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Economic and labour market effects through the electrification of powertrains in passenger cars

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Electromobility 2035
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Abstract

This study focuses on the economic effects of the phenomenon of the electrification of powertrains in passenger cars (e-mobility). The automotive industry is one of the leading sectors in Germany and the country is one of the world’s leading car producers. Therefore the economic impact could be extensive. Using the scenario technique, a number of assumptions have been made and integrated into the QINFORGE analytical tool. At the beginning of the scenario, the underlying assumptions have a positive effect on the economic development. However, in the long run they lead to a lower GDP and level of employment. The change in technology will lead to 114,000 job cuts by the end of 2035. The economy as a whole will lose nearly 20 billion euros (0.6 % of the GDP). In the scenario, we assumed a share of only 23 percent of electric cars as compared to all new registered cars in 2035. The electrification of powertrains will have negative effects especially on skilled workers. The demand for specialist and expert activities will also decrease with a time delay. A much higher market penetration could lead to stronger economic effects. Furthermore, a higher market share of domestically produced cars and traction batteries could generate more positive economic effects.

Zusammenfassung

Dieser Beitrag untersucht für Deutschland die Wachstums- und Beschäftigungseffekte einer Elektrifizierung des Antriebsstrangs bei Personenkraftwagen (Pkw). Unter Zuhilfenahme der Szenarientechnik wurden eine Reihe von Annahmen getroffen und in das Analyseinstrument QINFORGE integriert. Die Ergebnisse weisen, im Vergleich zum Basisszenario, zwar zunächst einen positiven Wachstums- und Beschäftigungseffekt aus, langfristig muss aber mit einem niedrigeren Bruttoinlandsprodukts- und Beschäftigungsniveau gerechnet werden. Im Jahr 2035 werden ca. 114.000 Plätze aufgrund der Umstellung verloren gegangen sein. Die Gesamtwirtschaft wird bis 2035 einen Verlust in Höhe von 20 Mrd. EUR realisieren. Dies entspricht ca. 0,6 Prozent des preisbereinigten Bruttoinlandsproduktes. Von der Elektrifizierung des Antriebsstrangs werden vor allem Fachkräfte negativ betroffen sein. Zeitverzögert sinkt auch der Bedarf nach Spezialisten- und Expertentätigkeiten. Dabei wird von einem Elektroauto-Anteil an den Neuzulassungen von 23 Prozent bis 2035 ausgegangen, bei einer stärkeren Marktdurchdringung muss mit deutlich höheren Effekten gerechnet werden. Positive Wachstums- und Beschäftigungseffekt wären realisier bar, wenn Deutschland in der Lage wäre den Markt stärker mit inländisch produzierten Autos und produzierten Traktionsbatteriezellen zu versorgen.

JEL-Classification

E17, E23, E24, E27

Keywords

electromobility, e-mobility, Germany, automotive industry, e-cars

1 Electromobility – Status and Expectations

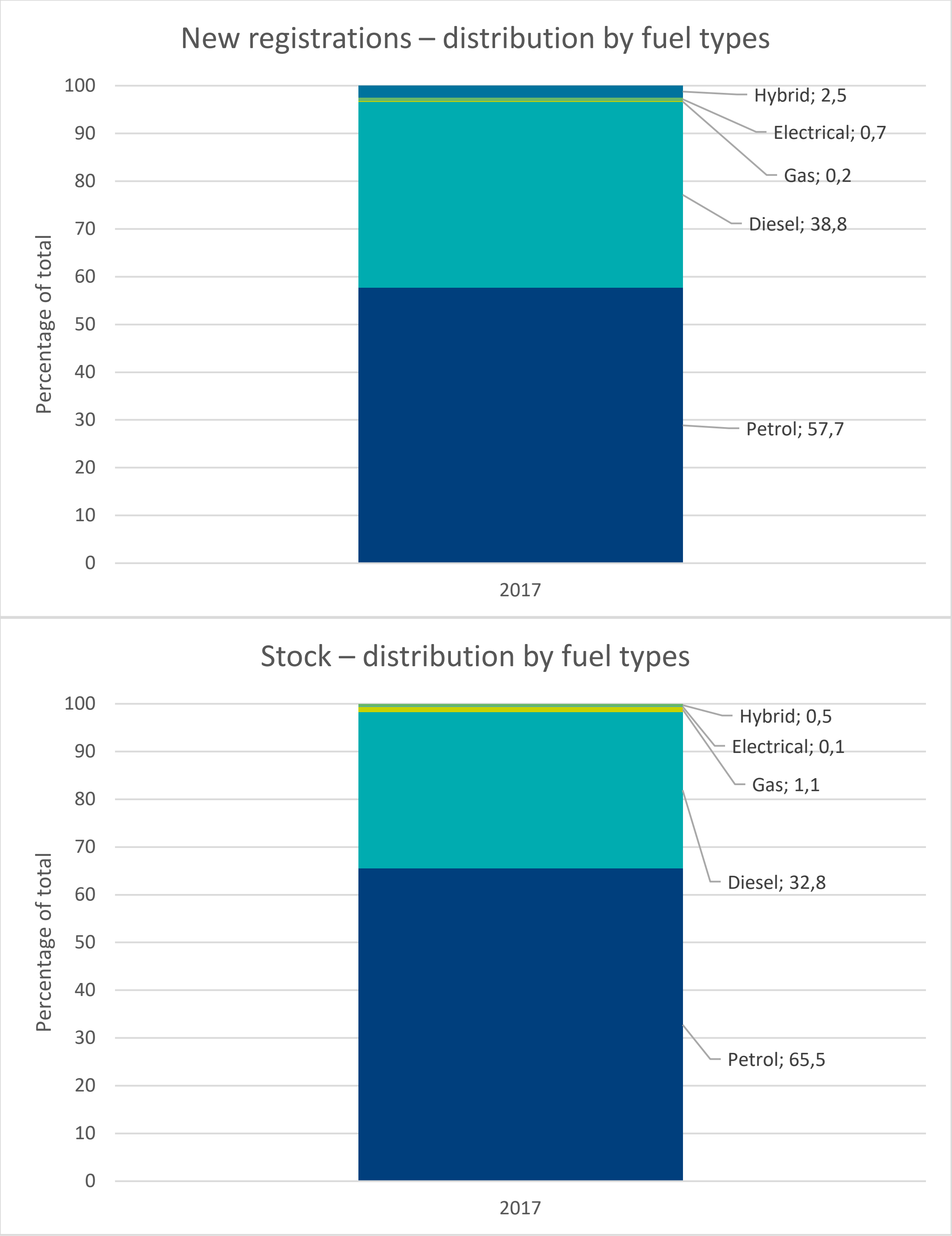
The automotive industry is one of the leading sectors of the German industry and the country is one of the world's leading car producers. Due to its high share of added value, its high export quota, and its high direct and indirect number of employees, the automotive industry is regarded as system-relevant and therefore receives a high degree of political, economic, and social attention. This is all the more true today, as the industry is currently in a phase of upheaval: Corporate conspiracy, software manipulation, driving bans for diesel vehicles in cities, the planned end of the combustion engine in France or Great Britain, e-quotas in China, or EU fines for increased carbon dioxide emissions as of 2020 (< 95 grams of CO_2 per kilometre) and 2030 (35 % less than in 2020) are urging manufacturers to make changes and are currently promoting the development of battery-operated cars in particular. The German automotive industry has announced a model offensive in the field of electric cars for the coming years. However, the presumed lead supplier (Nationale Plattform Elektromobilität (NPE) 2016: 2) does not have a lead market to the same extent: With 0.7 percent, the share of electric cars in total new car registrations in Germany is very low (Figure 1). The high growth rates of +120 percent (2017) are due to the low base level. Electric cars account for an even smaller share of 0.12 percent in existing vehicles. In 2017, 53,861 electric cars were registered in Germany.

The Federal Government promotes the electrification of the German automotive market with various measures: In 2016, a package of measures with an investment volume of almost one billion euros was made available. The package primarily contains three main market incentive programmes, which, on the one hand, provide for purchase premiums for electric vehicles of up to 4,000 euros; on the other hand, 200 million euros are provided to improve the battery charging infrastructure and, finally, at least 20 percent of the federal vehicle fleet is to be electrified. In addition to that, electric vehicles will be exempt from motor vehicle tax. There are also funding programmes that support research and development work in the field of "renewable mobility". According to the current progress report of the National Platform for Electric Mobility (NPE 2018), however, the target of 1 million electric cars in Germany by 2020 cannot be achieved. That goal will probably not be achieved until 2022.

Due to a lack of infrastructure, the short range of batteries, and the high purchase price, sales based on the combustion engine will continue to dominate in the coming years. Nevertheless, in view of the developments outlined above, a substantial change in the way vehicles are powered is to be expected.

Some studies so far have dealt with the economic and, in particular, labour market-specific effects of the electrification of powertrains. Particularly because electric cars contain significantly fewer and simpler parts and the largest and most important component—the battery and the battery cells required for it—is not yet manufactured in Germany or by German manufacturers or suppliers (NPE 2016b), there are fears of high job losses in the course of the advance of electromobility.

Figure 1: New passenger car registrations and existing passenger cars by fuel type in 2017



Source: Kraftfahrtbundesamt (KBA)

Table 1: Employment effects of the electrification of powertrains in the literature – sorted by year of publication

Source	Employment effects
Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB) 2010	In all scenarios, a steady to rising employment situation is expected in powertrain production. However, there may be massive shifts and upheavals in the value-added chain. Net effects are determined.
Büro für Technikfolgenabschätzung beim Deutschen Bundestag (TAB) 2012	0.8 percent increase in GDP by 2030. Employment growth by 230,000 persons. Net effects are determined.
Schade et al. 2014	Depending on the scenario, positive or negative employment effects are expected. Net effects are determined.
NPE 2016	A comprehensive promotion of electromobility will create about 25,000 new jobs by 2020 in the automotive sector alone as compared to a "passive" scenario where the current promotion continues. In addition to the job gains from the creation and operation of the battery charging infrastructure and fiscal effects, 30,000 additional jobs will be created by 2020. Gross effects are determined.
European Climate Foundation (ECF)2017	More employment, especially in the area of manufacturing and installation of the battery charging infrastructure. Less employment in the manufacturing of combustion engines. Higher overall growth. Battery manufacturing location is crucial. Gross effects are determined.
Institut für Wirtschaftsforschung (Ifo) 2017	600,000 industrial jobs are affected directly and indirectly. Jobs in SMEs in particular would be in danger. About 13 percent of the gross added value of the German industry would be affected. Net effects are determined.
ELAB 2018	The overall employment effect will be negative in all scenarios. The range extends from -11 percent to -53 percent in personnel requirements. The increase in employment in the production of alternative powertrains cannot compensate for the reduction of personnel requirements for combustion engines. Results are more negative when productivity gains are taken into account. Net effects are determined.

Source: see studies

Table 1 gives an overview of the expected employment effects in the literature researched. The effects on the labour market differ significantly, from positive to negative employment effects. This inconsistency can be traced back to the different underlying assumptions, the different modelling and forecasting methods, and ultimately the consideration of gross and net effects. The difference between gross and net effects lies in the fact that only the direct and indirect effects of a measure are taken into account for the gross effects and that consequential effects such as substitution or budget effects are not included in the analysis.[1]

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[1] The difference between gross and net effects is mainly found in the analysis of the transformation of the energy system. Here the investment in renewable energies and its impact on employment is seen as a positive gross effect. If rising energy costs were taken into account in the analysis, which could be expected as a result of the restructuring of the energy mix, the macroeconomic employment effects would be classified as a net effect (Dehnen et al. 2015).

2 Modelling, Scenario Technique, Definitions

2.1 Modelling

As already mentioned above, the available studies on the subject also differ in their choice of methods. While the majority of the analyses are based on literature analyses, surveys, and simple empirical analyses using scenario techniques (ELAB 2010, ELAB 2018, ifo 2016, NPE 2016), there are only a few approaches that use complex economic models to estimate employment effects (TAB 2012, Schade et al. 2014, ECF 2017). All three of the latter studies build on input-output tables for economic modelling. While TAB (2012) and Schade et al. (2014) use the ASTRA model, ECF 2017 uses the Cambridge Econometrics E3ME model. Both model types used are multi-country models. However, while the ASTRA model follows the approach of a System Dynamic Model (Lehr et al. 2011), Cambridge Econometrics' input-output model E3ME is a macroeconometric forecasting and simulation model the properties of which go beyond those of a general equilibrium model. The models are also used in conjunction with scenario techniques.

The method we have chosen follows the approach of complex economic modelling in conjunction with scenario techniques as also pursued by ECF (2017), TAB (2012), and Schade et al. (2014). The macroeconometric input-output model INFORGE used here is similar to the E3ME model in many ways. However, the focus is not on multi-country modelling but on mapping labour demand not only by sector but also by occupations and requirement levels. The bottom-up structure also allows for industry-specific assumptions to be made. INFORGE is the economic core of the QINFORGE model, which was extended within the framework of the QuBe project (see Method box 1). INFORGE is described in detail in Ahlert et al. (2009). Its most important properties can be found in Method box 2.

Method box 1: QuBe project

The BIBB IAB qualification and occupational projections (QuBe project), which were developed in cooperation with the Gesellschaft für Wirtschaftliche Strukturforschung (GWS), use model calculations to show how the supply of and demand for qualifications and occupations may develop in the long term. Several data sources are coordinated as a data basis. As official representative statistics of the Federal Statistical Office, in which one percent of all households in Germany participate annually, the microcensus (last survey year 2015) provides information on the population and the labour market. The national accounts (in the present projection up to the year 2016) form the basis for the projection of the economy as a whole. The register data of the employees subject to social insurance contributions (SVB) and the exclusively marginally employed (AGB) of the Federal Employment Agency (BA) provide additional information on the number of employed persons by occupation and the corresponding wages paid (in the present projection up to the year 2015). The results are differentiated by up to 144 three-digit figures (occupational groups) from KldB 2010.

