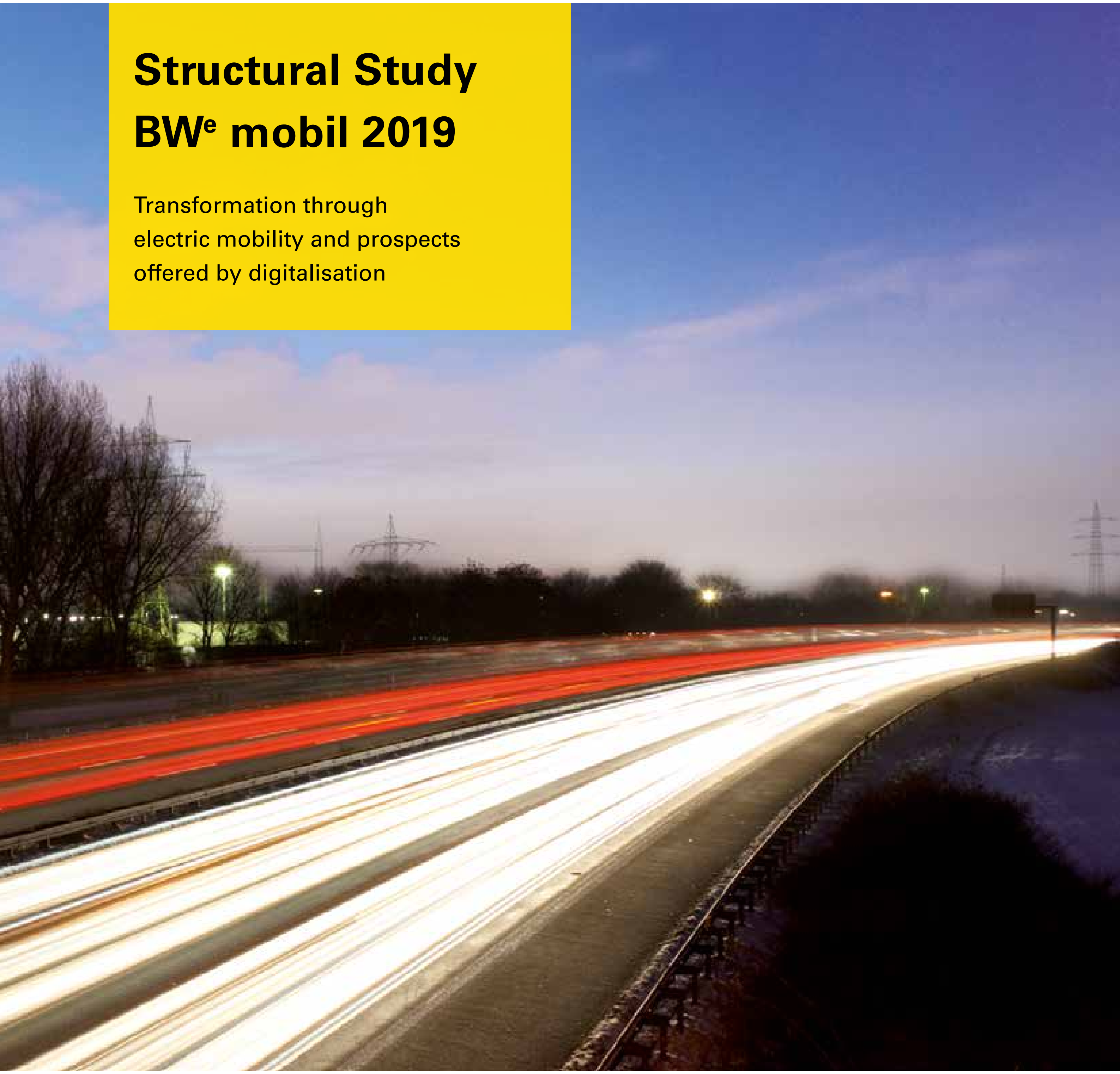
Short version

Structural Study BWᵉ mobil 2019

Transformation through electric mobility and prospects offered by digitalisation



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State Agency for New Mobility Solutions and Automotive Baden-Württemberg

Structural Study BWe mobil 2019

Transformation through electric mobility and prospects offered by digitalisation

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A. Management Summary

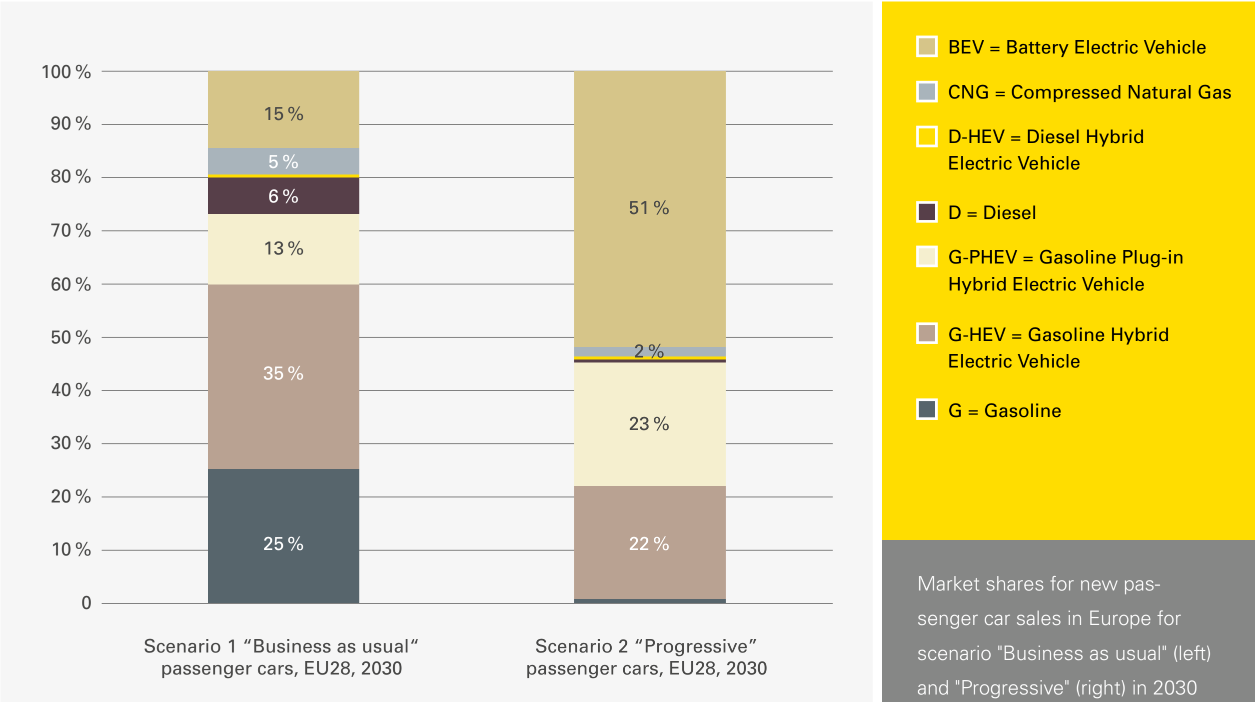
Technological change is transforming the mobility industry.

Electric mobility is a megatrend, which, along with connected vehicles, driverless cars and digitalised vehicle production is set to transform the way we use and manufacture vehicles over the next few years. The electrification of the powertrain, in particular, is changing existing value creation and employment structures in the automobile industry, as traditional components such as combustion engines lose significance, while new electric mobility components become more important. This transformation is being driven primarily by passenger car markets in Asia, with China being the prime mover. For Baden-Württemberg it is important to embrace this transformation and structural change and make use of its economic opportunities.

As soon as 2030 the majority of new cars in Europe could have an electric powertrain.

The EU's CO_2 emission limits for new passenger cars and the efforts of automobile manufacturers to comply with these are the main factors driving widescale electrification. Parallel to this, vehicles with internal combustion engines will become more efficient and electrified, due to new efficiency and hybrid technologies.

