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Jobwende

Effects of the Energiewende on Work and Employment

FOR A BETTER TOMORROW

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FOREWORD

The Intergovernmental Panel on Climate Change (IPCC) warns that greenhouse gas emissions will have to be reduced to zero by 2050 at the latest if global warming is to be limited to 1.5 °C. If we fail to achieve that objective, we risk setting in motion mechanisms whose consequences are almost impossible to predict – and today still appear abstract and unreal. The current scientific consensus suggests that the effects will far exceed the increase in extreme weather events already observed. We face the irredeemable destruction of entire ecosystems, and with them the livelihoods of whole societies.

In the Paris agreement of December 2015, 195 states agreed to take this warning seriously. A year later the German government fleshed out its commitment and presented a Climate Action Plan with a long-term goal of making the country greenhouse gas–neutral by 2050. This presents Germany, as the world's sixth-largest greenhouse gas emitter, with enormous challenges – in the electricity sector, in its building sector and even more so in agriculture and mobility.

The transformation required in these sectors will involve deep changes in our economy, including impacts on work and employment. The Commission on Growth, Employment and Structural Transformation cast a very sharp light on these issues last year: Ending the generation of electricity using coal will inevitably mean a loss of jobs in the conventional power sector.

Other sectors will also experience deep transformation processes. This is often discussed in terms of the end of industry in Germany and a resulting massive loss of good industrial jobs, whether through energy-intensive industries moving abroad or the loss of international competitiveness. But that line of argument neglects both the real challenges and the positive effects that a comprehensive Energiewende can offer for work and employment.

In fact the comprehensive scenario modelling by Prognos AG shows that in overall economic terms just as many people will be employed in an almost GHG-neutral Germany in 2050 as would be in a scenario without an ambitious Energiewende – and if anything, slightly more.

Employment will continue to grow particularly strongly in the lead markets for climate protection technologies and services. More than half a million new jobs have been created since 2003 in the renewable energy sector and the lead markets for energy efficiency and green mobility. By 2050 the share of employment in these sectors is set to rise to 4.9 percent. That is more than currently work in the car industry (including all the sectors depending on it). Today that is one in every twenty-five workers in Germany. Sectors associated with the construction industry will profit especially from the investment that will be required in infrastructure and renovation. Employment growth can also be expected in the electricity, gas, heating and cooling sectors if the Energiewende is pursued energetically. The study also indicates that the newly created jobs will encompass all levels of qualification. As the findings underline, the crux now is effective political management of this transformation. If full use is to be made of the available potential, the expansion of renewable energy needs to be significantly accelerated to the point where electricity demand is entirely covered, along with energy modernisation of buildings and complete conversion of vehicle fleet to alternative drive technologies. The concrete needs today are: a significantly more ambitious expansion path for wind power, the creation of sufficient storage capacity, and action to step up the pace of energy modernisation.

For those employed in conventional electricity generation, the coal and oil sectors, and the engineering and vehicle industries, possibilities need to be created to smooth the transitions to new employment. That requires suitable labour market policies and training opportunities. The metalworkers' union IG-Metall, for example, has proposed an innovative concept in the guise of a short-time working allowance tailored to transformation.

The winds of change will be felt by regions as well as individuals. The models show that the eastern German states would profit somewhat more strongly from an ambitious Energiewende than their western counterparts. The study examines what this would mean for the states of North Rhine-Westphalia and Brandenburg. Both will have to shoulder burdens associated with ending the generation of electricity using coal, but under different circumstances. These differences in the existing economic structure will need to be reflected in the economic and structural policy approaches.

Not least, it will be crucial to ensure that the new jobs are "good jobs". Only then will the Energiewende find lasting acceptance among the workforce. In this respect the study supplies first pointers as to what developments are to be expected. New jobs will be created disproportionately in small and medium-sized enterprises while sectors with traditionally strong union representation and widespread collective bargaining agreements will tend to decline. Nevertheless, the overall finding is that the proportion of the workforce covered by collective agreements could increase slightly on average. In this connection special attention should be given to the construction sector, given that especially strong growth in employment is forecast but currently only one-third of workers are covered by collective agreements.

If the potentials for employment and good work are to be tapped to the full, Germany will have to determinedly pursue its Climate Action Plan and sectoral targets; the Paris climate targets also need to be implemented through binding decisions at the global level. Germany must therefore campaign vigorously for internationally coordinated action, but at the same time forge ahead without fear and assume an international pioneering role. As the present study shows, we can take a significant step towards fighting global warming without endangering our country's economic base – even if it is not (yet) possible to persuade all other countries to participate. If we want to see a better tomorrow we must get to work today.