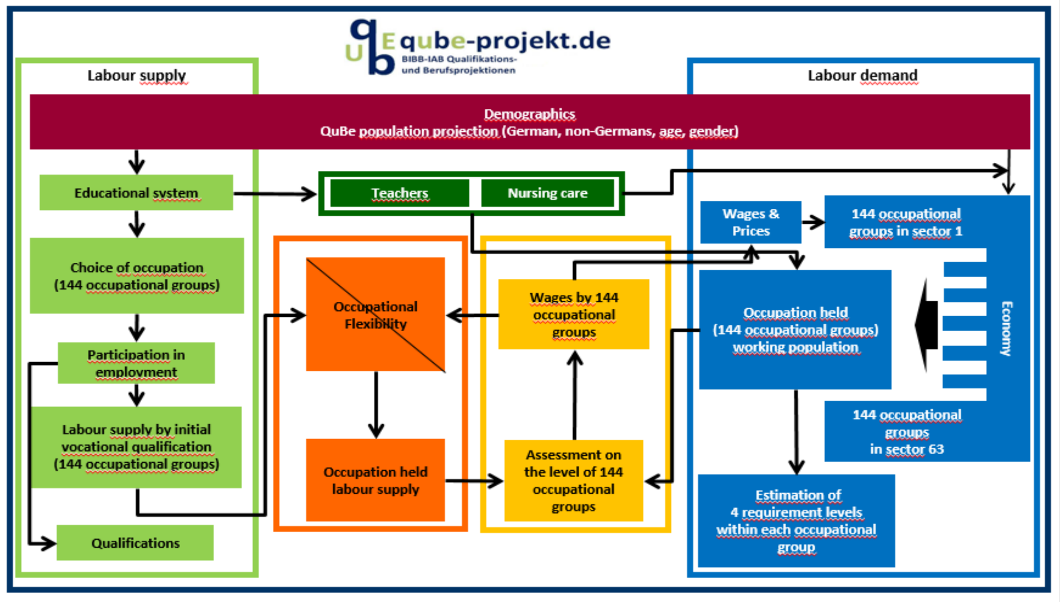
The unique characteristic of the QuBe project lies in the linking of the labour supply by a learned occupation with the occupation-specific labour demand through the use of occupational flexibility matrices. This makes it possible to draw up a professional balance of the labour market by comparing the labour force and employed persons by occupational groups.

The present results are based on the baseline projection of the fifth projection wave. It is based on the methods of the previous waves (Helmrich & Zika 2010; Maier et al. 2014; Maier et al. 2016, Zika et al. 2012) and includes further innovations. For the determination of personnel requirements in nursing, education, and teaching, detailed modules ("Nursing" and "Teaching") have been developed, which take into account not only the demand for labour but also the economic consequences for the health and social services. Like the revised household module, which determines the number of households with German and non-German heads, these modules are based on the QuBe population projection.

The QuBe project follows an empirical concept in the baseline projection: Only behaviour patterns that are measurable so far are projected into the future. Changes in behaviour that could not be detected in the past are therefore not part of the baseline projection. This also applies to the modelled market adjustment mechanisms. The following illustration gives a rough overview of how the model works.

Further information can be found at www.QuBe-Projekt.de; results are available at www.qube-data.de.

Figure 2: QINFORGE at a glance

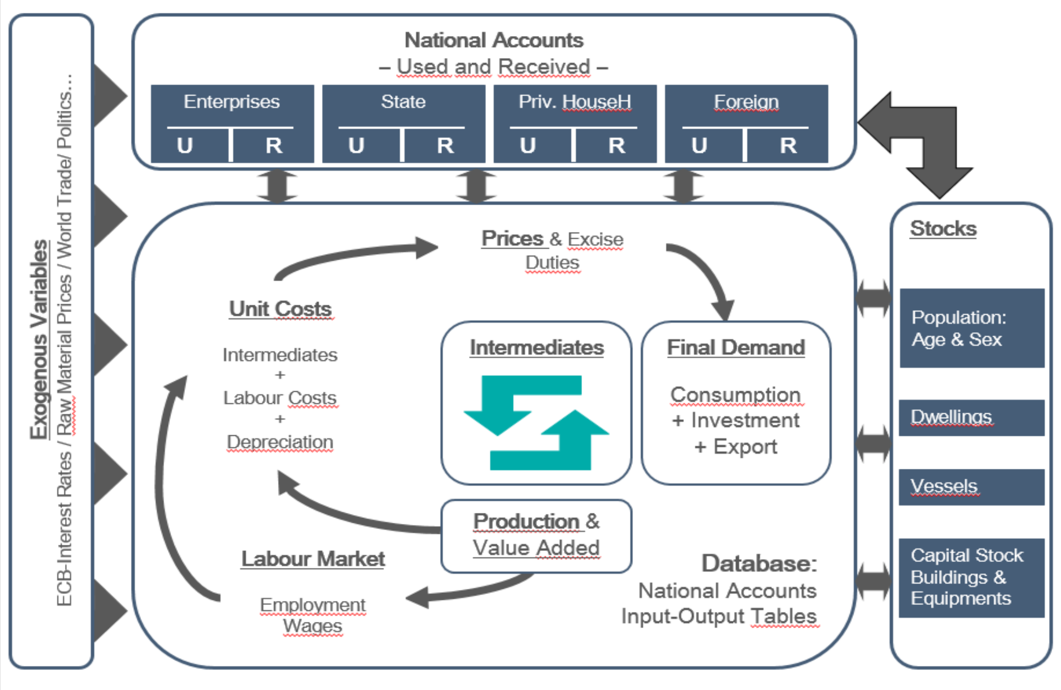


Source: QuBe project

Method box 2: The IAB/INFORGE model

The IAB/INFORGE model is an econometric forecasting and simulation model for Germany deeply disaggregated by manufacturing sectors and groups of goods which has been developed by the Gesellschaft für Wirtschaftliche Strukturforschung (GWS) and operated and updated continuously since 1996 (Ahlert et al. 2009). The model is based on the construction principles "bottom-up" and "full integration". "Bottom-up" means that the individual sectors of the economy are modelled in great detail and the macroeconomic variables are formed by aggregation in the model context. This allows for both a complete representation of the individual sectors in the macroeconomic context and in the intersectoral interdependence as well as an explanation of the macroeconomic contexts, which the national economy understands as the sum of its sectors. "Complete integration" refers to a model structure with an illustration of interindustrial interdependence and an explanation of the income use in private households from income generation in the individual sectors (Figure 2). Export demand is determined by the world trade model TINFORGE (Wolter et al. 2014), which projects the bilateral trade links of 154 countries and one region. The import demand for German products forecast in TINFORGE determines Germany's goods exports via bilateral trade matrices.

Figure 3: IAB/INFORGE at a glance



Source: QuBe project

2.2 Scenario Technique

The effects of certain (economic, technological, social) developments are usually examined by means of “what-if” analyses in order to calculate the implications of diverging assumptions.[2] The comparison of two scenarios reveals the implications of different assumptions. One scenario is the reference scenario, which represents plausible and consistent future developments. In an alternative scenario, other assumptions are varied, e.g. with regard to economic or demographic developments. The model relationships remain unchanged, so that differences in the results can be attributed solely to the changed assumptions. The results can be represented over time for one scenario or by comparing two scenarios at a certain point in time (Figure 4). In the model framework used here, Wolter et al. (2016) already carried out such a scenario analysis on the effects of Economy 4.0 in Germany. In the present study, the scenario technique is used to quantify the effects of the electrification of powertrains on the economy and employment.

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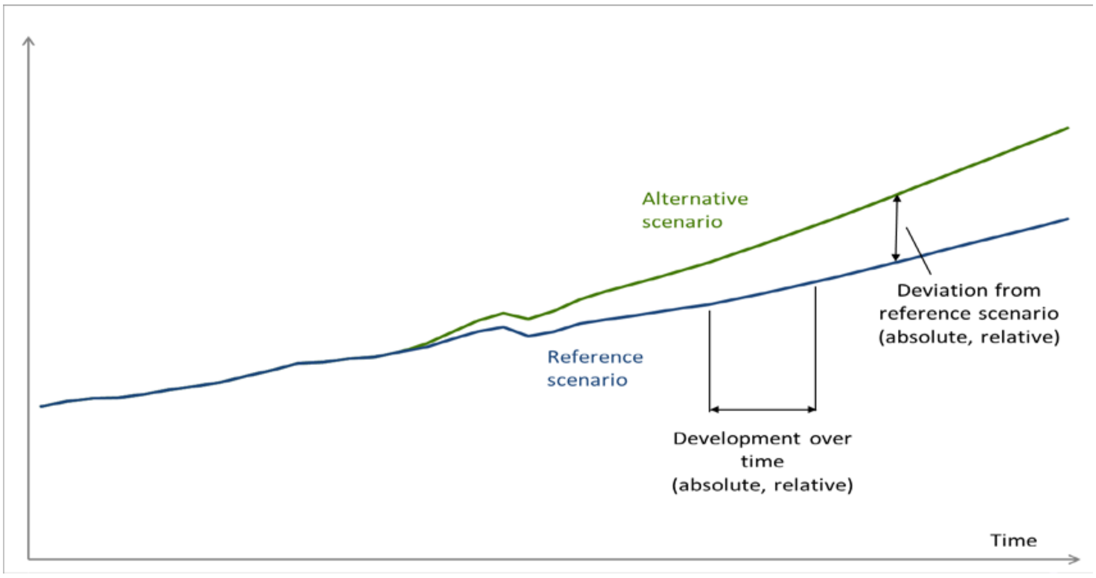
[2] For the method, see also: Helmrich/Zika 2018

Figure 4: Application of the scenario technique



Source: QuBe project

The reference scenario used is the baseline projection of the BIBB IAB qualification and occupational field projection (QuBe base projection), which was published as part of the 5th wave of the QuBe projection (Maier et al. 2018 to be published; Method box 1). The development described therein already contains assumptions regarding the development of the degree of motorisation, new registrations, and the total number of passenger cars. There is no differentiation by engine type, which must be included in the scenario development in the form of assumptions. Further consequences of electrification which go beyond the endogenous measure of modelling, such as investment and further training requirements, cost implications for batteries, chemicals, or plastics, or shifts in trade, must also be part of the assumptions made. The detailed modelling of the sectors with their cost structures on the basis of the input-output calculation of the Federal Statistical Office and the detailed representation by 63 sectors, 144 occupations, and 4 requirement levels is particularly valuable for the scenario analysis. Thus, changes in the production method of the industries as well as the occupation and requirement structures are depictable by industries.

2.3 Definition of Electromobility

The Federal Motor Transport Authority defines electric vehicles as “vehicles with exclusively electric drive” (KBA 2017: 6). This definition of electric cars is narrower than that of the Federal Government, which, in addition to purely electrically operated cars, also considers combinations of electric engines and small combustion engines and hybrid vehicles rechargeable in the power grid to be electric vehicles.[3] We follow the definition of the Federal Motor Transport Authority, according to which only passenger cars with an electric drive will be considered in the following. This also includes fuel cell vehicles, which are also classified as electric cars, as they use electrical energy for locomotion and store it temporarily in traction batteries. However, hybrid vehicles with at least two different types of drives fall within the “residual range” of passenger cars. In addition to that,

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[3] See http://nationale-plattform-elektromobilitaet.de/

only passenger cars will be considered in the following. Light trucks, small vans, or light commercial vehicles are not included in the analysis.

3 Assumptions

The operationalisation of the electromobility scenario is based on a total of 17 assumptions and 14 quantitative settings which, in addition to the necessary investments, concern components on the final demand side as well as the cost structure of individual sectors and the productivity of vehicle construction (cf. Table 2). The complexity of this scenario therefore requires a large number of interventions the macroeconomic effects of which cannot be estimated in their entirety without a model-theoretical background. Individual settings can strengthen, weaken, or offset each other in their effects—the overall effect is therefore *a priori* completely unknown. This makes the determination of the necessary adjustment screws and the assumptions made all the more decisive. These build the output via the model mechanisms and therefore require precise description and justification.

Table 2 lists all assumptions. They are explained in the following subchapters “General Assessment” to “Productivity Effect”.

Table 2: List of assumptions

	Assumptions	Sub-scenario
1	Degree of motorisation	-/-
2	Market penetration	-/-
3	Export	-/-
4	Investment needs of the automotive industry	Electromobility_4
5	Infrastructure 1 – Charging stations	Electromobility_4-5
6	Infrastructure 2 – Power system	Electromobility_4-6
7	Import demand for e-cars	Electromobility_4-7
8	Imported intermediate inputs for batteries	Electromobility_4-8
9	Cost effect 1 – Battery	Electromobility_4-9
10	Cost effect 2 – Chemicals	Electromobility_4-10
11	Cost effect 3 – Plastic	Electromobility_4-11
12	Cost effect 4 – Electronics	Electromobility_4-12
13	Cost effect 5 – Further education	Electromobility_4-13
14	Cost effect 6 – Supply industry	Electromobility_4-14
15	Fuel need 1 – Private households	Electromobility_4-15
16	Fuel need 1 – Commercial demand	Electromobility_4-16
17	Productivity effects of the automotive industry	Electromobility_4-17

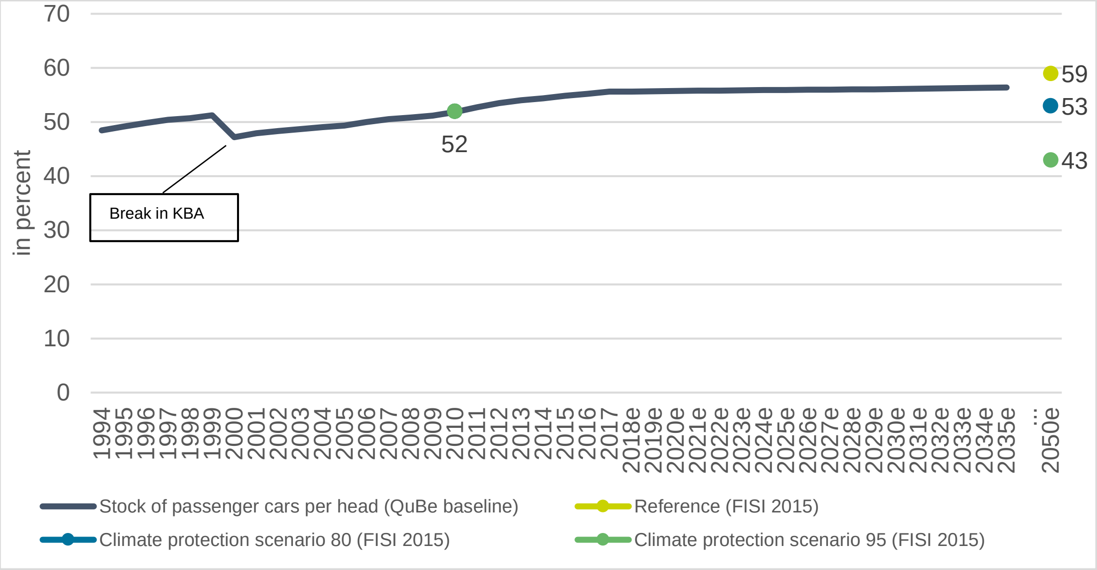
Source: QuBe project

3.1 General Assessment – Assumptions 1 to 3

The **degree of motorisation**—measured on the basis of the number of passenger cars as compared to the population—is used as an important influencing factor for the future achievement of e.g. CO_2 emission reduction targets, especially in climate studies (Fraunhofer Institut für System- und Innovationsforschung (FISI) 2015). However, since the electrification of powertrains does not imply a change in driving behaviour or even in the demand for motor vehicles per se, we assume that there will be no change in the degree of motorisation as compared to the reference scenario.

