REPORT

Country report: Germany

Exchange Group: Just Transition in the European Car Industry

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Alt-Moabit 91
10559 Berlin
+49 (030) 8900068-0
office@adelphi.de
www.adelphi.de

Authors: Daniel Weiss, Lucca Maixner, Lea Mohnen

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List of Abbreviations

AV	Autonomous Vehicle
BEV	Battery Electric Vehicle
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GDP	Gross Domestic Product
ICE	Internal Combustion Engine
ICT	Information Communications Technology
OEM	Original Equipment Manufacturer
NPHEV	Non Plug-In Hybrid Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
R&D	Research & Development
VDA	Verband der Deutschen Automobilindustrie
SME	Small and Medium-sized Enterprise
GDP	Gross Domestic Product

1 Introduction

The German automotive industry has been at the core of Germany industry for decades. The history of German car manufacturing dates back even to the late 19th century, when Carl Benz handed in the first patent for his three-wheel gas engine fired automobile. Especially in the course of the post-war economic resurgence, the car industry gained the reputation as the growth engine of the German economy and has not lost this attribute since. In the last decades, German car manufacturing continued its strong increase in production volumes, from 4.1 million vehicles in 1989 to 5.1 million in 2018 (Grieger, Manfred 2019).

In light of two major trends - digitalization and climate neutrality – the German car manufacturing industry has been increasingly confronted with the need for change. While German car manufacturers for some time proved hesitant on the development of ambitious strategies to transform production capacities towards EV, increased demand and public regulation has increased the pressure on the industry for delivering towards their climate responsibility. Additionally, digitalization impacts both production systems as well as product offerings. Both trends do not only change value creation, but also deeply impact employment and skill demand in various ways. The challenge of the industry is hence not only to maintain economic viability by becoming ecologically sustainable. Politicians, industry representatives, scientists and unions all agree that the transition also needs to roll out in a socially just manner, by ensuring that employment numbers and high quality of employment are maintained.

The following country report assesses the current status of this just transition in the German car industry. To do so, the report provides an overview of the economic relevance of the car manufacturing industry with respect to value creation and employment structure and trends in the most recent years. Additionally, recent trends with respect to EV production and demand, CO_2 emission levels, and current trends in EU and German regulations that impact the German car sector are outlined.

Further, the report assesses how digitalization and electrification shape the German car industry with respect to production systems and demand, but also with respect to employment and skill demand. To provide in-depth insights into the current status of just transition in the industry, a detailed overview of different studies assessing employment effects in the transition is provided, outlining major differences in assumptions and scope that drive significant differences in the study's findings. Building on these findings, the report summarizes different strategies to manage the transition as suggested by research and industry experts. It additionally provides an insight into which strategies are already employed in politics, companies and unions to manage the transformation. Information for the analysis is drawn both from desk research as well as from 8 interviews with company experts.

1.1 Past and present of the automotive sector in Germany

Value creation in the German car industry and German suppliers

Considering overall turnover, the German automotive sector is not only the largest manufacturing sector, but also the largest industrial sector in Germany. In 2021, its turnover slightly exceeded €410 bn, constituting almost 20% of the overall turnover of the manufacturing sector (Statistisches Bundesamt 2022a). Since 2005 the sector has seen a largely steady increase of its turnover. Only the 2008 financial crisis put a serious dent into the

sector's steady growth trajectory, which took two years to overcome. Also, just recently, the Covid-19 pandemic induced a short-term dip in turnover in 2020 which – despite quick recovery in 2021 – has not yet regained pre-pandemic levels.

Also, in terms of gross value added, the German car manufacturing sector significantly contributes to the German GDP. In 2019, the gross value added in the automotive sector amounted to around €102 bn, which represented roughly 3% of Germany's overall GDP in that year (Statistisches Bundesamt 2022c; Statista 2022a). Alongside a strong home market, the German car manufacturing industry also benefits from high market potentials in and outside Europe. In 2019, roughly two thirds of the overall turnover was generated outside of Europe (Janson 2021).

Also, in terms of production sites, most German car manufacturers have long established production sites in all major markets. Only slightly less than a third of the total cars produced by German brands are actually produced in Germany (Puls and Fritsch 2020). At the same time, while other European car producers have increased off-shoring in the past decade, the share of international production of European car manufacturers has almost stagnated since 2005 (Puls und Fritsch 2020).

In addition to the direct value creation from the automotive industry, a range of different sectors are directly or indirectly linked to the automotive sector. Estimations based on input-output data state that almost the same value added as directly created in the automotive industry is additionally generated in companies from other sectors that are linked to the automotive sector. In other words, considering only national demand, roughly 55% of the overall value created due to car manufacturing is directly generated in the automotive sector; the remaining 45% can be attributed to indirect or induced value added in companies linked to the automotive sector. When considering global demand, the contribution of indirect and induced value added is even higher as only 48% of value added due to car manufacturing is directly generated in the automotive sector itself (Puls und Fritsch 2020).

Employment structure

In terms of employment, the car manufacturing sector is of high importance for the German economy. In 2021, roughly 786,000 Germans were employed in the automotive sector, representing 1.7% of all working Germans in that year. Despite this overall high level, total employment in the sector has decreased non-steadily since 2005. While decreasing trends in overall employment between 2005 and 2010 were reversed in the years afterwards, employment started to fall again in 2018. In 2021, employment was almost 6% lower than it was in 2018 (Statistisches Bundesamt 2022a, 2022b).

Similar to the case of value created, in addition to direct employment in the sector, the car manufacturing industry is further responsible for a large number of indirect jobs created. National demand accounts for 313,000 employees in the automotive sector (in 2017). Indirect and induced employment accounts for another 624,000 employees and, thus, for 66.7% of the overall jobs generated. Total employment generated by the German car manufacturing increases to 3.2 million when including global demand. The share of employment directly in the automotive sector is even smaller here. Only 28% of the total employment linked to automotive production is directly in the automotive sector (Puls und Fritsch 2020).

