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Scenario-based Analysis of Electrification Effects on Value Creation and Employment Structures for the Automotive Cluster in Baden-Wuerttemberg, Germany

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Executive Summary

The transformation path to electric mobility will have fundamental impacts on the existing value chain and employment structures in the automotive industry. This paper examines these effects on the basis of two different electric mobility market scenarios for the European (EU28) passenger car market 2030 with special focus on the highly export-oriented industrial automotive cluster Baden-Wuerttemberg. On the basis of a detailed analysis of the industrial branch, value creation and employee structure, shifts from internal combustion engine to electrified component production will be derived and illustrated for each single employee segment. The detailed display of the Baden-Wuerttemberg automotive cluster in this study allows for the first time regionalized statements on possible employment effects.

Keywords: Market development, BEV (battery electric vehicle),cost, state government, strategy

1 Introduction

The technological change is leading to a transformation of the mobility industry. Driven by the trends of electrification, digitalization and automation, additional economic opportunities will emerge throughout the markets worldwide. Electric mobility, in particular, will alter the existing automotive industry structures, with classic components such as the internal combustion engine (ICE) ultimately losing importance, while at the same time new, electrified components become more relevant [1].

As one of the most important automotive industry locations in the world, Germany and especially the region of Baden-Wuerttemberg will be affected in terms of shifts in value creation and employment structures [2]. To sustain its role as a leading cluster of industrial innovation, it is essential for Baden-Wuerttemberg to adopt to and shape this process of transformation and structural change in order to precociously take advantage of evolving economic opportunities.

2 Methodology

The aim of this analysis is to derive and quantify the effects of electrification on added value and employment for the region of Baden-Wuerttemberg and its automotive cluster in detail. The focus of the scenario-based investigation lies on the development of the EU28 car markets and electrified light duty vehicles under different framework conditions, as well as the development of their technologies and components until 2030. The methodology to achieve this goal is:

- Analysis of the industrial, value chain and employment specifics of the automotive sector in Baden-Wuerttemberg
- Analysis of existing European electrification scenarios and critical parameters for market success of electrified vehicles throughout literature research and expert interviews
- Simulation of two European light duty vehicle market scenarios with DLR VECTOR21 vehicle technology scenario model, based on each one moderate and one progressive set of critical parameters
- Investigation of market potential for different powertrain configurations in Europe, production cost and volume development until 2030
- Derivation of Fade-Out/Fade-In effects for ICE-related / electrified technologies and components
- Impact analysis on employee groups for each individual automotive cluster level and value-added segment in Baden-Wuerttemberg

3 DLR VECTOR21 Electric Mobility European Car Market Scenarios 2030

On the basis of a meta analysis, 75 relevant market scenarios for electric vehicles currently available in the literature were examined and their core assumptions in terms of critical parameters for the market success of electric vehicles were analyzed [3]. The analysis generally shows a decline in the market share of ICE vehicles under both moderate and progressive conditions, but with significantly varying dynamics until 2030, as Figure 1 illustrates. Battery costs, infrastructure availability, CO_2 legislation and the annual production capacity of electric vehicles (EVs) are cited as critical parameters for market success [4].

