TAB

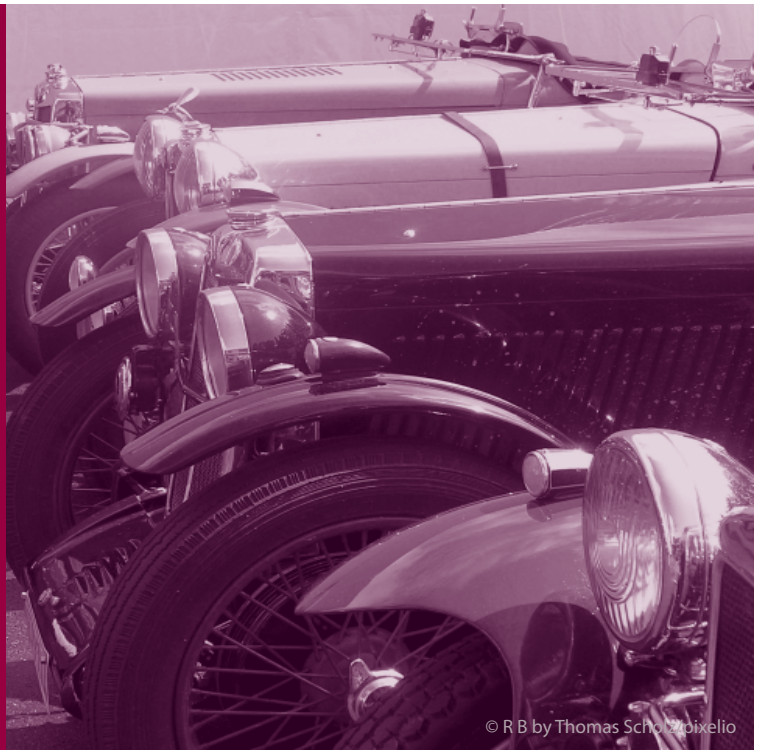
OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

Wolfgang Schade
Christoph Zanker
André Kühn
Steffen Kinkel
Angela Jäger
Tim Hettesheimer
Thomas Schmall

Future of the automobile industry

Summary

September 2012
Working report no. 152



SUMMARY

This innovation report on the »Future of the Automotive Industry« was initiated by the German Bundestag's Committee for Economics and Technology and commissioned by the Committee for Education, Research and Technology Assessment. The objective of this report is to examine the potentials of the German automotive industry, the foreseeable changes on the global car markets and the introduction of new mobility concepts from a systemic perspective. Strategic options for industry and options for setting the policy framework will be derived from the results. The analyses focus on the market for passenger vehicles (cars), because the changes presumed in the political questions relate primarily to the car market, while the market for light and heavy duty trucks is mainly driven by economic trends and also makes a significantly lower contribution to the value added of the German automotive industry.

To start with, this summary recaps the findings from the individual work steps in the same sequence as the chapters in the innovation report. Subsequently, these are combined in a synthesis of the results. This synthesis is oriented on the seven challenges derived for the German automotive industry and assesses the results with reference to these challenges, in order to derive options for how to act on this basis.

Facts and figures on the automotive market

The automobile industry represents a major pillar of the German economy with a turnover of 351 billion Euro in 2011, which corresponds to about one fifth of the turnover of the entire manufacturing industry in Germany, as well as the 719,000 persons directly employed at automobile producers and suppliers (based on the German statistical classification, WZ 29), and a grand total of 1.8 million employees (if the component suppliers of other sectors are included). The automobile industry is responsible for almost one third of all the expenditure on research and development (R&D) in Germany.

Studying the future development of the automobile industry is even more important given its economic significance for Germany, because there are clear indications of significant changes to car markets looming over the next two decades. There are several drivers of these changes: the increasing shortage of fossil fuels due to strong growth in newly industrializing countries and related questions about the security of energy supply; the growing necessity of and ever more am-

bitious national and European climate policies, which demand a reduction in the greenhouse gases from transport as well; the foreseeable availability of alternative drives powered by non-fossil fuels in automobile traffic and the shifts taking place in the production and sales markets for vehicles in the direction of new markets in several newly industrializing countries which are strong and rapidly growing in relevance, especially China, Brazil and, potentially, India.

