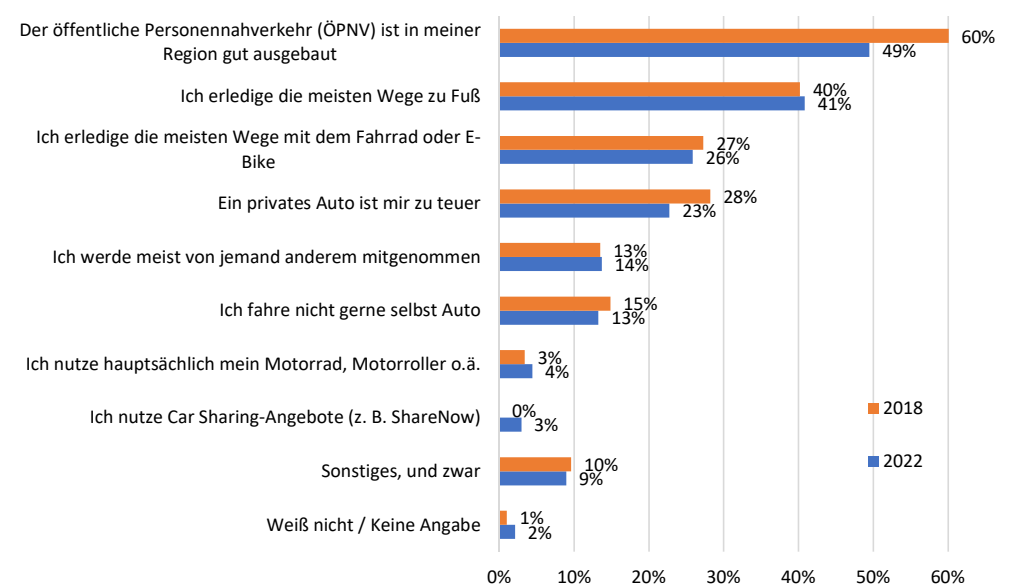
Attractiveness of local public transport as a key influencing factor on the importance of owning a private car

- Two reasons for people's attachment to their own private cars are cited equally often in the latest survey: One is that 56 percent of respondents see no better way of meeting their transport needs than by using their own car. The other reason is the perceived unattractiveness of public transport. The figures for both reasons differ only slightly from 2018. However, people are not enjoying driving as much as before: In 2018 the fact that they liked driving was a reason for 52 percent of survey participants to get into their own car, while in 2022 this is only true for 38 percent.
- Public transport is also the main reason for doing without a car. Of those surveyed, 49 percent are so satisfied with the local public transport system in their own region that they do not need a car of their own. However, this represents a significant decline on the 60 percent recorded in 2018. The differences in the other reasons (walking or using a bicycle/e-bike) are small.

Reasons why a private car is important*



Reasons why a private car is not important*



Source: CAM/YouGov * The exact question was: *For what reasons is it important / not important for you to have a car of your own? Please state the reasons most important to you.* (More than one answer possible, max. 3 answers). n = 2,022 (2022), n = 988 (2018).

Mobility services as a future trend

Strong growth in willingness to sacrifice other things to buy a new car, especially among younger people

- Mobility services could be a reason for people to do without a car of their own. However, the survey shows that in 2022, especially in the younger age group, more people are willing to do without other things such as a holiday or pension in order to buy a new car than in 2018. This applies almost equally to young people living in cities and those in rural areas. In 2018, 25 percent of city dwellers and 30 percent of rural dwellers were prepared to do without a holiday, and by 2022 this had increased to 30 percent and 38 percent respectively.
- The percentage of people prepared to do without other things is currently 40 percent across all age groups (down 2 percent). Only 28 percent of young city dwellers (younger than 35 years of age) would not give up anything for a new car – 20 percent fewer than in 2018. In other words, **cars have become significantly more important for this group**. In the 18 to 34 age group overall, people are becoming less willing to give up something else for a new car. This applies especially to the even younger 18-25 age group: only 25 percent of these are prepared to sacrifice something for a new car, while in 2018 this figure was 42 percent.

Survey: willingness to sacrifice other things to buy a new car in Germany (What would you be most willing to give up to buy yourself a new car?)

