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Decarbonisation in Crisis: Conditions and Trends in the (Ecological) Transformation of the German Automotive and Steel Industry

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Abstract: European key industries such as the automotive and steel sector have been subject to intense transformation pressure for some time. Intensified international competition and more active industrial policy intervention by national governments and the European Commission are driving process and product innovations with far-reaching consequences, among them significant implications for employment conditions. Alongside digitalisation, decarbonisation constitutes a central development trend. In the automotive industry, this is manifesting primarily as a transition to electric mobility, while parts of steel production are in the process of switching from the emission-intensive blast furnace route to direct reduction of iron ore, ideally using green hydrogen. Both developments are contested and have recently been superimposed by militarisation and a fossil rollback. This working paper analyses the conditions and trends of decarbonisation processes in both industries. It identifies workplace conflicts, workers' subjectivities, and the impact of overarching social and international developments on industrial decarbonisation as an important research desideratum.

JEL Codes: J5, L5, P1

Keywords: Decarbonisation, Digitalisation, Geopolitics, Automotive Industry, Steel Industry

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1. Introduction

The escalation of the ecological crisis and its serious consequences for the material foundation of life in all societies make the decarbonisation of industrial production one of the key challenges of our time. In Europe, this particularly affects German industry, which produces by far the largest share of greenhouse gas emissions within the EU (European Parliament 2025). However, the dynamics of industrial decarbonisation are subject to significant political shifts: at the start of the 2020s, the decarbonisation of industrial production in Germany appeared to be under way, and a strategy of ecological modernisation of European and German capitalism was emerging. In response to the Paris Climate Agreement and the growing climate movement, climate protection targets became more ambitious and decarbonisation plans were extended from the energy sector to industrial production. The economic stagnation that persisted during the Covid pandemic also increased interests by tapping into new fields of accumulation through increased competitiveness in 'green' future markets (Haas and Jürgens 2021). Renewable energy appeared to be on the rise; the expansion of hydrogen infrastructure was strongly promoted; in the German automotive sector the share of electric cars grew; and in the steel sector, pilot plants for converting blast furnaces to lower-emission direct reduction plants were being tested. At both the EU level and within German economic policy, the reduction of industrial carbon emissions was supported through regulatory measures as well as through financial support for expanding renewable energy, developing carbon reduction technologies, and advancing decarbonisation. A trend toward a new capitalist formation, a ‘green capitalism’, was emerging (Brand & Wissen 2024; Brand et al. 2024: 152ff.; Köncke 2025).

However, this transition has always been contested. The history of energy shows that renewable energy has tended to complement fossil fuels rather than replace them (Fressoz 2024). Although interests related to fossil fuel were at times on the defensive, they by no means disappeared. More recently, fossil capital has regained strength, and the strategy of state-subsidised ecological modernisation has come under considerable pressure due to changes in the broader economic and (geo)political climate (Zeller 2023). Since then, the conditions of industrial decarbonisation have been subject to crisis dynamics and upheavals that are as profound as they are complex. The outcome remains to be seen. Various internal societal and global shifts are overlapping: alongside the intensification of the ecological crisis, a shift in the global division

of labour linked to the rise of China, and an intensification of global competition and economic crisis dynamics represent key developments. A further dynamic is the crisis-ridden shift in the international balance of power and the international order, the rise of authoritarian and explicitly right-wing political formations, and an escalation of geopolitical conflicts with military conflicts occurring in closer geographic proximity to the societies of the capitalist core. The interweaving of these various crisis dynamics - a central thesis of our paper - exerts a cascading influence on society's response to the ecological crisis and, specifically, on the project of decarbonising the energy and industrial sector.

However, little research has yet been conducted into how these global and intra-societal crisis dynamics and upheavals are reflected in the field of ecological transformation and in strategies for industrial decarbonisation. While a whole series of studies examined the starting point of industrial transformation against the backdrop of changing climate policy regulation (Bendel and Haipeter 2022; Blöcker 2022a, 2022b; Lehndorff 2022; Witt 2022), the consequences of the crisis dynamics and upheavals unfolding since 2022 for industrial transformation have thus far received only sporadic scholarly attention (Babić and Mertens 2025; Urban 2025). Our contribution aims to analyse the changing conditions for the industrial decarbonisation of key sectors in German industry, to identify shifts in central contextual factors that influence how the contradictions of the socio-ecological crisis are addressed, and to explore the implications for the dynamics of industrial decarbonization. At the same time, we examine developments in two sectors that are crucial to the German regime of accumulation and are under considerable pressure to decarbonise: the steel and automotive industries. We analyse how the multiple crisis, geo-economic competition, anti-fossil fuel movements and changing government strategies are affecting decarbonisation in the automotive and steel industries. To this end, we identify the enabling and constraining forces of decarbonisation and investigate how these influence developments in the sectors under pressure to decarbonise.

The paper is structured as follows: Chapter 2 first outlines the contextual conditions of current industrial transformation processes. The focus is on intensified geo-economic competition, e.g., dynamics of digitalisation, increasing geopolitical and 'eco-imperial tensions' (Brand/Wissen 2024), and the 'state-interventionist' (Bieling 2024) strategies to support industrial decarbonisation as well as their contestation. In this chapter, we identify the contradictory trends that shape industrial decarbonisation today. Chapters 3 and 4 then examine how these overarching dynamics influence decarbonisation processes in two key sectors, the German automotive and steel industry. To this end, we analyse the changing sector-specific conditions, the regulatory environment and corporate strategies that influence decarbonisation pathways,

as well as the consequences this has for production, work and employment. Chapter 3 focuses on the automotive industry, where decarbonisation is primarily taking the form of *product decarbonisation*, i.e. the transition from the internal combustion engine to electric propulsion. Chapter 4 focuses on the steel industry, where *process decarbonisation* is taking place through the shift from blast furnaces to a combination of electric arc furnaces and direct reduction using (green) hydrogen and natural gas. Unlike in the automotive industry, the end product does not change here. Finally, Chapter 5 brings together the open questions arising from these analyses and develops a research agenda. This lies in combining a macro-analysis of the framework conditions of industrial decarbonisation with the analysis of the micro-political and workplace-based foundation for social science research on decarbonisation. Building on Michael Burawoy, we propose to focus further research on the processes in which societal and political decarbonisation targets as well as negotiations between company management, works councils and factory workers are translated into a new factory regime, a 'decarbonisation regime'.

2. Turbulent times: the changing conditions for ecological transformation

The ecological transformation of German industry is taking place in turbulent times. The political course set towards a strategy of ecological modernisation, which emerged in Germany and Europe over the last decade, has shifted significantly over the past few years due to changes in the social and economic context. In the following, we outline these crisis-induced shifts in key contextual factors for the ecological transformation of German industry, focusing on both global and domestic social dynamics.

Ecological modernisation as crisis strategy

Over the last decade, a partial readjustment in the development model of the German and European economies towards ecological modernisation began to emerge. Parts of the political elites in the EU, the US and the People's Republic of China were driving forward projects of 'green capitalism' (see, for example, Köncke 2025; Brand et al. 2024, p. 152ff.). Within Germany and the EU, initiatives aimed at establishing green capitalist strategies gained momentum between 2015 and 2021. This development was a response to the 2015 UN Climate Change Conference in Paris, which envisaged limiting global warming to below 1.5 degrees Celsius compared to the pre-industrial average. It was also a response to the mobilisation successes of the climate movement, which were reflected institutionally in a rise in support for green parties in the 2019 European Parliament elections. At the end of 2019, the newly formed

European Commission under Ursula von der Leyen presented the *European Green Deal* (EGD) (European Commission 2021a). With the EGD, the EU announced the goal of becoming 'climate-neutral' by 2050, meaning it should reduce its net greenhouse gas emissions to zero. In 2021, a comprehensive package of measures to implement the EGD followed under the title *'Fit for 55'* (European Commission 2021b). Among other things, it provides for measures to decarbonise the energy sector and industrial production. In Germany, the Climate Protection Act (later repealed) defined sectoral targets for a significant reduction in greenhouse gas emissions. By 2030, these were to be reduced by 65 per cent; for the entire industrial sector, this represents a reduction of 68 million tonnes of CO2 (Witt 2022). The changes to climate and environmental legislation significantly increased the pressure on German industry to decarbonise energy use and production processes. At the same time, the German government pledged substantial funding to promote sustainable technologies, particularly in the field of decarbonising industrial processes (Federal Ministry for Economic Affairs and Climate Action 2020).