The German car market has by far the highest production and sales figures in a European comparison and is characterized by an above average share of premium vehicles. This refers to the share of executive cars and large family cars as well as vehicles in other segments which are equipped with premium features. The purchase of company cars plays a leading role on the German market with around 50% of sales to commercial owners. A very high share of the premium car segment, both nationally and globally, is covered by German carmakers like Audi, BMW, Daimler, Porsche and, more recently, also Volkswagen.

Political and legal requirements define important framework conditions for the automobile industry and thus also steer the direction of innovations. Examples of these include the greenhouse gas reduction targets from the European Commission's 2011 White Paper on Transport and the reduction of energy consumption in transport in the German government's 2010 Energy Concept. Legal specifications set the standards today for the exhaust emissions and CO_2 efficiency of new vehicles.

Currently, three quarters of the cars produced in Germany are exported. While the exports and thus the foreign sales of German producers have continued to climb over the last few years – with the exception of 2009, the year of the global financial crisis – national sales have stagnated for more than 6 years now. In 2010, 61.7 million cars were sold world-wide. 11.6 million of these were made by German OEM (»original equipment manufacturers« – producers of automobiles with their own brand names), of which somewhat less than half were actually produced in Germany. On the German market, in contrast, the German OEM only sold 1.8 million cars in 2010, i.e. only about 15% of their global production. Three of the four vehicles manufactured in Germany are exported. Three regions or countries are of outstanding relevance for German car exports: 83% of the exported vehicles are destined for Europe, North America and China. The development of the export figures over the last 10 years also shows that the increased production volume of cars was primarily induced by exports.

With regard to world-wide production activities, German producers are already well established globally compared to other OEM. In the last 10 years, primar-

ily the foreign production facilities of German manufacturers have been able to profit from the global growth. The production volumes at locations in Germany have remained more or less constant. However, the analyses show that executive cars are being produced to an increasing extent at domestic locations with the consequence that turnover here increased much more strongly related to output quantity. In addition, it can also be stated that German producers utilize almost 90% of the capacity of their domestic production facilities, which is above the average. In a global comparison, the capacity utilization of production facilities located in the rest of Europe is assessed as critical.

Compared to the OEM, the automotive component suppliers tend to be established nationally, apart from a few global system suppliers, and predominantly supply the OEM in Germany. This is apparent from the survey of German suppliers conducted for this report. The direct export ratio of the suppliers is only around one third. This is chiefly due to the fact that the automobile supplier industry tends to be characterized by small and medium-sized enterprises apart from the few large system suppliers like Bosch, Continental or Brose. However, indirectly, the dependency on exports is much higher considering the fact that the automobile suppliers' products are used to make final products, three quarters of which are then exported.

These figures offer impressive proof of the international orientation of German automobile producers with regard to both production and sales. This does not apply to the German automobile supplier industry to the same extent.

Diversification in the automotive industrie

Greater diversification will be an important slogan for the automobile industry in the next two decades and can be observed at four levels:

> Diversification of the available propulsion concepts with electricity, biogas and hydrogen being offered as new energy sources alongside fossil fuels and a wide variety of hybrids combining two energy sources or two drive motors in the same vehicle.
> Diversification of the materials used with an emphasis on using lighter materials to reduce weight and save energy, as well as combining new materials such as e.g. aluminium, magnesium or carbon-fibre-reinforced plastics.
> Diversification of the range of models with new variations of car body types and new city and micro cars.

> Diversification of the value added of OEM as they evolve from purely product suppliers (i.e. vehicles) to suppliers of products and mobility services such as car-sharing.

The global market - three scenarios

Analysing and predicting global markets are two main components of the report. Traditional car markets (EU, Japan, and USA) are stagnating at a high level of sales. At the same time, economically successful newly industrializing countries are showing strong growth in car and truck markets; especially China, India and Brazil stand out here. German manufacturers are already well positioned in China and Brazil (especially Volkswagen), in particular due to their success with premium cars. From today's standpoint, it is very hard to say whether and in which form the Indian market could become interesting and relevant for German OEM.