Demand and usage of electric vehicles

The usage of electric vehicles (EVs) in Germany is steadily increasing in relevance. The number of registrations for electric cars has constantly increased over the last decade, with a particularly steep increase the last few years. In 2020, almost 200,000 electric cars were registered, more than in the ten previous years combined (Kraftfahrtsbundesamt 2021). That

number constitutes 6.7% of all newly registered cars in 2020, which is more than three times the share in the previous year. In December 2021, fully electric vehicles constituted 21% of all newly registered cars, with plug-in hybrids making up another 14%. The strong increase in domestic demand for electric vehicle coincides with an increase in governmental subsidies to electric vehicles that was introduced in 2020 as part of the Covid-19 economy support program.

The development of the production of electric vehicles by German car manufacturers saw an even steeper increase than demand numbers. In 2021, 328,000 EVs were produced in Germany. That is an increase of 85.8% over 2020 and 268% over 2019 (Destatis 2022). Exports of EVs are similarly on a rapid growth trajectory. In 2021, roughly 300,000 EVs – 92.4% more than in 2020 and 210.7% more than in 2019 – were exported. Moreover, most German car producers have started to set targets for the electrification of their portfolio, though these often remain rather vague. While some producers have set a date for the electrification of their portfolio, meaning an EV offer in every production segment, others set a goal for achieving a certain share of the turnover through sales of EVs (Grimm and Pfaff 2022).

CO_2 emissions of cars in Germany

The status quo of CO_2 emissions of cars in Germany, as well as their development over the last couple of years is rather ambiguous. While the average CO_2 emissions in grams per kilometre for newly registered cars steadily declined until 2016, this trend was reversed in the years thereafter and the average emissions saw a sharp uptick in the year 2019 (Umweltbundesamt 2022). However, this uptick was primarily due to improved measurement methods in the aftermath of the “Dieselgate” and in 2020, the average CO_2 emissions dropped by 11% compared to the previous year (Statista 2022b). With respect to overall emission levels however, the overall efficiency gains are offset by a classical rebound effect. Between 1995 and 2018, car traffic increased by 14%, leading to an increase of overall CO_2 emissions of German car traffic by 3.7% (Umweltbundesamt 2022).

1.2 Current and future legal regulations

Despite its high economic relevance, but due to increasing environmental pressure and urgency, German public policy has increased the number of regulations and policy incentives schemes targeting the car manufacturing sector in the recent years. Maximum emission thresholds have forced car manufacturers to invest in more efficient combustion engines. Moreover, especially in the most recent years, market incentives for e-mobility have increased, increasing not only the incentive for consumers to buy e-vehicles, but also increasing the pressure on German car manufacturers to cater to this increasing domestic demand.

EU level regulations for cars’ CO_2 emissions are best understood in the context of the EU’s climate neutrality ambitions and the goals and strategies linked to them. These ambitions were most recently laid out in the so-called “European Green Deal”, which explicitly articulates the goal of reaching climate neutrality by 2050. Essential towards reaching this goal is a reduction of greenhouse gas emissions by at least 55% until 2030 compared to 1990 levels (EU Commission 2019).

In light of the key role of the transport sector for achieving these goals, a central element of the European Green Deal is the “Sustainable and Smart Mobility Strategy” by the European Commission. To achieve its aim of cutting transport emissions 90% by 2050 compared to 1990 levels, it details its plan of achieving 30 million zero emission cars in Europe by 2030, and a near complete conversion of all road traffic to zero emission vehicles by 2050 (EU Commission

2020b). A key instrument to achieve these goals is a ban on internal combustion engines (ICEs). While at the time of report writing the EU has not articulated a date to phase out ICEs, efforts are underway to do so. While some individual member states have already passed bans on registering new ICEs by 2030, on EU level, discussions are still ongoing. The “Fit for 55” package by the EU Commission even raises the ambition that all newly registered cars should be emission-free by 2035 (EU Commission 2021). In contrast to the ongoing discussion on ICE bans, binding CO_2 emission caps for newly registered cars have already been put in place on a European level. With the EU fleetwide average emission target for new cars at 95 g CO_2/km (2021 until 2024), European institutions aim for a reduction scenario for CO_2 emissions of new passenger car registrations of 15% by 2025 and 37.5% by 2030, compared to 2021 levels (EU Commission 2020a).

Beyond EU regulations, the German government is trying to actively promote alternative fuels and drive systems through funding tools and tax reductions. Of particular importance with regard to the national e-mobility targets is the federal government’s goal of establishing e-mobility as a key market with at least one million vehicles until 2020 and at least six million until 2030 (Bundesregierung Deutschland 2009). The federal “Klimaschutzprogramm 2030” further raises this goal to seven million electric vehicles in 2030 (Bundesregierung Deutschland 2019). To reach these goals, the federal government has implemented a number of incentive schemes and policy measures, including purchasing incentives through tax incentives and premiums, expansion of the charging infrastructure and an increasing share of electric vehicles in the vehicle fleet of the federal government. The incentives have been extended until 2025 and increased as part of the Covid-19 economic recovery program.

As expanding charging infrastructure has proved to be a key element for increasing the attractiveness of electric vehicles, the expansion of the German charging infrastructure has been shaped by the “Förderrichtlinie Ladeinfrastruktur” (Bundesministerium für Digitales und Verkehr 2022), which provided €300 m for fast and regular charging stations between 2017 and 2020. This program is supposed to be renewed and expanded this summer. There are further federal funding programs with regard to the charging infrastructure aimed at charging private electric vehicles at home and at work, charging commercially used electric vehicles, and supporting cities and municipalities in the context of establishing a charging infrastructure (Wissenschaftliche Dienste - Deutscher Bundestag 2021). Further, to highlight the role of public procurement in providing a good example and in increasing demand, the federal government has stated the goal to increase the portion of electric vehicles in its fleet to 20%.