This assumption also means that there will be no change in the mobility behaviour of private and commercial consumers of vehicles beyond that assumed in the QuBe baseline scenario. As Figure 5 shows, the degree of motorisation is currently just under 55.6 percent. By 2035, the per-capita stock will increase slightly, and by 2035, it will be 56.4 percent. This means that expectations are below the assumptions of the reference scenario from the FISI study (2015). However, it is well above expectations for the climate protection scenarios calculated for FISI (2015).

Figure 5: Degree of motorisation in different reference scenarios

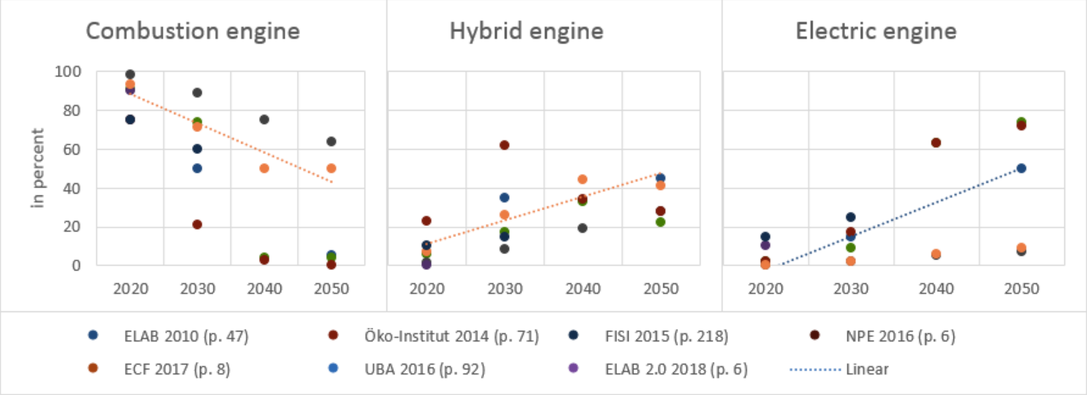


Source: KBA, FISI 2015, QuBe baseline projection

The **market penetration** of electrically powered passenger cars is a decisive assumption for the following analysis, as all other assumptions are based on it. At present, the market penetration of electric vehicles for both new registrations and existing vehicles is very low in Germany (cf. Figure 1). In fact, what future market penetration will look like will be the result of political, economic, technological, and social changes. A mandatory electrical quota—such as that introduced in China, for example, and which has already been discussed at the EU level—is currently not foreseeable in Germany. For this reason, the market penetration assumed in the following—which is specified exogenously here and does not result endogenously from the model context—is to be seen as a means to an end for the analysis of employment effects rather than as the actual determinant. Thus, no prognosis is made for the possibilities of achieving this degree of market penetration, but the effect on the economy and the labour market when an assumed market penetration is achieved is considered.

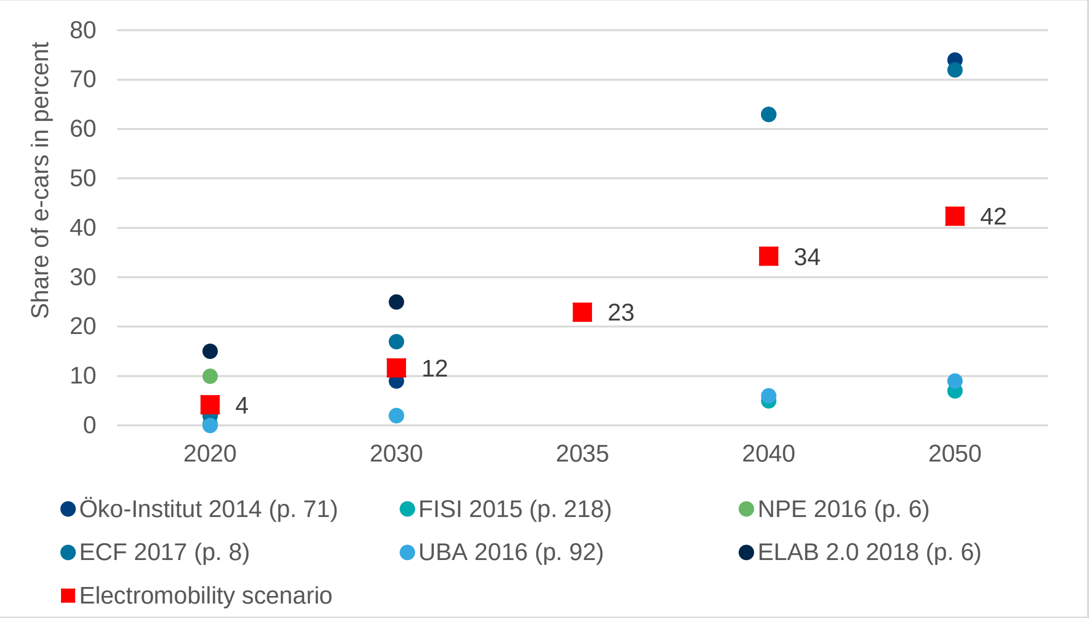
To derive the assumption regarding the market penetration of electric cars, the assumptions from a large number of studies have been collected and combined. Since all studies—similar to the present one—provide an exogenous indication of market penetration, there are usually different target scenarios for market penetration. In the reference scenarios, a market penetration is described which could be achieved from today's perspective and without more intensive promotion of electric cars. For this reason, the market shares of electric cars are consistently lower in the reference scenario than in the alternative target scenarios. An overview of the market penetration by fuel type in the reference scenarios is shown in Figure 6. Basically, it becomes clear in all scenarios—albeit to varying degrees—that in the long term the market share between combustion engines and electric engines will shift to the disadvantage of the combustion engine.

Figure 6: Market penetration by fuel type in different reference scenarios



Source: see studies

Figure 7: Market penetration of electric cars in different reference scenarios



Source: QuBe project, see studies

If an average value is calculated for the assumptions, the market penetration of pure electric drives will be 23 percent by 2035 (cf. Figure 7). The studies increasingly diverge in their assumptions as we look further into the future. While the two studies FISI (2015) and Umweltbundesamt (UBA) (2016) assume only a very weak increase in the market penetration of electric cars of less than 10 percent by 2050, the Öko-Institut (2014) and ECF (2017) believe that a market penetration of over 70 percent is possible. Observing the assumptions made here, new registrations of electric cars will reach almost 600,000 in 2035.

With an **export quota** of 75.5 percent today (Wietschel 2017: 9), around 74,000 electric cars produced in Germany are exported. This means that the export quota for electric cars is similarly high as for combustion engines. According to McKinsey's Electric Vehicle Index (EVI)[4], Germany holds a share of 18 percent of the worldwide production of electric cars. Together with the high export quota, this confirms the image of a leading supplier. For this reason, the present projection does not make any additional assumptions about the (nominal) export development of electric cars. The export volume of motor vehicles will develop along the path given by the baseline projection. This assumption is a crucial one for the growth prospects of the automotive industry. If export opportunities would increase (or decrease) due to the electrification of powertrains, Germany could hope for more (or less) growth in the future.

3.2 Investment Needs of the Automotive Industry

In order to build competence in the manufacturing of electric powertrains, the automotive industry must first invest in research and development. On the other hand, there is a need for investment in the expansion and/or modification of the production platforms so that the electrified vehicles can also be produced. The German Association of the Automotive Industry (VDA)[5] estimates the investment requirements of the automotive industry at 40 billion euros for the years 2018 to 2020.

In the scenario, the 40 billion euros are equally distributed over the years 2018 to 2020 and added to the automotive industry's investments in equipment and other facilities. That is 13.3 billion euros of additional investments per year.

In the following years, investments related to combustion engines will decline in line with the proportionate decline in new registrations. This applies both to research and development activities and to investments in equipment. On the other hand, the investments required for the production of electric cars will continue to rise. Analogous to the assumed increase in productivity (see the Productivity Effect chapter), we assume that investments per electric car will increase faster than investments per combustion engine in the QuBe baseline projection. Figure 8 shows that the investment trend will approach the level of the QuBe baseline projection in the long term.

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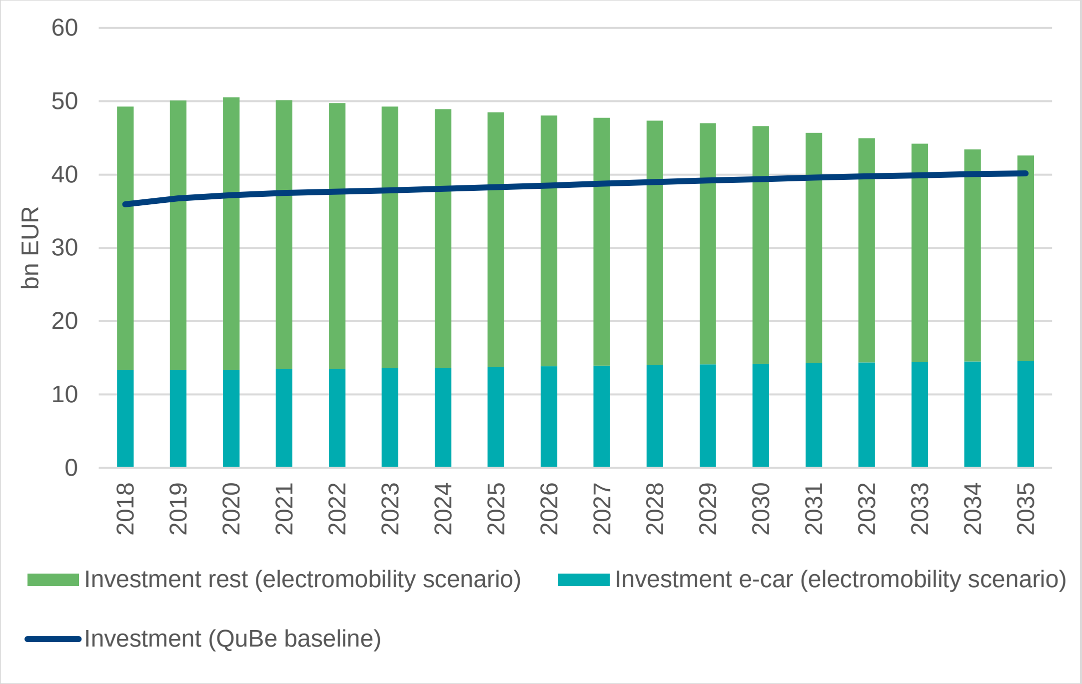
[4] https://www.mckinsey.de/branchen/automobil-zulieferer/electric-vehicle-index

[5] VDA press release 3 July 2018 “Mattes: Deutsche Automobilindustrie setzt auf Elektromobilität, Digitalisierung und Vernetzung“.

Figure 8: Investment needs of the automotive industry in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

3.3 Infrastructure 1 – Charging Station

A nationwide battery charging infrastructure is a prerequisite for the market penetration of electric cars. Accordingly, an assumption must be made about the expansion of the publicly accessible charging stations—both normal and fast-charging stations.

Currently, the number of publicly accessible charging stations is 11,371, about 12 percent of which are fast-charging stations.[6] With an electric car fleet of currently 53,861, this results in a ratio of 4.7; i. e., one charging station for almost every fifth electric car in the fleet. If there were no additional infrastructure expansion, almost 524 electric cars would share one charging station by 2035.

In order to maintain the ratio of electric cars to charging stations at 5:1 (ECF 2017: 2016), additional investments in the battery charging infrastructure are required. The investment requirement arises both in cities to avoid undersupply and on motorways and federal highways to ensure continuous e-mobility (NPE 2015). Figure 9 shows the estimated investment requirements according to the assumed development of the electric car fleet.

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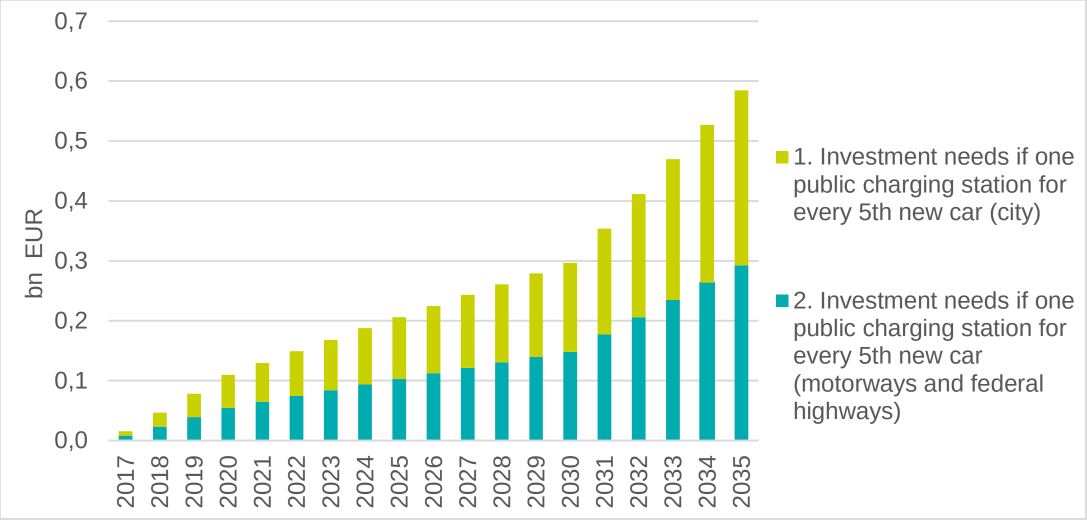
[6] Charging station register of the Federal Network Agency, last updated: 5 September 2018

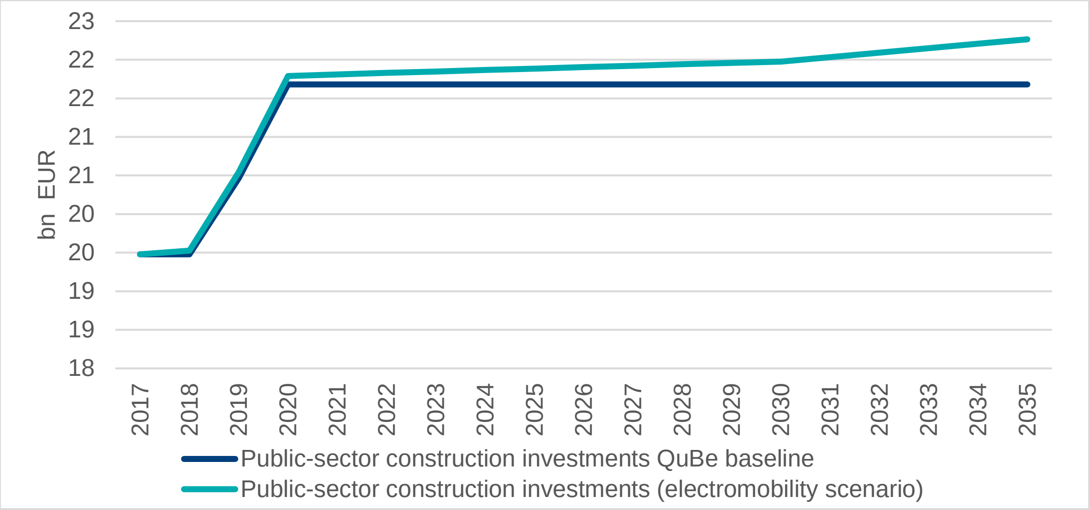
Figure 9: Investment needs for charging stations in the electromobility scenario



Source: QuBe project

For construction and maintenance, an average of 2,000 euros per charging station is estimated.[7] The necessary construction investments are borne by the state, since the construction of fast-charging infrastructure is predominantly carried out within the framework of subsidy programmes (NPE 2015).