It is becoming apparent that German OEM premium vehicles will continue to be produced in Germany in the future, while the production plants for city cars and small and large family cars without premium features will probably be increasingly relocated to where the sales markets are. This means rising pressure on the capacity utilization of European plants. In 2010, more than 75 million vehicles could have been manufactured globally, but only about 62 million were actually produced, which is equivalent to about 81% capacity utilization - with significant regional variations. With the exception of Opel, the domestic production plants of German carmakers have been operating at almost 90% capacity after the 2009 crisis. Plants in the rest of Europe, however, are suffering from the biggest regional excess capacities on a global scale and have a much lower capacity utilization of about two thirds. This also affects those German OEM with production plants in other European countries.

Three scenarios were constructed and quantified to predict global sales markets: »Conservative«, »Technology break« and »Mobility concepts«. These scenarios differ regarding the diffusion of new drive technologies in the market as well as the introduction of new mobility concepts. Regionally-specific, plausible development paths were assumed. In the »Conservative« scenario, fossil drive technologies continue to dominate, while alternative drives do not manage to break into the market and therefore the cost of these technologies is not reduced due to economies of scale. In the »Technology break« scenario, support programmes and incentives manage to lower the costs of new drive technologies (battery, plug-in hybrid, hydrogen fuel cell), which are then introduced to the

market. In both scenarios, global car sales climb from around 70 million today to about 125 million in 2030. In the scenario »Mobility concepts«, it is expected that integrated mobility services which link car-sharing, bike-sharing, dynamic car-pooling and public transport will become more relevant in the triad markets and, to a lesser extent, in China, too. As a result, the number of cars sold by 2030 only rises to 105 million. The main question arising from the scenarios is whether and how significantly alternative propulsion technologies or new mobility concepts could improve or adversely affect the market chances of the German automobile industry in the future.

Value added and employment scenarios

Almost one quarter of the value added of fossil-fuelled cars is attributed to the powertrain, i.e. the combustion engine and the gears. The German automobile industry has the technological edge in developing highly efficient combustion engines. In cars with alternative drive technologies, the combustion engine's share in the value added is either reduced (in hybrid vehicles which can make do with a smaller engine) or even vanishes completely (in purely battery-powered electric vehicles or fuel cell vehicles). The same thing is true for the gears and exhaust components.

In this report, alternative drives are understood to be all the variants of hybrid drives comprising a combustion engine and an electric motor which can be charged externally (PHEV, also includes those with a combustion engine used to charge the battery, i.e. the combustion engine is only used for charging and not for driving the vehicle directly), as well as purely battery-powered electric vehicles (BEV) and vehicles with fuel cells as the energy source (FCEV). Biofuels including biogas and wind gas – which is methane produced using (excess) renewable electricity – can be used in (partially slightly modified) combustion engines and should therefore also benefit from the technological leadership of the German automobile industry in developing more efficient combustion engines.

If alternative cars (PHEV, BEV and FCEV) are commercially successful, an important share of the value added, which today is mainly allocated to the OEM themselves, would be significantly reduced or even vanish altogether. It would be replaced by value added in components like power electronics, the electric vehicle battery or electric motors. Besides the described scenarios of global car demand, any analyses of the future value added in the German automobile industry therefore also require analyses to be made of how production and value added will be distributed in the future across the new components needed for alternative drives. The value added scenarios examined different assumptions

about the imported share of electric mobility-relevant components and the domestic share of cars produced abroad by German OEM.

The development of value added and employment in Germany varies widely in the three car demand scenarios, and the variation due to the assumptions in the value added scenarios also clearly affects the results. The »Conservative« scenario focuses mainly on efficient combustion engine technologies, a field in which the German automobile industry is currently the leader and is likely to remain so in the future. For this scenario, continuous growth in value added is expected and even additional jobs of 120,000 to 300,000 in Germany due to the growth on the global markets. The range results from comparing the most positive value added scenario with the most negative one depending on the aforementioned import shares and domestic shares of German OEMs' foreign plants.