Beyond these three main elements laid out in the “Regierungsprogramm Elektromobilität”, there are several other measures that have been implemented over the last couple of years or are planned for the near future. These include, among others, the establishment of consistent charging and payment standards, tax incentives for electric vehicles or extended privileges for electric vehicles on the road, such as usage of bus lanes or exclusive parking.
While the federal government does not consider the usage of natural gas as an alternative fuel a long-term key technology towards reaching its CO_2 emission goals, there are measures in place that promote its usage. There are tax reductions for gas as a fuel, as well as lower taxes for the purchase of gas-driven vehicles due to their lower emissions in air pollutants. Additionally, the usage of gas-driven vehicles, as well as the retrofitting of conventional-driven vehicles, is subsidized by the government.

2 Challenges driving the transformation of the car industry

2.1 Climate change and environmental improvements

The acknowledgement of the reality of climate change in the Paris Agreement with a commitment to limit "global warming to well below 2°C and pursuing efforts to limit it to 1.5°C" is emblematic of globally increasing efforts towards a more sustainable and climate friendly planet. Given the large contribution of the transport sector to global emissions, the automotive sector is strongly affected by these developments. In addition to increasing international efforts on global climate change mitigation, a ground-breaking Federal Court of Justice ruling in Germany forced the former German government to further raise its climate ambitions as fixed in the climate law ("Klimaschutzgesetz"). In the renewed climate law as passed in 2021, the overall transport sector has to decrease its emissions by 65% until 2030 (compared to 1990 levels), constituting an increase by 10% points compared to the former legislative. As outlined in the previous chapter, more ambitious emission caps for the automotive sector as well as a number of legal instruments reflect these trends on the EU level and in Germany. At the same time, not only legislators increasingly acknowledge the impending challenges related to climate change and environmental improvements. The industry itself, represented by the Verband der Deutschen Automobilindustrie (VDA), emphasizes the need for a fundamental transformation of the automotive sector (Verband der Automobilindustrie 2021).

Beyond the reduction of CO_2 emissions and the fight against climate change, a nexus of sustainability and health considerations will likely affect the future of mobility in Germany. A variety of immediate health effects are attributed to motorized private transport (IPE Institut für Politikevaluation 2020). Nitrogen oxides and particulate matter, both caused by the automotive sector, have been shown to have adverse health impacts. Beyond these, there is also a growing sensitivity with regard to more abstract health considerations. Schade et al. (2020) detail different pathways for the future of mobility in Germany and emphasize the decisiveness of efforts to achieve "more livable" cities for its inhabitants. Against the backdrop of unbroken trends of urbanization, issues such as the future importance of public transport or the general urban geography and its walkability will be decisive.

Both issues outlined above are associated in particular with ICEs. Their persistently high market shares and the remaining reluctance by certain car brands to resign from alternative-fuel fired combustion engines in the future to this day is proof that previous strategies of increasing efficiency or reducing environmental effects have failed to materialize fundamental environmental and health-related improvements. At the same time, interviews with representatives from the industry all shared the opinion that a fundamental transformation of the automotive sector and mobility as a whole is imperative to overcome the existential challenges. However, there was substantial disagreement with regard to the question of to what extent this transformation is already reflected in strategies and respective legislation.

2.2 Digitalization and electrification

While neither the updated EU emission caps for the automotive sector nor their predecessors explicitly favor a certain drive technology, the last decade was clearly dominated by BEVs. The trend towards BEVs has been shaped by German legislators from the onset. As outlined above, there is already a set of measures in place that subsidize the acquisition and use of electric vehicles. The coalition agreement of the current government has outlined the

ambitious target of 15 million fully electric vehicles in the existing vehicle stock until 2030 (Bundesregierung Deutschland 2021). Again, beyond legislative action, the sector itself is increasingly trying to take initiative and shape the impending transformation. For one, almost all German automotive companies have determined dates for the (partial) electrification of their fleet (Grimm and Pfaff 2022; Köllner 2021). These decisions, however, can be assumed to have been influenced by the trend towards declaring the phase out of ICEs all across the world, particularly in important export markets. Since exiting the EU, Great Britain has moved the end of ICEs from 2040 to 2035. Similarly, China has, for example, established a binding quota requiring producers to sell a certain percentage of electric vehicles (W. Stauffer 2020).

Another important trend is the increasing digitalization of cars. This trend is most notably visible in the fundamentally changing product and service landscape of the automotive industry. Another interesting indicator is the increasing importance of new players in the industry, often times players that were formerly exclusively focused on the information and communication technology (ICT) sector. The most prominent new technologies and services in this context are autonomous and interconnected driving, as well as a variety of digitally accessible, sharing and mobility services (Bormann et al. 2018). While the feasibility, the consumer acceptance or the data protection compliance of these services and technologies is often times highly controversial, the investments in their development are already substantial. Research in this context, as well as interviews with industry representatives consistently conclude German automotive companies to be lagging behind compared to their competitors from Silicon Valley or China (Grimm and Pfaff 2022). A potential reason identified by one of the interviewees was the fact that German automakers are more in the limelight as they are larger and more established, and as a result cannot afford similar mistakes as up and coming competitors.

2.3 Digitalization and automation in production

The Digitalization and automation of production in the automotive sector is commonly associated with large potentials for increasing cost-effectiveness and reducing CO_2 emissions (Dispan, Schwarz-Kocher und Stieler 2021). In particular, Industry 4.0 technologies are assumed to enable cost cutting through reduced development periods, reduced labor demand, higher quality, lower energy demand or higher flexibility (IPE Institut für Politikevaluation 2020). Reducing emissions is becoming increasingly relevant in the context of electric vehicles. While their usage is commonly associated with the avoidance of emissions, their production is characterised by the opposite. Particularly along early stages of the value chain, emissions are high and often times cannot directly be influenced by Original Equipment Manufacturers (OEM) (Grimm and Pfaff 2022). Here again, increasing the share of new production technologies can improve the sustainability of production as well as its efficient monitoring. However, also along the value chain within Germany, the uptake of new production technologies differs substantially. While large OEMs are able to invest in the development and acquisition of new technologies, smaller suppliers often lag behind. An additional obstacle for the uptake of new technologies, particularly for smaller suppliers, is a shortage in the necessary skilled labor, as well as a general lack in experience with digital technologies (IPE Institut für Politikevaluation 2020).