The DLR VECTOR 21 model was used to simulate market and consumer behaviour and produce plausible scenarios of the market for new passenger cars in Europe under two different framework conditions. Whether or not these scenarios actually occur depends mostly on factors over which Baden-Württemberg has no direct influence. The DLR VECTOR 21 simulation of the business as usual scenario suggests that, given a moderate development of the general external conditions, 15 % of all new passenger cars



Market shares for new passenger car sales in Europe for scenario "Business as usual" (left) and "Progressive" (right) in 2030 sold in Europe will be fully electric vehicles, with plug-ins and full-hybrids accounting for 13 % and 35 %, respectively. In this simulation, fuel cell vehicles will not achieve any appreciable market share until 2030. Should the prevailing conditions develop in an extremely favourable way for electric vehicles – in particular with respect to battery costs and infrastructure availability – the progressive scenario points to fully electric vehicles accounting for 51 % of all new passenger cars sold in Europe by 2030. Another 47 % would be partially electrified vehicles, still with an internal combustion engine installed. In this scenario, a fully electric mid-range vehicle would be sold at a price comparable to a gasoline-engine vehicle no later than 2030, making it competitive even in terms of purchase price. While in 2015 conventional vehicles were more than EUR 10,000 cheaper than electric vehicles, the progressive scenario assumes that by 2030 the tables have turned, making a conventional vehicle EUR 1,000 more expensive than an electric vehicle. This is partly the result of the increasing complexity and costs of the technologies required to ensure vehicle efficiency. These will be mandatory to comply with legal emission limits, and will also result in a significant drop in fuel consumption.

Milestone of the Climate Action Plan 2030 will be attained – provided that strict boundary conditions are met.

The German government's Climate Action Plan sets the traffic and transport sector a target of a 40 to 42 % reduction in the 1990 level of CO_2 emissions by 2030. According to calculations, this target would be achieved in both scenarios. In the business as usual scenario, the passenger car sector would achieve a reduction of 50 % of the 1990 levels of CO_2 emissions, while in the progressive scenario the figure would be 55 %. This, however, is based on the extremely unlikely assumption that there is no further increase in the number of kilometres driven per year or in the average engine power. Realistically then, it can be expected that the increasing volume of traffic and average engine power will counter the technical progress, making it impossible to achieve in full the potentials calculated. Moreover, other means of transport (e.g. railways, heavy goods vehicles and air transport) would also have to do their bit to achieve the targets for the transport sector. This represents a significant risk. Because of the slow rate of renewal of the vehicle stock by more efficient cars, an early transition of the passenger car fleet to electrified vehicles would have a major influence on long-term CO_2 emissions and a robust, positive effect on efforts to achieve greenhouse gas neutrality by 2050. To protect the climate, measures are needed to accelerate the rate of transition and achieve a faster rate than that presumed in the business as usual scenario.

Impacts on employees in Baden-Württemberg will vary significantly.

In the reference year (2016), about 470,000 people were working directly or indirectly in the Baden-Württemberg automobile cluster. This is equivalent to about 11 % of all employees with social insurance cover in the State of Baden-Württemberg. The growth of the market for new components for electric mobility, and the parallel decline in demand for conventional components will, depending on the scenario, result in between a 1.9 % increase in overall employment (+8,900 jobs) and a 6.6 % cut in employment (-30,800 jobs) by 2030. These impacts on employment can be considered moderate for Baden-Württemberg's automobile sector as a whole. However, this will only apply if the cluster is able to retain its worldwide leading role in innovation also for alternative powertrain technologies, and if it can obtain market shares for the new components comparable to their market shares in conventional components today. For this, concentrated efforts will be needed on the part of all actors in the sector, along with active industrial policy support to retain the special status of the Baden-Württemberg automobile cluster.

Although the positive and negative impacts on employment more or less offset one another for the sector as a whole, the impacts will be very unevenly distributed. The true impact of employment trends thus only becomes apparent when the single production plants in Baden-Württemberg that depend directly on the powertrain are taken into account, with a total workforce of 70,000.

- Under the **business as usual scenario,** about 10 % (including productivity gains: 27 %) of the workforce of powertrain-dependent production plants could be affected by the fade-out of the conventional powertrain by 2030. Of the total of 18,500, about 5,000 could find employment in the manufacture of new components (fade-in).

- Under the **progressive scenario,** on average, almost half of those working in powertrain-dependent production plants would be affected by 2030 (46 %; with productivity gains: 56 %). A total of 39,000 employees in Baden-Württemberg would be adversely affected by the fade-out of internal combustion engine technologies, while about 8,000 new jobs could be created, thanks to new electric components.

The transformation of Baden-Württemberg's automobile industry as a whole will only be possible if corporate strategies and the flanking industry policy measures also take into account the imperatives of ensuring the sustainable development of Baden-Württemberg's (manufacturing) sites, and if employees are involved in the transformation.

Baden-Württemberg's place as a leading centre of industrial innovation must be secured.

The economic strength of Baden-Württemberg has for years been based on a specific innovation cluster, which has specialised in innovations relating to industrial manufacturing and has a leading position worldwide. The transition to electric mobility could provide important impetus for the further development of Baden-Württemberg's industrial innovation cluster, in spite of the structural changes this will mean in terms of employment. This does, however, presuppose that specific innovation patterns, arising from the dovetailing of manufacturing expertise and product innovation are used in new powertrain designs to re-establish Baden-Württemberg's position as a leading innovator. Baden-Württemberg must become the leading market and leading provider in the sustainable mobility sector, and thus a pioneer in the transition to electric mobility.

This will only be possible if corporate as well as location and site strategies are geared to achieving this development goal. The strategies must be paired with the will on the part of the workforce to embrace change and have the support of the political level and of the science and research community. Ensuring lasting prospects of employment can be an important element in overcoming any reluctance on the part of the workforce to accept change. It is not the transition to electric mobility per se that could jeopardise the economic strength of Baden-Württemberg, but the failure to grasp the opportunity to shape the transition and actively develop the sector.

B. Summary and key outcomes

1. Objectives of the study

The transition in the mobility industry – driven by the trends towards electrification, digitalisation and automation is opening up new economic opportunities worldwide. In Germany, and specifically in Baden-Württemberg, which is one of the world's leading centres of the automobile industry, there is currently a prevailing uncertainty as to how these changes will impact on future value creation and employment.

The status quo (chapters 1–3)

- Electrified powertrains and connected mobility concepts
- Survey of the automobile industry

Scenarios of structural change (chapter 4)

Modelling 2030
- New car sales
- Existing vehicle stock

Development of the automobile industry (chapter 5)

- Components and markets
- Impacts on employment and value creation

Role of BW as an industrial innovation cluster (chapter 6)

- Production optimisation and productivity impacts
- Production networks and industrial innovation clusters

Shaping transformation (chapter 7)

- General conditions, scope to shape these
- Recommendations for action, change management

Procedure and key contents of the Structural Study BWe mobil 2019

In this context of transformation, the potential negative consequences for Baden-Württemberg as a centre of manufacturing are generally raised, although this transformation could equally bring positive outcomes if it can be actively and successfully shaped.

This study aims to present the potential changes to Baden-Württemberg as a centre of the automobile industry, and on this basis will identify the challenges and opportunities arising from electrification, but also digitalisation and automation.

Compliance with climate-related targets is an important criterion for successful transition, with the focus on the electrification of the engines used in passenger cars and the impact this will have on employment. Other studies, including 'Mobile Baden-Württemberg. Ways of transformation on sustainable mobility' (Baden-Württemberg Stiftung, 2017) have looked at and will continue to look at the necessary changes in mobility behaviour.

The objective, transparent, scientifically and methodologically well-founded analysis is intended to support efforts to actively and positively shape change in the realms of politics, society and industry. It provides answers to the following questions:

- What is the ongoing technological change?
- What is the status of electrification, digitalisation and automation and what trends can be identified?
- How is the automobile sector structured in Baden-Württemberg?
- How rapidly and under what conditions are alternative powertrain concepts becoming accepted?
- How will value creation and employment develop?
- What options exist to shape the transformation?

The focus of the scenario-based study is on electric passenger cars, the technology and components used and on **quantifying the impacts of electrification on value creation and employment.** Possible impacts of digitalisation and manufacturing 4.0 (the digitalisation of traditional manufacturing) have not been calculated here using our own simulation models, but are described in qualitative terms.

2. Technological change – an overview and trends in 'electrification'

- The number and range of electric vehicles on the market is increasing steadily; German manufacturers are to launch a product offensive as of around 2020.
- There are already a number of different construction types and levels of electrification (from hybrid models to battery electric vehicles) on the market – each with its own electric output, range and driving modes.
- Internal combustion engines will continue to be used in many powertrain concepts, with the exception of battery electric vehicles and fuel cell vehicles.
- Classic components will continue to be used, in a more efficient, smaller, lighter or more compact form.
  New components will significantly shift the proportions of value added, with a shift away from mechanical components to electric and electronic components.