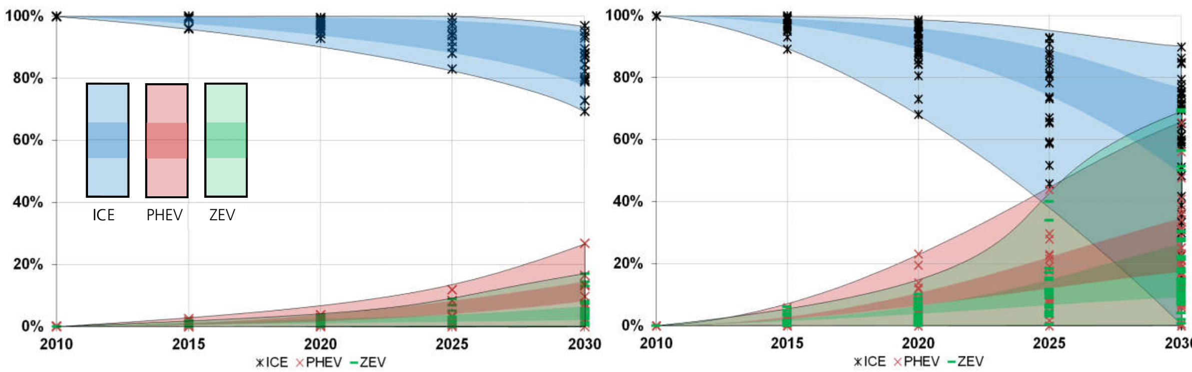

Figure 1: Result of meta analysis – market share ranges of ICE, PHEV and ZEV (BEV + FCEV) for "business as usual" (left) and "progressive" (right) development of key framework conditions, based on the analysis of 75 existing electrification scenarios for the European EU28 passenger new car market (ICE = Internal Combustion Engine; PHEV = Plug-in-Hybrid Electric Vehicle; ZEV = Zero Emission Vehicle; BEV = Battery Electric Vehicle; FCEV = Fuel Cell Electric Vehicle)

Derived from the meta analysis, two different sets of critical parameters were defined and used as input data for market development simulation with the DLR VECTOR21 Vehicle Technology Scenario Model: The assumptions for charging station availability, maximum production of BEV per year and CO_2 limits differ in each scenario, since they have been identified as critical for the market success of electrified vehicles on the

European car market. Energy prices and availability of gasoline, diesel, CNG (Compressed Natural Gas) and H_2 stations however were identified as non-critical parameters and therefore used for both scenarios equally.

Table 1: Overview of framework parameters for creating the DLR VECTOR21 scenarios (representative for the German car market)

			2010	2015	2020	2030	Source
Energy price development (for both scenarios)	Oil price	€/bbl	59.5	67.2	74.9	90.3	[5]
	Gasoline price	€/l	1.41	1.46	1.52	1.63	Own calculation
	Diesel price	€/l	1.24	1.30	1.37	1.50	Own calculation
	CNG price	€/kg	0.94	1.11	2.06	2.17	[6]
	Electricity price	€/kWh	0.25	0.26	0.27	0.26	[7]
	H_2 price	€/kg	19.8	11.8	7.9	6.0	[8]
Availability of infrastructure (for both scenarios)	Fuel stations	%	100	100	100	100	Model assumption
	CNG stations	%	7	8	10	17	Model assumption
	H_2 stations	%	0	0	3	20	Model assumption
Specifics for business-as-usual scenario	Charging stations	%	0	5	31	58	Model assumption
	Maximum of BEV production	pcs./a	0	12,000	115,000	550,000	Model assumption
	CO_2 limit	g/km	–	130	95	67	[9]
Specifics for progressive scenario	Charging stations	%	0	5	35	75	Model assumption
	Maximum of BEV production	pcs./a	0	12,000	120,000	2,200,000	Model assumption
	CO_2 limit	g/km	–	130	95	50	Model assumption

The scenario model VECTOR21 allows to specifically simulate the purchase behavior of vehicle buyers for each EU28 car market, taking into account complex political, social, market-based and technological framework conditions. On the one hand, the simulation generates individual customer profiles with different characteristics (e.g. annual mileages and transport tasks) and specific requirements for the vehicle to purchase. As a result, the customers' individual willingness-to-pay is simulated depending on the customer type, taking also into account factors of innovation behavior and the attitude towards environmental protection. Costs are then calculated on the basis of TCO (Total Cost of Ownership), which consist of the acquisition costs and the operating costs. On the other hand, the DLR model generates vehicles with different powertrain concepts, technologies and fuel types, which are then offered to customers in every market each year. Over time, technological and cost improvements of the vehicles and their components (e.g. battery system, electric motor, power electronics, etc.) are calculated, altering the specifics of the vehicles themselves. Each single purchase decision is then simulated in a modeled environment based on political decisions / discussions (e.g. fuel taxation or CO_2 emission limits) and on literature data (e.g. development of energy costs or the expansion of charging and refueling infrastructure).

The customer is assumed to be buying the one vehicle that meets his requirements best, has the necessary infrastructure available and is most favorable in terms of overall cost. The vehicles generated in the scenario model differ according to vehicle segment and powertrain concept, so that each vehicle is defined by a specific energy consumption as well as specific costs of the installed components. For the calculation of the vehicle and component costs, cost curves and DLR cost models are used.