3 Just Transition

3.1 Expected changes in the industrial sector

The challenges and trends described in chapter two – and most notably changing production lines from ICE to EV – significantly change both components and production processes and will hence have a significant impact on employment. Studies analyzing the transformation of the automotive sector draw significantly different answers to the question of whether the transformation will lead to a net-positive effect with respect to employment numbers and quality of employment. Reasons for the differences in projections include differences in assumption, e.g. with respect to ownership shares, but also to what extent not only the automotive industry itself but also linked industries and employment effects are addressed.

To achieve a comprehensive understanding of the expected changes, this chapter compares core findings of different studies. To do so, it places a special focus on their differences with respect to key assumptions and consideration of supplying industries.

One of the most incisive trends in the industry sector is the shift to alternative drive systems. Production costs for these new types of vehicles are currently still higher than those of traditional ICEs. Affecting the margin of profit, this reduces the availability of capital for necessary investments, particularly into R&D, as claimed by industry representatives. (Nationale Plattform Zukunft der Mobilität 2020). This issue has been further aggravated by the Covid-19 crisis and the resulting decrease in demand. However, studies predict that investments, not only in automotive production, but also in the establishment of charging infrastructures or refitting of the power grids, will drive positive effects with respect to GDP for the sector in the medium term (Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO 2018).

In addition, production of EVs is known for assembling fewer components making their production is less labor intensive. A shift from ICE vehicles to EVs hence may risk a sharp drop in employment when only considering production lines themselves. However, the differences between producing ICE vehicles and EVs, and therefore the effects of shifting production from one type to the other, are more nuanced. The Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO (2018) finds a significant employment effect of the ICE to EV shift. However, this effect can be more attributed to adjusted predictions with regard to production quantities or altered production processes than to differences in production itself. Furthermore, such negative effects are found to likely be absorbed by the insourcing of previously outsourced production steps and components (Falck and Czernich 2021). In a similar vein, the Boston Consulting Group and Agora Verkehrswende (2021) find an increase in labor requirements for the shift to EV production. According to their findings, while some production steps may be lost or reduced in their complexity, new ones (e.g. related to battery production, installation or maintenance) can offset these losses. However, in both studies the findings strongly depend on the extent to which the insourcing and maintenance of production in house truly materializes.

A second trend that will yield substantial changes for the sector is the digitalization of cars and their production. Expected changes are heterogenous across sectors. On the one hand, some occupations – especially related to electronics and IT – will gain in importance and employment as a result of strategic and structural adjustments. On the other hand, more manual and lower-skilled tasks are more likely to be substituted by digitization and hence risk experiencing a significant decrease in employment. In particular with respect to work along the assembly line, Digitalization will most likely lead to a significant drop in employment (Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO 2018). The primary cause will

here be the increasing automation of repetitive tasks. In contrast, IT departments will become critical in their importance for automotive companies and see substantially increasing labor forces (Falck and Czernich 2021; Bormann et al. 2018). In particular the latter trend is already becoming visible as automotive companies are scrambling to find suitable candidates for their IT departments. The increasing need for IT specialists is rooted in both the automation and Digitalization of automotive production, as well as the digitalization and networking of cars themselves (Falck and Czernich 2021).

The shift to e-mobility and the increasing digitalization does not only affect the car manufacturing sector itself but also has immediate impacts on suppliers. The most obvious impact from both trends – e-mobility and digitalization – is the need for different components, hence suppliers need to adapt in terms of product portfolio. Additionally, in order to keep employment levels constant, large automotive companies might be sufficiently equipped with capital to insource production steps and thus make previously relevant OEMs obsolete. Similarly, especially large multinational OEMs might be well-placed to shift their production to the new needs of the automotive companies. This is considered, as previously discussed, a key strategy for automotive companies to cushion the negative employment effects of both trends. However, this might come at the expense of SMEs, which are, in Germany, currently often among the world market leaders and are of an accordingly significant economic importance (IPE Institut für Politikevaluation 2019). Implementing a successful transformation to cater to the new needs of the off-takers can be more difficult for smaller companies, due to higher capital limitations and stronger human resource constraints to manage the transformation (ibid.).

3.2 Expected changes in employment

The previous section outlined how central trends as discussed in chapter two will change the production systems of the industry. These will consequently have a direct effect on employment in the sector. Studies that set out to estimate expected changes in employment due to these trends come to heterogenous results. These are rooted in two central elements. First, there is the question of which trends are to be included the analysis. While some researchers focus exclusively on automotive companies and their suppliers, others also include an increasing role for public infrastructure and transport. Second, the predictions with respect to the degree and speed of these transformations in, e.g. the development of EV production, differ. An overview of different studies and their central results and assumption is provided in Table 1.

In summary, across all studies considered, the predictions for the development of employment in the automotive sector range from an overall loss in employment of around 410,000 in the year 2030 (Nationale Plattform Zukunft der Mobilität 2020) to a net gain of roughly 196,000 in 2035 (Schade et al. 2020). Studies that find rather negative outlooks for the development of employment are characterized by a focus on automotive production as well as pessimistic assumptions with regard to the development of market shares for key technologies. Through employing the INFORGE (Interindustry Forecasting Germany) macroeconomic input-output model, Möhring et al. (2018) find a net loss of employment. According to their model, a market penetration of 23% EVs (E-mobility scenario) in 2030 will lead to a loss of 114,000 jobs compared to the model's baseline scenario[1]. To obtain these results, the authors assume comparably high import shares for both EVs, as well as electronic equipment, particularly batteries. In light of recent EU legislation on CO_2 emissions and the German Climate

[1] The base scenario follows an empirically based approach and thus only projects previously observed behaviour into the future, while disregarding any predictions about future behavioural changes.

Protection Program 2030, the assumption of a market share of 23% for EVs in 2030 appears rather conservative as well (Bundesregierung Deutschland 2019).