Engine types / Components	ICE	HEV	PHEV	REEV	BEV	FCEV
	Changes to the systems by 2030					
Internal combustion engine	modified	modified	modified	modified	n.a.	n.a.
Starter and generator	modified	modified	modified	modified	n.a.	n.a.
Exhaust/ventilation system	modified	modified	modified	modified	n.a.	modified
Fuel supply	modified	modified	modified	modified	n.a.	modified
Transmission	modified	modified	modified	modified/ n.a.	modified/ n.a.	modified/ n.a.
Electric drive	n.a.	new	new	new	new	new
Battery system	n.a.	new	new	new	new	new
Power electronics	n.a.	new	new	new	new	new
Internal charging system	n.a.	n.a.	new	new	new	n.a.
Fuel cell system	n.a.	n.a.	n.a.	n.a.	n.a.	new

Overview of new, modified and no longer needed components, broken down by powertrain concept

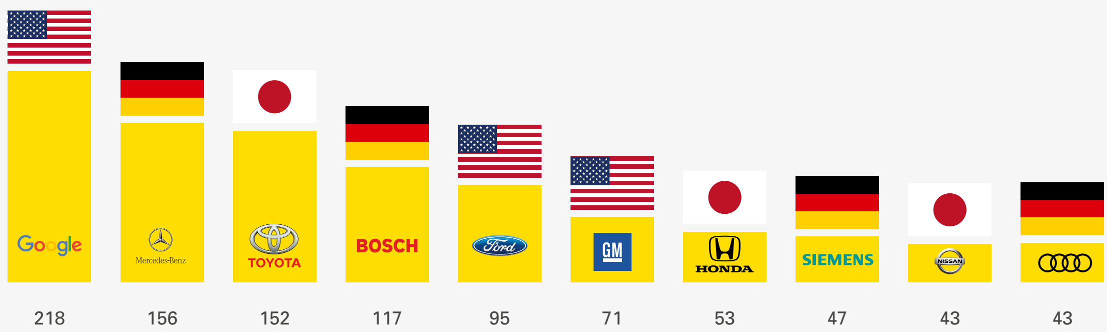
ICE = Internal Combustion Engine; HEV = Hybrid Electric Vehicle; PHEV = Plug-In Hybrid Electric Vehicle; REEV = Range-Extended Electric Vehicle; BEV = Battery Electric Vehicle; FCEV = Fuel Cell Electric Vehicle

Overview and trends – digitalisation

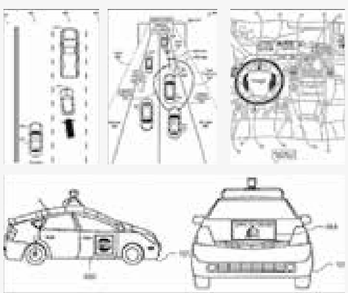
- One major aspect of digitalisation in mobility is connectivity, or enabling vehicles to communicate with one another, with the infrastructure or with special platforms, including platforms operated by manufacturers.
- The combination of connected, smart elements in traffic and automated/driverless vehicles is spawning the development of new mobility services and business models.
- New providers are entering the market and competing with 'classic' automobile manufacturers and suppliers. German companies are strongly represented in research and development activities relating to autonomous driving (level 5) as a whole.

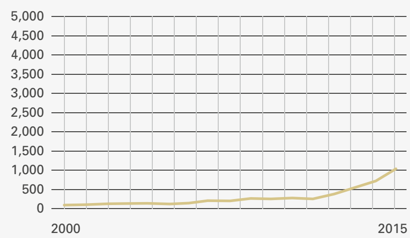
Patent activities as an indicator of R+D, company ranking for:

- autonomous driving for road vehicles
- Time period: 2000–2016
- No.: 5,553



Volkswagen AG	38
Valeo GmbH	29
BMW AG	27
Continental GmbH	21
SICK AG	19
SEW Eurodrive GmbH	13
Kuka Roboter GmbH	9





Analysis of patents for the autonomous driving (level 5) of road vehicles (passenger cars and heavy goods vehicles), 2000–2016

- Partially-automated vehicles already exist, and fully driverless cars are expected to be on the roads by 2025-2030.
- The technical and legal frameworks, by comparison, are still in their infancy. Autonomous or automated driving is intended to increase road safety and mobility for all sections of society.

Overview and trends – automobile manufacturing 4.0

- The buzz word ‘industry 4.0’ refers to highly automated and flexible manufacturing, achieved through the use of across-the-board digital technology.
- The automobile industry is responding to the pressure of intense competition by steadily adapting production and the technologies used in manufacturing. It is considered to be an innovator and a driver in the modernisation of manufacturing and logistics concepts. Flexible manufacturing is also to help the industry shift to new powertrain technologies.
- The application of industry 4.0 concepts will thus radically change manufacturing work, and hence the qualifications structure in the industry’s workforce in the medium term.
- It is not, however, possible at this stage to quantify the (net) impacts on employment of industry 4.0 concepts.

3. Baden-Württemberg’s automobile industry

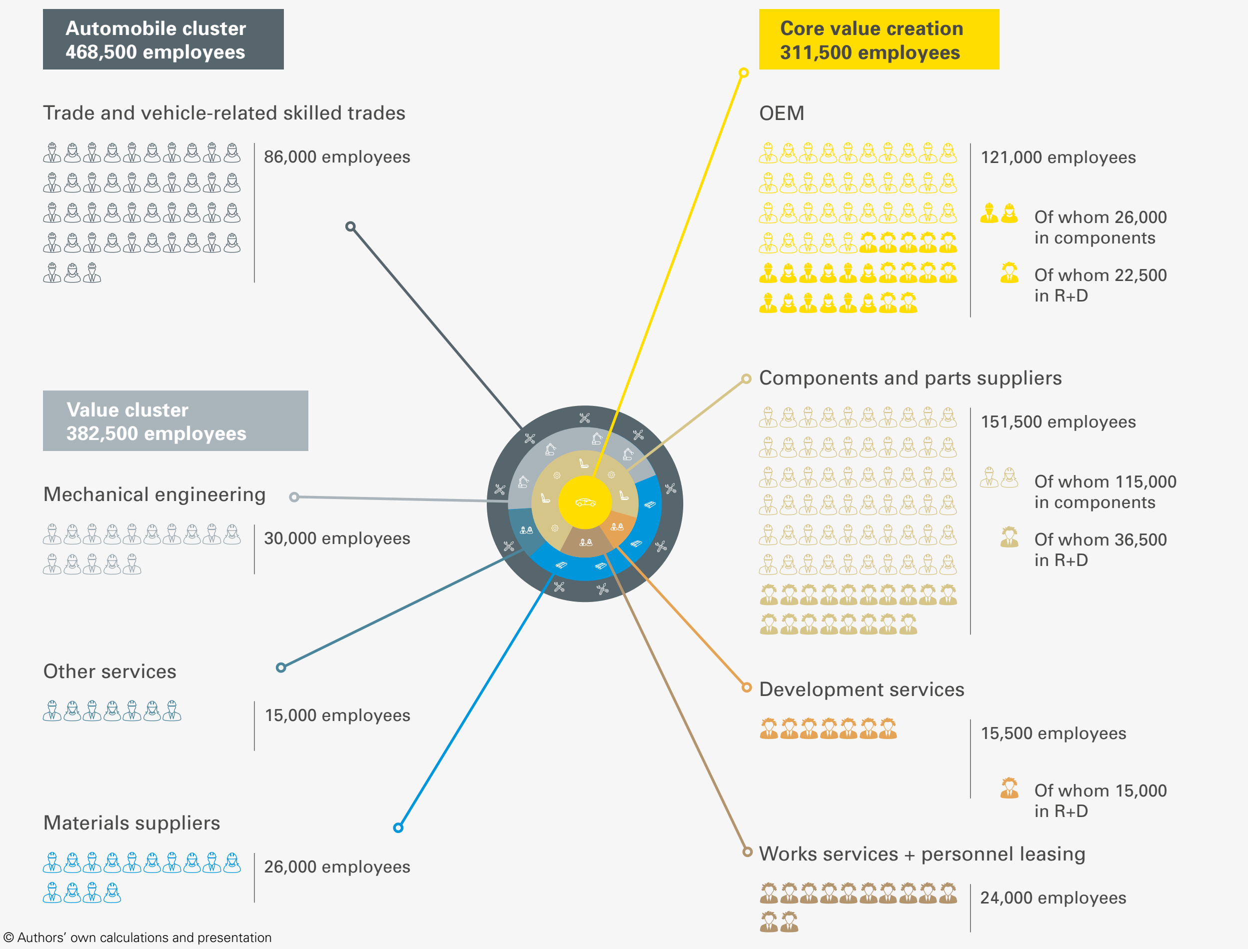
Baden-Württemberg is one of the world’s leading centres of the automobile industry, with a fully developed ‘automotive cluster’ that embraces the entire value chain of automobile production, ancillary services and suppliers from the mechanical and plant engineering sectors. The three Baden-Württemberg-based manufacturers (OEMs) are classed as belonging to the premium segment, and numerous suppliers specialise in powertrains.