The background of this development was not only the ever-worsening ecological crisis, which was attracting increasing public attention within Germany and the EU in the face of a growing climate movement and recurring extreme weather events, such as the 2021 floods in the Ahr Valley in Germany or the wildfires in southern Europe. Economic contradictions and crisis dynamics within the EU and Germany also constituted key driving forces behind the shift towards ecological modernisation. The economic crisis tendencies in the market-liberal mode of development, which had become glaringly apparent with the outbreak of the global financial and economic crisis in 2008, were contained but not overcome through austerity policies in the years that followed (Demirović and Sablowski 2012). On the contrary, the austerity-driven response to the Euro Crisis from 2010 to 2015 gave rise to new economic crisis tendencies (Sablowski et al. 2022, p. 242ff.). The crisis dynamics within European capitalism were subsequently exacerbated by growing international competition for key German and European industries, particularly from emerging economies in the semi-periphery, led by China. The increasing international competition on global markets was closely linked to the geoeconomic escalation of the competition between the US, the EU and China, especially with the intensification of tensions between the US and China under the first Trump administration (Hopewell 2021; Scherrer 2021; Simon 2025; Bieling 2019). Finally, the economic consequences of the Covid-19 pandemic, such as disrupted trade routes and supply chains, further dampened the dynamics of accumulation and exacerbated recessionary trends in Europe,

particularly in Germany's export-oriented industry (Herr et al. 2023; Das et al. 2022; Ryner 2023).

During this phase, German and European economic policy responded to the triad of environmental crisis, economic crisis dynamics and geo-economic tensions with comprehensive support and stimulus programmes, as well as an increasingly visible industrial policy. In the face of growing international competition, this policy strategy aimed at securing technological leadership and competitiveness in new 'green markets'. At the heart of this was a growth strategy that was underpinned by massive financial support for strategic industrial sectors, such as hydrogen or battery cell production, and linked to the decarbonisation of the energy, industrial and mobility sectors.

Automation and digitalisation

The implementation of political decarbonisation requirements in industrial production and particularly in large enterprises is linked to the trend towards automation and digitalisation. However, the relevance of digitalisation and automation varies by sector. In 2019, the automotive, machinery and electronics industries were considered as highly digitalised and automated. The basic materials industry, which also includes the steel production and processing sector, ranked fifth among the most digitised and automated sectors (Demary et al. 2021, 34ff). In recent years, digitalisation and automation – partly in response to growing international competition and the hope of cost savings and productivity gains – have also been further developed in the areas of production and logistics process control, as well as networking with suppliers, subsidiaries and customers (Blöcker 2022a, 13ff, 2022b, p. 14; Krzywdzinski 2021). Furthermore, data stemming from processes of industrial production is increasingly being treated as intangible assets (Schneidemesser and Butollo 2025).

Steel production and the automotive sector are among the sectors where digitalisation and decarbonisation are closely intertwined (Blöcker 2022a, 13f, 2022b, p. 14). However, digitalisation and automation can also come into conflict with decarbonisation. For instance, digitalisation significantly increases electricity consumption due to greater server requirements and data transfer (Demary et al. 2021, p. 160; Bitkom 2024, 85ff). At the same time, these two trends are closely related, particularly in the technical restructuring of production facilities. Here, on the one hand, digitalisation of energy and resource use focuses on optimisation and efficiency gains. On the other hand, new production facilities geared towards reducing emissions – such as battery cell production in the field of e-mobility, or direct reduction

facilities for steel production – are based on highly automated and digitalised technologies. With regard to electric mobility, product digitalisation is also inextricably linked to product decarbonisation. Furthermore, companies in the steel and automotive industries are using digitally supported strategies to optimise *lean production* tailored to customer requirements (Blöcker 2022a, 13f, 2022b, p. 14; Demary et al. 2021, p. 160; Krzywdzinski 2021; Bitkom 2024; Fraunhofer ISI 2017). The interplay between the dynamics of digitalisation and decarbonisation is discussed under the banner of the 'twin transition' as one of the key trends in industrial change and the EU links both trends to the growth potential of a green, digitalised industry (European Commission 2022; Muench et al. 2022; Prinz et al. 2025; Wannöffel et al. 2024).

In line with the imperative of growth, economic and ecological crises thus continued to be addressed primarily through market-based approaches (Brand et al. 2024, p. 159; Sablowski et al. 2022, p. 237ff.). At the same time, the EU relaxed the dogma of austerity policy at least partially in favour of strategic industrial policy that aimed both at greater European autonomy and industrial decarbonisation (see also Abels and Bieling 2022; Eder and Schneider 2018). Although highly contested, the decade between the global financial crisis and the easing of the COVID-19 pandemic thus saw the emergence of strategies for ecological modernisation and trends towards the establishment of 'green capitalism'.

Global tensions and the fossil backlash

In recent years, trends towards 'green capitalism' have increasingly been overshadowed or even counteracted by geo-economic and geopolitical conflicts, as well as by shifts in the balance of power within societies. This development has been exacerbated by the Russian war of aggression against Ukraine, which has been ongoing since 2022. Since then, the patterns of regulation and stabilisation of global capitalism appear to have been further destabilised:

Firstly, the global division of labour and global competition are undergoing constant change. A key element of this dynamic is the growing importance of semi-peripheral economies. They account for an increasing share of global gross domestic product. Supported by state-capitalist development strategies, countries such as India and, in particular, China are increasingly gaining importance in economic sectors that were traditionally central to accumulation strategies of the capitalist centres, such as the automotive sector, mechanical engineering or high technology (Schmalz 2018; Simon 2026). This spatial shift in the dynamics of accumulation is leading to intensified price competition on global markets, shrinking global

market shares for European companies, and even to outright sales crises and deindustrialisation trends in key sectors of European economies (PwC 2022). In the automotive sector, for example, exports by European manufacturers are falling sharply, whilst Chinese manufacturers are gaining significant market share. This is particularly true in the field of electric vehicles, where Chinese car manufacturers have risen to become technology leaders (Eurostat 2025; Winton 2025).

In this context, *secondly*, geo-economic and geopolitical conflicts are on the rise, also beyond the US-China-EU triad (Bundestag 2020). Intensified geo-economic competition for affordable energy and key raw materials is coupled with increasing geopolitical and military confrontations. These often mirror 'eco-imperial tensions' sparked by access to the raw materials required for ecological modernisation (Brand and Wissen 2024). In addition to the growing threat of war, the increasingly conflictual nature of geopolitics has manifold consequences. On the one hand, it intensifies international competition and the dynamics of economic crises, particularly in export-dependent economies such as Germany. The abrupt halt to imports of Russian natural gas following Russia's war against Ukraine, for example, contributed to a sharp rise in energy prices, higher inflation and recession in 2023 and 2024. On the other hand, in conjunction with this more conflict-ridden geopolitical phase, a reorganisation of the modus operandi of globalisation can be observed, e.g., in the form of a spatial restructuring of production networks in the high-tech sector, or trends towards deglobalisation in areas of the economy relevant to security policy (Chase-Dunn et al. 2023; Schindler et al. 2024; Schmalz 2022). Finally, the increasing geo-economic and geopolitical conflicts are further fuelling dynamics of militarisation within Europe and Germany, a trend that was already emerging before. This trend toward militarisation is evident, among other things, in a massive increase in defence spending and in the adaptation of physical and social infrastructure for military purposes (Wagner 2025).