Figure 10: Public-sector construction investments in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

Figure 10 shows the development of construction investments in the QuBe baseline projection and in the electromobility scenario. This results in cumulative additional investments of just under 5 billion euros up to 2035. Possibly declining replacement investments in fuel filling stations are not considered.

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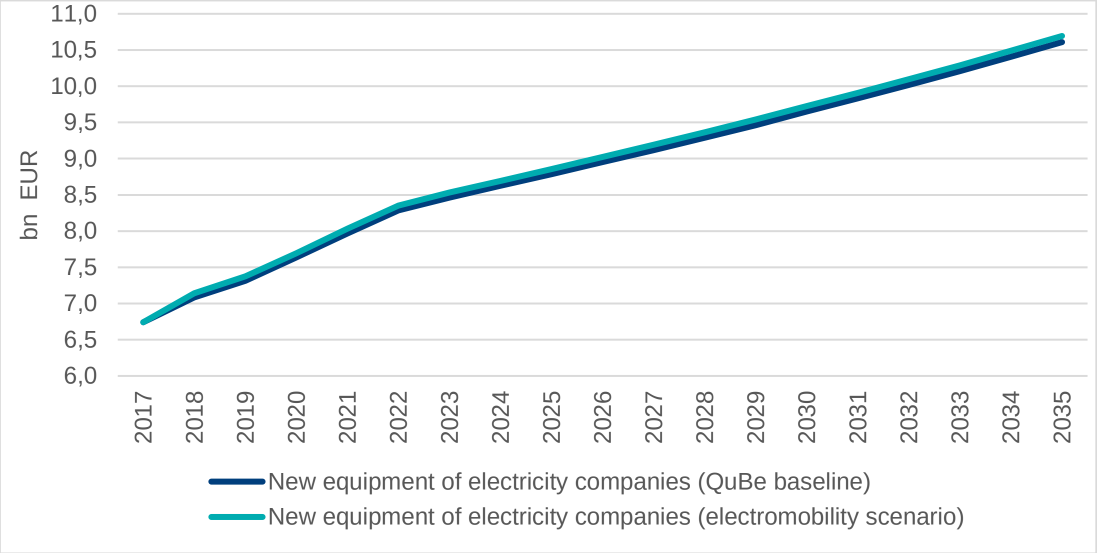
[7] The costs for construction and maintenance of charging stations currently vary substantially (cf. http://www.just-park.de/fakten/ladestation-kosten). The estimated costs of 2,000 euros per charging station are somewhat higher than the average value, but contain maintenance costs as well.

3.4 Infrastructure 2 – Power System

The market penetration of electric cars requires not only the development of a nationwide battery charging infrastructure but also the modernisation of the electricity grid. The system load which would be caused by (uncoordinated) charging of more and more electric cars is likely to result in current peaks (especially in the evening) and thus "lead to increased capacity requirements on the grid and electricity generation and high electricity generation costs" (ECF 2017: 14). Intelligent charging systems could prevent negative effects on electricity distribution and generation.

In the electromobility scenario, it is therefore assumed that electricity companies are interested in the expansion of an intelligent charging system. The investment requirement is used by ECF (2017: 18), which will be a cumulative amount of 1.350 billion euros by 2035 (cf. Figure 11).

Figure 11: Investment requirements for the power system in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

3.5 Import Demand for Electric Cars

The import demand for electric cars is not published in any known database. The data on imported electric cars are derived from Table 3. From Wietschel et al. (2017: 10), it is known that approx. 98,000 electric vehicles are produced in Germany. Domestic sales amount to around 24,000 cars and are the result of the subtraction of domestic production from the export of electric cars: the additional demand for electric cars must be met—if not satisfied from domestic production—by imports. The Federal Motor Transport Authority (KBA) has published new registration figures by fuel type. In 2017, 25,056 new electric cars were registered. The demand for imports is the balance between new registrations and domestic sales. As a proportion of new registrations, an import quota of 4 percent can be estimated.

Table 3: Derivation of the import demand and the import quota of electric cars in the electromobility scenario

	2017
E-car production in DE	98,000
Sales of e-cars in DE	24,010
Export of e-cars in DE	73,990
New registrations of e-cars in DE	25,056
Import demand for e-cars	1,046
E-car import quota (imports/new registrations)	4.2 %

Source: QuBe project

Figure 12: Import quota of electric cars for all new registrations of electric cars in the electromobility scenario

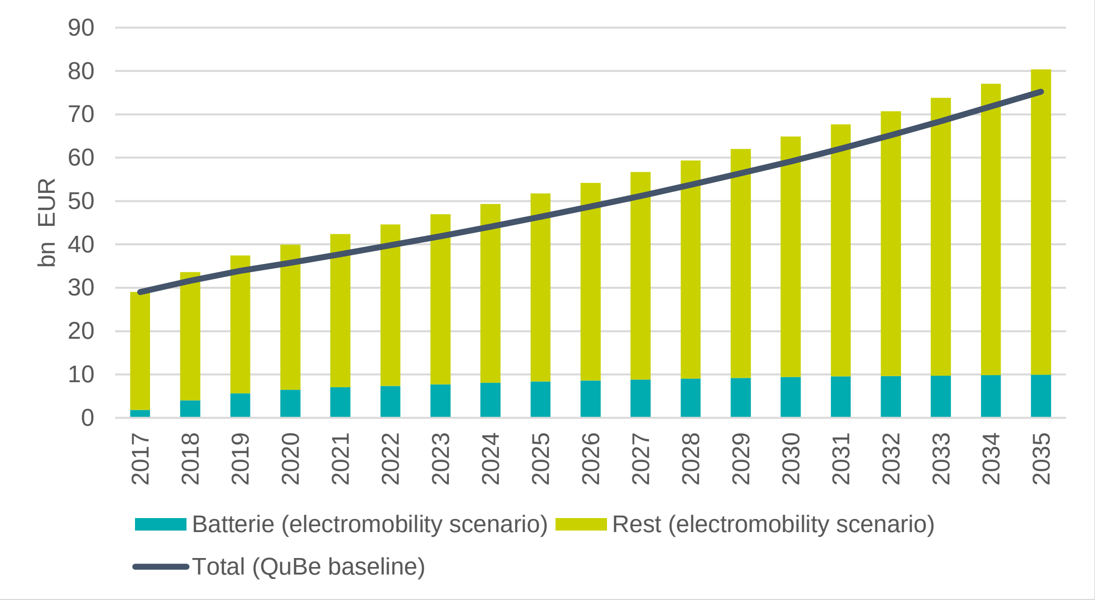
Source: QuBe project

In the electromobility scenario, it is assumed that import demand will increase, because (as with combustion engines) domestic production minus exports will not be sufficient to cover the rising demand. It is assumed that the import quota will increase in line with the development of the e-share in all new registrations. Figure 12 shows the import quota for electric cars. The import quota will rise to 66 percent by 2035. This will be roughly the same level as the import quota for combustion engines (2017: 64 %). The share of electric cars in the imports of all motor vehicles will then be at 31 percent—in 2017, the share was still 0.05 percent.

3.6 Imported Intermediate Inputs for Batteries

While the previous assumption is related to the import demand for complete electric cars, the following assumption will be made regarding the import demand for the batteries necessary for the engine of an electric car. Traction batteries are needed for the operation of electric cars. Since 2015, there has not been any factory in Germany with the capacity to produce sufficient numbers of battery cells required for traction batteries (NPE 2016b: 5). Since the traction battery cell accounts for 60–70 percent of the added value of the entire battery pack (NPE 2016b: 5), it has a high system relevance. Domestic production of electric cars will therefore require an increased intermediate inputs demand for traction battery cells. However, German manufacturers have so far concentrated on the assembly of the battery packs. The battery cells themselves must be imported from abroad, with Japan, Korea, and China being the primary suppliers.

Figure 13: Imported intermediate inputs for electric equipment in the electromobility scenario and in the QuBe baseline projection



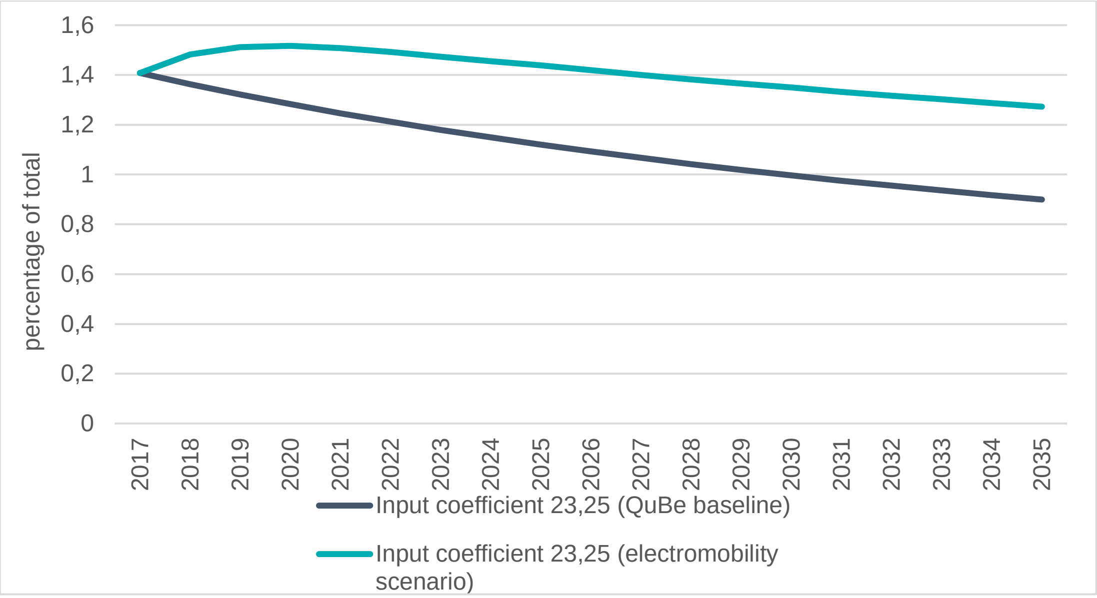
Source: QuBe project

In the classification of economic activities, batteries are classified as electric equipment (WZ-27). The import share of batteries in total electric equipment is about 6.7 percent. However, this includes all batteries (and accumulators) and not only traction batteries relevant for electric cars. With 6.7 percent, the import share of electric equipment is therefore overestimated. The import demand for batteries will continue with the domestic production of electric cars. Accordingly, the imported intermediate inputs for electric equipment will increase more strongly than in the QuBe baseline projection (Figure 13).

3.7 Cost Effect 1 – Battery

Batteries and accumulators belong to the intermediate inputs for electric equipment (WZ-27). The automotive industry demands around 5 billion euros in intermediate inputs from electrical equipment suppliers, which is 1.4 percent of the production value. For electric cars, the entire battery accounts for almost 40 percent of the added value (Wietschel et al. 2017: 11, NPE 2016b: 5). The domestic production share of electric cars in total cars produced in Germany is 1.7 percent.

Figure 14: Input coefficient of electric equipment in cars in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

The future development of the input coefficient of the automotive industry for electric equipment is based on the domestic production share of electric cars and the value-added share of the battery. As the production share of electric cars increases, the costs also rise with the increase in electric car production. The value-added share of the battery remains constant at 40 percent over the entire projection period.[8] Figure 14 shows the course of the input coefficient in the QuBe baseline projection and in the electromobility scenario.

3.8 Cost Effect 2 – Chemicals

The shift to electromobility will not only involve the battery but will also lead to further changes in the components required to manufacture a vehicle (ELAB 2012, McKinsey 2011). The additional demand for chemical inputs is not only the result of the increased use of traction batteries. With the increasing use of electrified powertrains in vehicles, the electric efficiency of a vehicle will also become more important. Chemicals can make a valuable contribution in this regard (Verband der Chemieindustrie (VCI) 2011). For example, new, chemicals-based products can reduce energy requirements for heating (e. g. insulating materials) or cooling (e. g. sun blockers for windscreens) (VCI 2011).

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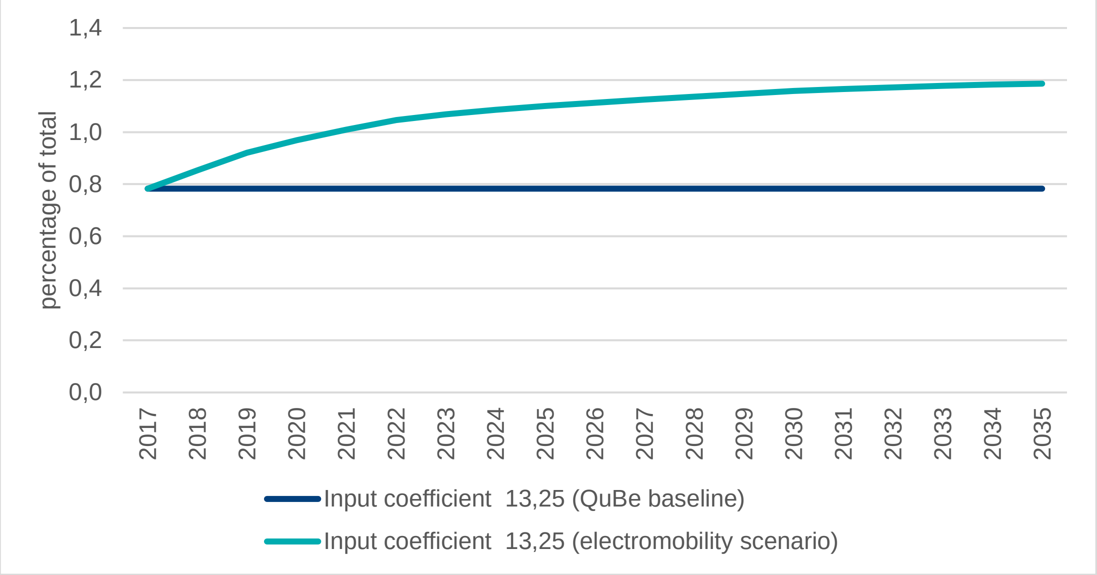
[8] According to Wietschel et al. (2017: 11), a decrease of the value-added share is possible. However, it is unlikely that it will fall below 10–20 percent for pure electric cars even in the long run (Wietschel et al. 2017: 11).