The automobile industry in Baden-Württemberg is one of the core industry sectors with an annual turnover of slightly over 105 billion euros (2016). Vehicle construction alone generates about one tenth of the entire gross value creation of the Federal State. At the same time, the automobile sector in Germany and in Baden-Württemberg is considered to be research intensive. In Baden-Württemberg, it accounts for almost half of all research and development spending in the business sector.

Directly or indirectly, just under 11 % of employees with social insurance cover depend on the automobile industry. Almost 470,000 jobs can be attributed to the automobile cluster. The transition to electric mobility will impact very differently on different groups of employees. As a basis for the impact analysis, the employment structure in Baden-Württemberg’s automobile sector has thus been analysed in detail, and the various groups of employees have been categorised at different levels of the cluster and value segments.

- The **core of value creation** embraces the companies and workforces that have specialised in products for vehicles, and are integrated into joint production innovation processes. About 311,500 employees working for the OEMs, component and parts suppliers (levels 1 and 2), (development) service providers and personnel leasing firms belong to this category.
- The broader **value cluster** includes parts and materials suppliers and other services serving the automobile industry, without specialising in vehicles as a product. This cluster level also embraces parts of the mechanical and plant engineering sector specialising in equipping the automobile industry. This entire value cluster comprises 382,500 employees in Baden-Württemberg.
- About 86,000 employees in the vehicle trade round off the entire **automobile cluster** in Baden-Württemberg, reaching a total workforce of around 468,500.

Employees in these value segments can be further broken down into different functional areas.



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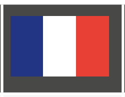
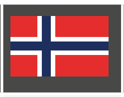
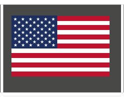
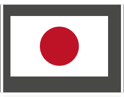
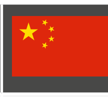
Employment structure in Baden-Württemberg's automobile cluster

4. Transformation to electric mobility – Increasing market share of electrified vehicles and resulting impacts on employment

In 2017, over 1 million electric vehicles were registered world-wide for the first time, bringing the total number of electric vehicles on the roads to more than 3 million. The percentage of the total vehicle stock accounted for by electric vehicles is still very low, when compared to conventional vehicles. Of the stock of 3.2 million vehicles in 2017, only about 0.3% were electric. But demand is growing steadily, and at an ever faster rate. Over the last three years the number of electric vehicles has more than quadrupled. In 2014, only about 0.76 million electric cars were on the roads worldwide. The main factor in this expansion is the Chinese automobile market, which accounts for some 1.2 million passenger cars (or one third of the total stock of electric vehicles worldwide). China is followed by the USA, with a total of about 750,000 vehicles. To date, Germany has around 130,000 battery electric vehicles and plug-in hybrid electric vehicles on its roads, which puts it a long way behind China and the USA both, in absolute terms and in terms of market share.

Political goals, purchase incentives, emission limits and the availability of infrastructure all vary widely from one country to another. The development of international automobile markets for electric and alternative-engine-technology vehicles is happening at different rates, often as the direct consequence of political goals and measures. Critical levers in this context include CO_2 legislation and regulations for environmental and health protection (limiting maximum exhaust emissions, for instance), political goals and directives (e.g. an electric vehicle quota), financial subsidies and incentives to purchase (e.g. direct monetary subsidies when electric vehicles are purchased), support for R+D activities and the development of charging infrastructure.

									
First-time EV registrations until 2017 (Proportion of)	98,280 (0.73 %)	125,940 (1.41 %)	149,350 (1.46 %)	121,540 (6.39 %)	187,270 (28.76 %)	751,510 (0.91 %)	201,410 (0.59 %)	4,800 (0.02 %)	1,212,280 (1.37 %)
Target, electric vehicles	2020: 1 million 2030: 6 million	2020: 1.6 million	2020: 2 million	2020 0.2 million 2025: 1 million	-	2025: 3.3 million	2020: 1 million	2020: 7 million	2020: 4.6 million
Purchase incentives	BEV: € 4,000 PHEV: € 3,000	BEV: € 5,150 PHEV: € 2,860	BEV: up to € 6,300 PHEV: up to € 1,000	-	-	Up to € 5,400	BEV: up to € 6,300	Regional subsidies	BEV: up to € 7,200 PHEV: up to € 4,200
Emission limits	2021: 95 CO_2 g/km 2025: 81 CO_2 g/km (15 % down on 2021) 2030: 59 CO_2 g/km (37.5 % down on 2021)				-	2020: 121 CO_2 g/km	2020: 105 CO_2 g/km	-	2020: 117 CO_2 g/km
Regulatory framework	-	Sales ban as of 2040 Driving ban as of 2050	Sales ban as of 2040	Planned sales ban as of 2030	-	Rising quota for electric vehicles in 9 states	-	Vehicle fleet electrified by 2030	Rising quota for electric vehicles (sales ban)
Charging infrastructure 2017	Slow: 22,213 Fast: 2,076	Slow: 11,479 Fast: 2,037	Slow: 14,407 Fast: 1,571	Slow: 32,976 Fast: 455	Slow: 8,292 Fast: 1,238	Slow: 39,601 Fast: 6,267	Slow: 21,507 Fast: 7,327	Slow: 222 Fast: 25 (2016)	Slow: 130,508 Fast: 83,395

An international comparison of market situation and conditions

Market development scenarios for electric mobility

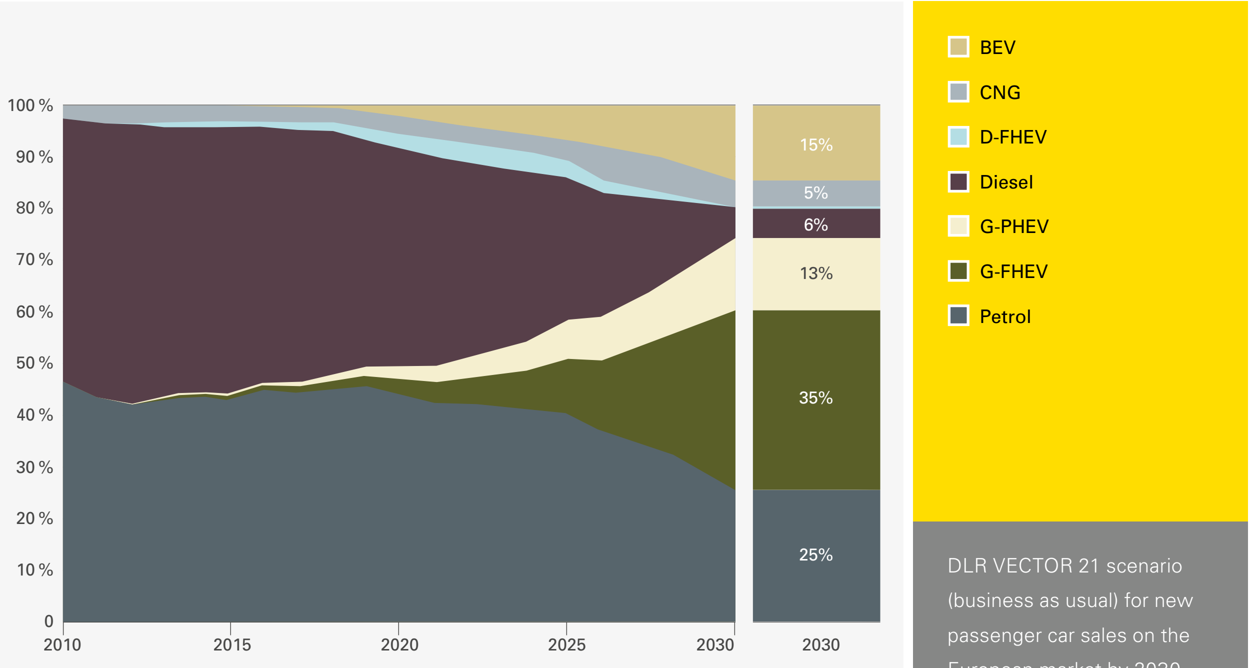
On the basis of a meta-analysis, all relevant scenarios proposed in the literature currently available regarding the market development for electric mobility were examined, and the fundamental assumptions on which they are based were analysed. This analysis served to identify the conditions for the two scenarios simulated here (DLR VECTOR 21). The meta-analysis indicated a drop in the market share of pure internal combustion engine vehicles under both moderate and progressive conditions, although the speed of the decline varies significantly. In-depth analyses look at the costs of batteries, the availability of infrastructure, CO_2 legislation and the annual production figures as critical factors determining the speed at which electric vehicles will increase their market share.