Thirdly, the shifting competitive dynamics and increasingly conflictual geopolitical and geo-economic relations are having an impact on the mode of regulation of global capitalism, on the previously hegemonic world economic order, and on the balance of political power – both internationally and within nation states. At the global level, key pillars of market-liberal regulation, such as the WTO regime, are increasingly being undermined. The global economic order has become more contested, and trends towards fragmentation are emerging (Simon 2025; Scherrer 2025; Hopewell 2024). In many EU countries, these developments are fuelling debates on how to address the changing international political and economic conditions (Sablowski et al. 2022). In this process, the market-liberal orientation of economic policy is changing, at least

in part, as is evident in new technology and industrial policy strategies (Schneider and Syrovatka 2024; Schneider 2023; Bieling 2024; Abels and Bieling 2023). Thus, whilst the EU essentially adheres to a market-liberal globalisation strategy, it supplements this with more direct state intervention in strategically important fields. Examples include stricter controls and restrictions on foreign direct investment, such as in the case of Chinese involvement in the Port of Hamburg, or the massive financial support for key technologies and infrastructure through the *Important Projects of Common European Interest* (IPCEIs) (Schneider 2023). These also include projects to promote 'green' technologies and production facilities, such as the development of a hydrogen industry and the transition to the production of green steel.

Alongside these shifts in economic policy, a growing tendency towards authoritarian politics can be observed not only within the EU. This development is accompanied by profound upheavals in national party systems and political power dynamics, in particular the decline of social democratic parties and the rise of right-wing and far-right political movements (Klein and Taylor 2025; Nachtwey and Heumann 2019). The political rise of right-wing forces and international competition between locations reinforce one another. At the same time, right-wing movements often position themselves in opposition to projects of ecological modernisation and, where they hold government office, block progressive efforts to address geo-economic and geopolitical tensions as well as the climate crisis (Lockwood and Lockwood 2022; Urban 2025; Daggett 2018).

Contradictory dynamics of capitalist restructuring

Overall, the current dynamics of the crisis point to a phase of profound restructuring of global capitalism and its regulatory frameworks. The various crisis trends are coalescing into a dynamic that is discussed as multiple crisis (Demirović and Sablowski 2012) or "polycrisis" (Tooze 2022). These crisis phenomena do not exist in isolation from one another, but are closely interlinked. They reinforce one another and are an expression of a profound crisis in the current form of capitalism, which is manifesting in far-reaching upheavals both within the economies of the core and in the global economy and international relations. The further expansion of the market-liberal dynamic of globalisation is in question – even if there is no consensus on the extent and depth of this dynamic of change, and market-liberal modes of regulation (such as austerity policies, competition-orientation and a fixation on growth) continue to be of great significance (Sablowski et al., 2022, p. 248f.; Solty, 2025).

In the context of the various crisis dynamics, major shifts can also be observed in the field of industrial production. The developments outlined above coalesce into three megatrends that are influencing the transformation processes across various industrial sectors, albeit with partly contradictory dynamics and varying degrees of intensity across regions and sectors. *Firstly*, the digitalisation and automation of production will continue to deepen and will be further accelerated by intensifying international competition. *Secondly*, the ongoing trend towards digitalisation is linked to the trend towards decarbonisation, which, however, appears to be increasingly fragmented. The escalation of the climate crisis and the ambition of national industries to assume a leading role in 'green' markets are fuelling further efforts for an ecological modernisation of energy production and CO_2-intensive industries, as evidenced, for example, in steel production or the shift towards e-mobility (see below). At the same time, the direction and scope of decarbonisation are increasingly contested. Political trends are slowing down the pace of change, national austerity policies and a deterioration in the broader economic climate on global markets are having a negative impact on investment decisions regarding industrial transformation, and in recent years a "fossil counter-offensive" has emerged (Zeller 2023, authors' translation) which works against industrial decarbonisation and green growth strategies. In Germany and Europe the dual transformation of digitalisation and decarbonisation has recently been accompanied by a *third* trend: a dynamic of militarisation and the growing importance of security policy considerations, including in the field of industrial production. Growing competition in global markets, the fragmentation of the global economic order and the escalation of geopolitical conflicts are not only leading to rising state investment in the defence industry and a shift towards the production of defence equipment by civilian companies. Industrial and infrastructure policy is also increasingly being aligned with security policy considerations, for example through the reshoring of key industries and the diversification of supply chains (Abels and Bieling 2023; Rodrik 2020; Schindler et al. 2024).

The current, crisis-induced restructuring of capitalism – to summarise the points made so far – is characterised by several, sometimes contradictory, logics of transformation and new (conflicting) objectives. For instance, militarisation increases the likelihood of conflicts being resolved by military means; it is highly climate-damaging; and increased military spending competes with social and environmental investment, creating so-called 'guns versus butter' conflicts of interest (Solty 2025). The strategy of ecological modernisation, through its focus on 'green' growth, threatens to further exacerbate the ecological crisis (Hickel 2020). A strategy geared towards decarbonisation, which attempts to combine growth, competitiveness and ecological goals, remains fragile and is undermined by economic crisis trends, geopolitical and

geo-economic tensions, and fossil counter strategies. Against this backdrop, one can speak of a "blocked transformation" (Becker 2023; Candeias 2025; Kastrup and Kellershohn 2025), in which neither a new stable capitalist formation is emerging, nor is a post-capitalist resolution of the crisis through socio-ecological transformation on the horizon. Rather, contradictory, 'green-capitalist' and fossil-authoritarian strategies overlap. At the same time, approaches of a new form of state governance are emerging that some call a 'decarbonisation state' (Brand et al. 2025). Yet these too remain contested and face limitations. The state's industrial policy interventions operate within the tension between neoliberal fiscal rules, fossil interests and authoritarian tendencies. Whilst the state is developing new forms of interventionist strategies, it is failing to create a coherent framework for ecological modernisation. The varying crisis dynamics and trends of restructuring are also reflected in sectoral developments within the automotive and steel production sectors.

3. Industry trends in the German automotive sector

The automotive sector plays a pivotal role in Germany's economic system: at the start of the decade, the production of motor vehicles, car parts and (electronic) accessories accounted for approximately five per cent of gross domestic product (GDP). The automotive industry is a major employer, with around 817,000 direct employees and 1.6 to 2.2 million employees when upstream and downstream sectors are included (Blöcker 2022a, p. 7). The German automotive industry is heavily export-oriented, with exports accounting for 70 per cent of total turnover (Federal Statistical Office 2024). Furthermore, it plays a significant role as a customer for a whole range of other industries, such as the steel sector. However, the German automotive industry is undergoing a profound transformation, driven by digitalisation as well as European and German environmental legislation. At the same time, the automotive industry faces intensified international competition, and its export-oriented accumulation strategy has recently reached its limits. The most pressing problems are global overcapacity in production and the loss of international competitiveness. Added to this, an increasingly protectionist global market environment with tariffs on imports, disruptions to global supply chains (semiconductors, critical raw materials) and delays in the construction of factories and production lines for electric cars, electric motors and batteries produce problems. The German automotive industry is thus in the midst of a profound structural crisis, which is putting massive pressure on workers: companies are responding by reducing production capacity, cutting jobs in Germany and relocating production facilities abroad (EY 2025; German Association of the Automotive

Industry 2025). At the same time, the crisis is affecting the automotive sector's decarbonisation strategies.

The global economic context and the crisis in the German automotive sector

The automotive industry is particularly dependent on developments in the global economic environment because it relies on the secure supply of critical raw materials and key technologies. Due to its export-oriented nature, it is also dependent on access to foreign markets, whilst at the same time facing growing international competition. In this respect, the shifts outlined in global economic dynamics are reflected in the automotive sector.

The global automotive market is particularly competitive. Global overcapacity amounted to approximately one-third of production volume in 2019: whilst there was global capacity to manufacture 130 million passenger cars, only around 89 million were sold (Global Data 2020). Consequently, in 2022, the plants of German car manufacturers were operating at an average capacity utilisation of just two-thirds (dpa 2022). In the field of electric mobility, companies such as BYD from China and Tesla from the US are gaining in importance and are intensifying competition in terms of prices, costs and technology. Whilst Tesla relies on economies of scale with a limited number of models and high production volumes in its 'gigafactories', BYD has a fully integrated value chain with its own batteries, software and vehicles, and is managing to offer cheaper electric cars than its German competitors through an aggressive export push into Europe (McKinsey & Company 2024). Chinese companies are thus now not only dominating the Chinese market and displacing German brands there. On the European market too, they are in the process of becoming serious competitors to German manufacturers, just as Tesla did previously (Ma 2025). With the changing dynamic of international competition, Europe is increasingly shifting from an export to an import market, and it appears that in 2025, for the first time, more Chinese cars will be sold in Europe than vice versa (PwC 2022). This is also due to the fact that European manufacturers are focusing in particular on the low-volume premium segment and remain dependent on the technological path of the internal combustion engine (Blöcker 2022a, p. 7). Although electric car production in Germany has risen significantly in recent years and a third of passenger cars manufactured in Germany are now electric (German Association of the Automotive Industry 2025), German car manufacturers are struggling to gain a foothold in the growing global electric vehicle market.