Figure 15: Input coefficient of chemicals in cars in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

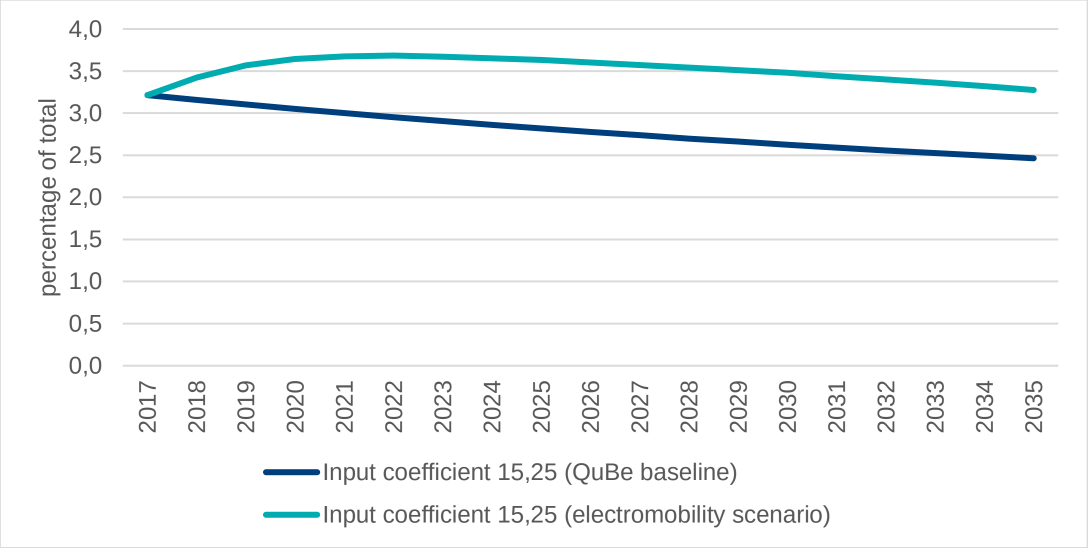
At present, chemical products (WZ-20) in the amount of 2.3 billion euros are required as intermediate inputs by the automotive industry. The input-output table does not specify which chemical products are needed by the automotive industry. However, it can be assumed that there will be demand for products such as paints and adhesives, but also for antifreeze agents or generally chemical substances for production. Relative to the production value, this accounts for 0.8 percent. In the electromobility scenario, the input coefficient of chemicals in cars is extrapolated according to the approach in the Cost Effect 1 – Battery chapter. Figure 15 compares the course of the input coefficient for the QuBe baseline projection and for the electromobility scenario.

3.9 Cost Effect 3 – Plastic

The production of electric cars will cause a change in the use of materials. In particular, more plastic will be needed in the production of every car (ELAB 2012, ECF 2017 b). On the one hand, this is necessary for the construction of a lighter car body. On the other hand, more plastics are needed to install the battery.

At present, plastics (WZ-22) in the amount of 11 billion euros are required as intermediate inputs by the automotive industry. Relative to the production value, this corresponds to a share of 3 percent. In the electromobility scenario, the input coefficient of plastic in cars is extrapolated according to the approach in Chapter 3.7. Figure 16 compares the course of the input coefficient for the QuBe baseline projection and for the electromobility scenario.

Figure 16: Input coefficient of plastic in cars in the electromobility scenario and in the QuBe baseline projection

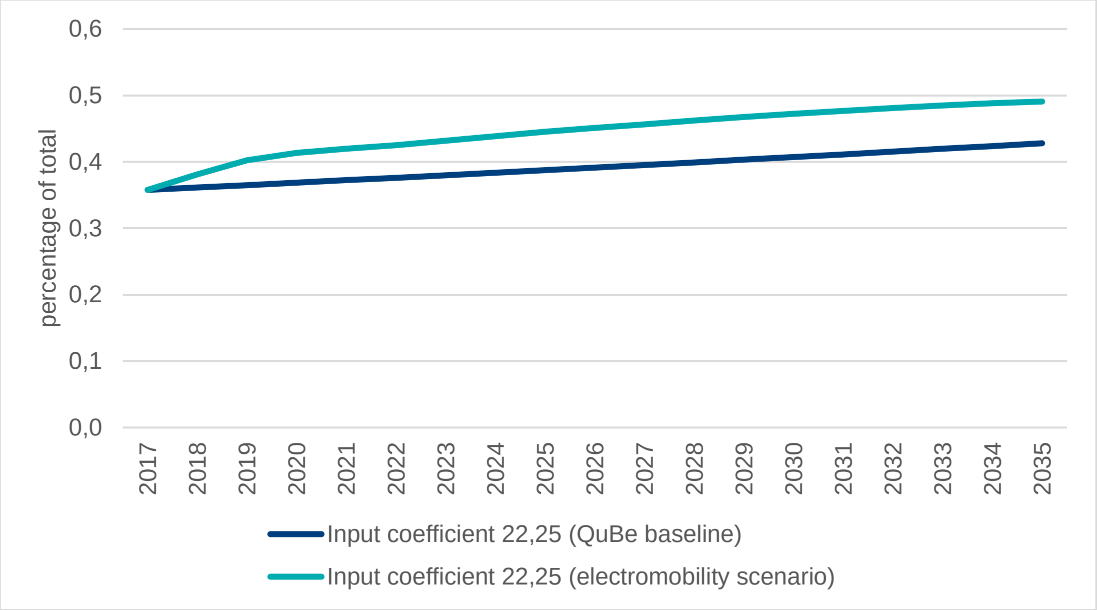


Source: QuBe project

3.10 Cost Effect 4 – Electronics

Compared to cars with a combustion engine, electric cars will contain more electronic parts and in particular power electronics (Wietschel et al. 2017: 23). Electronics (WZ-26) in the amount of 1 billion euros are required as intermediate inputs by the automotive industry. This corresponds to 0.4 percent of the production value. In the electromobility scenario, the input coefficient of electronics in cars is extrapolated according to the approach in Chapter 3.7. Figure 17 compares the course of the input coefficient for the QuBe baseline projection and for the electromobility scenario.

Figure 17: Input coefficient of electronics in cars in the electromobility scenario and in the QuBe baseline projection



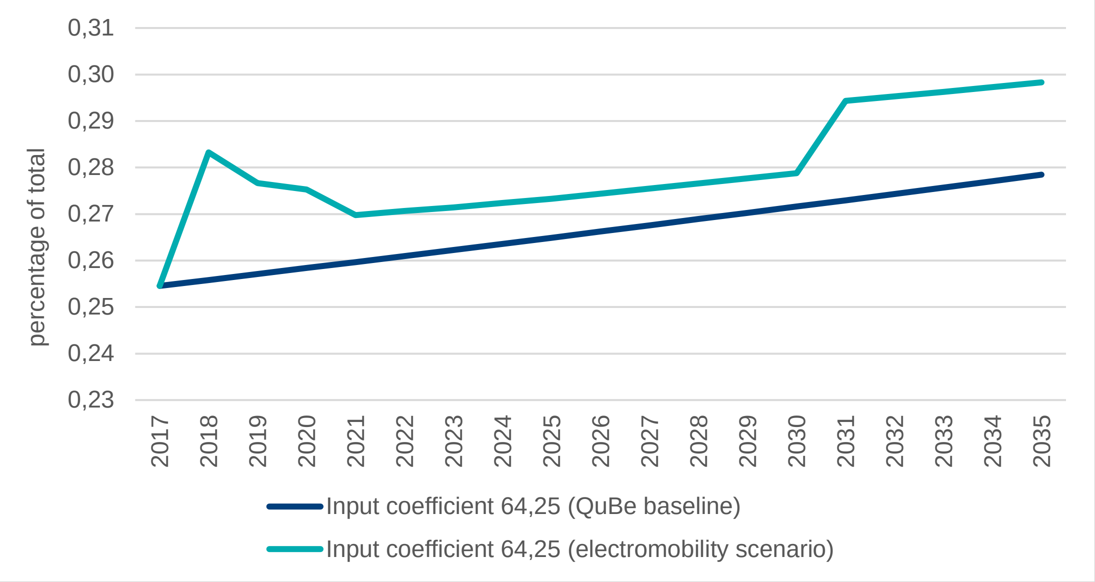
Source: QuBe project

3.11 Cost Effect 5 – Further Education

For the production of electric cars, specific further training and education of the employees is necessary (ELAB 2012). A shift in qualification requirements is to be expected (McKinsey 2011), which cannot be covered by the recruitment of new employees only. This also means that existing employees will have to be trained in the new production processes. To date, the automotive industry has spent 1 billion euros on training services (WZ-85). Relative to the production value, this corresponds to a share of 0.25 percent.

In the projection for the estimation of future further training measures within the automotive industry, it is expected that 23 percent of employees will have received further training by 2035—corresponding to the e-share in new registrations. The development corresponds to the change of e-shares in new registrations. Assuming estimated further training costs of 718 euros per person (Statistisches Bundesamt 2013), additional costs of 7.5 billion euros will be incurred over the entire forecast horizon. Figure 18 compares the course of the input coefficient for the QuBe baseline projection and for the electromobility scenario.

Figure 18: Input coefficient of further training for cars in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

3.12 Cost Effect 6 – Supply Industry

The automotive industry not only has strong links with other sectors through intermediate input deliveries; with over 30 percent, it is also one of the sectors with the highest level of internal supply integration.[9] The automotive industry is divided into original equipment manufacturers (OEMs) and suppliers.

The latter can be divided into Tier-1 and Tier-2/3 types, the difference being whether they are direct suppliers to OEMs (Tier-1) or not (Tier-2/3). According to the classification of economic activities (WZ-2008), car manufacturers are classified in the economic sector 29.1 ("Manufacture of motor vehicles and their engines"). The basic characteristic for this classification is the property of manufacturing engines and (complete) motor vehicles. The automotive suppliers belong to WZ-29.3 ("Manufacture of parts and accessories for motor vehicles"), where essential parts and components for vehicle construction are manufactured.[10] These include components which are independent of the powertrain, such as alternators, window regulators, axles, or airbags. However, suppliers, in particular, also supply drive-dependent parts and accessories (exhaust pipes and poppets, radiators, clutches, or catalytic converters) which are no longer needed in electric drive trains.

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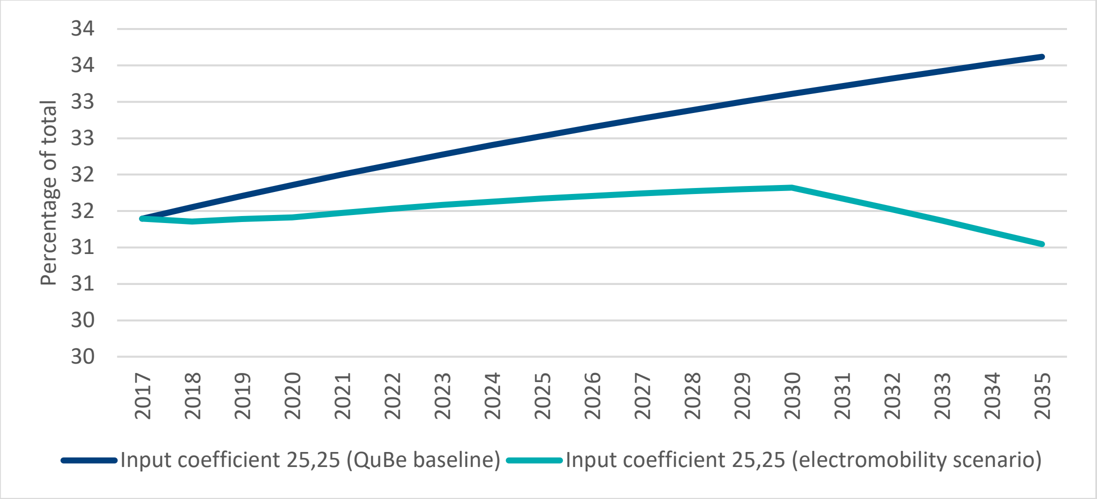
[9] With just above 30 %, only the paper industry, the chemical industry, and IT service providers have a similarly high share of internal deliveries. With over 50 %, the non-iron metal industry and the services of travel agencies, tour operators, and other reservations (cf. input-output table 2014) are the fields with the highest internal deliveries.

[10] The supply industry for the automotive industry can also be defined in a broader sense. In this case, companies from other industries that provide intermediate inputs for the automotive industry will also be classified as suppliers. In the following, the term "supply industry" will be used for the automotive industry within the narrow definition of the Federal Statistical Office according to the 2008 classification of economic activities.

Figure 19: Input coefficient of cars for cars in the electromobility scenario and in the QuBe baseline projection



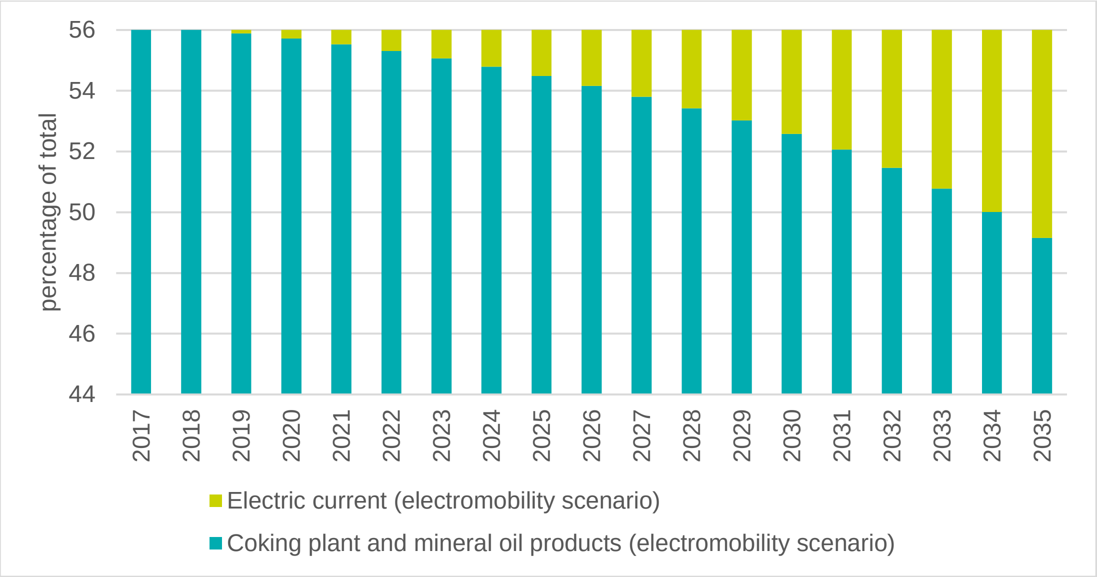
Source: QuBe project

The input-output table does not distinguish between manufacturers and suppliers, which is why the interdependence within the industry between WZ-29.1 and WZ-29.3 is not known. Nevertheless, the transition to the age of electromobility is also a change that will particularly affect the interdependence within the industry: On the one hand, manufacturers are likely to have an intrinsic interest in maintaining a particularly high level of competence in the manufacture of electric cars. On the other hand, the proportion of valuable components in electric cars is significantly lower than in combustion engines. This applies in particular to the gearbox, which is highly complex for combustion engines but very simple for electric engines (ELAB 2012: 24). But also the number of components required for vehicles with combustion engines alone exceeds the number of components required for vehicles with electric engines. Thus, it can be concluded that the interdependence within the industry will decrease with the electrification of powertrains. Figure 19 shows the (price-adjusted) input coefficient of the QuBe baseline projection and the electromobility scenario. Taking into account the productivity differential and the shift in the share of new registrations between combustion engines and electric cars, the proportion of intra-industry intermediate input deliveries will decrease as compared to the QuBe baseline projection.