As a result of the simulation, the Battery Electric Vehicle (BEV) reaches a market share of between 15% ("business as usual scenario") and 51% ("progressive scenario") in the European new car market in 2030 as can be seen in Figure 2 and Figure 3. All other light duty vehicles sold in 2030 in the progressive scenario still use internal combustion engines as primary propulsion unit, however already have additional electrified components installed, e.g. start-stop systems, electrified auxiliary units or 48-V systems.

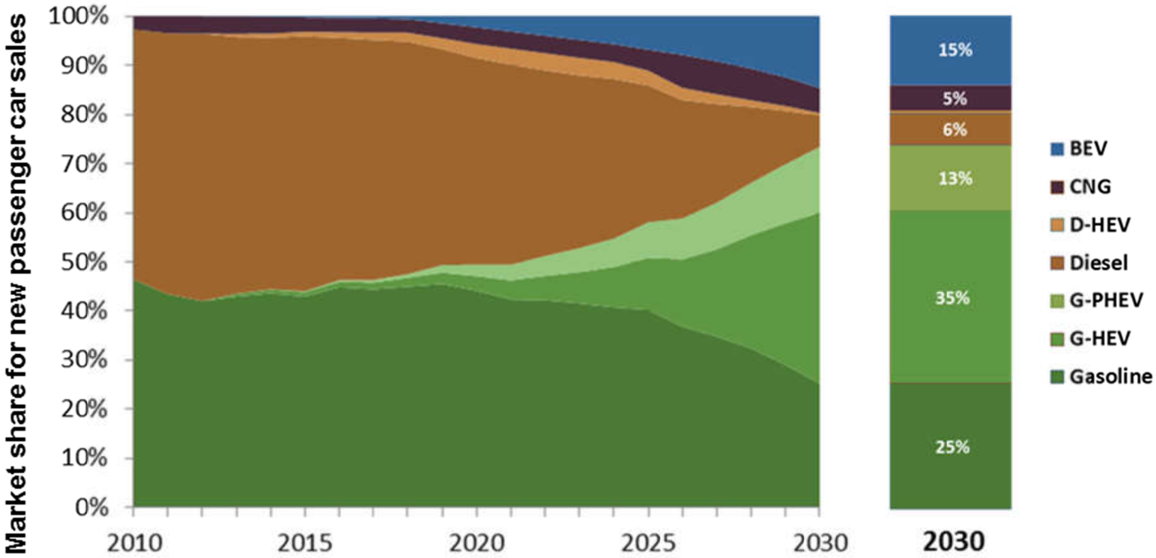

Figure 2: DLR VECTOR21 "Business-as-Usual" scenario for European EU28 passenger new car market until 2030 (BEV = Battery Electric Vehicle; CNG = Compressed Natural Gas Vehicle; D-HEV = Diesel Full-Hybrid Electric Vehicle; G-PHEV = Gasoline Plug-in-Hybrid Electric Vehicle; G-HEV = Gasoline Full-Hybrid Electric Vehicle)