To counter the industrial and trade policies of its US and Chinese competitors in the electric vehicle market, the European Commission introduced anti-subsidy duties of up to 35 per cent on Chinese electric cars in 2024 (Schüler-Zhou 2019; Chamber of Industry and Commerce

2024). In addition, the transatlantic tariff dispute escalated in 2025 when the US imposed a 25 per cent tariff on imported cars and the President of the European Commission negotiated a reduction to 15 per cent (Tagesschau 2025a).

In addition to fierce international competition and global trade policy conflicts, electric vehicle manufacturing is strongly dependent on access to resources, particularly from China: 80 per cent of battery cells originate from there, and dependence on Chinese exports is also high for raw materials such as lithium and certain battery materials (LFP active materials) (Fraunhofer IML 2023). Against the backdrop of growing geo-economic and geopolitical conflicts, these dependencies are increasingly leading to supply problems for critical raw materials. This also applies with regard to Russia. Russia's war of aggression against Ukraine has hampered access to neon gas, palladium and nickel, which are important for semiconductor production (Ulrich 2022). Global trade disputes between the US and China are also hampering access to key intermediate products, such as chips manufactured from semiconductors (Beyen and Hensolt 2025). To reduce global dependencies, the EU adopted the *Critical Raw Materials Act* in 2023. The targets are a domestic extraction rate of ten per cent for critical raw materials, a recycling rate of 15 per cent and a processing capacity of 40 per cent within the EU. At the same time, investment incentives are being created for the extraction and processing of lithium, cobalt and nickel in the EU and Germany through so-called *'onshoring'* and *'friendshoring*'. The combination of sustainability and security aspects in European raw materials policy is referred to as the "security-sustainability nexus" (Riofrancos 2023).

Whilst the European Commission and companies are therefore increasingly striving to diversify access to raw materials, and the EU is strengthening trade policy measures to protect its own automotive industry, global competition continues to intensify. The crisis in the German automotive industry is also having a significant knock-on effect on decarbonisation strategies in the mobility sector, as evidenced, for example, by the slowdown in the European phase-out of internal combustion engines.

Changes in environmental regulation, new industrial policy and consequences for the German automotive industry

In addition to the international market situation, changes to the EU's environmental regulations have brought about far-reaching changes for the German automotive industry. In response to the escalating ecological crisis and the Paris Climate Agreement, the European Commission

and the German government tightened environmental legislation regulating the automotive industry in the early 2020s. This primarily referred to the production of internal combustion engines and the support for the expansion of electric mobility. At European level, the setting of CO_2 fleet limits as part of the *'Fit for 55'* climate package effectively banned the registration of new combustion engines from 2035 onwards (dpa 2022). Added to this was the extension of the EU Emissions Trading System (EU ETS) to the transport sector from 2027 (Federal Environment Agency 2025b). Also, the adoption of the *Alternative Fuels Infrastructure Regulation* (AFIR), intended to drive the nationwide roll-out of charging infrastructure along the EU's major transport routes and thereby create the infrastructural conditions for a comprehensive transition towards e-mobility (European Parliament 2023). By 2025, Germany had approximately 160,000 public charging points, and the federal government is aiming to increase this number to one million by 2030 (National Centre for Charging Infrastructure 2025). The 'Deutschlandnetz' initiative launched by the federal government aims to provide over 1,000 locations with around 9,000 fast-charging points by the end of 2026, thereby closing gaps in the charging infrastructure (Federal Ministry of Transport 2021).

In addition, the EU has also bolstered battery cell manufacturing, which is crucial to the transition to electric vehicles: the *European Battery Alliance* - launched in 2017 and expanded in 2020 - aims to meet up to 90 per cent of Europe's battery demand from domestic production by 2030 (Gräf 2024). Through the *Important Projects of Common European Interest initiative*, two projects and more than six billion euros in public funding have so far been mobilised to support the construction of battery factories, for instance in Salzgitter (EuRH 2023, p. 14). Whilst the German battery market grew by 239 per cent between 2020 and 2024, it declined by 16 per cent to 20.5 billion in 2024, reflecting the stalling transition to electric vehicles. In Germany, investments were made in cell factories, such as CATL in Arnstadt and PowerCo in Salzgitter, which are intended to secure local value creation and strengthen Europe's position in the global competition for battery cells. However, several projects are facing delays, such as the construction of a gigafactory in Heide due to the insolvency of the Swedish battery company Northvolt (Geißlinger 2025).

In addition, the EU has supported the development and establishment of alternative fuels, such as the further expansion of biofuel use or the development of synthetic e-fuels, some of which are produced using hydrogen (European Parliament 2023). Although these will be scarcely available and very expensive for the foreseeable future, the focus on e-fuels helps German car manufacturers to cling to the internal combustion engine and delay a shift in propulsion technology (Greenpeace 2025). In addition to e-fuels, hydrogen cars with fuel cells are

increasingly being discussed as an alternative to battery-powered cars under the banner of ‘technology neutrality’, although the lack of hydrogen availability, low energy efficiency, high costs and the absence of refuelling infrastructure make this route unlikely. Among German car manufacturers, BMW is playing a pioneering role in this area with the company receiving over €190 million in federal funding to develop a hydrogen-based fuel cell electric vehicle (BMW Group 2025b). Overall, however, the environmental regulations primarily bolstered the expansion of German carmakers’ battery-electric mobility divisions and also increased their dependence on international suppliers.

In recent times, there has been a noticeable rollback in environmental regulation. CO_2 reduction targets at both EU and national level have been scaled back or postponed. For example, the planned tightening of EU fleet limits for 2025 has been postponed by three years (European Parliament 2025). At the end of 2025, the EU ban on combustion engines was relaxed. Not least due to pressure from the German government, an exemption was introduced at EU level for combustion engines powered by e-fuels (Liboreiro 2023). In 2023, the ruling by the German Federal Constitutional Court on the Climate and Transformation Fund (KTF) led to the abolition of the purchase subsidy for electric cars, resulting in a slump in new electric car registrations of around 27 per cent the following year. However, sales figures began to rise slowly again in 2025 (Federal Motor Transport Authority 2025). In response, the new German government presented an eight-point plan in 2025 offering tax incentives for electric mobility, including reduced company car taxation, social leasing models for people on lower incomes and special tax allowances. In terms of climate policy, the sectoral emission targets introduced in the 2021 Climate Protection Act were abolished again in 2024 (Bundestag 2024). This means that CO_2 emissions from the transport sector, which fell far short of its sectoral targets, can be offset by CO_2 savings in other sectors, thereby reducing the pressure on car manufacturers to decarbonise their production (Federal Environment Agency 2025c).

Overall, the political initiatives aimed at regulating the environmental and climate impacts of the automotive industry and promoting electric mobility, both at EU level and within Germany, reflect a pattern of ecological modernisation. Other transformation strategies, such as new mobility concepts or strategies focused on sufficiency, play only a minor role by comparison. The deepening crisis in the German automotive industry and international trade conflicts have contributed to a watering down of European and German decarbonisation targets. These developments can be seen as concessions to the economic interests of the automotive industry,

which threaten to entrench dependence on the internal combustion engine and delay the transition to electric mobility.