Table 1 Employment forecast of different studies in comparison

Study	Assumptions	Considered drivers	Employment Forecast
Möhring et al. (2018)	• Constant rate of car ownership • Market share of pure EVs of 23% of all newly registered cars in 2035 • Export share of 75.5% • EV production less labor-intensive than ICE production • Higher productivity gains p.a. for EV over ICE production	+ Initially positive employment effects through high level of investments (e.g. R&D, charging infrastructure, energy grid) – The share of imports to satisfy national demand increases – Need to import battery technology	Reduction in employment by 114,000 until 2035
Nationale Plattform Zukunft der Mobilität (2020)	• Constant rate of car ownership • Market share of pure EVs of 30% of all newly registered cars in 2035 • Export share of 75.5% • EV production less labor intensive than ICE production • Higher productivity gains p.a. for EV over ICE production	+ Initially positive employment effects through high level of investments (e.g. R&D, charging infrastructure, energy grid) – The share of imports to satisfy national demand increases – Need to import battery technology	Reduction in employment by 410,000 until 2030
Falck and Czernich (2021)	• Market share of EVs 35-47% of all newly registered cars in 2030 • Share of employees currently connected to ICE production	– Reduction in ICE production	Reduction in employment by 215.000 - -289.000 until 2030[2]

[2] This effect is substantially reduced when incorporating age related staff turnover.

Bundesministerium für Wirtschaft und Energie (2019)	• Decreasing rate of car ownership • Market share of EVs (BEVs, PHEVs and FCEVs) of 39-49% of all produced cars in 2030 • Export share of 80%	– Higher productivity gains p.a. for EV over ICE production and increasing capital intensity in EV production – Decreasing demand for cars + new jobs through construction of public and private charging infrastructure	Reduction in employment by 100,000 - 150,000 until 2030 (up to 140,000 new jobs could be created in the context of the necessary charging infrastructure for EVs)
Bundesministerium für Wirtschaft und Energie (2019)	• Decreasing rate of car ownership • Market share of EVs of 39-49% in 2030 • Export share of 80% • Depending on the underlying scenario varying assumptions with regard to the development of autonomous driving and the (price) development of mobility services	+ New jobs in the context of mobility-on-demand, mobility-as-a-service, car sharing and public transport – Decreasing employment in the taxi sector	Increase in employment by 80,000 - 130,000 until 2030
BCG and Agora Verkehrswende (2021)	• Market share of EVs 92% (BEVs, PHEVs and NPHEvs) of all newly produced cars in 2030 • Increasing export share	+ Increasing market volume + Digitalization + Distribution of produced cars across different segments + Additional parts in the context of EV production will primarily be produced in Germany – Production of EVs is less labor intensive – Increasing productivity – Migration of jobs to other European countries	Increase in employment by 25,000 until 2030

More ambitious assumptions with regard to the future relevance of EVs are made in a study on the employment effects of increasing EV production by Falck and Czernich (2021), assuming a share of 35 to 47% EVs out of all newly registered cars in 2030. By extrapolating the number of jobs that are currently connected to the production of cars with conventional drives to the scenario with an increased share of EVs in 2030, the study finds a total of 215,000 to 289,000 jobs at risk. This number must be put into perspective, as the study does not analyze the creation of new jobs in the context of increased EV production.

An additional aspect that is considered in the ifo study is the effect of age-related employment turnover. According to the study, around 140,000 jobs will be affected by this turnover until 2030 and thus substantially dampen the negative effects of the shift away from producing conventionally driven cars.

The bleakest outlook on the effect of increased EV production can be found in a study by the National Platform Future of Mobility (2020). Extending the research approach by Möhring et al. (2018) discussed above by a more realistic scenario for EV market penetration (inventory of 10 Million EVs in 2030), they find a potential loss of roughly 410,000 jobs compared to the model's baseline scenario. At the same time, the study again assumes that a fairly low share of EVs and their batteries will be produced domestically.

A study by Hagedorn, Hartmann and Heilert (2019) yields more ambiguous results. Combining different models on production, value creation and employment, the study analyses four scenarios on the future development of electrification and automation in the automotive sector. Compared to employment in 2017, the study finds a gross loss of jobs between 100,000 and 150,000 by 2030. This study, as well as its extension (IPE Institut für Politikevaluation 2020) also find that these losses may be offset and even lead to net employment gains by new jobs created due to the need for increasing e-mobility infrastructure as well as in the mobility services sector. For building the e-mobility infrastructure alone, the study assumes 140,000 new jobs until 2030.

Two further studies predict even more positive employment developments in the automotive sector. The Boston Consulting Group and Agora Verkehrswende (2021) analyze six trends that will influence employment in the automotive sector. These trends include, beyond the shift to EVs, changes in the market volume, productivity gains, and job offshoring. When considering all of these as a whole, BCG and Agora estimate a gain of 25,000 jobs in 2030. Even limiting the focus to the trend of a shift to EVs still results in a net gain in employment by 15,000 jobs. In a similar vein, Schade et al. (2020) comprehensively assess different development scenarios and their effects on the automotive sector itself as well as connected industries. When focusing only on the automotive sector, the study quantifies (on average) a gain of jobs of around 56,000 if a substitution of ICE by EVs is considered as a main trend. However, when looking at scenarios where individual modes of transport are substituted by more shared mobility, employment loss due to a decrease in car production amounts to roughly 139,000. Extending the analysis to the mobility sector as a whole (e.g. including public transport, mobility infrastructure or the production of other modes of production), even in the case of more shared mobility, estimated employment effects are positive.

As the divergences of the discussed study results exemplify, employment effects in the automotive sector will highly depend on the market ramp up of EVs. At the same time, it shows that positive employment effects are more likely when taking a wider perspective on the sector, i.e. when also including employment gains from linked industries, production insourcing and alternative business models (e.g. shared mobility). Further, the most consistent result across all studies is the fact that there will be unparalleled disruptions to the employment structure in the automotive sector. Even if the jobs connected to ICEs that will inevitably be lost can be replaced by new ones, shaping this transition in an employee-friendly manner will require massive retraining and relocation programs.

3.3 Strategies for a Just Transition

3.3.1 Political Strategies: Recommendations from ministries and/or political parties on how to manage the transformation

Relevant political strategies can be classified along two lines. First, there are those strategies that aim at bolstering the continued economic strength of the German automotive sector, particularly industrial policies. Second, another strain of strategies aims at managing the ensuing challenges for employees in the sector, primarily through labor market policies. While a broad range of different strategies exist, the focus in this report is placed on those that are most salient across research papers and in the interviews conducted with industry representatives.