Based on these variables, the purchase behaviour was simulated using the DRL VECTOR 21 model, so as to generate plausible images of the market for new passenger cars in Europe in future. The two scenarios provide a possible spectrum of how the car market in Europe could develop between now and 2030, given different conditions and critical variables. Most crucial factors lie out of the control of Baden-Württemberg. BEV are expected to account for between 15% (business as usual scenario) and 51% (progressive scenario) of first-time registrations of passenger cars in Europe in 2030. By this time, all other powertrain concepts will also have electric components, e.g. start-stop systems, electrified auxiliaries and 48V systems. Fuel cell vehicles are not expected to command any significant share of the European passenger car market by 2030, although they could benefit from spill-over effects from other areas (including commercial vehicles) and the concomitant infrastructure development and drop in costs. No later than 2030, under simulated conditions, a fully electric mid-range vehicle should be slightly cheaper to purchase than a vehicle with an internal combustion engine, making it competitive even in terms of purchase price. While a conventional vehicle was still more than EUR 10,000 cheaper than an electric vehicle in 2015, it is expected to be EUR 1,000 more expensive to purchase in 2030. This is partly the result of increasing costs of technologies needed to ensure efficiency and compliance with legal emission limits, which should also significantly reduce fuel consumption.

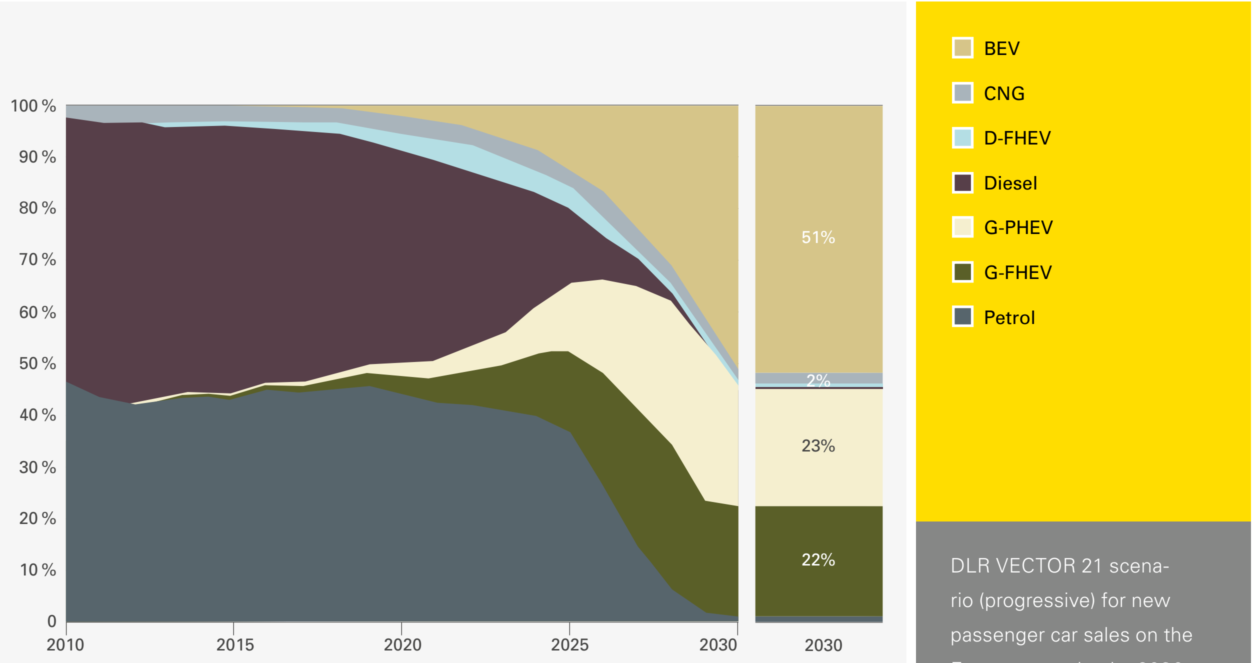
The technologies that will be used range from lightweight construction, downsizing and the use of tyres with reduced rolling resistance, to the electrification of ancillary and auxiliary aggregates (ICE efficient). On the basis of the assumptions and calculations made in this study, optimised internal combustion engine vehicles could achieve a 40-50% reduction in CO_2 emissions by 2030. The critical factor in cost development for BEV is declining battery costs, expected to drop by over 50% in the period considered. This is primarily due to economies of scale as production rises, but also the result of technological upgrading and further developments of the cell chemistry used in the battery. In addition to the battery systems, power electronics and electric engines will become more affordable, although the impact on the purchase price will be significantly less in absolute terms.

Both scenarios achieve the milestone for 2030 to be attained by passenger cars in the transport sector, as laid out in the Climate Action Plan. This, however, is based on the currently extremely improbable assumption that there is no increase in the number of kilometres driven per year or in the average engine power, enabling more efficient powertrains and technologies to be effective. Moreover, other means of transport, in particular air transport and goods transport, would have to contribute equally to achieve the sector goals. The milestone for 2050, however, is only achieved under the progressive scenario, since the early electrification has a strong positive impact on long-term CO_2 emissions and the aim to achieve carbon neutrality as a result of the slow pace of renewal of the passenger car fleet.

This makes it clear that a more rapid technological shift to electric mobility is an important precondition for achieving climate-relevant targets, but that these can only be attained in combination with changes in mobility behaviour. The development of local and long-distance public transport could help ensure that rising demands for mobility do not automatically lead to an increase in the number of kilometres driven by each passenger car. Innovative vehicle concepts could help decouple developments in vehicle comfort and safety from any further increase in engine performance, by using lightweight technologies and ensuring aerodynamic modernisation.



DLR VECTOR 21 scenario (business as usual) for new passenger car sales on the European market by 2030



DLR VECTOR 21 scenario (progressive) for new passenger car sales on the European market by 2030