	2018							2022						
	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total
Holidays	25%	30%	23%	33%	21%	29%	27%	30%	38%	24%	34%	22%	30%	30%
Savings	10%	18%	10%	11%	11%	15%	13%	11%	17%	12%	11%	6%	9%	11%
Bigger apartment/house	11%	6%	10%	10%	14%	6%	9%	13%	7%	8%	8%	4%	8%	8%
Pension	3%	6%	3%	3%	1%	3%	3%	14%	6%	4%	3%	2%	1%	4%
I am not prepared to sacrifice one of these things to buy a new car.	48%	31%	50%	33%	47%	41%	42%	28%	24%	43%	33%	59%	45%	40%
Do not know / no answer	4%	9%	4%	10%	7%	6%	7%	3%	8%	9%	10%	6%	7%	7%
Total	115	128	169	182	165	243		195	244	275	416	343	594	

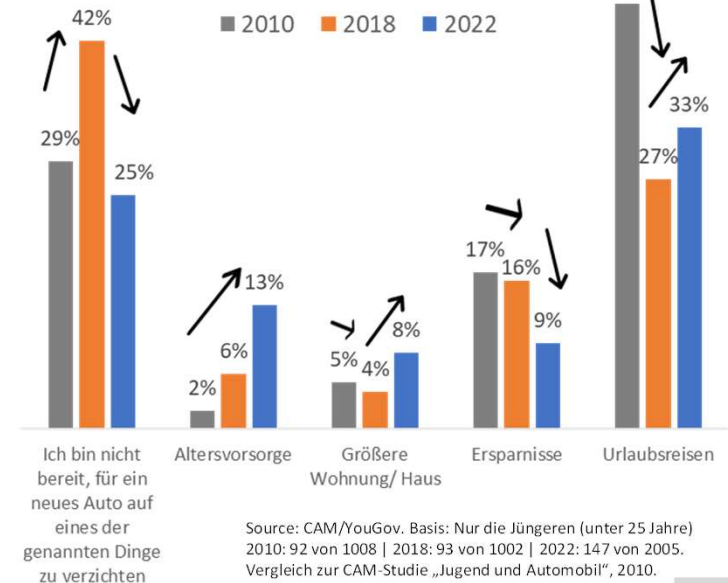
Source: CAM/YouGov.

if figure has grown by more than 5 percent between 2018 and 2022
if figure has fallen by more than 5 percent between 2018 and 2022

=

=

Nur Jüngere unter 25 Jahren



Mobility services as a future trend

Willingness to use car sharing declines between 2018 and 2022

Survey findings on free-floating and station-based car sharing in Germany in 2018 compared with 2022



- Car sharing is one of the most common mobility services in Germany, and is available in both the free-floating model (in which vehicles can be picked up and returned to anywhere in an urban area) and the station-based model.
- However, a longitudinal comparison shows that the public's willingness to use car sharing declined between 2018 and 2022. Only 26 percent *would definitely* consider using free-floating car sharing in 2022 or *might* consider it. In 2018 this was 34 percent (down 8 percent). People who have never used free-floating car sharing would not consider using it.
- With station-based car sharing, a similar trend is evident: Fewer than 30 percent *would definitely* consider it or *might* consider it in 2022 (down 5 percent).
- However, younger people in cities and even in rural areas are significantly more open to car sharing (42 percent, or 40 percent in the case of station-based car sharing).

Free-floating car sharing:

	2018							2022						
	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total
I would definitely consider using it	13%	12%	9%	6%	9%	7%	9%	10%	12%	8%	7%	6%	3%	7%
I might consider using	41%	22%	29%	23%	23%	22%	25%	25%	22%	22%	19%	14%	19%	19%
I would not consider using it	34%	49%	48%	58%	59%	63%	55%	43%	48%	57%	61%	72%	72%	61%
Do not know / no answer	12%	17%	14%	13%	9%	7%	11%	22%	18%	14%	13%	8%	6%	13%
(n)	76	99	141	162	144	227		102	74	196	183	291	276	

Station-based car sharing:

	2018							2022						
	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total	City dweller aged between 18 and 34	Rural dweller aged between 18 and 34	City dweller aged between 35 and 54	Rural dweller aged between 35 and 54	City dweller aged 55 or older	Rural dweller aged 55 or older	Total
I would definitely consider using it	7%	8%	8%	6%	5%	9%	7%	10%	9%	5%	7%	5%	4%	6%
I might consider using	38%	31%	29%	24%	28%	22%	27%	32%	31%	30%	21%	19%	22%	23%
I would not consider using it	41%	44%	51%	57%	60%	62%	55%	39%	43%	53%	57%	68%	67%	58%
Do not know / no answer	13%	17%	13%	13%	8%	6%	11%	19%	17%	12%	15%	8%	7%	13%
(n)	76	99	141	162	144	227		102	74	196	183	291	276	

Legend: if figure has grown by more than 5 percent between 2018 and 2022 = 
 if figure has fallen by more than 5 percent between 2018 and 2022 = 

Source: CAM/YouGov. *Question: Would you consider using these existing mobility services?

Mobility services as a future trend

Young city dwellers the target group most likely to avail of mobility flat rates

- In addition to the combination of different modes of transport in one booking, advance payment for transport in the form of a flat rate is possible. This involves payment of a monthly sum for a certain type of transport (e.g. public transport, bike sharing, limited number of journeys by taxi). At present, such flat rates are only offered sporadically and have therefore only achieved a low level of market penetration. The reason for this is that mobility flat rates are based on multimodal transport services, but these services are still in their infancy. Also, the conditions for establishing a platform and a flat rate model differ from city to city. The development of the services is mostly very slow and tedious, and usually involves separate negotiations with each city.
- However, the survey of the German population shows that, at least in urban areas and among younger people, there is high level of willingness to use these services. Almost 58 percent of city dwellers in the 18 to 34 age group and more than 40 percent in the middle age group would (probably) consider using them. In rural areas, however, people in all age groups are considerably less willing to use flat rate services; here, the rate ranges between 34 percent (18 to 34-year-olds) and 24 percent (55 and older) (see tables below). Of course, the actual willingness to use these services will depend on how high the mobility flat rate is.

Survey: possible use of a future mobility flat rate in Germany*

City: residents of urban areas

cam10 – use of mobility flat rate	Age 18 to 34	Age 35 to 54	Age 55 or older	All
Yes, definitely	17.7%	14.2%	12.1%	14.3%
Yes, probably	40.1%	26.8%	18.6%	27.0%
No, probably not	16.2%	18.3%	23.3%	19.7%
No, definitely not	15.7%	27.4%	34.4%	27.1%
Do not know / no answer	10.3%	13.4%	11.6%	11.9%
(Probably) yes	57.8%	40.9%	30.7%	41.3%
(Probably) no	31.9%	45.7%	57.7%	46.8%
Unweighted N	195	275	343	813

Source: CAM/YouGov

Country: residents of rural/suburban areas

cam10 – use of mobility flat rate	Age 18 to 34	Age 35 to 54	Age 55 or older	All
Yes, definitely	7.0%	6.2%	4.3%	5.5%
Yes, probably	27.3%	22.9%	20.0%	22.5%
No, probably not	27.3%	20.5%	26.5%	24.5%
No, definitely not	24.1%	35.9%	40.3%	35.6%
Do not know / no answer	14.3%	14.4%	8.9%	11.9%
(Probably) yes	34.4%	29.1%	24.3%	28.0%
(Probably) no	51.4%	56.5%	66.8%	60.1%
Unweighted N	113	218	295	626

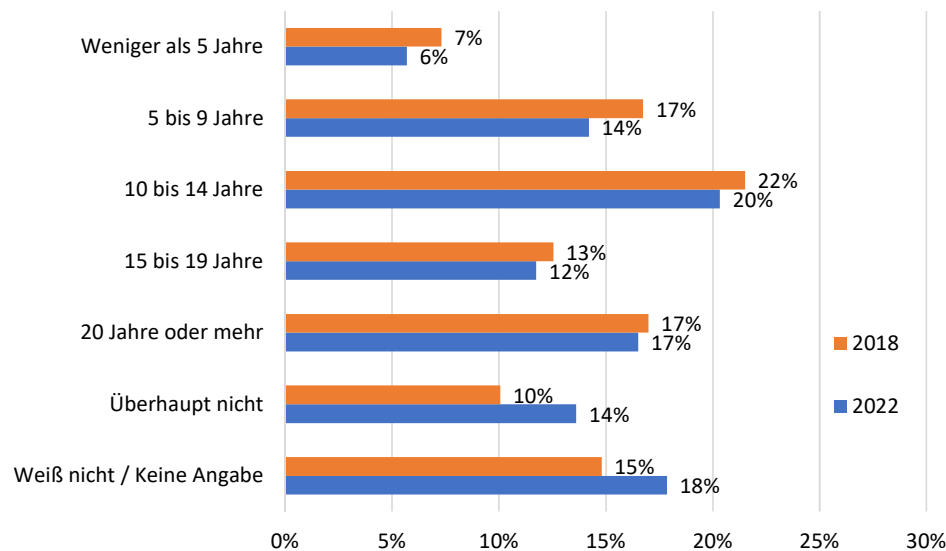
*The exact question was : We would now like to introduce you to mobility services that do not exist yet. Can you imagine using the following future mobility services? Please state for each service whether you can imagine using the service or not – mobility flat rate.