A concrete strategy that has been identified by both researchers and the industry itself is the provision of support for SMEs in managing the transformation. As discussed above, SMEs face a set of specific challenges and will likely struggle in a variety of areas. In contrast to the industry leaders, SMEs often lack the necessary resources, particularly capital, to successfully manage the transformation on their own. Here, one of the most striking issues is a lack of knowledge with regard to the specifics of the transformation in the context of e-mobility (Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO 2018). The issue is often amplified by the SME's size and their distance to OEMs. A potential avenue to tackle SME specific challenges can be an increase in the exchange between SMEs and research institutions or universities. Other support measures for SMEs can include the streamlining of applications for government funding, increased consulting during the application period, and improved access of midrange companies to funding programs (Politikevaluation 2019). Measures aimed at SMEs should have a specific focus on young and innovative companies. In the context of SME support, a study by Herrmann et al. (2020) for the Fraunhofer IAO in collaboration with Volkswagen stresses the importance of assistance with regard to identifying key trends and technologies and the resulting new business segments, which will likely be located outside of the industry or in highly specified niche technologies. According to their study, SMEs will not be able to identify these opportunities on their own, given their insufficient resources. Proposed options to tackle this challenge include the establishment of a transformation fund and a transformation agency to aid SMEs during the transitional period.

As developing new business lines and insourcing production steps have been identified as key determinants for employment gains or losses, a set of strategies directly targets the fostering of innovation and development of future key technologies. There is consensus among researchers that the extent to which key technologies, most importantly battery technology, will be developed and produced in Germany is critical when it comes to securing future jobs. Consequently, researchers emphasize the importance of according measures. Already in 2017, the EU launched the European Battery Alliance which encourages the development and production of batteries for cars with alternative drive systems. The German Federal Ministry of Education and Research (BMBF) is also already supporting battery research through the "Battery research factory" with approximately €500 m until 2022. Despite this already existing policy support, to achieve the goal of increasing European battery production, Schade et al. (2020) argue that additional funding along all steps of the value chain, particularly when it comes to R&D, is necessary. Establishing such an industry will then not only create jobs in the production and development of batteries, but along all steps of the value chain. Furthermore, the according measures should not be limited to battery production, but should also address other new technologies, such as the production of semiconductors and sensors for driver assistance systems or the development of related software. This strategy is supported by other researchers. The Institut für Politikevaluation (2019) emphasizes the future significance of battery technology with regard to shares of value added

and the possible spill over effects of the technology for other sectors and the necessity to foster the technology in Germany. As a specific instrument, they propose the continuation of the "Battery research factory" and the linked R&D funding. Additionally, funding should be moderate and selectively distributed along the whole value chain of battery development and production and focus on those stages of value creation that are currently underdeveloped. A focus only on production of batteries and excessive funding should be avoided in light of the uncertainties with regard to the future of batteries.

A strategy that can neither be limited to a singular actor, nor one of the two types of strategies mentioned above, is that of increasing dialogue between the relevant stakeholders. The Fraunhofer IAO (2018) highlights the potential value of intensified and new forms of dialogue. Instead of continuing existing routines, dialogue should be “both genuine and open” and rather than being abstract, be “directed towards action plans”. Bormann et al. (2018) further specify these ideas. In their opinion, increased dialogue between politics, the industry and special interest groups is essential in identifying the earlier discussed knowledge gaps and barriers for funding and support. A best practice example that is based on these ideas is the “Strategy dialogue automotive industry Baden-Württemberg”. Here, platforms for meaningful exchange between industry representatives and state legislators are provided in order to discuss both concrete issues as well as potential solutions. A different necessity will be new forms of inter-company cooperation to accommodate the increasing differentiation of value chains and the introduction of new, highly specialized technologies. An area where increased communication is also greatly needed is between municipalities and providers of new forms of mobility services and public transport (IPE Institut für Politikevaluation 2020). Particularly, municipalities need more information about available services to profit from existing possibilities. At the same time, the respective companies profit through acquainting themselves with local rules and regulations.

A final industrial strategy focuses on Germany’s digital infrastructure and the Digitalization of the industry. As pointed out in chapter two, automation and Digitalization of mobility and automotive production will result in substantial new requirements for the digital infrastructure. In order to address these challenges, researchers have proposed a variety of different measures. One of the most important measures concerns the general extension of the digital infrastructure to geographical areas that have been neglected thus far (Schade et al. 2020). A nation-wide fast and up-to-date digital infrastructure is a fundamental requirement for virtually all digital business models in the mobility sector. Furthermore, the increasing concentration of data services providers gives rise to the need for a unified framework ensuring of data protection requirements. New digital business models will also require a legal and organizational environment that allows for the development and testing of new technologies (IPE Institut für Politikevaluation 2019). This includes both the continued funding of related R&D and the identification of promising business models and their specific support.

Restructuring education, academia and apprenticeships is clearly a labor market strategy, but can, nonetheless, benefit both the economic strength of the automotive sector as well as an employee-friendly transformation of the industry. The Fraunhofer IAO (2018) identified the expansion of apprenticeships in the electronic and IT sectors and of study programs with a focus on e-mobility as essential to secure the supply of qualified employees. Such a supply is essential in securing a realistic pathway towards keeping significant share of value added in Germany. Another contributing factor is a reorientation of study material within high schools and the emphasis that is put on e-mobility aspects in the context of job orientation programs. Schade et al. (2020) similarly stress the increasing demand for engineers and high skilled works in the e-mobility and digital sector. Adjustments to study programs would need to be made right now, to ensure sufficient supply in accordingly qualified workers in five to seven years from now. Finally, the studies by IPE (2019) and Falck, Czernich and Koenen (2021) underline the importance of training and retraining efforts at all stages of the working life.