MAX OSTERMAYER
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1

BACKGROUND, OBJECTIVES AND STUDY DESIGN

BACKGROUND AND OBJECTIVES OF THE STUDY

One important objective for any forward-looking energy and climate policy (which includes the so-called Energiewende) will be to achieve a low-carbon, low-GHG economy in a comprehensive sense (including buildings, mobility, consumption). This massive structural transformation will create enormous pressures on businesses that experience difficulties adjusting to the changes, and thus also on jobs. This frequently leads the discussion into a trade-off between climate protection and jobs. At the same time new jobs are created in businesses that are able to profit from the Energiewende, for example by developing and manufacturing the required technologies. So ecological sustainability and prosperity should not be treated as incompatible, even if the turn to a low-energy, resource-saving way of life transpires to be conflictual on many fronts.

That is the background against which Prognos was commissioned by Friedrich-Ebert-Stiftung (FES) to produce a study on the significance of the Energiewende for future employment in Germany. Alongside the purely quantitative aspects, the study also explores the qualitative aspects of the employment effects and their regional distribution. Additionally, it lays out a tentative outlook on possible recommendations for a socially acceptable structural transformation. The concrete questions that the study set out to answer were:

– What employment effects have occurred in the past in response to energy and climate policy measures?

– How large are the future employment effects associated with the Energiewende, both overall and by branch? What effects are found in the various lead markets for climate protection technologies and services?

– What regional differences are found?

– Are changes in relation to type of employment (in terms of occupations and qualifications) to be expected as a consequence of the Energiewende?

– What shape might recommendations for a socially acceptable structural transformation take?

METHODOLOGY

In answering these questions the authors were frequently able to draw on prior research by Prognos. The description of developments to date references work on the macroeconomic effects of the Energiewende conducted on behalf of the Bundesministerium für Wirtschaft und Energie (BMWi) (GWS et al. 2018). The discussion of future developments builds on the findings of the scenario study "Klimapfade für Deutschland" (Climate Paths for Germany) conducted for the Bundesverband der Deutschen Industrie (BDI) (BCG/Prognos 2018). Taken together, these two studies form the basis for our discussion of past and future developments.

Those results are supplemented by relevant findings from other studies and existing Prognos models. In connection with modelling the lead markets for environmental technologies, these include detailed investigations of particular lead markets (ZAB/Prognos 2016; Prognos 2018; ESPON et al. 2019) and studies for various German federal states (MKULNV/Prognos 2017; StMWi/Prognos 2017; ThEGA/Prognos 2019). In relation to the quality of employment effects we refer to the latest study in the "Arbeitslandschaften" (Work Landscapes) series commissioned by the Vereinigung der bayrischen Wirtschaft (vbw) (vbw/Prognos 2019).

In light of the volume of prior research, the following sequencing was adopted in answering the research questions:

– Employment trends since 2000 were examined, in order to account for historical experience. Year 2000 is frequently cited as an important milestone in the Energiewende process, as the point where the Electricity Feed-In Law (Stromeinspeisungsgesetz, StrEG) was succeeded by the much more incisive and far-reaching Renewable Energy Law (Erneuerbare-Energien-Gesetz, EEG). But numerous other energy policy measures and instruments have been introduced since then. In order to assess the effects of the energy policy instruments, a counterfactual scenario without them was modelled first. This was then used to determine the net employment effects of the Energiewende.[1]

– To identify the future branch-level employment effects associated with the Energiewende, the findings of a suitable scenario from the "Klimapfade für Deutschland" (Climate Paths for Germany) study were used (in this case the so-called 95-percent climate path, in which total national GHG emissions are reduced by 95 percent by 2050 (compared to 1990). The effects of branch trends on lead markets were inferred using the envigos model for environmental industry, goods and services.

– The effects at regional level were derived from the branch-level findings, on the basis of the forecast of branch-level employment trends across all states published by Prognos (Deutschland Report 2025–2035–2045; Prognos 2018). Two regions were also examined in greater detail.

– In order to model future change in type of employment attributable to the Energiewende, an existing Prognos labour force model was used to first identify the occupation- and qualification-specific employment effects. This model permits conclusions about specific occupations to be derived from the branch-level findings. These results were supplemented with selected indicators supplying insights into the factors influencing the quality of the resulting employment effects from the workers' perspective.

– When identifying areas of action for a socially acceptable structural transformation we first identified the areas where there is actually any need for action at all. Building on this, first pointers to possible areas of action are presented in comprehensible form and discussed in relation to literature analyses and prior research.

These steps and their findings are reported in the following chapters, with the findings summarised at the end.