Corporate strategies of German car manufacturers

German car manufacturers initially responded to the tightening of EU climate targets primarily by expanding their electric mobility divisions. In 2024, Volkswagen delivered 744,800 battery electric vehicles (BEVs) (8.3 per cent of total global deliveries), BMW 426,594 BEVs (17.4 per cent) and Mercedes-Benz 185,100 BEVs (around 9 per cent) (Volkswagen Group 2025; BMW Group 2025a; Electrive 2025). However, at 3.3 per cent in January 2025, the share of BEVs of the total amount of passenger cars in Germany remains low (Deutschlandatlas n.d.).

Against the backdrop of a worsening sales crisis, German car manufacturers decided to implement cost-cutting measures, some of which were far-reaching: In autumn 2024, the VW Group announced that it would cut jobs, close plants, and relocate production abroad in the coming years. VW introduced a hiring freeze and terminated employment protection schemes to facilitate redundancies (IG Metall 2024). Although VW's electric mobility division is set to be further expanded, there have been setbacks recently. For example, the all-electric car plant Trinity in Wolfsburg was not built, and battery production in Salzgitter will initially be smaller than originally planned (Volkswagen Group 2022). Mercedes-Benz has also responded with cost-cutting measures, whilst simultaneously investing in an electrification programme in the luxury segment (Mercedes-Benz Group 2021). BMW has not introduced cost-cutting programmes as drastic as those of VW and continues to pursue a strategy of 'technological openness' with a portfolio of combustion-engine cars, electric cars and hydrogen-based fuel cell (electric) vehicles, which BMW is developing in collaboration with Toyota (BMW Group 2024).

The joint strategy of German car manufacturers is to preserve the internal combustion engine by lobbying against the 2035 ban on combustion engines, against strict CO_2 fleet limits, and in favour of e-fuels and biofuels (Tagesschau 2025c). For example, in a letter to the European Commission, Ola Källenius, CEO of Mercedes-Benz and the European Automobile Manufacturers' Association (ACEA), states that the automotive industry is at a crossroads and that it is essential to subject the European Green Deal to a "reality check" and to scale back decarbonisation targets (ACEA 2025 authors' translation). German car manufacturers are thus pursuing a twin-track approach: on the one hand, they are focusing on gaining new market share in the electric mobility sector, particularly in the premium segment; on the other hand, they are attempting to maintain sales markets for the internal combustion engine for as long as possible.

An additional dynamic arises from a reverse armaments conversion. Instead of the socio-ecological conversion of the car industry, the trend is moving towards a shift from civilian to military production. The increase in the target for defence spending to 3.5 per cent of GDP and the special funds for defence production create incentives for arms manufacturers, such as Rheinmetall, on the one hand to repurpose their own automotive supplier plants from civilian to military production (e.g. in Berlin), and, on the other hand, to consider taking over automotive industry plants affected by closures and converting them for defence production, including, for example, the VW plant in Osnabrück and a plant belonging to the automotive supplier Continental in Gifhorn (Reimann 2025). At the same time, struggling automotive suppliers are looking for new products and customers in military vehicle production (Tagesschau 2025g).

Impact on work processes and employees

The diverse dynamics of change have far-reaching consequences for employees. For a long time, the automotive industry was a guarantor of secure employment and good working conditions. In recent years, however, precarious forms of employment such as agency work and fixed-term contracts have increased. In autumn 2024, VW abolished its employment security scheme. Whilst studies by Dörre et al. (2011) point out that for a long time the company itself was still perceived as a safe haven in turbulent times, Goes (2024: 122, 331) shows that despite relatively good pay and overall satisfaction, industrial workers suffer from increased time and work pressure as a result of high performance expectations, a lack of recognition and monotonous work. This is the context in which quantitative and qualitative employment effects arise from the energy transition.

The specific quantitative effects of the transition to electric mobility on employment are a matter of debate (Blöcker 2022a, pp. 22–25). Numerous studies agree that there will be a profound structural shift including job losses in traditional vehicle production, which will particularly affect suppliers in the drivetrain, engine and combustion engine technology sectors. However, the effects of the transformation and the automotive industry's attempt to increase profitability in the face of intensifying global competition cannot always be clearly distinguished. VW plans to cut 50,000 jobs by 2030 and the German Association of the Automotive Industry (VDA) expects 215,000 jobs to be lost across the entire sector by 2030 (German Association of the Automotive Industry 2021). In just one year, around 51,500 jobs have already been lost in the German automotive industry (EY 2025). Studies suggest that these

losses can be offset or mitigated by new areas of employment arising from the transition to electric vehicles, particularly through growth in battery production, digital systems and charging infrastructure. The expected net effects vary depending on the study: from significant losses (e.g. 114,000 jobs by 2035 in the study by Mönning et al. (2018) to a nearly balanced outcome in the study by Herrmann et al. (2020) for selected VW plants. In the short term, retirements are also expected to partially cushion job losses (Interview P_10), while regional employment effects vary considerably.

The transformation within companies is also leading to a reorganisation of work processes in factories and having a significant qualitative impact on the nature of employment (Interview P_5, P_10, P_12). Either new electric vehicle plants are being built, such as the Tesla factory in Grünheide, or, more commonly, new production lines for electric vehicles are being integrated into existing plants. In addition, battery production facilities are being established with new chemical-technical work processes that differ significantly from traditional car production, as is the case at the VW engine plant in Salzgitter. Furthermore, digitalisation with a focus on IT and software is leading to the establishment of new innovation labs with agile management and greater personal responsibility (Blöcker 2022a, p. 22). These new production and work processes are accompanied by a shift in skill sets and job profiles. Traditional skilled work, e.g. in metalworking and engine manufacturing, is declining, whilst new jobs are increasingly emerging in battery production, IT and software development, and electronics (Mönning et al. 2018; Herrmann et al. 2020). At the same time, an in-house job change is likely for those employees working in production areas affected by decarbonisation, such as the production of engines or exhaust systems (Interview P_05; P_10; Blöcker 2022a, pp. 24–26). Whilst many smaller suppliers lack the resources and structures for upskilling measures, the major car manufacturers have launched retraining programmes. Regardless of the upskilling opportunities, a change of role within the company can be associated with uncertainties and disadvantages for employees, for example through the devaluation of specialist knowledge or the disruption of career paths within one's own field of work (Interview P_5). At the same time, the collective bargaining implications of the qualitative changes in the production process – such as what constitutes work or how new tasks are remunerated – must be renegotiated (Interview P_10).

Overall, both the structural crisis in the German automotive industry and the transition to new drive systems are creating considerable uncertainty for employees. The fossil rollback exacerbates these uncertainties for employees, both in terms of job security and the consequences of qualitative changes in production processes. However, how these dynamics

overlap and what consequences the various factors have in their interrelation on the decarbonization constellation, and specifically for the employees, is largely shaped by their interaction with internal company conditions.

4. Industry developments in the German steel sector

Just like the automotive industry, the steel sector is of great importance to the German economy, not only as one of the traditionally key raw materials industries. Also, the steel industry is an important supplier to key sectors of the German accumulation regime, such as the mechanical engineering sector and the automotive industry, electrical engineering and the construction sector. Steel therefore also plays a vital role as a raw material for the German export economy. Total crude steel production in 2022 stood at 36.8 million tonnes, accounting for just under a third of the steel produced in the EU. The steel industry generated a turnover of around €55.2 billion in 2022. The main buyers of German steel are the EU and the USA (Federal Ministry for Economic Affairs and Climate Action 2025; EUROFER 2024). The steel industry employed approximately 80,000 to 90,000 people directly. When the supplier industry is included, the number of employees increases significantly once again (Federal Ministry for Economic Affairs and Climate Action 2025; regarding the difficulties of calculation, see Blöcker 2022b, 6ff).

However, the German steel sector is undergoing a period of profound transformation. On the one hand, in recent years the steel industry has increasingly been faced with the need to decarbonise its production processes: steel production is one of the most emission-intensive sectors of the German economy. CO_2 emissions amounted to approximately 48.9 million tonnes in 2022, accounting for around 29 per cent of total German industrial emissions (Competence Centre for Climate Action in Energy-Intensive Industries 2025). The bulk of carbon dioxide emissions is produced during the production process through the combustion of coal (Competence Centre for Climate Action in Energy-Intensive Industries 2025). Whilst the possibilities for decarbonising crude steel production appeared to have been largely exhausted by the middle of the last decade, and German companies in particular emitted relatively little CO_2 per tonne of steel by international standards (IG Metall 2016). New technological developments now enable a significant decarbonisation of the production process compared to the traditional blast furnace route. So-called direct reduction can produce crude steel in a significantly more CO_2-efficient manner using natural gas and hydrogen, especially when it is generated from renewable energy sources. At the same time, changes in European and German

environmental legislation have increased the pressure to reduce CO_2 emissions, particularly in large integrated steelworks (see below).