In the »Technology break« scenario, value added does not grow as much in Germany, although the global growth of automobile value added is even higher than in the »Conservative« scenario. This means that German plants do not profit as much from the future growth because their share in the production of new drive technologies including batteries declines. The possible change in employment for the year 2030 ranges from a loss of 70,000 and a plus of 140,000 jobs in the German automobile industry. In both scenarios, it is assumed that premium cars and emerging technologies continue to be manufactured in Germany, but that additional production capacities for city cars and small family cars are established in the growing foreign markets.

In the »Mobility concepts« scenario, the value added which can be generated by conventional vehicle technologies drops, while the value added due to components relevant for electric mobility increases up to 2030. Due to productivity improvements expected at the same time, employment in the German automobile industry falls by between 56,000 and 400,000 jobs by 2030. This negative result occurs if the automobile industry does not act as a mobility service provider and cannot compensate the loss of value added in product sales with new service offers. Estimations of the potentials of new mobility concepts show that it would be possible to provide profitable mobility services in Germany. This marketability of new mobility concepts presumably applies to other European countries, the USA, Japan and China as well. A large share of the product sale losses in value added could be compensated in this way.

Overall, the most positive scenario »Conservative« also seems to be the least probable, because both a technology break and new mobility concepts are al-

ready discernible today, which make the »Mobility concepts« scenario more probable.

SYNTHESIS OF THE CHALLENGES FOR THE AUTOMOTIVE INDUSTRY

The global automobile industry is currently facing great changes and upheavals. New markets for cars are rapidly becoming more important. In 2010, China became the world's largest market for new cars, while sales on established markets in the so called triad cluster (EU, USA, Japan) are close to stagnation point. Essential framework conditions are changing and the car has to be adapted to meet them. These include the expected continuous rise in fossil energy prices and the implementation of ambitious climate policy targets in the transport sector. These developments will trigger innovation and market dynamics, which result in a greater diversification of the propulsion concepts in the direction of highly efficient and alternative drives, but which also make the introduction of new mobility concepts attractive as well. The automobile industry should be a major stakeholder in this transformation phase.

The report identifies seven major challenges for the automobile industry over the next 2 decades, which can be summed up as follows:

> Development of efficient vehicles
> Development of alternative propulsion concepts
> Retaining the position of the German automobile industry as a technology leader and manufacturer of premium products on the global market
> Complementing the product portfolio with new micro and city car concepts
> Penetrating the growth markets in the BRICS countries and managing the crisis in Europe
> Reducing the number of vehicle platforms in spite of continued differentiation of the product portfolio
> Participation in the introduction of new mobility concepts

The German industry certainly seems to be in a position to successfully meet these challenges.

Efficient vehicles

The German automobile industry has a head start when it comes to the development of highly efficient combustion engines. Up until a few years ago, priority

was being given to improving diesel engines, but the even greater efficiency potentials of petrol engines are now being tackled as well. The German automobile industry is also in a good position with regard to other technologies important for the development of more efficient vehicles such as lightweight construction and aerodynamics. The technological gap where hybrid drives are concerned, especially in relation to the Japanese manufacturers Toyota and Honda, could be bridged, or has already been compensated in certain car segments as shown by the products being offered by German manufacturers in the executive car and large family car segments. This means the German automobile industry holds a leading position with regard to the further efficiency improvements of vehicles with combustion engines. This obvious strength makes it hard to understand the reserved attitude of parts of the German automobile industry to the European Commission's suggested efficiency targets for the time horizons of 2020 and 2030.

Alternativ drives

German manufacturers are generally pursuing a second-mover strategy when it comes to alternative drives in the PHEV and BEV sectors, while carmakers like Renault/Nissan have chosen a first-mover strategy in BEV, as have General Motors/Opel and Toyota in PHEV. This seems to be an appropriate and understandable approach in view of the market risks, especially of BEV, regarding the present lack of acceptance and high battery costs as well as risks concerning battery lifetimes. However, neither does it seem to be the case that German manufacturers are underestimating the chances offered by these technologies as they are aiming to introduce their own BEV and PHEV to the market with a focus on 2013. One advantage of this approach compared to the foreign competitors pursuing a first-mover strategy could be that existing vehicle designs are not simply equipped with a new drive, but that vehicles are designed and developed from scratch under the specific conditions of electric mobility (e. g. lightweight construction, target group city and regional vehicles), with the result that the BEVs or PHEVs offered may be more appealing.