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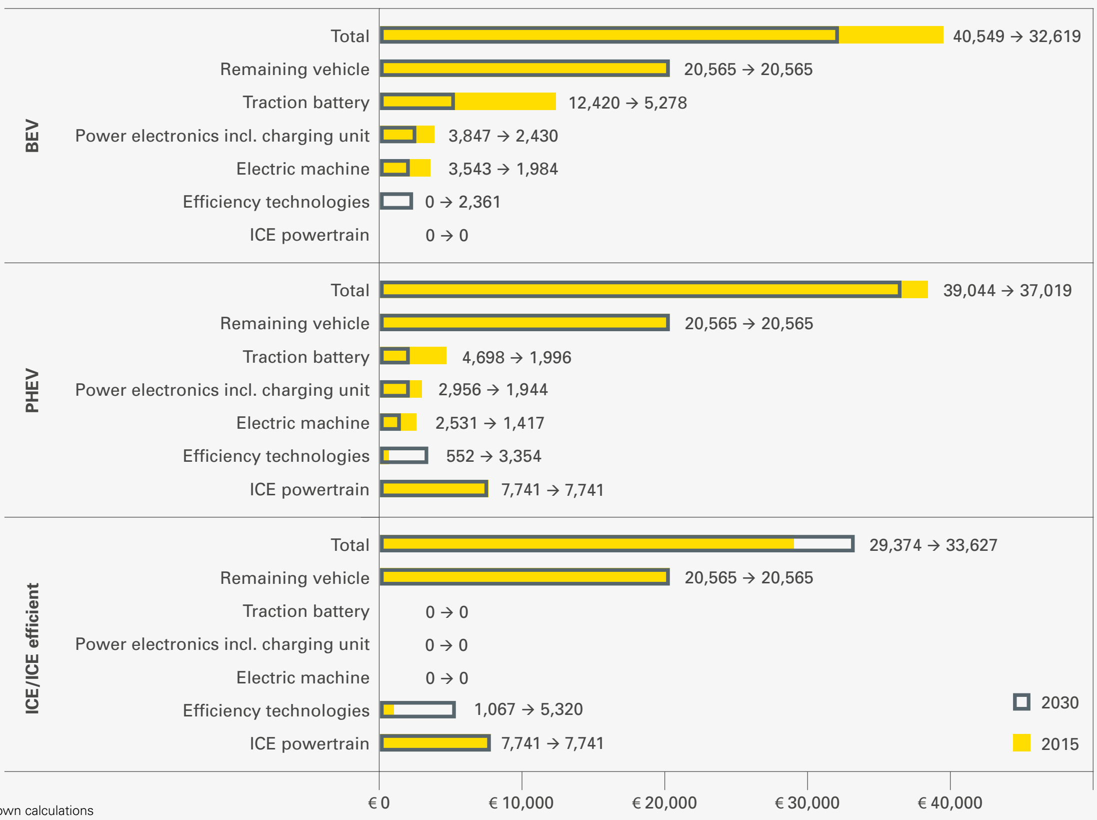

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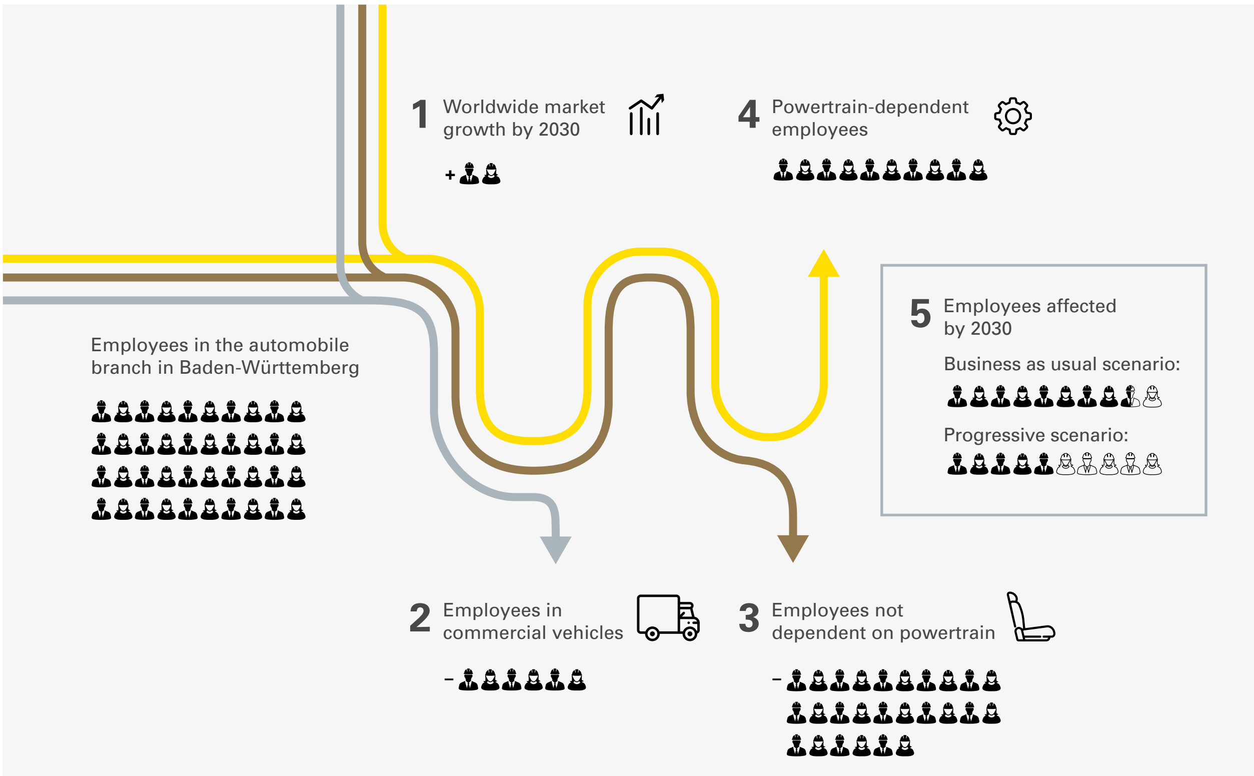
Example of (net) changes in costs of various mid-range vehicle types by 2030 in EUR

Impacts of electric mobility on employment

On the basis of the market penetration of the technological shift to electric mobility calculated in the DLR VECTOR 21 scenarios, the impacts on employment in Baden-Württemberg's automobile industry have been estimated. The study cannot take into account every impact this structural change will have on a business level. If a location ceases to be profitable or becomes less profitable, or if some companies are forced to cease trading, in the progressive scenario in particular, the impacts on employment could be stronger. The estimated impacts on employment laid out here cannot then be seen as a forecast of actual employment trends. It is merely an attempt to **indicate the extent to which employees could be affected by the change.**

A multi-stage procedure was used to identify fade-out effects as a result of the internal combustion engine being forced out of the market and fade-in effects as a result of the possible manufacture of new components for electric engines. The detailed presentation of the automobile cluster in this study allows for the first time to draw conclusions regarding the regional impact on employment.

In the fade-out analysis, we identify the employees in Baden-Württemberg´s automobile industry who are dependent on powertrains. We initially took the total workforce of the sector in 2016. We factored in impacts on employment of market growth by 2030. Then we deducted the employees working in the heavy goods and commercial vehicles sectors (step 2) as well as those not dependent on powertrain-related products (step 3). This gave us the number of employees who would be affected by a complete transition to battery electric vehicles (step 4). Step 5 involved assessing how the engine type mix emerging from the DLR VECTOR 21 scenarios would impact on employee numbers. The impacts are identified separately for all employee groups of the individual value segments.



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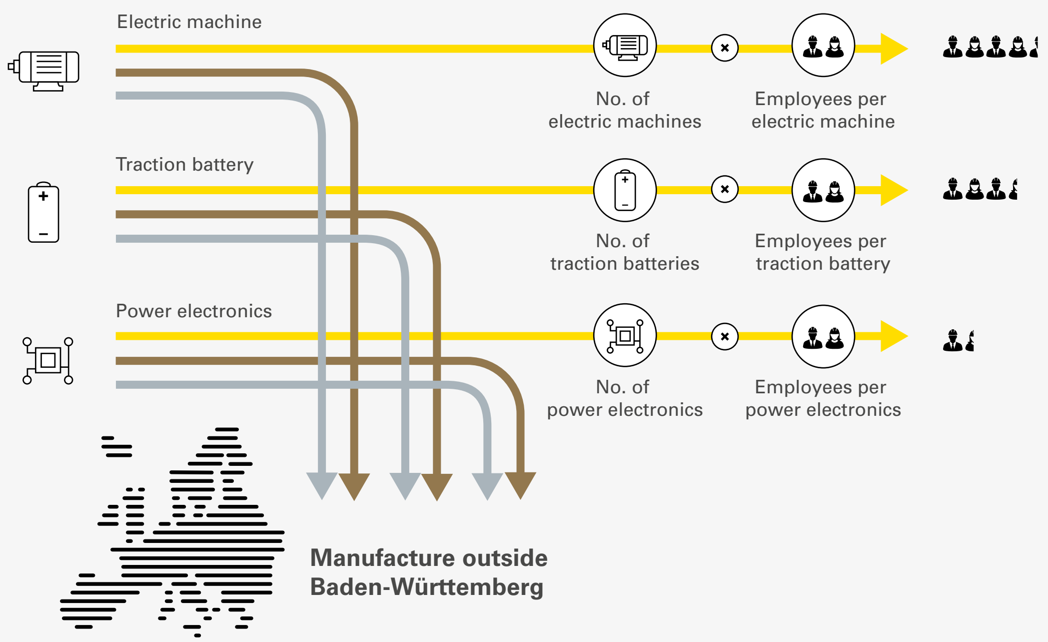
Procedure used to identify the number of employees affected by electric mobility in 2030

In the fade-in analysis we took as starting point the number of core components of electric engines identified in the DLR VECTOR 21 scenarios. Step 1 was to calculate the number of components needed on the European market in 2030. Step 2 identified which percentage of the European market for new electric mobility components could realistically be manufactured in Baden-Württemberg. On this basis, the productivity (employees per component) can be used to quantify the number of employees needed to manufacture these components (step 3). This gives the possible positive impacts on employment of new electric mobility components. This calculation was then performed in the same way as for the 'old components', for all employee groups of the individual value segments.