In addition to growing regulatory pressure to decarbonise, global economic and political shifts are also influencing the development of the German steel sector. These appear to be strengthening interest in domestic steel production, in a more active role for the state in this sector (including state participation in steel companies), and in a reorientation of steel production towards the arms sector (Bös et al. 2025; Tagesschau 2025b).

The global economic context and the crisis in the German steel sector

For years, the global steel market has been characterised by drastically increasing competition, which is also putting the German steel sector under growing pressure. Production capacities are now structurally exceeding demand, leading to a sustained fall in prices (Steelforum n.d.). Whilst price levels and profitability remained relatively high until 2021, a significant slump has followed since then. Production capacity utilisation will be only around 70 per cent in 2025, and even relatively competitive steel producers are now under pressure (OECD 2025). A key influencing factor here is the competitive advantage enjoyed by Chinese and Indian companies. The Chinese economy has become the global market leader in the steel sector and in 2024, its share of global steel production stood at around 55 per cent. As the domestic market becomes increasingly saturated, Chinese steel manufacturers are exporting their products in greater volumes, thereby increasing international competition. Other leading steel producers include India, whose market share is currently growing rapidly, Japan, the USA, Russia and South Korea. Within the EU, German steel producers dominate, while internationally, they rank seventh (Federal Ministry for Economic Affairs and Climate Action 2025; EUROFER 2024, 14ff).

As competition increases, so too do international disputes over industrial policy support measures for the steel sector (OECD 2025; Steelforum n.d.). Furthermore, trade policy conflicts in the steel sector have intensified since the first Trump administration took office. Tariffs and non-tariff trade barriers, particularly between China, the US and Turkey, are leading to a diversion of steel exports to the EU market. The EU, whose steel market had been relatively open until 2018, initially responded to US tariff policy by introducing import duties and various protective measures, in particular so-called anti-dumping measures and safeguards (Blöcker

2022b, 11f).[1] Since spring 2025, conflicts over steel import tariffs have intensified, with both the EU and the US repeatedly raising tariff levels. Following the renewed 50 per cent increase in steel tariffs in the summer of 2025, the EU is now also considering raising import tariffs from 25 to 50 per cent (European Commission 2025d; Tagesschau 2025e; O'Carroll 2025).

Both the overcapacity in the global steel market and the disputes over the regulation of increasing competition are putting pressure on German steel sector sales figures (German Steel Federation 2024). The consequences of the Russian attack on Ukraine further worsened the economic situation of the German steel sector as steel production suffered from sharply rising energy prices, domestic demand declined as a result of the ongoing recession and, in particular, the crisis in the automotive and construction industries (Federal Statistical Office 2024).

These developments have culminated in a structural crisis in the German steel industry: in 2025, production facilities are not operating at full capacity, output is declining, and leading companies, such as the steel division of Thyssenkrupp or Salzgitter AG, were in the red. Consequently, there is a threat of falling wage levels for employees, redundancies and site closures, a continuation of an already ongoing trend in the steel industry (Blöcker 2022b, 7ff; Tagesschau 2025f, 2025i).

However, despite these crisis dynamics, the steel sector is also benefiting from the changed global situation in certain respects. On the one hand, growing arms production in the face of geopolitical conflicts and Russia's war against Ukraine is increasing demand for steel. This concerns so-called 'security steel', which is used in the arms industry (Bös et al. 2025). Even beyond this special type of steel, an increased demand for steel is expected in order to "make civilian infrastructure fit for war. Or to ensure sufficient resources for the armed forces", according to CDU military expert Kiesewetter (Tagesschau 2025b, authors´ translation). On the other hand, in the changing global situation, steel is increasingly regarded as a systemically important raw material. For example, the European Commission's *Steel Action Plan*, adopted in 2025, explicitly refers to a strong steel industry as "crucial to guarantee the EU´s security in the current geopolitical context" and to "deliver on the […] 'ReArm Europe/Readiness 2030' plan" (European Commission 2025c). These interests in the steel industry, which are increasingly rooted in security policy, also heighten the willingness for state involvement in steel companies facing crisis (European Commission 2025c; Tagesschau 2025b; UK

[1] According to the European Commission's definition, dumping occurs when products are imported from third countries at prices below those in the exporting country or below the level of the estimated production costs plus a profit margin. The safeguards apply when a sudden increase in steel production threatens European companies. In such cases, import regulations may be amended even without evidence of dumping (Blöcker 2022:11).

Department for Business and Trade 2025). So far, however, the geo-economic and geopolitical revaluation of the steel sector has not been reflected in a stabilisation of the domestic steel industry, for example in the form of increased sales.

Changes in environmental regulation, new industrial policy and consequences for the German steel sector

In addition to changes in the global market conditions, the steel sector faces major challenges, particularly due to the tightening of EU climate targets and changes to environmental legislation at both EU and national level. The German *Climate Change Act* aims at reaching climate neutrality by 2045. To this end, the steel industry is expected to reduce CO_2 emissions by 26 million tonnes by 2030 (Federal Government 2021; Blöcker 2022b, p. 10). The *Fit for 55* package adopted by the European Commission in 2021 also reformed emissions trading. Although the steel sector had already been integrated into the European emissions trading scheme, the reduction targets have now been expanded and emission allowances have been restricted. This is leading to an increase in the prices of CO_2 allowances, while free allowances will be phased out by 2034 (Federal Environment Agency 2025b; European Commission 2021b). Overall, this massively increases the pressure to decarbonise the steel sector by 2030 (Schoppengerd 2024, 452 ff; Blöcker 2022b, p. 10; Interview P_01; P_03).

To accompany the stricter climate and environmental legislation, both the EU and the German government have launched a range of support measures designed to assist the steel industry with decarbonisation, for example within the framework of the *European Green Deal*, the *Fit for 55* package, hydrogen strategies and steel action plans. Unlike in the automotive industry, decarbonisation in the steel industry does not target the *product*, but the *process*: the aim is to replace blast furnaces using fossil fuels with direct reduction plants powered by natural gas or hydrogen. In particular, the use of green hydrogen produced using renewable energy would lead to significant CO_2 savings. In addition to switching from the blast furnace route to direct reduction, the electric steelmaking route, which is already significantly less CO_2-intensive, is also to be further expanded using renewable energy (Albrecht et al. 2022; Schoppengerd 2024, 545f; Blöcker 2022b, 10f).

The funding instruments include: first, Initiatives to support research and development on alternative energy sources, in particular hydrogen technology, hydrogen-based direct reduction and CCS technology (European Commission 2025a); second, EU laws on exemptions from state aid and competition, which allow high levels of state subsidies and industrial policy

support for green steel or facilitate the development of the hydrogen economy, in particular the so-called *Important Projects of Common European Interest* (IPCEIs) (European Commission 2026); third, financial support measures by the EU as well as national subsidies, with a large proportion of these grants earmarked for direct reduction and electric arc furnace projects (GMK Center 2025); fourth, measures to promote supportive framework conditions for the transformation of the steel sector and the protection of the European steel market, such as the reduction of electricity prices or the expansion of grid infrastructure. With the EU Commission's 2025 *Steel Action Plan*, the *Carbon Border Adjustment Mechanism* (CBAM) for steel imports, which was already enshrined in the *Fit-for-55* package, was extended to various downstream steel products (European Commission 2025b); fifth, policies to promote a market for green steel, e.g. via EU-backed off-take agreements or regulatory approaches that set CO_2 standards for specific product groups, give preference to low-carbon products in public procurement, or link public funding, for instance in the context of infrastructure development, to the use of green steel (Federal Ministry for Economic Affairs and Climate Action 2024; Reuters 2025; Tagesspiegel 2025).