Mobility services as a future trend

Mobility flat rate is a distant prospect, survey participants not willing to pay a large amount

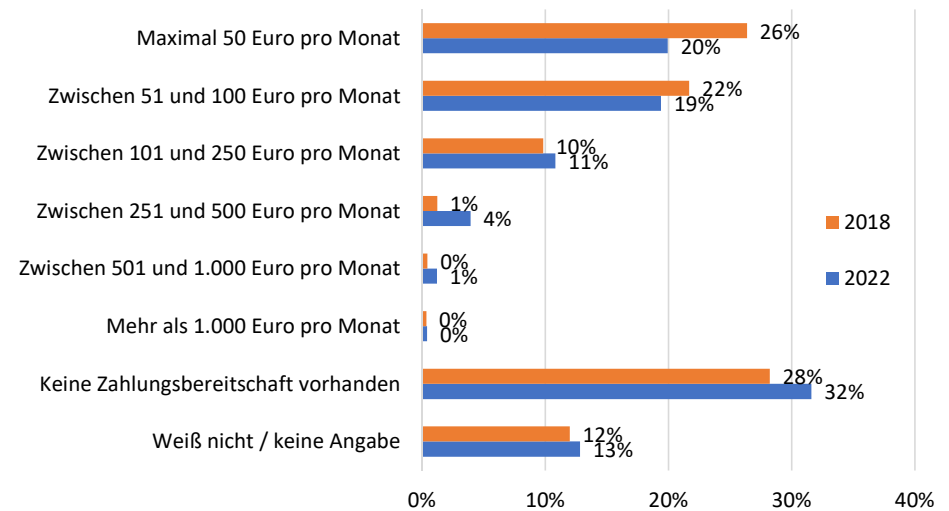
- Those surveyed believe the majority of Germans will not use a mobility flat rate for at least 10 to 14 years. This opinion is basically unchanged in comparison with 2018. Of those surveyed, 14 percent consider it generally unlikely that the majority will use a mobility flat rate, whereas in 2018 this was only 10 percent. Only six percent (2018: 7 percent) are optimistic and expect that the majority will use a mobility flat rate within the next five years.
- Around half of those surveyed are only willing to pay a low price for a relatively comprehensive mobility flat rate, including public transport, car and bike sharing and robotaxis. Those interested want to pay at most € 50 per month (20 percent); in 2018 this was 26 percent. However, most were not willing to pay anything (32 percent, up 4 percent). On the other hand, 35 percent have more realistic expectations with regard to costs and prices: 19 percent would pay up to € 100, and 16 percent would pay more than € 100 per month for a flat rate service.

Majority use of a mobility flat rate in Germany*



Source: CAM/YouGov * The exact question was: In how many years do you think these mobility flat rates could be used by the majority of the German population? n = 2,105 (2022), n = 1,002 (2018).

The price people are willing to pay for a mobility flat rate**



** The exact question was: How much would you be willing to pay per month for a comprehensive mobility flat rate of this kind (choice between car/bike sharing, bus and rail, autonomous robotaxi – available throughout Germany)? (For this amount, you could use all transport forms without paying extra, e.g. like the BahnCard 100, but extended to all modes of transport.) n = 2,105 (2022), n = 1,002 (2018).

5.