3.13 Fuel Need 1 – Private Households

In the electronic age, petrol and diesel will increasingly be replaced by electricity. So far, private households have spent 56 percent of their expenditure on “goods and services for the operation of private vehicles” on the purchase of “coking plant and mineral oil products”. “Electric current" is not yet in demand for this designated use.

Figure 20: Distribution of the designated use "operation of private vehicles" for mineral oil and electric current in the electromobility scenario



Source: QuBe project

Since the electromobility scenario does not assume any change in the degree of motorisation, the fuel requirement will also remain generally unchanged. However, the composition of the fuel demand will change: electric current will increasingly be used as an operating resource for private vehicles, too. This shift will take place by shifting the share between the groups of goods "mineral oil" and "electricity" in the consumption matrix while maintaining the same total share (56 %). Accordingly, private demand for coking plant and mineral oil products will be lower and private demand for electricity stronger than in the QuBe baseline projection.

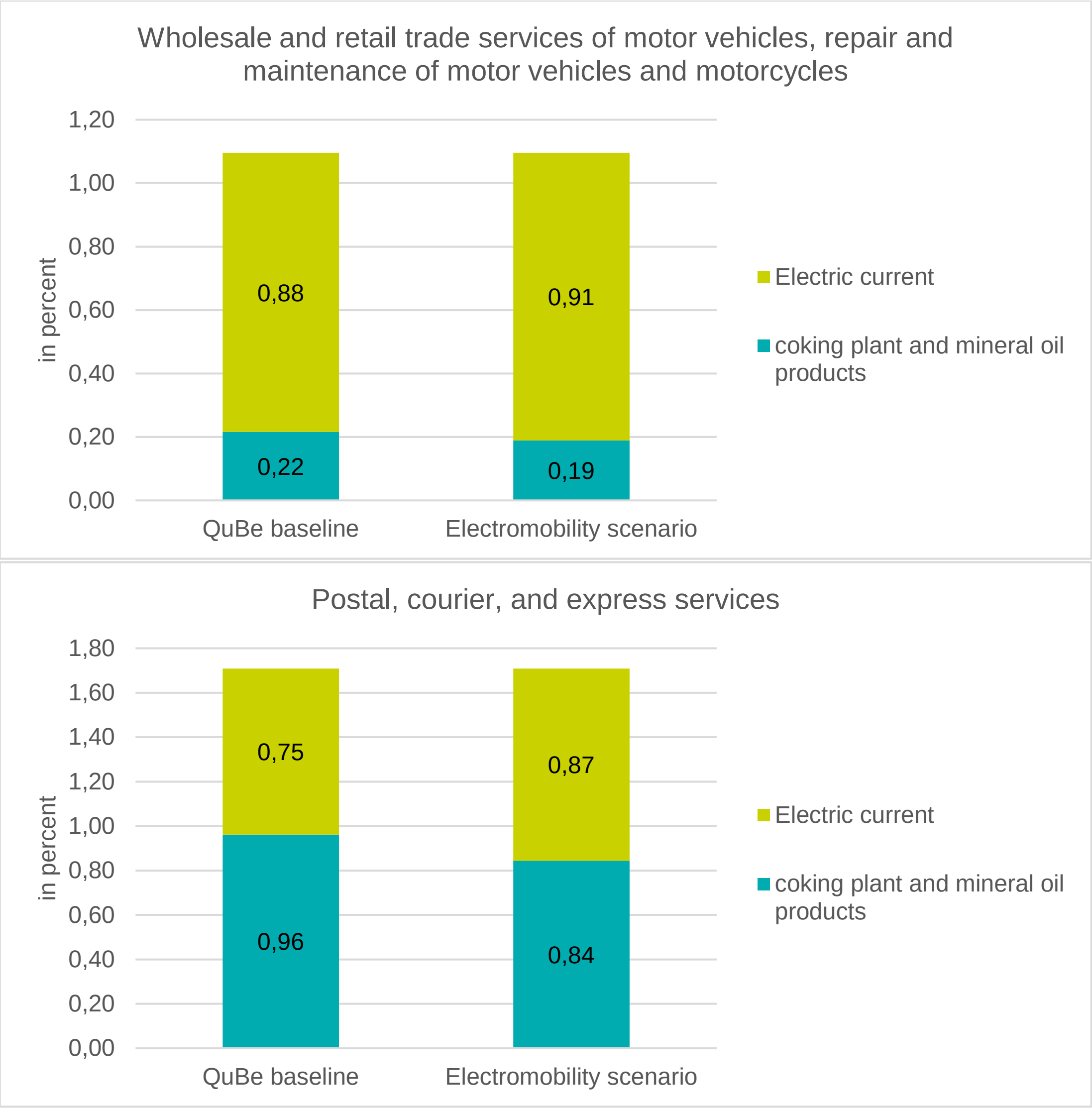
Figure 20 shows the shift in shares. According to this, the 56-percent share currently spent on coking plant and mineral oil products alone will fall by a good 7.5 percentage points to 48.5 percent by 2035. This loss will be fully distributed to the proportionate demand for electricity.

3.14 Fuel Need 2 – Commercial

Similar to assumption 12 from the Fuel Need 1 – Private Households chapter, commerce will also make a transition to electric cars and accordingly fill up with more electricity and less mineral oil. This will require an adjustment of the intermediate input structure. The assumption is that only the service sector will be affected, as electric cars are the main type of vehicles used here. The manufacturing industry also needs mineral oil for its production processes and not only as fuel for transport.

The service sector begins with the trading sector. Aviation is excluded from this sub-scenario, because it is assumed that it will not switch to electric current as fuel within the forecast horizon. For all other areas of the service sector, it is assumed that the real input coefficient—i. e., the ratio of intermediate input and production—of mineral oil will follow the decline in the share of new registrations for non-electric cars. The input coefficient of electricity will increase accordingly by the declining share.

Figure 21: Shift of the real input coefficients of coking plant and mineral oil and electric current using two selected sectors in the electromobility scenario in 2035



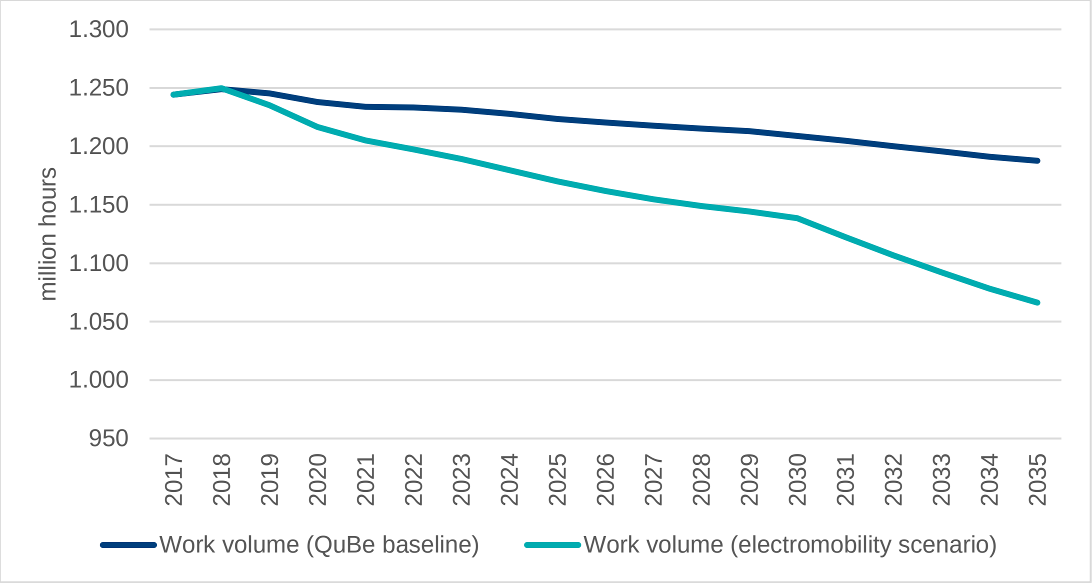
Source: QuBe project

Figure 21 is an example of two sectors to illustrate how the input coefficients will differ in 2035. For the area of trade services with motor vehicles, the QuBe baseline projection for 2035 shows a relative intermediate input of electricity of 0.88 percent and of 0.22 percent for mineral oil. In the electromobility scenario, the electricity input for the same sector will increase to 0.91 percent while the use of mineral oil will fall to 0.19 percent relative to the production value. A similar development is foreseeable for the postal, courier, and express services sector.

3.15 Productivity Effect

So far, the average annual increase in labour productivity in the automotive industry has been 4 percent. In the QuBe baseline projection, it weakens significantly to just over 1 percent p. a. The switch to electric powertrains may have an effect on productivity via two different channels. On the one hand, the production of electric cars is less labor-intensive than that of a passenger car with just a combustion engine, because significantly fewer components are installed and the complexity of the powertrain is reduced. According to ELAB (2018), the assembly of a passenger car running with a combustion engine requires 20 working hours. For an electric car, an average of 15 working hours is required. This makes the production of an electric car 25 percent or 5 working hours faster than the production of a car with a combustion engine.

Figure 22: Work volume of the vehicle industry in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

It can also be assumed that, in addition to the pure component effect, the efficiency of the production of electric cars can be increased as time progresses. This productivity effect must also be considered. For this purpose, the assumptions of ELAB (2018) are used, which assume a 50 percent higher productivity increase for electric cars as compared to combustion engines.

Taking into account the two productivity effects and the shift in the share of new registrations in favour of electric cars, a lower volume of work for the vehicle industry than in the QuBe baseline projection will be required, as shown in Figure 22. Due to productivity reasons, fewer working hours will be worked in the vehicle industry in the long term. By 2035, 120 million working hours will be lost in this industry, which corresponds to around 10 percent of all hours worked.

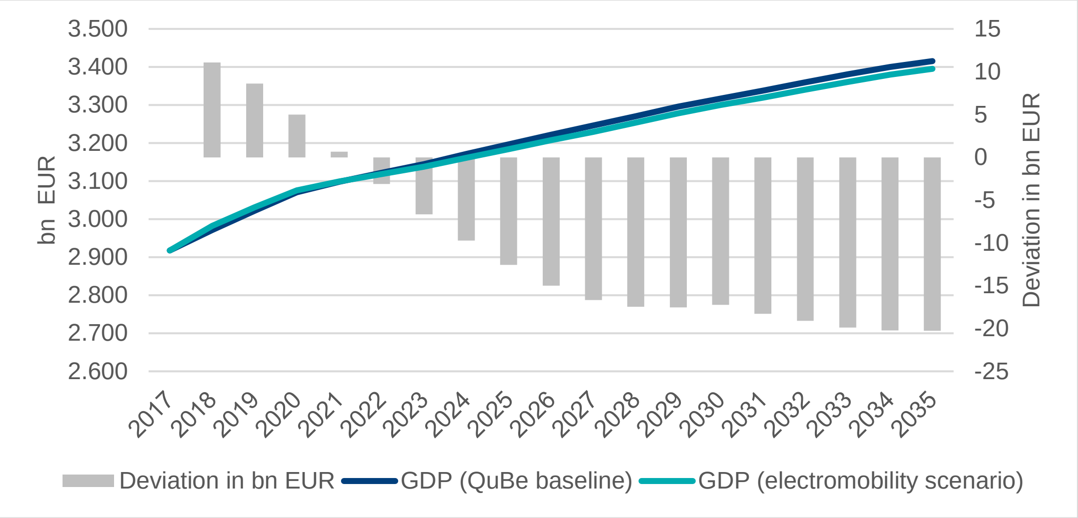
4 Results

The assumptions presented are implemented simultaneously in the QuBe model (Maier et al. 2016, Maier et al. 2018, to be published), so that the effects can be analysed. The results can be represented according to their partial results and in their overall effect on different sizes of the macroeconomic model. In the following, the effects on real GDP growth and its components as well as on the total number of employed persons will be described by economic sector, occupation, and requirement level.

4.1 Growth Effects

As a whole, the assumptions made for the increasing electrification of powertrains in passenger cars lead to a lower gross domestic product (GDP) level and to a weaker overall growth path of the price-adjusted GDP development (cf. Figure 23). Over time, however, there will be fluctuations that have a positive effect on growth, especially at the beginning. It also shows that, despite electrification of up to a 23-percent share of new registrations of electric cars by 2035, the growth rates of price-adjusted GDPs will not become increasingly worse. On the contrary, the initially much lower growth rates in the electromobility scenario will lead to an alignment of the dynamics to the QuBe baseline projection. However, the absolute loss of economic power cannot be offset by this. In 2035, the gross domestic product of the economy as a whole will be 20 billion euros below the level of the QuBe baseline projection. This corresponds to about 0.6 percent of the price-adjusted gross domestic product.

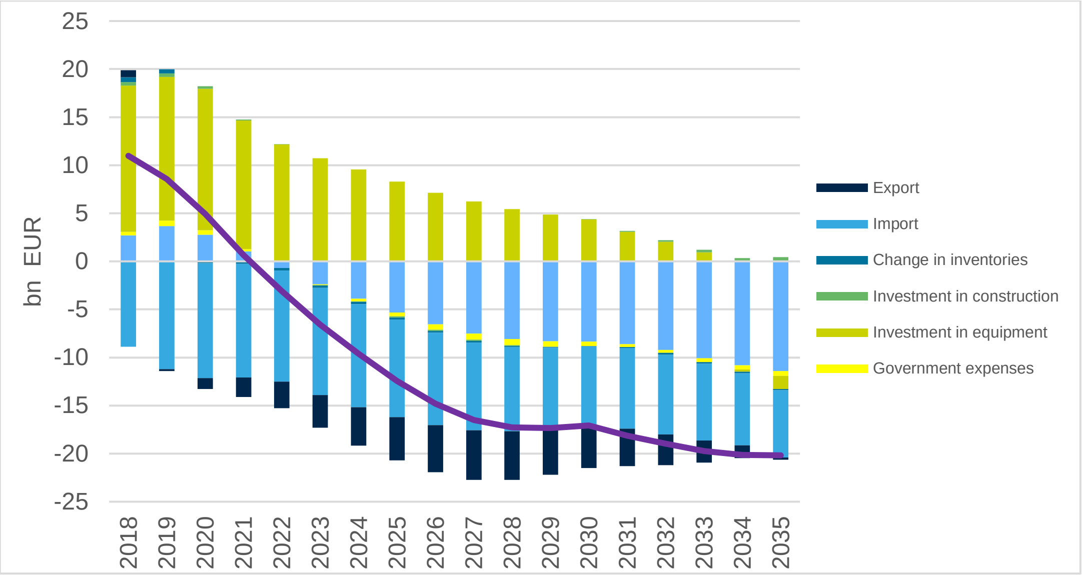
Figure 23: Real gross domestic product in the electromobility scenario and in the QuBe baseline projection



Source: QuBe project

Figure 24 shows which of the GDP components on the expenditure side is responsible for the macroeconomic growth trend. It is clear that the positive deviations of the GDP trend at the beginning are due to the additional investment needs of the automotive industry. The additional construction investments also support the development, but to a much lesser extent. Induced by the positive initial effects, private consumer spending will also make a positive contribution to growth in the early years of electrification due to the interrelationship of the cycle.