The decisive question for these variants of electric mobility (BEV, PHEV) is: should the German automobile industry be aiming to produce its own high-performance batteries in future (e. g. second generation lithium-ion batteries, lithium-sulphur, lithium-air)? The answer has to be yes based on today's understanding (or today's knowledge), because a large share of the value added of future BEV and PHEV is allocated to these batteries and this can compensate for the loss of value added from technically advanced combustion engines. Technologically, the German automobile industry should be able to do this by working

together with German material research, which is very well established in this field. One perceivable risk of this strategy is that a much faster decline in battery prices than has been predicted so far in the studies and scenarios of battery development could negate the effort and expenditure invested.

There is a different starting situation where fuel cell vehicles are concerned (FCEV). Here, a group of manufacturers, which also includes the Daimler Group, is striving for the first-mover position. The car manufacturers who have joined forces with companies from the production chain for hydrogen in the German »H2 Mobility« Initiative have come up with a concept for the parallel development of H2 refuelling infrastructure and hydrogen-powered vehicles. The first-mover position is founded on three factors and can be favourably assessed - particularly from the perspective of the Daimler Group: First, the Daimler Group has the knowledge edge over other OEM due to the long development and test phase of FCEV, which is also documented by the patent statistics on fuel cells. Second, the executive and large family car segments, which are especially targeted by the Daimler Group, are suited to developing technology leadership because the necessary price premiums are realizable here and the driving ranges demanded of today's state of the art limousines can only be achieved by a fuel cell if fossil fuels are not being used. Third, there is also a risk that, with an accelerated introduction of BEV and PHEV, battery technologies and the related business models could realize such large cost reduction potentials that the fuel cell is squeezed off the market even before the first vehicles can be commercially introduced. This final point is probably an important motivation behind the H2-Mobility's announcement of plans to launch FCEV onto selected target markets in the year 2015.

Positioning of the german industry

The German automobile industry has profited for years from its position as a leader and manufacturer of premium vehicles, which is firmly anchored in the image of Audi, BMW, Daimler, Porsche and, more recently at a global level, also VW. The term »premium manufacturer« no longer only refers to executive and large family cars, but can refer to all segments and to the top-of-the-range vehicles in them which are equipped with leading technology and exclusive features. As a result, a BMW MINI, an Audi A1 or a top-of-the-range VW Golf can all claim the status of a premium vehicle. The top position of these five OEM as technology leaders and premium manufacturers has to be held in the future in Germany, Europe and the world. Four reasons can be listed here: First, the biggest profits can be realized in the premium segment, which form the basis for the innovation strength of the automobile industry due to consistently high R&D

spending. Second, the section of the population with the highest and high incomes is increasing disproportionately, especially in newly industrializing countries as their economies catch up, so that the global market for premium vehicles is likely to experience a more stable boom in the near future than other market segments. Third, without the characteristics of technology leader and premium supplier, international competition would shift in the direction of price-based competition which would probably be detrimental to the carmakers producing in Germany. Fourth, this would also jeopardize the success of German OEM, who export around three quarters of the cars made in Germany. In other words: the German automobile industry would have to reckon with drastic losses if it were to lose its image and capability to be a technology leader and premium producer.