Annex

5.1 Background information on the methodology

Methodology

This study is based on a meta-analysis of current CAM studies

CAM studies

- **AutomotiveINNOVATIONS 2022 Report**
Bratzel, S.; Tellermann, R. (2022): AutomotiveINNOVATIONS 2022 Report; *Innovation strength of global car manufacturers and original equipment manufacturers*; working paper 9/2022 of the Center of Automotive Management, Bergisch Gladbach, Germany
- **Connected Car Innovation Study (CCI) 2022**
Bratzel, S.; Tellermann, R. (2022): CCI 2022 – Connected Car Innovation Study; Center of Automotive Management, Bergisch Gladbach, Germany
- **Mobility Services Report (MSR) 2022**
Bratzel, S.; Tellermann, R. (2022): Mobility Services Report 2022. Center of Automotive Management, Bergisch Gladbach, Germany
- **Electromobility Report 2022**
Bratzel, S. (2022): Electromobility Report 2022; CAM Report 09-2022; Center of Automotive Management, Bergisch Gladbach, Germany

Methodology

Step 1: research into automotive technology innovations by global original equipment manufacturers of all brands

Sources for the collection of automotive technology innovations by all global automotive manufacturers



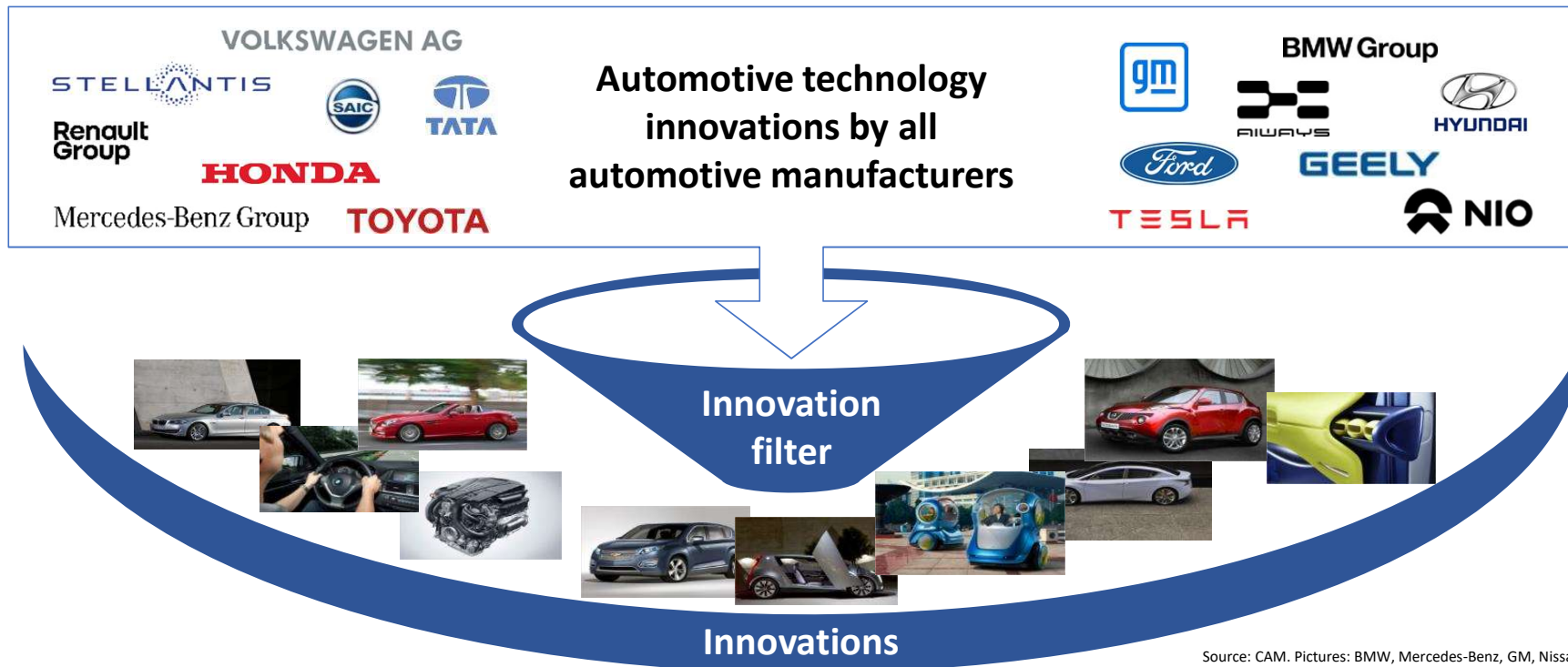
Source: CAM

Methodology

Step 2: verification of the researched innovations using the CAM definition

Verification of automotive technology innovations

Key question: *Is this innovation an automotive innovation as defined by CAM?*

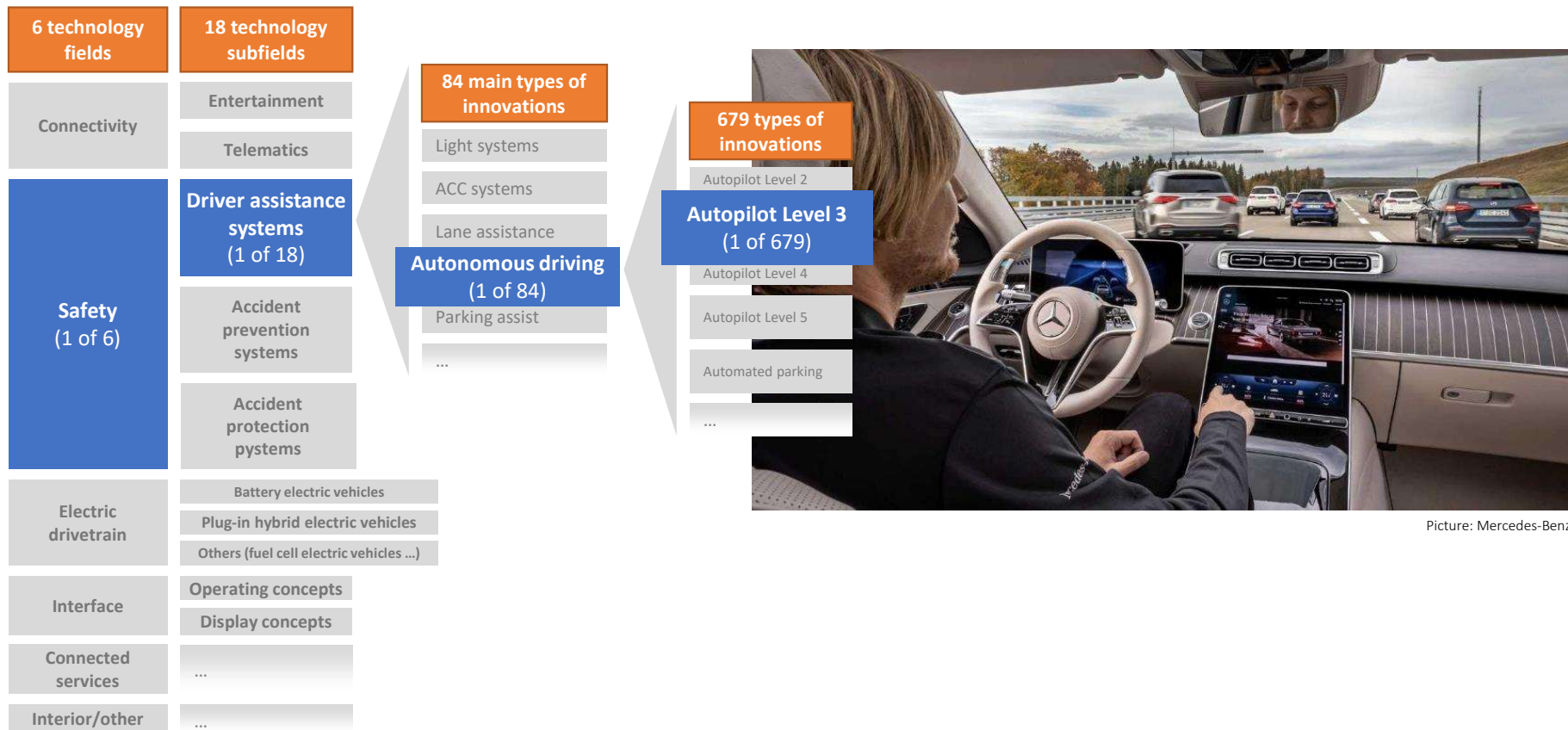


Source: CAM. Pictures: BMW, Mercedes-Benz, GM, Nissan.