Figure 24: Components of the real gross domestic product in the electromobility scenario vs. the QuBe baseline projection

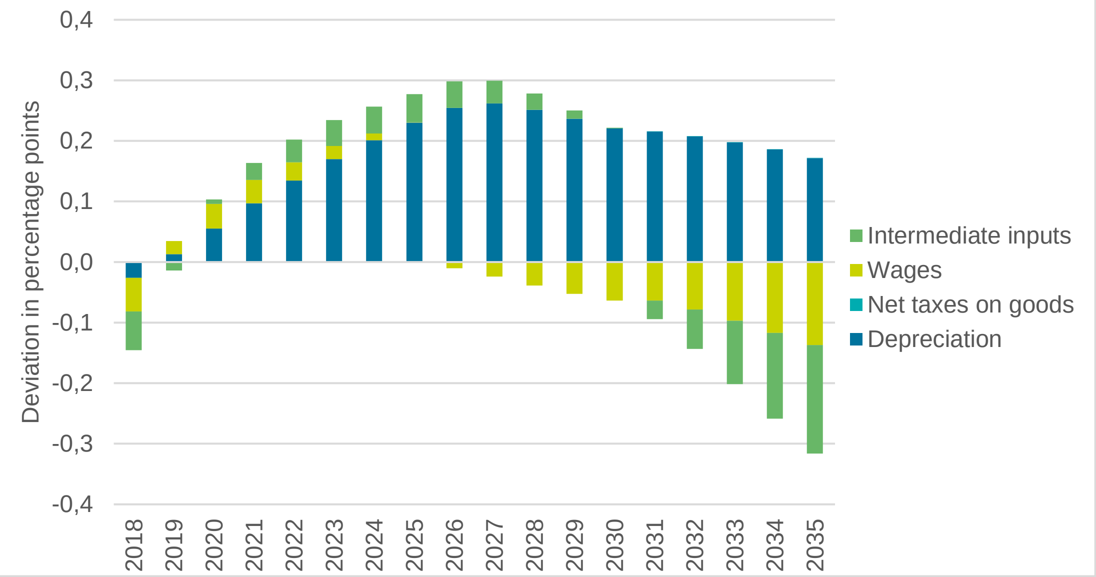


Source: QuBe project

The predominantly negative effects on the GDP result from the high import demand, which covers both the import of complete electric cars and the import of traction battery cells. Although no explicit assumptions (see above) have been made about exogenously inflowing nominal exports, price-adjusted exports change due to at least a temporary stronger rise in price levels than in the QuBe baseline projection.

The temporarily stronger rise in price levels can be attributed to rising unit costs in the economy as a whole. As Figure 25 shows, it is depreciations and additional material expenses in particular that drive the rise in costs. However, the adjusted additional expenditure for certain intermediate input products is not as high as the increased costs for electric equipment, chemicals, plastics, or further training suggest. The significantly lower internal supply requirements within the industry due to the reduced need for components will have a significant long-term positive effect on the costs of materials. Unit labour costs will have a positive effect on the economy as a whole. Although wage increases will also be felt in the first few years in particular as a result of the additional investments, this effect will level off later and, together with the loss of jobs, the overall wage bill will also fall below the level of the QuBe baseline projection.

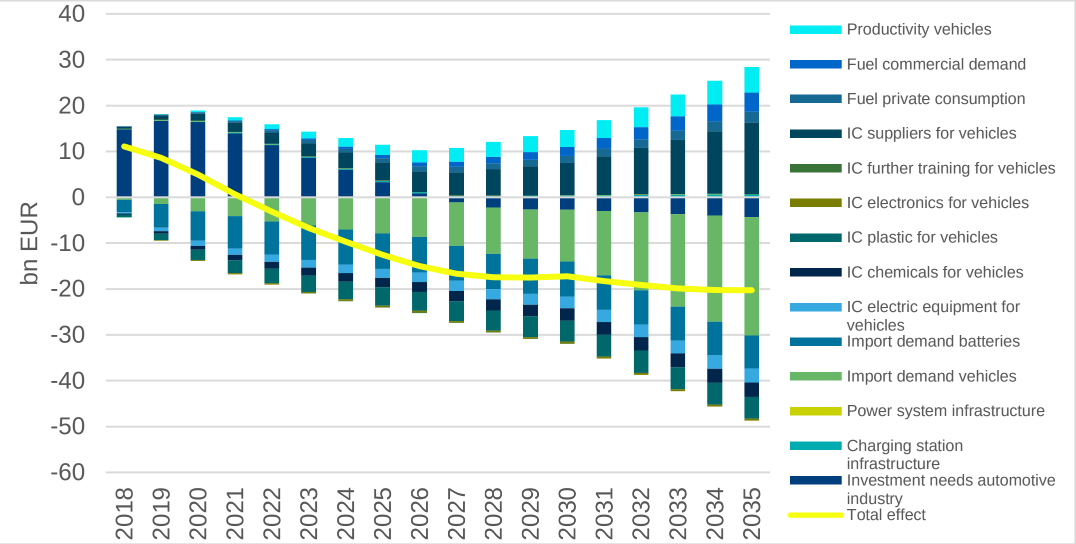
Figure 25: Macroeconomic unit cost components in the electromobility scenario vs. the QuBe baseline projection



Source: QuBe project

The growth effect can be broken down to the individual sub-scenarios. Figure 26 cumulatively shows the individual effects of the 14 quantitative sub-scenarios for the price-adjusted GDP. The overall effect (grey line) corresponds to the grey bars in Figure 23.

Figure 26: Real gross domestic product in the respective sub-scenario vs. the QuBe baseline projection



Source: QuBe project

As was to be expected, the greatest negative effects can be derived from the import assumptions. The negative effect will increase over time as the number of newly registered electric cars increases. With the exception of further training, the cost effects also have a negative impact on the GDP. Although the increasing use of intermediate inputs represents additional costs for the vehicle industry, it also induces additional demand in the relevant supply sectors. If these sectors are employment-intensive—such as the education sector—this can have a positive effect on the economy as a whole due to downstream income effects.

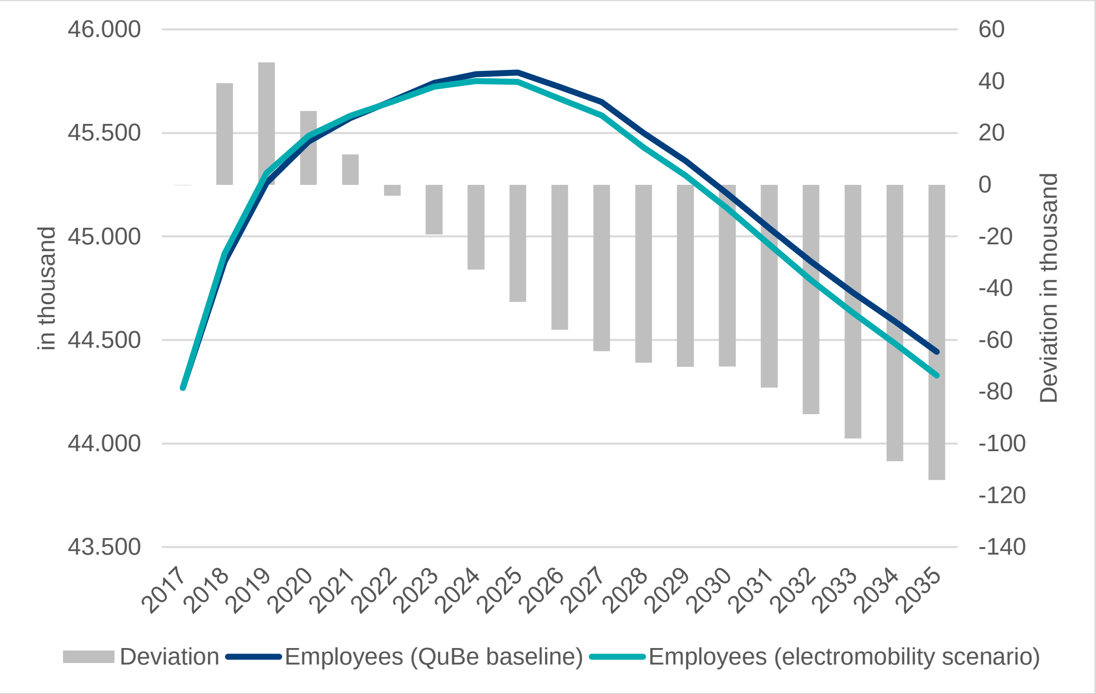
The investments made by the automotive industry, the productivity assumption made for the industry, and the cost reductions for deliveries within the industry also have a positive impact on the economy as a whole, as do the necessary infrastructure measures.

The change in fuel consumption—both on the part of private households and on the part of the service sector—has a positive effect on the GDP. This can be explained by the reduced demand to import coking plant and mineral oil products.

4.2 Consequences for Labour Demand

The effects and consequences of the assumptions in the electromobility scenario are also evident in the labour market. Figure 27 shows the employment trend vs. the baseline scenario.

Figure 27: Number of persons employed in the electromobility scenario and in the QuBe baseline projection

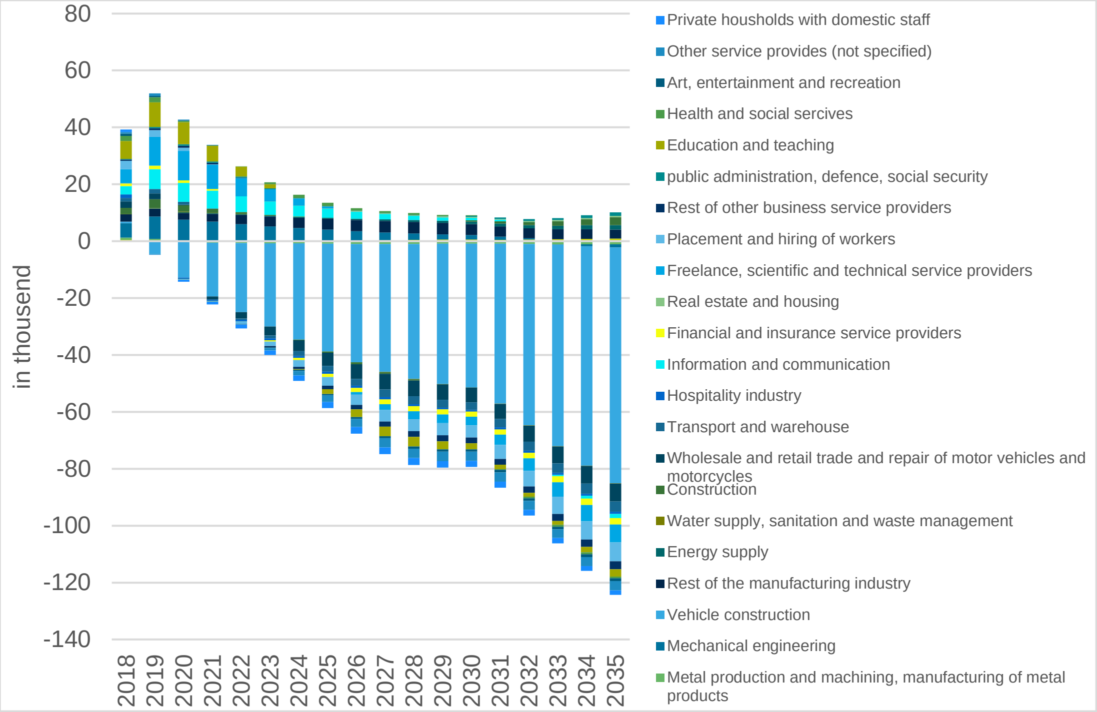


Source: QuBe project

According to this, the employment effect changes its algebraic sign as of 2022. Until then, the assumptions made will still have a positive effect on the labour market and the macroeconomic employment situation. By 2035, almost 114,000 additional jobs will have been lost due to the electrification of powertrains. This may correspond to only about 0.3 percent of the working population, but when measured using the unemployment figures, an additional 10 percent will become unemployed.

The relatively big macroeconomic employment effect is felt differently in the various sectors. A breakdown by 25, as in Figure 28, clearly shows the largest employment losses in the automotive industry. There alone, 83,000 jobs will be lost by 2035.

Figure 28: Number of employed persons in the electromobility scenario vs. the QuBe baseline projection by economic sectors

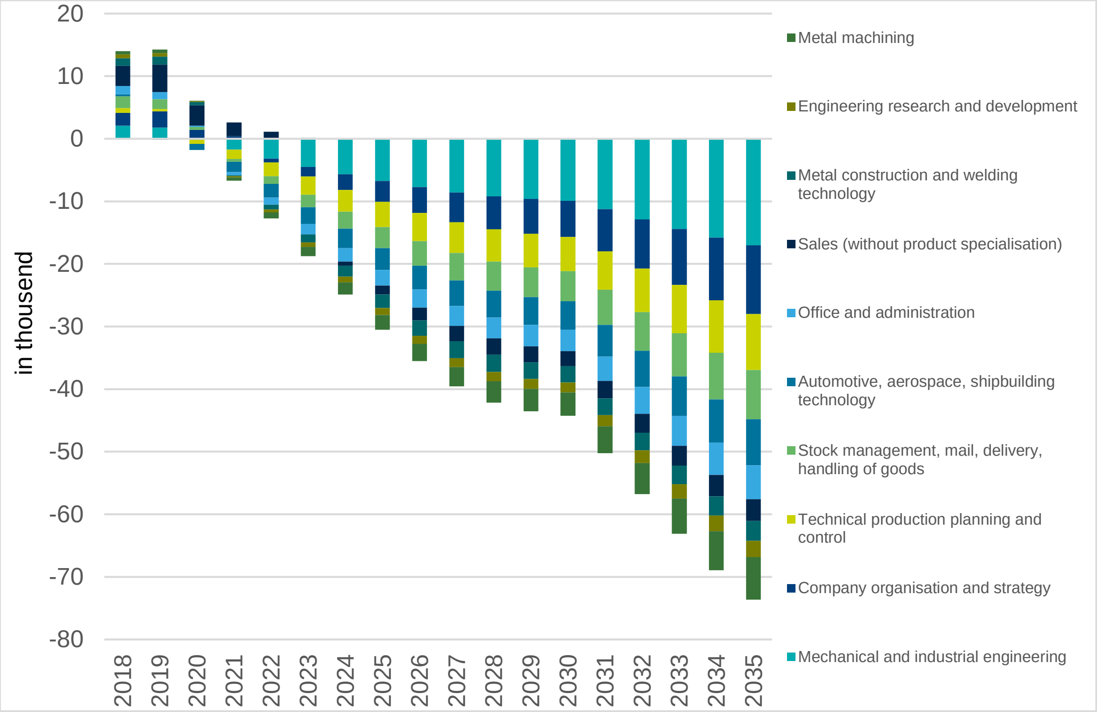


Source: QuBe project

Slightly delayed due to the strong need for investment and the associated higher demand for labour, there will be job losses in this **sector** as of 2019 due to the high increase in productivity. However, there will certainly be an increase in employment in other sectors. These are indirectly related to the investment needs of the automotive industry. Mechanical engineering, for example, but also information and communications technology and other freelancers will benefit. Employment brokers, who often work for the automotive industry, will initially benefit from the investments made in the sector, but as of 2022, some of their jobs will also be lost. The further education sector will also provide new jobs in the medium term. Energy suppliers will benefit from the transition to electricity as a means of propulsion and will all be able to create new jobs. In view of the provision of the infrastructure, the construction industry will also see a temporary increase in hiring.