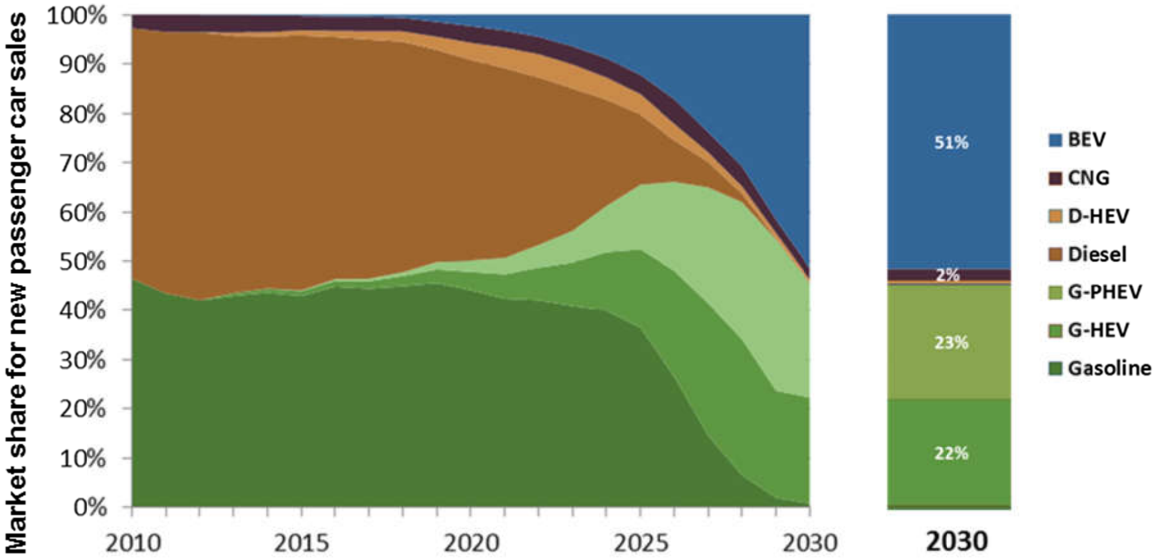

Figure 3: DLR VECTOR21 "Progressive" scenario for European EU28 passenger new car market until 2030

By 2030 at the latest, under the simulated conditions, a medium-sized BEV will be priced at the same level as a gasoline vehicle and thus be competitive even in purchase price, as Figure 4 illustrates. This is mainly due to the increasing complexity and costs of efficiency technologies, which are necessary to comply with statutory emission limits and at the same time lead to a significant reduction in consumption. As a result, the ICE vehicle can still achieve a potential for reducing CO_2 emissions by between 40 and 50% until 2030.

Decisive for the cost development of BEV are in particular declining battery costs, which decrease by more than 50% in the considered timeframe. This is mainly due to economies of scale achieved through increasing total production volumes, but also to technological improvements and advancements in the cell chemistry of the battery itself. In addition to the battery systems, the power electronics and the electric motor become cheaper, but with far lower absolute impact on the purchase price.

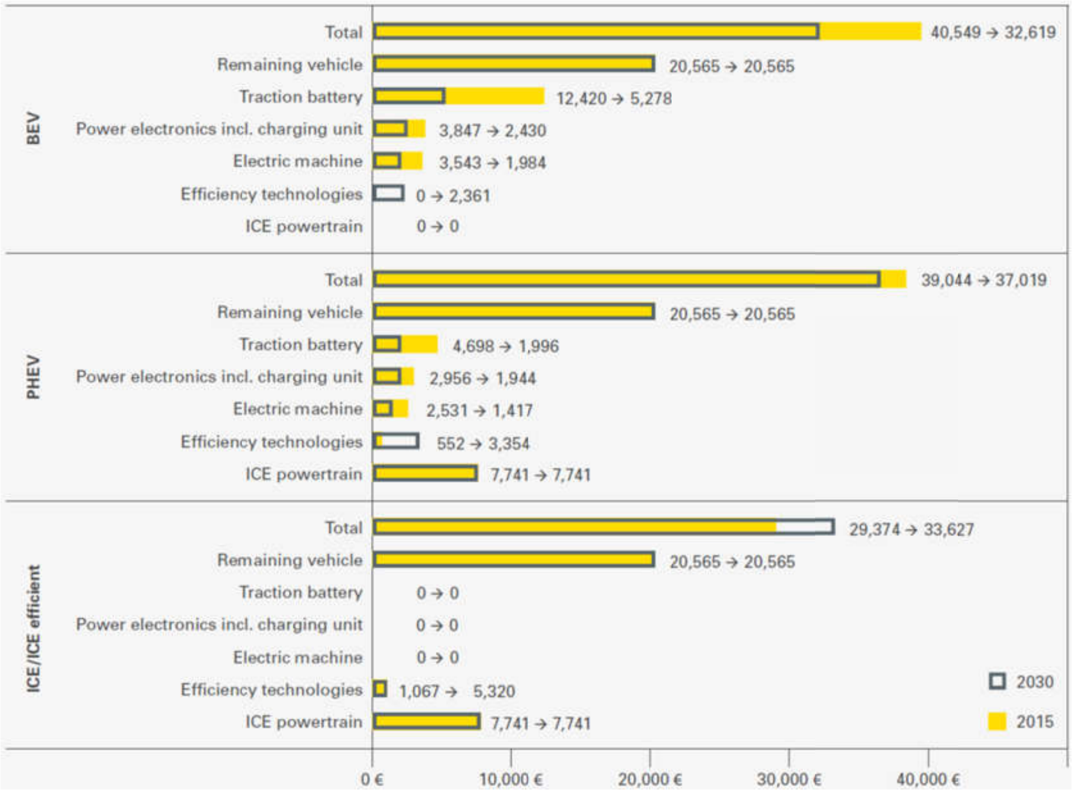

Figure 4: Example of (net) changes in costs of various mid-range vehicle types by 2030