New city and micro car concepts

Despite its established position as a manufacturer of premium cars, the German automobile industry should add new city car and micro car concepts to its product portfolio in the future. This finding is especially valid in the scenarios »Technology break« and »Mobility concepts«. Besides electric scooters and pedelecs, micro vehicles can also be one or two-seater cars. There are four reasons for expanding the product portfolio by this segment: First, the continuing urbanization requires the establishment of small, lightweight and manoeuvrable city and regional vehicles which can guarantee city-friendly mobility alongside local public transport services. Second, this growing urbanization is particularly marked in newly industrializing countries in which there will also be a relevant market share of new entrants to motorized mobility with low purchasing power. Third, the advances in electric mobility offer the possibility to establish small and light e-cars powered by batteries in urban areas. Today's stock of 120 million pedelecs and electric scooters in China is a striking demonstration of the possibilities of such transport means in up-and-coming economies. Fourth, there will be other opportunities to place innovative city and micro cars on the mobility market should new mobility concepts be established (slogan »using instead of owning«). The key issue here will certainly be cost competitiveness. The limited success of suppliers so far (e.g. ThinkCity, Sam) with car prices around 20,000 euros shows the need for drastic cost reductions. Whether the next generation of vehicles (like Renault Twizy) with prices around 8,000 euros already represent an interesting and marketable alternative for private users still remains to be seen. German carmakers could doubtless transfer their development and manufacturing skills to the micro car segment and create the corresponding solutions. It is still unclear at present to what extent a premium segment could also be established for these micro cars.

If these first four challenges are summed up in an interim conclusion, the result is steady growth on the premium market, which is very attractive for the German automobile industry and the future potential of newly emerging demand at the lower end of today's car segments, while the demand for German-produced, middle-of-the-range cars with no advanced technology features will probably decline.

Tapping new growth market

There are two different regional dimensions to another challenge concerning future market development: In the BRICS countries, it is worth pushing market penetration in these future growth markets of transport demand. Especially China and Brazil offer large opportunities on markets with significant volumes which will increase in the future. The sales of new cars in China could more than triple by 2030 in relation to today's figures. The German OEM are already well positioned here, for instance with Volkswagen, which is the leader in China and Brazil based on market shares, as well as with the traditional manufacturers of premium vehicles, who exported large parts of their production from Germany to China (which is how China has since become the largest and most important single market for Porsche as well), although these are less strongly positioned in Brazil and South America as a whole. Growth in the future will take place in the BRICS countries, while demand in the triad nations will tend to stagnate. The OEM and system suppliers are already much better positioned in the growth regions with extensive production and development capacities than the downstream suppliers, who mainly focus on business in Germany and Europe and have a much weaker position concerning direct exports to these growth markets.

The European export market forms the second regional dimension of market development. The challenge here is to cope with the financial and economic crisis, which will continue to burden at least southern Europe, but probably also France, Ireland and perhaps England for a longer period and, simultaneously, the low capacity utilization rates and existing excess capacities in all the car manufacturing plants in the rest of Europe outside Germany. Their high export dependency, with three quarters of national production being exported (to Europe among others), and the operation of under-utilized plants in the rest of Europe also place a strain on the German OEM. Those OEM which are successfully positioned on the BRICS growth markets can compensate the weaknesses in Europe. Even so, German OEM will also be affected by the necessary reduction of production capacities in Europe, especially those not engaged in the growth markets. Utilizing the existing capacities in Germany for national and international demand will remain a major objective of the OEM. At the same time, it

has to be asked to what extent local, on-site production has to be directly developed in the growth regions, especially in markets below the premium ones. This was not as important for the value added in Germany while Europe was still the main target market of German OEM. Shifting production to Asia or South America triggers greater shifts in the value chain than production distributed in Europe. European plants could be served by mainly national suppliers, while the Asian or South American plants of German OEM are more likely to be served by locally-based suppliers from these regions.

It is still uncertain how the Indian market will develop. Strong growth in the demand for cars is assumed here as well, but it is not yet possible to say whether production capacities will have to or can be successfully constructed in India, or whether the Indian market should be supplied from Germany/Europe – or whether Chinese manufacturers will take over its supply. Because of the expected size of the Indian market in the future, this should be monitored continuously and strategies have to be prepared for its development and updated at regular intervals.