Overall, the regulatory, industrial policy and financial initiatives aimed at decarbonising the steel sector and promoting green steel production thus represent a clear shift from the 2010s. However, they remain stuck in the paradigm of ecological modernisation and focus primarily on market-driven strategies and initiatives by industry players (Wigger 2025). In recent years, however, these strategies have also become increasingly contested – not least in view of growing international competition and the deepening crisis in the German steel sector. For instance, the 2024 amendment to the *Climate Change Act* relaxed the sectoral targets for the decarbonisation of the steel sector (German Bundestag 2024; Federal Environment Agency 2025a). Furthermore, the steel industry's access to further financial support measures was restricted by the ruling of the German Federal Constitutional Court on the Climate and Transformation Fund (KTF) at the end of 2023 (Federal Constitutional Court 2023). This complicates, for example, the financing of the second expansion phase of direct reduction at Salzgitter AG (Interview P_01). In this respect, too, a trend towards an environmental rollback is evident.

Corporate strategies of German producers

In the German steel industry, changes to environmental regulations at the European and German level initially had a clearly visible effect as a means of exerting pressure towards

decarbonisation (Interview P_01; P_08; P_09). All major steel producers began preparing for the decarbonisation of the production process: on the one hand, the CO_2-intensive blast furnace process for the production of primary steel is to be replaced by the direct reduction process. Instead of using coking coal to produce pig iron, which is then processed into steel, iron ore is now to be reduced to sponge iron in direct reduction plants using hydrogen or natural gas, from which steel is then produced. Secondly, steel production was to be expanded through steel recycling in electric arc furnaces (Blöcker 2022b; Albrecht et al. 2022).

Large steelworks have developed pilot projects to utilise direct reduction plants and, in some cases, to replace the blast furnace route. Substantial public funding was secured for the complex and years-long construction of the new direct reduction plants and the infrastructure for their (hydrogen-based) supply. The four major primary steel producers[2] submitted projects for converting production facilities under the IPCEI Hydrogen initiative and received significant public funding (Federal Ministry for Economic Affairs and Climate Action 2024). Whilst Thyssenkrupp Steel also tested the use of CCS technology, the SALCOS project based in Salzgitter not only explored the use of direct reduction plants, but also tested the production of renewable energy and green hydrogen on its own site. Furthermore, virtually all primary steel producers are pursuing a strategy of cooperation with regional stakeholders for hydrogen supply. As there is not yet enough green hydrogen available, all projects also plan to initially operate the direct reduction plants using fossil gas or hydrogen produced from fossil gas (Midrex 2023; Salzgitter AG 2018; Tufillo and Seiter 2025).

Since 2024, however, projects aimed at process decarbonisation and the production of green steel have stalled. In some cases, they have even been abandoned. One reason for this is the shift in the political balance of power: the new federal government's power plant strategy has, for instance, curtailed the expansion of the hydrogen supply (Polansky 2024; DNR 2025; Schwarz 2025). Furthermore, the legal challenge against *the Climate and Transformation Fund* has made access to funding more difficult (Federal Constitutional Court 2023; Fuhrmann 2025). On the other hand, the sectoral crisis in German steel production has intensified. After virtually all major corporations had already launched comprehensive restructuring programmes to achieve increases in productivity and profitability (Blöcker 2022b, p. 7), declining competitiveness also weakened decarbonisation strategies. In June 2025, ArcelorMittal announced its withdrawal from the previously planned shift to direct reduction in steel production with agreed public funding that will now not be utilised. Consequently, the primary

[2] Thyssenkrupp Steel (tkh2Steel) in Duisburg, Salzgitter AG (SALCOS), ArcelorMittal (DRIBE2) in Bremen and Eisenhüttenstadt, and Stahl-Holding Saar (Power4Steel) in Dillingen and Völklingen.

steel route at the ArcelorMittal plants in Bremen and Eisenhüttenstadt will also cease operations after 2029. Instead, according to the company, the operation of electric furnaces is to be further expanded (Tagesschau 2025d). Other major steel producers are also facing ongoing problems: although Thyssenkrupp Steel is continuing with the construction of a direct reduction plant in Duisburg, it has announced plans to cut production and costs by around ten per cent in its Steel Europe division. This is also expected to result in the loss of several thousand jobs (Tagesspiegel 2025). The SALCOS project of the Salzgitter AG is already underway, though funding for the planned second direct reduction plant is currently lacking. Here too, therefore, the electric route will be further expanded for the time being (Interview P_01; P_09).

In light of these developments, companies and IG Metall are jointly lobbying for an improvement in the framework conditions (German Steel Federation and IG Metall 2025). The joint policy demands made by IG Metall and the German Steel Association during the Steel Summit can be seen as paradigmatic in this regard. The summit, held at the Chancellery in November 2025 on the initiative of steel companies and the trade union, was intended to develop strategies to tackle the crisis in the steel sector. These include, for example, trade policy measures designed to protect the European steel market from international competition, such as the further development of the CBAM or import quotas. Furthermore, access to cheap energy is one of the main demands, for instance through a reduction in grid fees and the introduction of an industrial electricity tariff. With regard to the production of low-emission steel, IG Metall and steel companies are calling for support for the hydrogen economy and for boosting demand for green steel produced within the EU. The latter is to be supported, for example, through public procurement or by allowing the use of green steel to count towards the fleet limits of the automotive industry, which is the main customer of German steel production (German Steel Federation and IG Metall 2025; German Steel Federation 2025).

However, the corporations are pursuing different lobbying strategies with regard to the political regulation of CO_2 emissions in the steel sector and the timeframe for decarbonisation. For instance, since summer 2025, the Thyssen Group has been campaigning for an extension of the allocation of free CO_2 emission allowances. This would make it possible to continue traditional CO_2-intensive steel production via the blast furnace route without incurring additional financial costs for the steel companies. However, steel producers such as Salzgitter AG, Stahl-Holding-Saar, Dillinger Hütte and Saarstahl, which invested in the decarbonisation process at an early stage, view this as a disadvantage and oppose any weakening of ETS regulation (Klühspies et al. 2025; Klühspies 2025; Ohlinger 2025a).

In addition to these conflicts over the framework conditions for decarbonisation, steel companies are increasingly gearing their production towards the military sector. Whilst the Swedish company SSAB has hitherto dominated the European market for security steel and armour steel used in the military sector, German steel companies are now also responding more strongly to the rising demand in the military industry. For instance, in the summer of 2025, the Salzgitter subsidiary Ilsenburger Grobblech received approval to produce security steel for the German Armed Forces, whilst Dillinger Hütte has been supplying certified security steel for several years. In addition to the German Armed Forces, both companies aim to supply defence contractors within Germany, as well as the European market and NATO member states. This opens up additional business areas in military applications for German steel producers. In quantitative terms, however, this sector has so far been of little significance for the steel companies (Wermke et al. 2025; Wudtke 2025; Salzgitter AG 2025).

Impact on work processes and employees

The dynamics of transformation in the steel industry are having far-reaching quantitative and qualitative effects on workers and working conditions. The steel industry, when switching to steel production via direct reduction or the electric steel route, is not directly affected by *a 'jobs versus environment dilemma'* (Räthzel et al. 2021), as is the case, for example, in the coal mining sector (Schoppengerd 2024, p. 452). Nevertheless, it can be observed that the profitability crisis in the German steel industry, as well as the restructuring measures associated with decarbonisation, are linked to quantitative employment effects, a (looming) reduction in jobs and, consequently, a growing degree of uncertainty for employees. However, estimates of labour requirements for a transformed steel production sector vary considerably in some cases and have so far been difficult to quantify (Blöcker 2022b, 22f). The anticipated reduction does not only concern the discontinuation of blast furnace tapping; it also affects, for example, processes upstream of the blast furnace, such as the coking plant, where imported hard coal is processed into coke (Schoppengerd 2024, p. 457). At the same time, the decarbonisation of the steel industry represents a long-term strategy for safeguarding employment, which in turn is undermined by the fossil rollback and its consequences, in the form of a delay in the expansion of renewable energies and the hydrogen sector.