4 Value Creation and Employment Effects for the Automotive Cluster Baden-Wuerttemberg

Baden-Wuerttemberg is one of the world's leading center of the automobile industry, with a fully developed automotive cluster comprising the entire value chain of automobile production, ancillary services and suppliers from the mechanical and plant engineering sectors. The three Baden-Wuerttemberg-based manufacturers (OEMs) are classed as belonging to the premium segment and numerous suppliers specialize in the development and production of power trains.

The automobile industry in Baden-Wuerttemberg is one of the core branches of industry with an annual turnover of more than 105 billion euros (2017). Vehicle construction alone generates about one tenth of the entire gross value creation of the federal state. At the same time the automobile branch 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 about 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-Wuerttemberg's automobile branch has thus been analyzed in detail, and the various groups of employees have been categorized at different levels of the cluster and value segments, as Figure 5 shows:

The core of value creation includes the companies and workforces that have specialized 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 specializing in vehicles as a product. This cluster level also comprises parts of the mechanical and plant engineering sector specializing in equipping the automobile industry. This entire value cluster covers 382,500 employees in Baden-Wuerttemberg.

About 86,000 employees in the vehicle trade segment complement the automobile cluster in Baden-Wuerttemberg, resulting in a total workforce of about 468,500. Employees in these value segments can be further broken down into different functional areas.