As also outlined in chapter two, the German government has increased its support programs to manage the transition in the recent years. In addition to support programs targeting the demand for EVs or financing investments into new production systems or R&D, governmental programs also provide support for strategy development by financing the development of transformation strategies for both companies as well as stakeholder networks. In the interview, it was claimed financial support for the transition is currently not a major challenge in the transition and has been increasing in the past years. However, even though particular support programs for SMEs exists, access to these funds is perceived as challenging due to limited human resources and high administrative demand of applying for SME.

Further, over the past years, politics has increased its support to the development of diverse platforms and exchange formats in which stakeholders from different parts of the supply chain and interest groups come together to develop joint transformation strategies. Some of these new exchange formats are also in particular focused on changing employment demands, national platform mobility, regional qualification networks, and skilled-labor alliances. Some of these networks target SMEs in particular to address their specific needs and different capacities. Two noticeable outcomes in this respect are the support to regional qualification networks, where SMEs can target qualification demands jointly, as well as the development of a planning tool targeted to improve long-term human resource and skill planning in particular in SMEs. With a significant number of new support programs, networks, and alliances being introduced recently, some interview partners saw a challenge in communication between these networks as well as efficiency and oversight.

3.3.2 Entrepreneurial strategies: Which new products can or are already being switched to by automotive companies and suppliers

All of the aforementioned strategies require an active engagement of the industry itself. Hence, unsurprisingly, recommendations for companies on transformation support strategies also target increased network formation and large-scale engagement into reskilling.

At the same time, several research institutions and consulting firms outline how these reskilling programs should be designed and implemented. A study by the Boston Consulting Group and Agora Verkehrswende (2021) argues that an analysis of the status quo with regard to the expected changes in production, operations and job profiles is decisive in realizing employment potentials. Retraining and upskilling programs must also be based on a clear roadmap with regard to the future training and hiring needs, as well as bolstered by efforts to increase the willingness to participate in such programs among employees (Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO 2018). New and innovative retraining and apprenticeship programs are also identified as another way to satisfy future qualification requirements (Herrmann et al. 2020). These should include intra- as well as inter-company cooperation, but also new ways of interdisciplinary learning. McKinsey and Company (2019) emphasizes the previous success of the “dense network of universities, dual-system education, apprenticeship as well as professional development opportunities” in producing a highly qualified and acclaimed workforce. These structures should be built upon, but they must shift from “a mechanical and automotive engineering focus to a software and mobility engineering focus”.

In the context of transformed value-added structures and new business models, recommendations on business strategies go well beyond merely fostering future key technologies. McKinsey (2019) describes the need for a customer-centric philosophy, rather than a technology focused approach. Likewise, companies must adjust to the shift towards new profit pools. The larger trends away from the mere sale of vehicles towards mobility services, data-driven services, as well as autonomous and electrified vehicles must be reflected in companies’ strategies. For instance, modelling developments in the automotive sector, McKinsey (2019) identify an increase of the revenue share of “data-enabled services

and shared mobility" from 0.2% in 2019 to 27% in 2030. Similarly, intensifying their R&D for new technologies, such as batteries, software and hardware technologies is identified as a key company strategy (Herrmann et al. 2020). In this context, a study by Neuhausen et al. (2020) recommends a reduction of variants for powertrains to enable a concentration of efforts and resources in powertrain development. To ensure profitability, particularly during the Covid-19 pandemic, OEMs should focus on "cost-optimized powertrain platforms and a customer-oriented powertrain portfolio".

Another set of strategies where ownership of the industry is imperative is that of increased cooperation and dialogue. While politics can provide platforms for and stimulate interaction between the industry and legislators, inter-company cooperation is also indispensable. Herrmann et al. (2020) describe the potential for regional competence centers, each one of which considers the locally available competences and resources. To test new business models and innovations, companies should jointly establish innovation workshops and incubators. These could not only facilitate the research and development of new technologies, but also attract talented junior staff, for whom new structures of work become increasingly important. Strong collaboration between the industry's major players is perceived as key to develop new services and technologies, but also when deepening the supply chain (McKinsey 2019). Along the example of the development of autonomous vehicles (AV), cooperation is identified as particularly beneficial along the non-differentiating layers of AV technology, where big databases can improve the development process and where economies of scale can help save costs.

In particular larger OEMS and suppliers have already embarqued on implementing these strategies. First, they have increased communication internally and externally, by means of participation in exchange formats, but also by increasing communication on transition goals to customers and investors. Further, in addition to governmentally supported programs for re-skilling, companies themselves are aware of the upcoming labor changes and invest significant own funds in the reskilling of workers. One interview partner suggested that an overall loss of jobs in the industry is not a primary concern of the industry in Germany, as – on the contrary – a lack of skilled labor due to demographic change is perceived as an important challenge. However, companies are well aware of the fact that certain skillsets become more important but hard to find on the labor market and hence invest into own qualification programs. Additionally, interviews suggested that while inter- and intra- industry exchange has increased within Germany, suppliers from Eastern Europe are rarely considered in these exchange formats.

Further, many German OEMs have already announced strategies and increased investments in the development of new products and services. Most prominent examples are the provision of mobility services or the usage of vehicle batteries as energy storage devices. Interviews suggest that also suppliers start looking into the provision of components for other mobility segments such as bicycles or rail infrastructure. At the same time, concern is raised that many of these new ideas face challenges in becoming profitable and are hence quickly dropped again. With respect to the insourcing of the supply chain, a strong focus is currently placed on battery production, in with most large OEMs have now declared significant investments.

3.3.3 Trade union strategies: What do the unions propose in face of the upcoming changes

Interviews with union representatives revealed that the arguably outdated conflict line "climate versus jobs" is still present in the mindset of union members. However, recent union publications signify the growing realization that employment fundamentally depends on the extent to which the transformation towards more sustainable business models is actively managed and embraced.