Modular and platform strategies

The modular or platform strategy selected for vehicle production is a key factor for the future competitiveness of the OEM. The aim here is to underlay the market diversification of vehicle types by pursuing as focused a system strategy as possible featuring only a few modules/platforms in order to cost-efficiently meet customer demands for the widest variety of vehicle types (estates, limousines, convertibles, Sportbacks, coupés etc.). A focused system strategy makes large batch production and economies of scale possible for the system modules and allows variations of the vehicle types at the same time by varying the externally visible components. The international pioneer in this field is certainly Volkswagen with its two modular platforms (MQB, MLB), but other German OEM (e. g. Daimler) are also better positioned here than Japanese or American manufacturers. This lead should be held or even extended. At the same time, it has to be guaranteed that production plants are able to switch flexibly between the individual vehicle types of one module and are not fixated on manufacturing a single model. This approach can compensate demand fluctuations by temporarily shifting production volumes between individual plants instead of being dependent on having to order overtime at one plant while another is not being utilized to capacity.

New mobility concepts

The seventh and last challenge integrates almost all the previous ones and adds a new systemic one: the challenge of introducing new mobility concepts and the possible participation of the automobile industry as a mobility service provider. This would transform the OEM from purely product suppliers to mixed providers of products and services. New mobility concepts are based on the idea of using instead of owning and include different variants of car-sharing, bike-sharing, dynamic car-pooling and integrating these mobility services with each other or with public transport. Although car-sharing has been around for 20 years as a mobility option, it has only experienced a boom in terms of the number of offers and users over the last 5 years. There were more than 250,000 car-sharers in Germany in 2011, which means the number of users has doubled within 4 years, corresponding to an average growth rate of approx. 20%.

Within a few years, large bike-sharing schemes have been established in other European countries with up to 20,000 bicycles per town; and cities like Paris, Barcelona or Milan, in which bikes previously played no role as a means of transport, can now point to significant and growing shares of cyclists in the modal split. The biggest bike-sharing schemes are currently being constructed in China's major cities. Dynamic car-pooling has reached a new level of quality since internet and smart phone apps make ad-hoc offers and ad-hoc booking possible when sharing a ride. It is easy to imagine car-sharing schemes in urban regions using the new electric city and micro cars, both in Europe and in the growth markets. Besides the technological availability of small electric cars, other drivers of this development are certainly the increase in the costs of mobility, growing urbanization and changing status symbols. For young people in urban areas, smart phones, e-bikes or Segways are increasingly replacing private cars as status symbols.

The automobile industry will certainly feel the dampening effect new mobility concepts will have on car sales. But it can also assume a pro-active role in developing mobility concepts and compensate the loss of sales with revenue from supplying mobility services. In addition, these systems provide a platform for alternative drives and the opportunity for manufacturers to test new developments in practice. The OEM play diverse roles here. On the one hand, they can develop traditional as well as flexible car-sharing schemes. This applies to individual regions in Germany, but also to Europe, North America and selected countries in Asia. On the other hand, the OEM could take on more advanced functions as integrators of the new mobility concepts, because the automobile industry has the largest research budget in the German economy at its disposal.

From the customer's perspective, a standardized interface needs to be set up for the new mobility concepts, which can be used to obtain information about, book and use local public transport services, dynamic car-pooling, car- and bike-sharing schemes. Besides this interface, it also has to be mandatory for transport companies to provide information about connections. This development stage of integrated mobility can probably only be reached some time after 2020, but earlier market entry is necessary for it to be realized. To realize integrated mobility, technology know-how is needed in connecting large databases, in real-time data processing and in managing communications with very large groups of users. Alongside the automobile industry and other large transport operators like the Deutsche Bahn AG, the role of integrator could also be aspired to by leading technology concerns with an IT focus such as Siemens, IBM or SAP, but also by large companies from the field of internet and social media technologies like Google, Apple or Facebook.

RECOMMENDATIONS

The different recommendations which can be derived from this study can be divided into three categories using the respective addressees: market strategies, technology strategies and regulatory strategies. The first are directed at strategy management in the automobile industry, the second at its technology development strategy and the third at the legislator.