Overall, jobs are currently at risk across various companies in the steel industry. Thyssenkrupp, for instance, plans to cut around 11,000 jobs by 2030. Whilst redundancies for operational reasons are to be avoided, some of the jobs will be cut through outsourcing to external service

providers. Thyssen also discussed selling its steel division to the Indian steel group Jindal Steel (ifb 2024; SZ 2025; Tagesschau 2025h). A total of 760 jobs are also set to be cut at the Saarland-based steel companies Saarstahl and Dillinger Hütte by the end of 2026, with half of the cuts at Saarstahl and half at Dillinger Hütte. Here too, the plan is to avoid redundancies (Ohlinger 2025b). Although ArcelorMittal has not yet announced any large-scale job cuts in Germany, it is cutting jobs at other European sites (Maillasson 2025). Furthermore, the withdrawal from the production of low-emission steel based on direct reduction has led to considerable concerns about the future of the Bremen site. In Salzgitter, by contrast, IG Metall and the company are pursuing a strategy to maintain the overall size of the core workforce by integrating further parts of the value chain into green steel production, such as in-house hydrogen production on the plant site, or by reintegrating previously outsourced business units (Schoppengerd 2024, p. 461; Fuhrmann 2025). Regardless of the quantitative effects on employment, the sometimes massive economic pressure weakens the position of employees and IG Metall in collective bargaining disputes, as evidenced in various recent collective agreements (IG Metall 2025; ZDFheute 2025; Ohlinger and Nonnengardt 2025).

In addition to the quantitative effects on employment, restructuring processes in the steel industry also affect the organisation of work, the required skill set and other qualitative aspects of employment. In the field of crude steel production in particular, there will be a significant shift in the nature of the work processes. For example, the role of blast furnace steelmaker will no longer exist in the future; conversely, a new demand for skilled workers will emerge in the fields of IT and hydrogen. The sector of unskilled or low-skilled jobs will decline sharply in the long term. It is still unclear exactly what qualification requirements will emerge from this (Blöcker 2022b, 23f). In view of the far-reaching qualitative consequences, the training of employees in the affected areas of production, the specific operational organisation of the transition – including a reorganisation of break arrangements and shift systems, and the remuneration for the newly emerging fields of work – are key points of negotiation between employee representatives and company management.

Overall, both the structural crisis and the process of decarbonisation in the steel industry present significant challenges and uncertainties for employees. Whilst the shift towards the production of low-emission steel is likely to mitigate job losses in the long term, the fossil rollback exacerbates uncertainties for employees regarding both job security and changes to production processes.

5. Corporate decarbonisation regimes as a research gap

The aim of this working paper was to identify the framework conditions for decarbonisation processes, as well as the development trends of industrial transformation strategies. The focus was on product decarbonisation in the automotive industry and process decarbonisation in the steel industry. To understand what the workplace foundations of decarbonisation policies look like, the analysis of the framework conditions and overarching trends must be combined with an examination of concrete workplace conflicts, wage earners' awareness of environmental issues, and wage earners' subjectivity (Schaupp 2024). These need not be limited to active or passive consent to decarbonisation or its rejection, but can develop a dynamic that goes beyond this (see historical and current approaches to conversion; Wainwright and Elliott 1982; Kaiser 2023; in our region of study, Blöcker 2012). "What needs to be better understood," as Barca (2020: 44) puts it, "is the environmental dimension of class-making, that is, how working-class subjectivity meets ecology." Schulz and Trappmann (2023) demonstrate in their representative survey that employees in Germany, and trade union members in particular, have a strong awareness of the problem of climate change (similarly with regard to trade union actors: Barth and Littig 2021; Flemming 2022; Schröder and Urban 2018). Given the scale and scope of the projected changes on the path to 'climate neutrality', studies examining how affected workers interpret the escalating ecological crisis, the discourse on transformation and the associated organisational change processes are still scarce. Whilst Goes (2024) does explore the political consciousness of workers in times of upheaval, the focus of the study is not on the sphere of labour or the 'politics of production' (Burawoy 1985), but rather on party-political welfare state programmes.

Further research could build on the findings of studies on workers' consciousness (Dörre et al. 2013) and *Environmental Labour Studies* (Räthzel et al. 2021; Schoppengerd 2023). Both are central to our context insofar as, firstly, they focus on the ecological awareness of wage earners; secondly, they situate wage-earner subjectivity within a cross-organisational, multiscalar context; and thirdly, they raise the question of agency arising from the sometimes contradictory relationship between (external) ecological demands and subjective notions of justice. Thus, Dörre et al. (2014) report on the surprising industrial-sociological finding of a widespread critique of growth among workers, which not only opposes a logic of constant economic growth in competition, but also explicitly integrates ecological motives. In their study of VW employees' willingness to embrace change, Pfeiffer et al. (2023, p. 69) point to a high level of openness among respondents towards ecological issues in both the workplace and their private lives. Similarly, Tullius et al. (2023, p. 92) do not identify any questioning of sustainability

goals in connection with the phase-out of combustion engines, but rather criticism "of its character as a 'means' to achieve the goals: of its 'top-down' character, the speed with which it is being implemented, its technical one-dimensionality and ecological questionable nature – which would fail to live up to precisely those guiding social principles" (Blöcker 2020, p. 43f, authors´ translation; see also Wissen and Brand 2021; Wissen et al. 2022). However, the resulting experience of contradiction does not in itself lead to a willingness to act.

Our assumption that the specific decarbonisation processes are subject to criticism is thus based on the fact that they take place within the hierarchical, authoritarian structures of capitalist enterprises, which follow on from previous experiences of restructuring, and are therefore viewed with scepticism: "Transformation processes are always also crisis processes, and these intertwine with the workplace experience that the screws of performance and flexibility are tightened year after year" (Detje and Sauer 2021, p. 72 authors´ translation). Tullius et al. (2023, p. 71 authors´ translation) speak of an "experience-saturated interpretative pattern", interpreting transformation as a "politics- and management-driven top-down process of the ongoing alteration of one's own working and reproductive conditions", as a "class struggle from above". Exactly how this plays out in the case of transformation justified by the ecological motive of decarbonisation, and what the prerequisites would be for workers to take up the ecological issue in the sense of 'working-class environmentalism' (Barca 2020), is the subject of further research.

From a theoretical and conceptual perspective, this research can draw on Burawoy's approach to the 'politics of production' (Burawoy 1985). Burawoy assumes the fundamentally hierarchical nature of capitalist enterprises, but understands the concrete organisation of the labour and production process as the result of struggles in which the experience of contradiction, the subjectivity and the resistance of wage earners play a central role. What makes Burawoy's approach particularly interesting is that his understanding of workplace conflicts also incorporates the social context. Factors extending beyond the workplace, such as competitive relationships, social discourses or political course-setting, coalesce with relationships at the workplace level to form a 'production regime' or 'factory regime' (Krzywdzinski 2023). Such a heuristic can guide the analysis of what we identify here as a research desideratum: the investigation of the 'translation' of crisis-driven developments and political and societal shifts towards decarbonisation at the workplace, the perspective and role of workers in these processes, their connection to or confrontation with claims to justice, and ultimately: the emergence of a 'decarbonisation regime'.

It remains to be seen, however, to what extent and in what form such decarbonisation regimes will emerge. At present, the transition is proceeding in a contradictory manner. Alongside the trend towards decarbonisation, there are also signs of delays, partial stabilisation or even a resurgence of fossil-fuel-based production methods. For employees, the ecological transformation thus appears to be a future path that is both demanded yet uncertain. This is further exacerbated by the fact that, in parallel, security and military policy orientations and industrial development paths are gaining in significance. For parts of industry, this opens up alternative prospects for securing business locations and jobs. Decarbonisation regimes are therefore contested. It is therefore also important to examine how this simultaneity and intertwining of ongoing transformation processes and barriers to transformation are translated into everyday working life, and how they shape employees' perceptions regarding job security, fairness and collective agency.

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7. List of interviews

P1: Interview with a union representative and works council member at Salzgitter Flachstahl, conducted on 12 July 2025

P3: Interview with an industry expert, conducted on 12 July 2025

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P12: Interview with a trade union secretary at IG Metall, conducted on 9 January 2026

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