The long-term decline in labour demand is particularly at the expense of the mechanical and automotive engineering occupations and the occupations for technical development and construction of production controls (cf. Figure 29). But also **occupations** in metal production, machining, and metalworking will be less needed in the longer term. At the beginning of the scenario calculation, these are still needed more than in the QuBe baseline projection. However, after investments in new production facilities and processes, these occupations will be less needed. The same applies to the occupations of corporate management and organisation, which will initially create additional jobs but will significantly cut jobs in the long term.

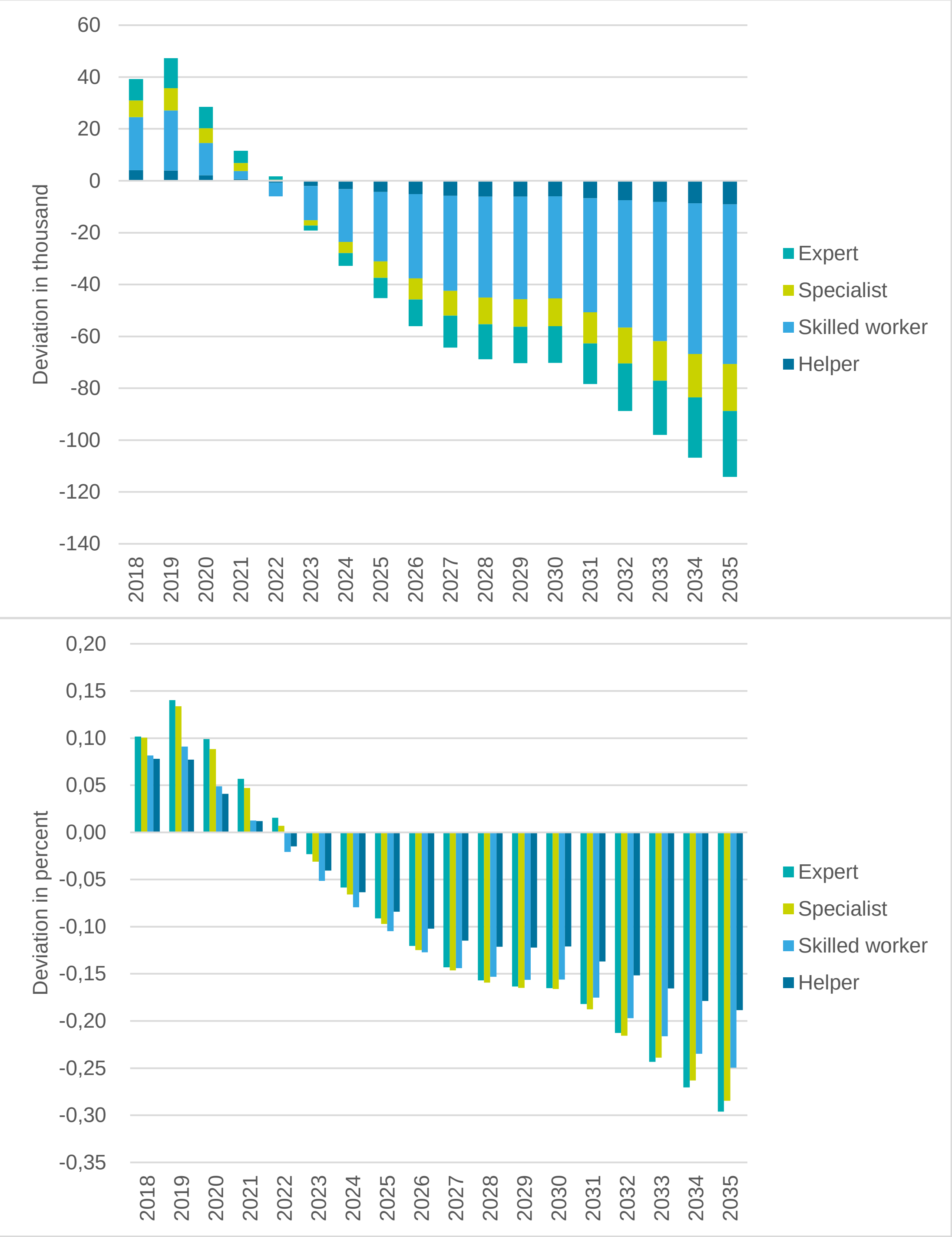
Figure 29: Number of employed persons in the electromobility scenario vs. the QuBe baseline projection by occupation with the largest deviations in the year 2035



Source: QuBe project

If employment effects are considered at the level of **requirement levels**, it can be seen that all requirement levels up to and including 2021 will be more in demand. In absolute terms, skilled workers in particular benefit, but a relative analysis shows that specialist and expert activities in particular will benefit from the development and expansion phase of the electrification of powertrains in the medium term (cf. Figure 30). The turning point in the employment effect will first hit those in employment with a lower requirement level—i. e., helpers and skilled workers. It will only be one year later that the need for specialists and experts decreases. Then, however, the decline of employment of experts and specialists will accelerate, which will continue to be more dynamic than for helpers or skilled workers as of 2025. One reason for this is the less complex structure of electrified powertrains in motor vehicles.

Figure 30: Number of employed persons in the electromobility scenario vs. the QuBe baseline projection by requirement level

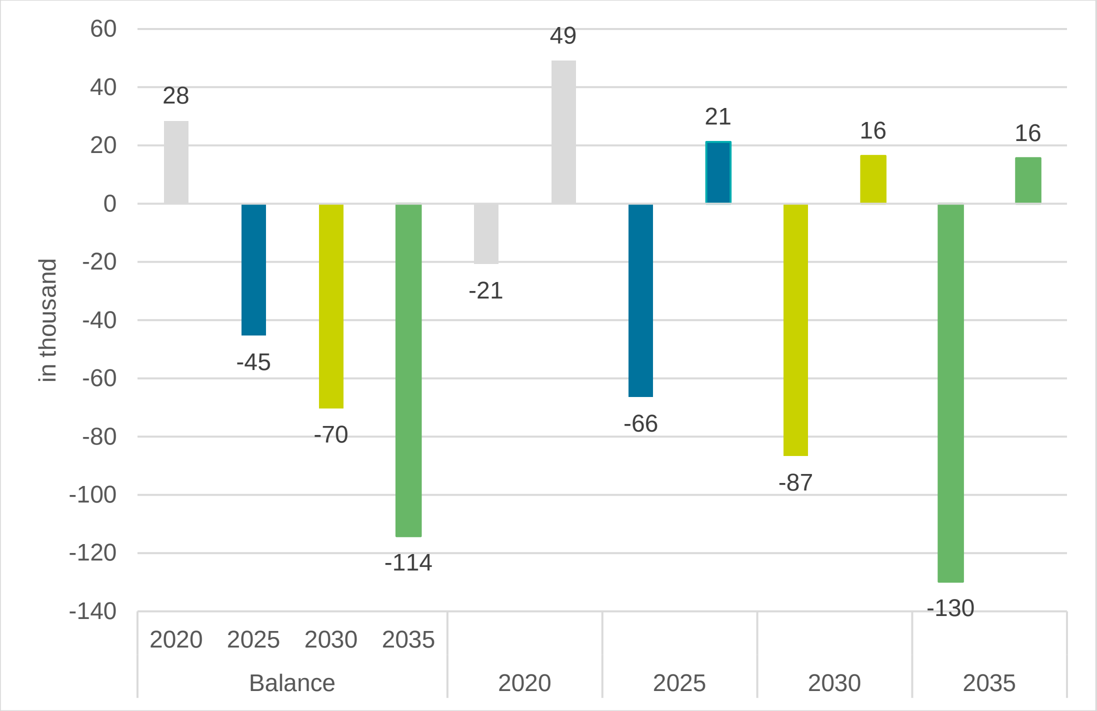


Source: QuBe project

4.3 Total Shift of Employed Persons

The impact of electrified powertrains in passenger cars on the overall level of labour demand is relatively strong, with a loss of 114,000 jobs in 2035.

Figure 31: Balance and number of jobs created and cut in the electromobility scenario vs. the QuBe baseline projection



Source: QuBe project

This is based on job cuts of over 130,000 jobs, 83,000 of which in vehicle construction alone. At the same time, however, 16,000 new jobs will be created in other sectors (cf. Figure 31). The total shift of employed persons resulting from the electrification of powertrains in passenger cars will therefore be almost 150,000 by 2035.

When jobs shift in the grid of 144 occupational groups and 63 economic sectors, this is considered an employment shift. In contrast to Wolter et al. (2016), the four requirement levels have not been used to model the grid. In Wolter et al. (2016), the shift caused by Economy 4.0 rises by 12 percent, because the requirement level is taken into account, namely to the extent that there are shifts between requirement levels without changing the economic sector and the main occupational group. With a corresponding development, a shift of up to 170,000 jobs could be expected in the present study.

In total, the job shift is lower as compared to other disruptive changes such as Economy 4.0 (cf. Wolter et al. 2016: 59ff), since the main loss of jobs takes place in vehicle construction and the compensating effects remain limited by job creation in other sectors. This is likely to turn out differently if other assumptions are made regarding the import demand for electric cars and battery cells.

5 Conclusions

The electrification of powertrains in vehicle construction has already been examined in several studies with regard to its economic growth and employment effects. The results of the studies vary depending on the chosen method and assumptions.

This contribution fits into the more complex previous studies by using a macroeconomic analysis tool and by performing a net analysis of the employment effects. The following aspects, among other things, lead to differences as compared to the comparative studies:

The model can map labour demand not only by sector, but also by occupation and requirement level.

The bottom-up structure allows industry-specific assumptions to be made.

In order to quantify the electrification of powertrains using the scenario technique, a number of assumptions had to be made. Possible assumptions were first collected from the literature and then checked for their implementation in the model.

The remaining assumptions were integrated into the overall system one after the other, building on each other, so that a sequential order of growth and employment effects was possible. Assumptions specifically relating to the supplier industry (diversification, substitution, competition) were only made in a simplistic way (see the Cost Effect 6 – Supply Industry section). In the current structure, the automotive industry as a whole (WZ-29) can be represented well, but no explicit distinction can be made between manufacturers (WZ-29.1) and suppliers (WZ-29.3).

In total, the analysis has shown that while both positive economic growth and employment effects will emerge initially, lower GDP and employment levels must be expected in the long run. While at the beginning, the necessary additional investments of the automotive industry but also the construction investments in the battery charging infrastructure and the re-equipment of the power grids will provide for positive effects, in the long run, the increasing import demand for electric cars and traction battery cells will dominate. With the exception of further education costs, the cost effects will also have a macroeconomic negative impact, but will not be dominant. The positive effect from the change in fuel demand—electricity instead of mineral oil—will soften the negative impulses. The manufacturing-related growth and employment impulses, which will also become important in the long run only, on the one hand, will also soften the mostly import-induced reduction of the economic momentum, but on the other hand contribute to a relatively strong macroeconomic loss of jobs.

On the whole, the technology-driven job losses must be classified as relatively strong. By 2035, almost 114,000 jobs will have been lost due to the transition to electric powertrains in cars. Although they make up only about 0.3 percent of the total workforce, they will increase the number of unemployed by almost 10 percent. The economy as a whole will be faced with a loss of 20 billion euros by 2035. This is about 0.6 percent of the price-adjusted gross domestic product.

A sectoral consideration of the employment effects shows that with a loss of 83,000 jobs, most job cuts are to be expected in vehicle construction. Other industries will suffer as well und will have to cut more than 30,000 jobs. However, 16,000 new jobs will be created, for example in the construction industry, at electric companies, or in parts of the service and manufacturing industry. The total shift of employed persons resulting from the electrification of powertrains in passenger cars will be up to 150,000 by 2035. Skilled employees in particular will be affected by the electrification of powertrains. With a time delay, the demand for experts and expert activities will also decrease. In the long run, there will be negative effects for all levels of requirements.

If we consider that the electromobility scenario “only” assumes a share of 23 percent in electric cars by 2035, it must be assumed that there will be significantly higher economic growth and employment effects in case of a stronger market penetration. However, the assumptions made here regarding the market penetration appear realistic from today's perspective. Import demand is also a decisive factor in the scenario. If Germany were in the position to better supply the market with domestically produced cars and with domestically produced traction battery cells, a positive economic growth and employment effect could be achieved even in the long term.

Even if the number of assumptions made in this scenario is quite comprehensive, additional need for research is required. In particular, this refers to the position of the supplier industry. As mentioned above, the calculation system does not know the difference between OEM (Original Equipment Manufacturer) and Tier-1 suppliers and Tier-2/3 suppliers. The literature expects a considerable shift in the value-added shares due to the electrification of powertrains, especially in the relationship between manufacturers and suppliers. As a consequence, the supplier industry might change its customer portfolio and increasingly enter the energy or medical sector. There is also a high probability that competition will intensify, especially in the supplier sector. New players from other sectors (information and communications technology, battery manufacturers, electrical engineering companies) might become competitors. Such developments are currently not reflected in the electromobility scenario.

Moreover, only pure electric cars are considered in the current scenario. Other drive types such as hybrid or gas have not been considered separately. If the transition to purely electric cars were to take place via the hybrid drive, the job effects would be different in terms of time and absolute dimension. Since hybrid cars have both combustion engines and electric engines, a higher number of components is used. The working time required to build hybrid powertrains is 9.7 hours (AlixPartners 2017).[11] A more detailed differentiation by fuel types would indicate an even more plausible development, but would also increase the necessary data volume. Generally, the impact analysis will expand if other forms of mobility are also included in the analyses (Mergener et al. 2018).

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[11] The required time for the construction of a combustion engine is 6.2 hours according to the Alix study (AlixPartners 2017) and 3.7 hours for an electric engine.

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