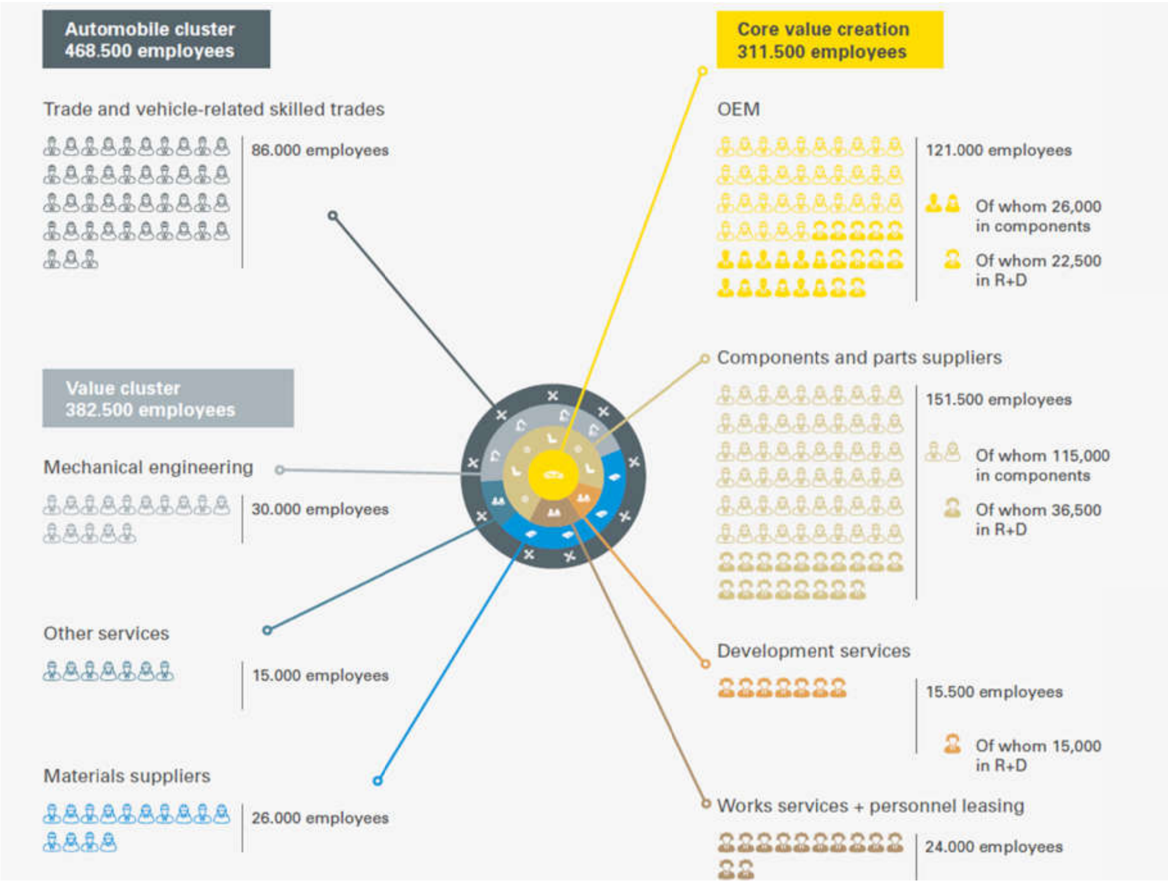

Figure 5: Employment structure in Baden-Württemberg's automobile cluster

Based on the outcome of the DLR VECTOR21 scenarios, the effects on employees of the Baden-Wuerttemberg automotive industry were estimated. This approach must be abstracted from all economic effects of this structural change: a lack of profitability for single production sites and effects of market adjustments at company level, in particular in the progressive scenario, can lead to further effects in structural employment. The employment effects estimated here should therefore not be understood as a forecast of real employment development. Rather, it is shown to what extent employees could possibly be affected by the transformation.

In a multi-stage process, "fade-out effects" due to the decline of market shares for internal combustion engine components and "fade-in effects" due to the increasing production volume of new components for electrified drivetrains were determined. The detailed display of the automotive cluster in this study allows for the first time regionalized statements on possible employment effects.

The fade-out analysis determines the drivetrain-dependent employees of the automobile industry in Baden-Wuerttemberg. To do so, the total number of employees in the industry is used as starting point to add the employment effects of market growth until 2030 (step 1), then subtract all employees in the utility, truck and commercial vehicle segment (step 2) and non-drivetrain products (step 3). In the final step it is then assessed how the powertrain mix of the DLR VECTOR21 scenarios affects the number of employees dependent on the powertrain in steps 1 to 3.