Procedure used to identify the number of employees potentially affected by new components in 2030

The results identified must be seen from a number of different perspectives.

1. With a view to developments in the **sector as a whole,** the results indicate that a successful transition process to electric mobility would not jeopardise the globally significant status of Baden-Württemberg's automobile cluster.

	Workforce in 2016	Overall effects in 2030 (Business as usual)		Overall effects in 2030 (Progressive)	
Total for automobile cluster as a whole (including vehicle trade)	468,500	8,900	1.9 %	–30,800	–6.6 %

Impacts on employment of electric mobility in vehicle trade

Under the business as usual scenario, the positive and negative impacts on employment by 2030 cancel one another out entirely for the sector as a whole. Because of higher value creation in the case of hybrid models and the expected worldwide growth potential, employment is actually expected to rise slightly.

Under the progressive scenario, there could be a drop in employment of under 7 %. Since this development would occur over a period of 12 years, active industrial and labour-market policy ought to be able to ensure that the economic strength of Baden-Württemberg is retained or even increased.

There will only be specific risks for the development of the sector as a whole if Baden-Württemberg's businesses and industry locations lose their position as a leader in competence and innovation in the course of the technological shift to electric mobility. Our model calculations presuppose that the automobile cluster in Baden-Württemberg will retain its worldwide leading role in innovation also for alternative powertrain technologies.

This is not, however, self-evident. Concerted efforts will have to be made by all actors in the sector, and active industrial policy support will be needed in order to retain the special importance of Baden-Württemberg's automobile cluster.

2. To enable us to assess the full impacts of structural change in the sector, the assessment of the overall development of the sector must be complemented by an analysis of the impacts on **individual locations** and, in particular, on **the production plants** in Baden-Württemberg. It cannot always be guaranteed that, although positive and negative impacts cancel one another out across the sector as a whole, this will necessarily hold true for individual companies or locations. A look at the development of individual locations is particularly important to allow us to gauge the development of Baden-Württemberg as an economic region, and of individual sites in particular.

   Our model calculation facilitates a specific analysis of the **powertrain-dependent manufacturing plants** in Baden-Württemberg which will be particularly harshly affected. In 2016, they had a total workforce of about 70,000.

	Powertrain workforce in 2016	Powertrain workforce in 2030 (Business as usual)		Powertrain workforce in 2030 (Progressive)	
Fade-out of powertrain-dependent manufacture	**69,600**	**–7,100**	**–10.2 %**	**–32,300**	**–46.4 %**
Productivity and low-cost-country strategy		–11,600		–6,800	
Development without fade-in		**–18,700**	**–26.9 %**	**–39,100**	**–56.2 %**
Fade-in potentials in manufacturing		5,000		7,900	
Overall balance of impacts	**69,600**	**–13,700**	**–19.7 %**	**–31,200**	**–44.8 %**

Impacts of electric mobility on employment in powertrain-dependent production plants

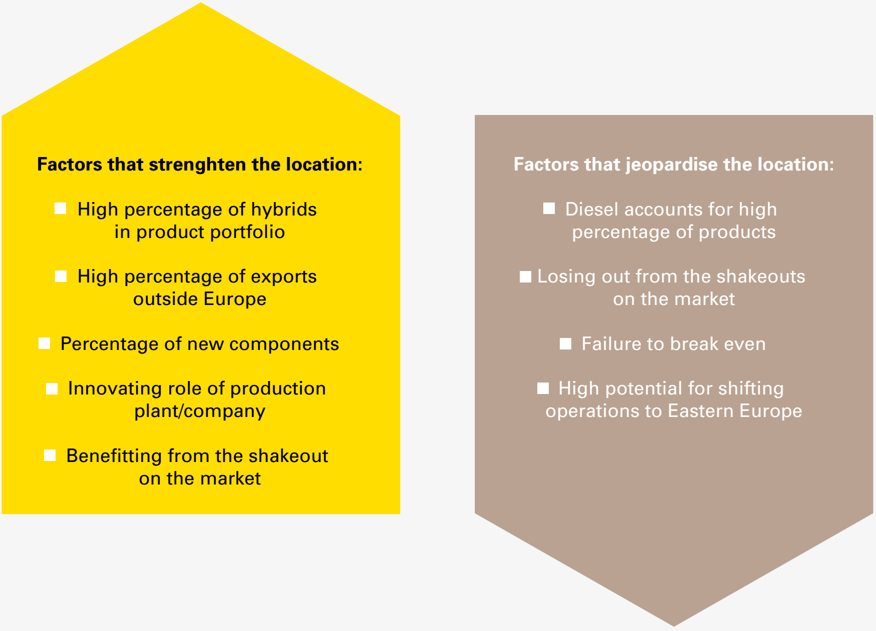
Under the business as usual scenario, the fade-out of internal combustion engine components would adversely affect about 7,100 employees (–10 %). If we also take into account expected productivity gains in the production plants and shifts of manufacturing operations to low-cost countries, a total of 18,700 employees could be adversely affected. That is equivalent to almost 27 % of the workforce employed in powertrain-dependent production plants in 2016. Even if it proved possible to manufacture all electric mobility components (fade-in effects) in Baden-Württemberg in the production plants hitherto dependent on powertrains, around 20 % of employees would be adversely affected. This makes it clear that, even in the business as usual scenario, major efforts will be needed on the part of all actors in the sector to master the transformation process and minimise impact on locations and employees.

Under the progressive scenario, on average one employee in two currently working in powertrain-dependent production plants will be affected (46%, if productivity gains are factored: 56%). Overall, this would mean that 39,100 employees in Baden-Württemberg would be adversely affected by the fade-out of internal combustion engine technology, while about 7,900 jobs could be created by the new electric components. Structural change is an enormous challenge for these production plants. Exceptional efforts will be needed on the part of all actors in the sector to underpin sustainable development prospects for as many powertrain production plants as possible.

3. Our analyses demonstrate that the **people working in R+D** in the sector are the second largest group that will be affected by the transformation. Under the progressive scenario, up to 3,700 jobs could be lost as a result of the shift to electric mobility. The detailed analysis indicates that, in this area, an additional 2,600 employees will have to be trained for new duties, if job losses are not to be even higher. This quantitative estimate does not take into account the fact that the digitalisation of vehicles will spawn diverse new tasks in the field of research and development. To ensure that this shift in duties and development fields can be realised as far as possible with the current workforce, extensive training and qualification concepts will be needed that are capable of addressing 10-15% of the over 70,000 people working in R+D. This challenge must be taken up if Baden-Württemberg's strength as a centre of industrial innovation (see below) is to be retained.

The possible development in Baden-Württemberg's production plants clearly illustrates the prerequisites for a successful transition to electric mobility. Corporate strategies must be extended to embrace strategies for the sustainable development of the affected locations, so as to ensure that as many new components as possible can be produced in the affected production plants. To ensure that this process can be supported by industry policy measures, the latter must be geared to the specific requirements of locations in Baden-Württemberg and not only to specific companies. Overall, even under the business as usual scenario, more than 18,000 employees will have to be trained for new tasks within the company or outside the company. To this end, inter-company training strategies and additional labour-market-policy instruments will be needed that will use short-time work concepts and regulated retiral schemes to prevent a significant percentage of those affected becoming unemployed.

This look at the scenarios indicates that the actual level of threat to powertrain-dependent production plants depends on a number of external factors and conditions. Sustainable location and site strategies can be aligned to these threat and opportunity parameters.