Methodology

Step 3: classification according to the current 84 main innovation types and 679 innovation types.

Classification of innovations taking the Mercedes S-Class Drive Pilot as an example (Level 3 autopilot system)



Picture: Mercedes-Benz

Source: CAM

Methodology

The four assessment criteria cover different aspects from the customer's viewpoint

- The **innovation level** is intended to indicate the innovative (technological) content, or the novelty, of the innovation. The important reference criteria here are the extent to which the customer derives extra benefit from the innovation, and the potential for it to improve the market and competitive situation. The innovation level is determined by means of a checklist, which enables transparent and traceable grading of the innovations in a four-level nominal scale (see above).
- The **originality** of an innovation identifies whether technological innovations are the first of their kind in the world, or new to the company.* An automotive innovation is designated as a world first if an automotive manufacturer has introduced it for the first time.
- The **degree of innovation maturity** puts the marketing aspect of innovations to the forefront. An innovation that is available in the current review period (series), or in the following year (pilot series) has a high degree of maturity. Studies that are far from the production stage are assumed to have a lower degree of maturity.
- Finally, innovations can be analysed by the extent to which they make the car as an asset more attractive to buyers in a specific area. The **innovation focus** therefore grades innovations according to which dimensions of customer benefit (e.g. economy, safety, environmental factors) are mainly addressed. Studies show that these factors are of differing relevance to the purchase.

Four criteria for assessing the innovations of automotive manufacturers

1.	Innovation level (innovative content)	Very high	The basic characteristics of the car are radically changed by the innovation or it is given fundamentally new functions (e.g. working, living, infotainment, food).	
		High	High – very high	The car is significantly improved in terms of its existing basic characteristics, particularly with regard to electrification and digitalisation.
		Medium	Medium – high	Medium improvement on existing situation: e.g. a subsystem is significantly improved; the innovation relates to an emerging area, especially electrification or digitalisation.
		Low	Low – medium	Slight improvement on existing situation: customer derives a noticeable, desirable benefit (<i>nice to have</i>)
2.	Originality (degree of newness)	World first	Innovation is presented/introduced for the first time on the global automotive market (of the companies considered here)	
		Company first	Innovation is not a world first, but has being introduced for the first time by the company	
3.	Degree of innovation maturity (closeness to production stage)	Series product	Innovation is already implemented in a series in the year under consideration, i.e. readily available to anyone in at least one important market (China, India, Russia triad)	
		Pilot series product	Innovation is being implemented in a pilot series in the year under consideration, series introduction planned for the following year, or small series	
		Study	No series introduction planned until end of following year, or no information on series introduction	
4.	Innovation focus (customer benefit)	Economy	Comfort	Versatility
		Safety	Environment	Vehicle dynamics

Source: CAM. * See Hauschildt 2004; Christensen/Raynor 2004; Pleschak/Sabisch 1996; Vahrs/Burmester 2002.

Methodology

After research, verification and categorisation, the MOBIL approach is used for assessment

Summary of methodology used and assessment of automotive technology innovations using the CAM MOBIL approach