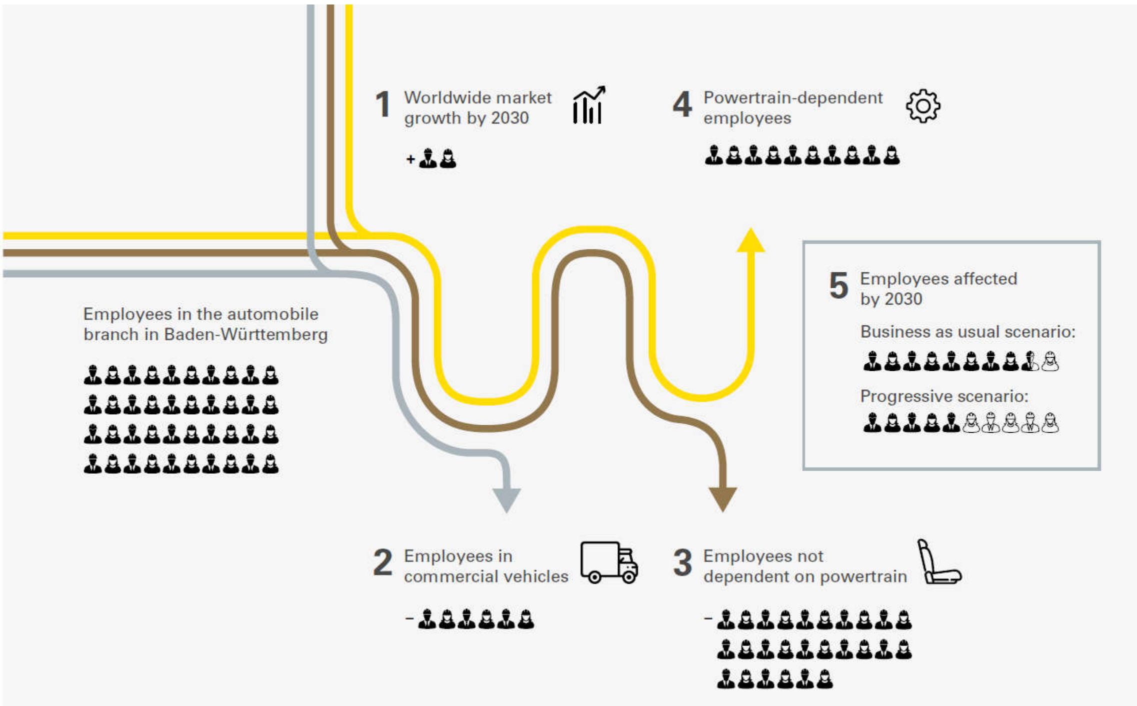

Figure 6: Procedure used to identify the number of employees affected by electric mobility in 2030 (Fade-Out effects)

The fade-in analysis takes the scenario-based production volumes of the electric powertrain core components as basis. Step 1 displays the number of components needed in the European market in 2030. In step 2 the proportion of new electric mobility components that could realistically be manufactured for the European market in Baden-Wuerttemberg is determined. On this basis, the respective labor productivity (in employees per component) can be used to determine the number of employees required for production (step 3). This results in the sum of positive employment effects posed by new electric mobility components.

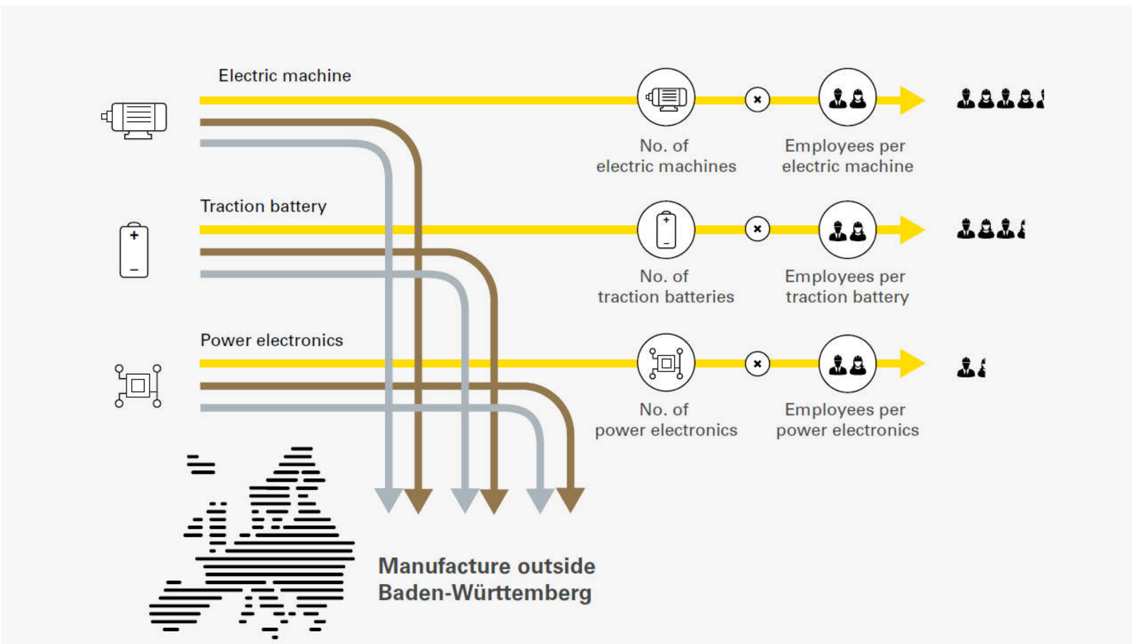

Figure 7: Procedure used to identify the number of employees affected by new components in 2030 (Fade-In effects)

As result of the analysis, the market growth for new components for electric vehicles and the simultaneous decline of conventional components leads to employment potentials from + 1.9% (+8,900 employees) to -6.6% (-30,800 employees) for the Baden-Wuerttemberg automobile location in 2030 as a whole, depending on the scenario.