The German Trade Union Confederation (Deutscher Gewerkschaftsbund 2018) articulates its expectations for a socially responsible transformation in its paper “Climate, Energy, Mobility - Shaping change equitably”. A key towards a “just transition” is seen in efforts to preserve high shares of value-added processes in Germany. Consequently, a number of the concrete measures that are described in the paper are in line with the strategies discussed in the previous two chapters. Those include investments in innovation, public and digital infrastructure, as well as new forms of cooperation. The importance of new platforms for cooperation between companies and politics was also emphasized in the interviews that we conducted. The ultimate goal of the unified engagement of all relevant stakeholders should then be a wholistic approach to the future of mobility. A clear outlook would ensure planning certainty for companies and would enable unions to identify challenges to employment and necessary training and retraining efforts.

Several major unions in Germany and a number of environmental and social organizations have joined forces in the “Alliance for Socially Responsible Mobility Transition” (2021). This alliance describes a clear vision for the mobility of the future and points out concrete actions that should be taken to achieve it. The most important aspect in the context of this report is the discussion of the future of the automotive sector. Again, a majority of the discussed measures are aimed at the continuous economic strength of the automotive sector and, thus, to some extent mirror the strategies discussed before. However, they also include a number of measures to achieve what they define as “good work”. According to the Alliance, “good work” includes, among others, secure employment with fair salaries, as well as healthy working conditions and scope for development. Essential in realizing this vision is a high quality for newly emerging jobs (e.g. in mobility services), including collective bargaining agreements and improved wage levels, but also the already mentioned training and retraining programs, which should be complemented by governmental support where part-time working models will be necessary. Avoiding precarious employment is, according to the Alliance, not only in the interest of the employees, but also benefits the overall economy through taxes.

A study by the German union IG Metall (IG Metall Bezirk Berlin-Brandenburg-Sachsen 2019) analyzed the conversion opportunities of employees for the impending transformation. Their findings are based on interviews with industry representatives and employees in Berlin, Brandenburg and Saxony. The authors point out the positive effects of existing measures such as the “Qualification Opportunities Act” and the adjustment of the short-time allowance into a transformation short-time allowance. However, they also denounce the heterogenous distribution of these positive effects. Particularly, low-skilled workers are not profiting to the same extent as high-skilled workers. On the contrary, they argue that opportunities and support for low-skilled workers are in fact shrinking. They also describe the fact that the transformation of the automotive sector is still widely associated with negative feelings among employees. To counter these developments, companies must communicate openly and honestly with them. Combining such ways of communication with jobs that adhere to the above described image of “good work” can help employees to see the transformation and the associated new ways of work as an opportunity rather than a threat.

4 Conclusion

The German Economy has been characterized by a strong car manufacturing industry for more than a century. Two major trends are shaping the current strategic developments and will be fundamentally shaping the industry in the upcoming years. At the same time, strategic decisions of German car manufacturers and OEMs deeply impact not only linked industries within German, but also suppliers in other European countries. In 2021, the industry itself accounted for almost 20% of the gross value added in the manufacturing sector and 1.7% of the total German employment. Further, recent estimates suggest that about the same volume of gross value added and double the amount of jobs are additionally directly linked to or induced by the automobile sector. Despite the long history of car production and its worldwide image as a technological lead, German car manufacturers for many years have acted rather reluctant with respect to a decisive and ambitious transformation towards e-mobility, as many industry representatives strongly advocated hybrid vehicles as well as combustion engines running on alternative fuels. However, production levels of EVs by German car manufacturers have strongly increased in the past three years and almost all German car manufacturers have now announced strategic goals on e-mobility. While these strategic goals differ in terms of scope and ambition level, they nevertheless exemplify that the German car industry has started a stronger shift towards e-mobility. This trend is supported by a number of new German and EU policy targets and regulations. In Germany, emission regulations, market incentives for EVs (purchasing premiums and public procurement), as well as investments into e-mobility infrastructure are among the most important policy instruments to increase production and demand of e-mobility.

At the same time, increased production in EVs will have a strong impact of the structure of the industry, as production lines and components change as well as labor and skill demand. Additionally, increased digitization both of production lines and products place additional transformation demands on the sector. Overall, most studies agree, that both trends will lead to a significant change in the employment structure in the industries. While certain labor tasks along the production line will be replaced by digitization and reduced vehicle complexity, other skill sets in particular in the area of digital services and engineering will become more important. Additionally, new jobs will be created in newly emerging business segments of the mobility sector for example shared mobility services, public transport and EV infrastructure.

This report analyses the strategies advocated by scientists as well as those chosen by companies, politics and unions to manage these significant challenges the industry sector faces. In summary, these strategies can be structured along three lines: diversifying product offering through insourcing production steps or developing new products and services, increased communication, and networking as well as reskilling. Both companies and politics have started to increase their engagement in all three strategies in the recent years. From the governmental side, increased financial support programs are complemented with the financing of the development of transformation strategies as well as the formation of transformation clusters and exchange networks. These programs are taken up by companies who also invest own means in product development and reskilling. With some of these initiatives being fairly new, interview partners claimed that it remains too early to judge on the effectiveness of these measure in shaping the transformation. At the same time, while consensus exists on the need for reskilling, networking and diversifying, divergent perspectives on how these strategies should be implemented remain, and both interest groups and scientific papers provide additional recommendations on how strategies are to be implemented. Additionally, findings from this report suggest that current measures in Germany for a just transition in Germany rarely incorporate the perspective of Eastern European suppliers.

In summary, while different stakeholders in the German car manufacturing industry share a common picture on what has to be done to ensure a just transition, there are still multiple approaches and opinions on the question of how.

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Interview with Kai Bliesener, representative IG Metall Baden-Württemberg (now:), 15.01.2021.

Interview with Dr. Sabine Stützle-Leinmüller, head of business unit kkilled workers business development region Stuttgart, 19.01.2021

Interview with Alexander Reizenstein, automotive expert Third Generation Environmentalism Ltd (E3G), 18.01.2021

Interview with Dr. Martina Gikadi, Unit IVA5 - vehicle industry, automated and connected driving at the German Federal Ministry for Economic Affairs and Climate Protection, 19.11.2021

Interview with Dr. Susanne Gewinnus, head of unit industrial and research policy - Deutsche Industrie und Handelskammer, 29.11.2021

Interview with Martha Selwyn, automotive expert at United Nations Global Compact, 12.10.2021

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