The following four market strategy premises can be derived from the analyses and results of this report:

> Safeguarding its global premium market is a major objective for the preservation and growth of the German automobile industry. Premium offers enable high value added to be achieved and help to preserve the industry's technology leadership. In global terms, the premium market will probably be one of the most stable markets in the next two decades.
> Establishing a strong position on the growth markets and then expanding this, especially in China and Brazil and, as a slightly weaker priority, in other South American countries and in Mexico.
> Continuously monitoring the Indian automobile market is necessary to be able to develop, test and realize appropriate market entry strategies for this country should the opportunity arise.
> Changing values and efficiency considerations make it probable that new mobility concepts will be developed. The OEM should develop and test business models here in order to be able to profit from this market as the providers of

mobility services. This would enable them to compensate declining car sales figures by establishing a second main pillar of business.

> Even if it is generally assumed that drive concepts will diversify in future, three main technology strategy challenges can be derived based on this study:

> The development and realization of lightweight construction technologies will be essential in all types of vehicles, for both general energy saving reasons (energy and climate efficiency) and from the viewpoint of electric mobility which will have a limited energy storage capacity for the foreseeable future.

> Because of the battery's high share of value added in electric mobility concepts, it seems strongly advisable to start building up domestic production of them, at least for second generation lithium batteries (lithium-ion) as well as future systems (e. g. lithium-sulphur, lithium-air). This could compensate for losses in value added due to omitting the combustion engine and its auxiliary components.

> The market introduction of hydrogen fuel cell technology should be pushed by promisingly positioned OEM, in order to avoid the situation where a faster breakthrough in battery technology – which cannot be ruled out completely – makes it completely impossible to introduce FCEV because the problem of driving range in e-cars would then be solved which would prevent FCEV entering their learning curve.

> Three main regulatory options can be derived from the above described strategies as supplementary support accompanying the imminent changes in the automobile industry:

> Building up domestic production of high-performance batteries in Germany should be supported by sufficient research funding, especially for basic research on second generation lithium-ion batteries (i.e. lithium-ion, lithium-sulphur, lithium-air).

> German manufacturers are well positioned in efficiency technologies for combustion engines and in optimizing vehicles, e.g. due to lightweight construction technologies. Correspondingly, the so called CO_2 Strategy of the EU, which also forms part of the German »Integrated Energy and Climate Programme«, should be supported by setting ambitious CO_2 efficiency targets. In addition, this measure can also make the most effective contribution to reducing the greenhouse gas emissions (GHG emissions) from transport.

> Germany and German car manufacturers should take on a pioneering role for the successful introduction of new mobility concepts aiming at integrated mobility in the sense of generating multimodal trip chains from a single source. Existing obstacles to this have to be dismantled. These include changes to the parking by-lawswhich today demand a minimum number of parking spaces per (new) residential unit in almost all the German federal states, even in car-free or highly car-moderated residential areas, but which would not be needed for integrated mobility. At the same time, the opportunities to create parking places

reserved for car-sharing vehicles are often limited. More important, however, is the need to open the market so that customers of one regional mobility service provider can also use the services of other mobility providers in other regions, similar to the roaming concept for mobile phones. This would at least lead to a national uniformly utilizable system. Ideally, this system of integrated mobility could then be expanded to include neighbouring countries and the rest of Europe or transferred to other regions, so that the German pioneering enterprises could generate additional value added from this market expansion.

The Office of Technology Assessment at the German Bundestag is an independent scientific institution created with the objective of advising the German Bundestag and its committees on matters relating to research and technology. Since 1990 TAB has been operated by the Institute for Technology Assessment and Systems Analysis (ITAS) of the Karlsruhe Institute for Technology (KIT), based on a contract with the German Bundestag

OFFICE OF TECHNOLOGY ASSESSMENT AT THE GERMAN BUNDESTAG

BÜRO FÜR TECHNIKFOLGEN-ABSCHÄTZUNG BEIM DEUTSCHEN BUNDESTAG

KARLSRUHER INSTITUT FÜR TECHNOLOGIE (KIT)

Neue Schönhauser Straße 10
10178 Berlin

Fon +49 30 28491-0
Fax +49 30 28491-119

buero@tab-beim-bundestag.de
www.tab-beim-bundestag.de