However, this will only apply if the cluster also retains its leading international role as an innovator in alternative drive technologies and is able to gain similar market shares in the new components as today. In detail, the results of the impact analysis have to be evaluated from different perspectives:

Table 2: Potential impacts of electric mobility on Automobile Cluster Baden-Württemberg

	Cluster segment	Employees 2016	Total effects scenario BAU 2030		Total effects scenario progressive 2030	
OEM	Components	26,000	300	1.2 %	-5,100	-19.6 %
	R+D	22,500	2.100	9.3 %	-500	-2.2 %
	Assembly plant	57,000	1.900	3.3 %	1,800	3.2 %
	Main administration	15,500	0	0.0 %	0	0.0 %
Automotive suppliers WZ 29.3	Components/parts Core Value Creation	72,500	1.500	2.1 %	-7,000	-9.7 %
	R+D	23,000	700	3.0 %	-1,800	-7.8 %
Automotive suppliers from other branch of industry	Components	32,000	-400	-1.3 %	-3,600	-11.3 %
	R+D Core Value Creation	10,000	400	4.0 %	-600	-6.0 %
	Components	26,000	-500	-1.9 %	-3,100	-11.9 %
Engineering and plant construction WZ 28	Pistons and engine parts	10,500	-100	-1.0 %	-2,800	-26.7 %
	R+D	3,500	0	0.0 %	-900	-25.7 %
	Equipment supplier	30,000	1.500	5.0 %	-2,100	-7.0 %
Development service providers	For OEM and suppliers	15,000	1.500	10.0 %	100	0.7 %
Temporary employees	For OEM and suppliers	16,000	300	1.9 %	-1,500	-9.4 %
In-plant services	For OEM and suppliers	8,000	200	2.5 %	-800	-10.0 %
Other services	For OEM and suppliers	15,000	-100	-0.7 %	-2,000	-13.3 %
Vehicle business and trade	Automobile cluster	86,000	-400	-0.5 %	-900	-1.0 %
Total of Value Cluster (w/o vehicle trade)		382,500	9.300	2.4 %	-29,900	-7.8 %
Total of Value Cluster (with vehicle trade)		468,500	8.900	1.9 %	-30,800	-6.6 %

1. Looking at the development of the industry as a whole, the results show that a successful transformation process towards electric mobility will not endanger the special significance of the Baden-Wuerttemberg automotive cluster. In the business-as-usual scenario, positive and negative employment effects in the

industry will be completely offset by 2030. The progressive scenario could lead to a possible reduction of less than 7%. Since this development will take place over a period of 12 years, it will be possible to actively shape this transformation by means of industrial and labor market policy support so that the economic strength of Baden-Wuerttemberg could be maintained or even expanded.

2. In order to be able to assess the overall effects of structural change in the sector, the analysis of the total industry development must be supplemented by an investigation of the effects on individual locations and in particular on single production sites in Baden-Wuerttemberg: In 2016, around 70,000 employees worked in this segment. When the expected increases in productivity for production plants are taken into account, the particular challenge of development becomes apparent: Even in the "business-as-usual" scenario, a negative employment effect of about -27% is expected for individual production plants by 2030. If it was possible to manufacture every new electric component made in Baden-Wuerttemberg in the production plants that were previously aligned with the conventional powertrain, around 18% of employees would still be affected.

In the progressive scenario, on average, almost every second employee in the conventional powertrain production plants would be affected. Mastering this structural change in a positive way could be very difficult to handle. In this scenario, there is a threat that effects on this value segment could endanger the positive development of the entire cluster.

3. The impact analysis also shows that the industry's R&D employees would be the second largest group of stakeholders affected. In the progressive scenario, up to 3,700 previous jobs could be substituted through the transformation process towards pure electric mobility. The detailed analysis shows that in this area an additional 2,600 employees have to be qualified for new tasks, e.g. to exploit the potentials of digitalization, connectivity and autonomous driving. The development of these technologies leads to new and diverse tasks for the research and development sectors. In order for this shift in the task and development area to be realized as far as possible with the current employees, extensive qualification concepts are required, which can cover approximately 10-15% of the more than 70,000 R&D employees.

The analysis of the specific situation at the production plants in Baden-Wuerttemberg makes it clear that the transformation process can succeed if corporate strategies for electric mobility will be supplemented by concepts of a sustainable development of the affected locations, so that as many new components as possible will be assigned to the most affected production plants. In order for this process to be successfully supported by industrial policy measures, they should be aligned with the specific requirements of the individual production sites and locations in Baden-Wuerttemberg.

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