The authors also looked at how the shift to electric mobility could impact on the economic core competences of Baden-Württemberg. For years, Baden-Württemberg's economic strength has increasingly been based on its strong industrial innovation capacities. In Baden-Württemberg, 42.9 % of value is generated in knowledge-intensive segments. The state thus tops all comparable figures for the world's most successful industrial regions. 22 % of value created in the manufacturing sector can be attributed to knowledge-intensive fields – a figure almost twice as high as the German average. 15 percentage points of this figure are accounted for by vehicle construction and mechanical engineering alone. Baden-Württemberg is also a leader in traditional innovation indicators. In terms of input factors, such as R+D intensity of the private sector and output factors like patents per worker and percentage of employees working in knowledge-intensive sectors, Baden-Württemberg has for years topped the ranking list of comparable regions. In 2015, the R+D intensity (the ratio of spending by a company on research and development to the company's sales), at 4.9 %, was almost twice as high as the average for Germany as a whole (2.9 %) and for the EU28 (2.0 %).

These figures make it quite clear that Baden-Württemberg's innovation cluster has specialised in innovation revolving around industrial production, in which it is a worldwide leader. The sustainable development of the state's economic power will depend in no small way on how this specific strength can be further developed. In this context, the transition to electric mobility can provide an important impetus for the further development of Baden-Württemberg's cluster for industrial innovation, in spite of the potentially adverse impacts on employment. This presupposes that the necessary external conditions for this success model are recognised and further developed by all stakeholders. Companies must continue to support this industrial innovation cluster. In spite of further steps to internationalise production networks, they must do their bit to retain the innovation cluster that embraces manufacturing and research and development, in order to secure their own future.Especially for the development of new electric mobility, a comprehensive understanding is needed of manufacturing and all relevant processes. In addition, universities and other research facilities can support this change process and help drive it forward. New education and study concepts will help ensure that experts are available to further develop the industrial innovation cluster.

Baden-Württemberg must become the leading market and leading provider for sustainable mobility, and thus a pioneer for the transition process to electric mobility. This will only be possible if corporate and location strategies are geared to achieving this goal and are coupled with the will of employees to embrace change and support from the realms of politics, science and research. Ensuring lasting prospects of employment can be an important element in overcoming any reluctance on the part of the workforce to accept change. It is not the transition to electric mobility per se that could jeopardise the economic strength of Baden-Württemberg, but the failure to grasp the opportunity to shape the transition and actively develop the sector.

5. Conclusions and recommendations for action

Baden-Württemberg has a complete automobile cluster, which is home to internationally important OEMs and global suppliers as well as many leading suppliers in the plant and mechanical engineering sectors. About 470,000 workers are part of the cluster, which relies, in particular, on industrial innovation for its performance and competitiveness.

The emerging transition process in the automobile industry – driven by electric mobility and digitalisation – is thus not only a question of environmental necessity. A successful transition will definitely enable Baden-Württemberg to further develop its industrial strength. The failure to shift to new technologies, by contrast, could swiftly impact adversely on the industrial structure and prosperity of the State.

A look at the climate action aspects of the two scenarios makes it clear that there is a need to accelerate the process of market penetration of alternative engine technologies beyond developments laid out in the business as usual scenario. Although both scenarios would achieve the climate-related targets laid out in the government's Climate Action Plan 2030 under strict conditions, efforts should be made to achieve a higher level of electrification at an early stage, given the long time scale that will be needed to renew the vehicle stock, in order to achieve carbon neutrality by 2050. This presupposes both high market shares of electric engines and also major changes to mobility as we currently know it. This will entail negative impacts on employment in Baden-Württemberg's automobile cluster. Although these will be moderate for the sector as a whole, 25–50% of jobs in production plants specialising in powertrains will be affected. To successfully master this transformation, joint efforts will be needed on the part of politicians, the private sector and the workforce. Options for action can be seen in three fields in particular.

I. Baden-Württemberg – a leading market for sustainable mobility

Promotion of a faster market penetration for alternative powertrain concepts. Measures are proposed here to develop charging infrastructure, PR work to support CO_2-aware mobility and financial assistance for people prepared to switch rapidly to electric mobility.

II. Baden-Württemberg – a leading provider of sustainable mobility

Underpinning and developing value creation in the transition process. This will involve the establishment of a complete value cluster for electric powertrains, promoting battery technologies and support concepts for sustainable location and site strategies.

III. Baden-Württemberg – skills and innovation cluster for electric mobility

Securing and developing employment for technological change. Special post-graduate courses will be needed for those working in R+D and upgrading services for those working in manufacturing as well as additional measures to foster digital skills and labour-market-policy instruments to help master the transition process.

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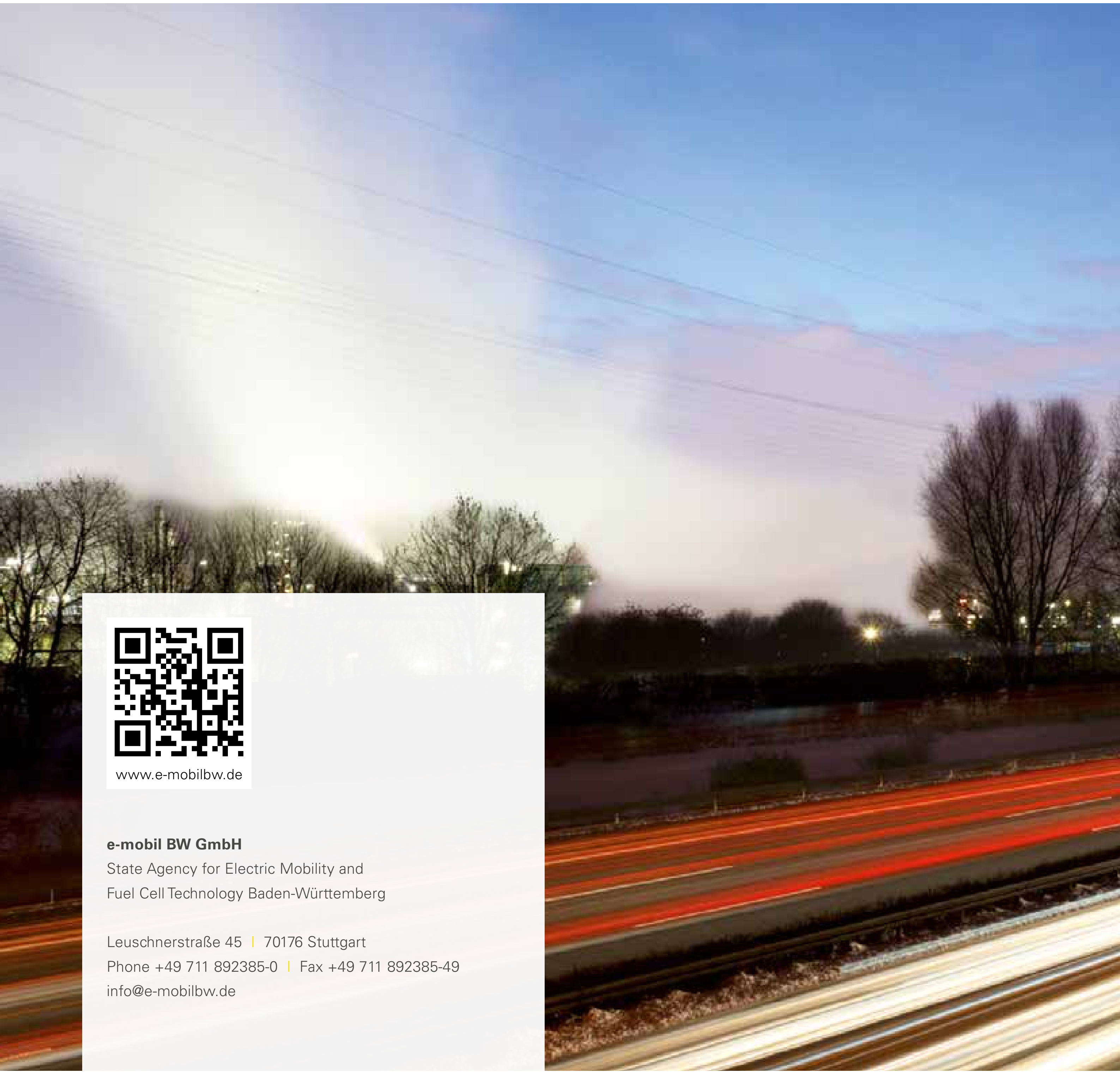

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