1 Research
Collection of automotive technology innovations of global original equipment manufacturers



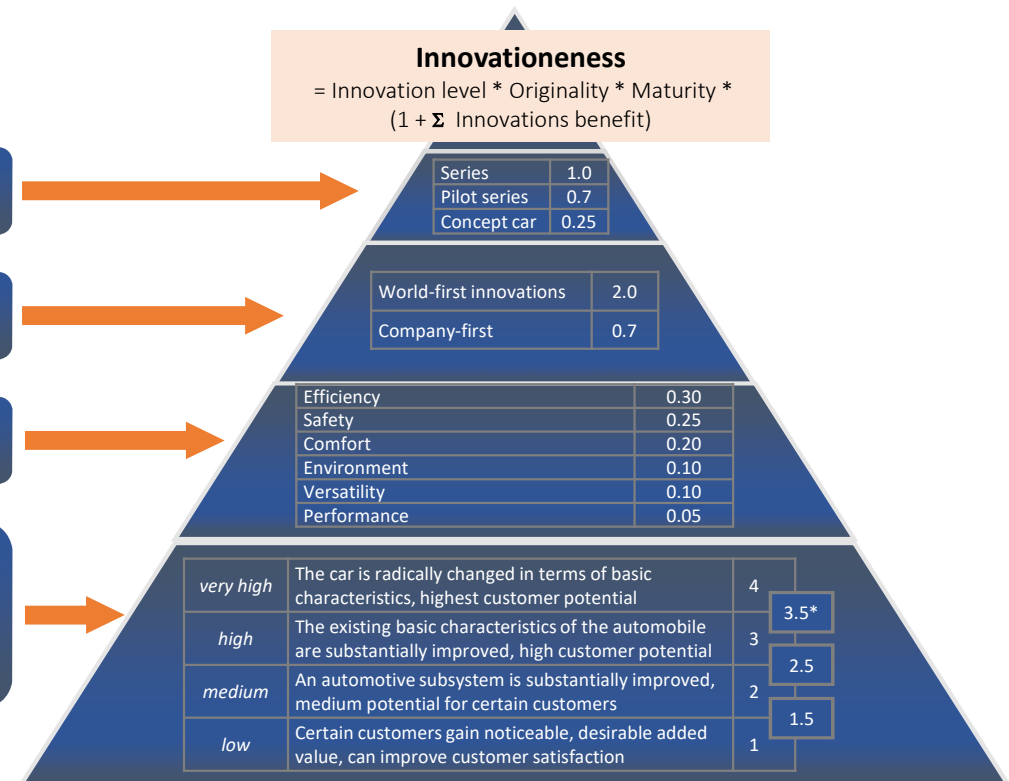
2 Verification
Do the innovations meet the criteria of our definition of innovation?



3 Categorisation
Categorisation by technology fields, innovation types etc.



4 Evaluation



Source: CAM. *Example: High to very high

Methodology

Automotive technology innovations according to technology fields

- From the dimension of the criteria it is possible to compare the innovativeness of automotive manufacturers. The innovativeness of an automotive manufacturer is the total of the weighted individual innovations.
- The individual innovations are rated by groups of internal experts according to the four quantitative factors, using an intersubjective classification grid.
- Example: VW ID.3 AR head-up-display innovation (Volkswagen Group, 2020)
 - Level of innovation: medium to high (value 2.5)
 - Originality: world first (value: 2.0)
 - Degree of maturity: series (value: 1.0)
 - Innovation focus: comfort (value: 0.20) and safety (value: 0.10).
 - Calculation of the innovativeness of ID.3 AR head-up-display: $2.5 * 2.0 * 1.0 * (1 + 0.20 + 0.25) = 7.25$
- The theoretical range of values for the innovativeness of a new feature is defined as follows: smallest possible value*: 0.2 (reason: company first, study, innovation level 1, benefit *vehicle dynamics*). This case (seldom) arises in the innovation database. Highest possible value: 16.0 (reason: world first, series, innovation level 4, all customer benefits addressed). This case has not yet arisen, as it is difficult for an innovation to address all customer benefits simultaneously. Empirically the highest value so far is 11.6 points.

Four criteria of company innovativeness

Innovativeness of a new feature = level of innovation* (1 + Σ innovation focus) * Originality * Degree of maturity Company innovativeness = total of individual examples of innovativeness of a company		
Criterion	Attribute dimensions	Index value
1) Innovation level Innovative content	Very high	4
	High to very high	3.5
	High	3
	Medium to high	2.5
	Medium	2
	Low to medium	1.5
	Low	1
2) Innovation focus Customer benefit, several options possible	▪ Economy	0.30
	▪ Safety	0.25
	▪ Comfort	0.20
	▪ Environment	0.10
	▪ Versatility	0.10
	▪ Vehicle dynamics	0.05
3) Originality Degree of newness	World first	2.0
	Company first*	0.7
4) degree of innovation maturity Closeness to production stage	Innovation during the reporting period, in series production	1.0
	Pilot series: series introduction planned for the following year	0.7
	Study/no series introduction up until the following year	0.25

Source: CAM. Note.: *in the case of company innovations by the start-up companies considered and shown separately, the factor for company innovations is limited to 0.1 to avoid over-estimating the process of catching up to the state of the art by these companies; world firsts unchanged; the smallest possible value for innovativeness in this case is 0.03.