1 As mentioned above, we draw here on the findings of GWS et al. (2018).

2

EMPLOYMENT TRENDS UNDER THE RENEWABLE ENERGY LAW

2.1 INTRODUCTION TO GROSS AND NET CHANGE IN EMPLOYMENT

The German Energiewende, whose origins can be traced to the 1991 Electricity Feed-In Law, received a strong legal framework for electricity generation with the introduction of the Renewable Energy Law in 2000. The Renewable Energy Law introduced the principle of prioritising renewable sources of electricity and defined technology-specific feed-in tariffs. The years that followed saw a significant expansion of green electricity generation in Germany. By 2018 its share of domestic gross electricity consumption had reached 37.8 percent (AG Energiebilanzen 2019). The most important source of green electricity in Germany is wind power, followed by biomass and photovoltaic. Renewables are also used in the heating and mobility sectors. In 2018 renewable energy accounted for 14 percent of total primary energy consumption (AG Energiebilanzen 2019).

Alongside renewable energy, energy efficiency represents a second decisive pillar of the Energiewende. In fact the German Federal Ministry of Economics regards it as the top priority, following the principle of “efficiency first”. There is still great potential to improve efficiency both in the building sector and in industrial production. Another central field for climate action is the mobility sector (“Verkehrswende”). This includes promoting walking, cycling, public and shared transport; intelligent networking of transport systems; and the development of alternative and green drive technologies. While these three areas of action are frequently discussed in terms of their climate impact, they are also economically relevant.

Renewable energy, energy efficiency and green mobility are associated with a range of economic activities and employment effects. This chapter addresses the employment impact of climate protection. We begin by examining the gross employment effects associated with climate protection technologies and services (see 2.2). Then the aggregate net effects are scrutinised (see 2.3). Net employment effects represent the overall change in employment, including the losses associated with structural transformation. To accomplish this, the actual trend was compared with a counterfactual scenario that simulates the course of developments without the Energiewende on the basis of specific assumptions about the legal framework and investment. On the other hand, the gross employment effects discussed in the next section represent only the changes in employment in the respective fields of activity of the individual lead markets of climate protection technologies and services.

2.2 GROSS CHANGE IN EMPLOYMENT IN THE LEAD MARKETS FOR CLIMATE PROTECTION TECHNOLOGIES AND SERVICES

2.2.1 DETERMINING THE GROSS EFFECTS

To determine the gross effects, in other words the direct and indirect employment effects of climate protection technologies and services, one must first identify and quantify the economic activities involved.[2]

The basis for this is Prognos AG’s model for environmental industry, goods and services (envigos) (see text box); which assigns environmental technologies and services to various lead markets. Three lead markets cover the direct and indirect economic activities associated with climate protection (referred to in the following as “climate protection lead markets”): renewable energy (REW), energy efficiency (EEF) and green mobility (KMO). These lead markets are further differentiated into various market segments and technology sectors (see Table 1).

The various green generation technologies form the heart of the renewable energy lead market (REW). Here employment arises not only in the scope of energy production itself, but also in upstream and downstream elements of the value

2 “Direct employment” means jobs that are directly connected to the renewable energy sector, specifically the manufacture and operation of generating plant. Indirect employment covers areas such as inputs for the production of green energy installations (components) and plant installation tasks (project planning, building work). The approach described here accounts for both of these aspects. Other less closely connected activities – such as unspecific inputs (with unspecific purpose), inputs for inputs (such as raw materials) and induced effects (resulting from consumer spending by workers in the renewables sector) – are not included.

Table 1
Lead markets for climate protection technologies and services

Lead market	Market segment	Technology sector
Renewable energy (REW)	Renewable energy generation	Bioenergy
		Geothermal
		Solar
		Hydro power
		Wind power
		Consulting and research
	Intelligent energy systems and networks	ICT for energy systems
		Network expansion and operation
		Network engineering
	Storage technology	Electrochemical energy storage
		Mechanical energy storage
		Thermal energy storage
Energy efficiency (EEF)	Energy-efficient buildings	Construction and installation
		Insulating materials
		Building technology
	Energy-efficient production processes and technologies	Waste heat utilisation
		Compressed air and pump systems
		Installation and consulting services
		Process control engineering and instrumentation
Green mobility (KMO)	Intelligent traffic management systems and infrastructure	Infrastructure for green mobility
		Traffic management
	Climate-friendly logistics and mobility services	Public transport and sharing systems
		Climate-friendly logistics
	Green mobility and drive technologies	Alternative vehicles
		Drive technologies
		Vehicle technologies

chain such as R&D, manufacturing and not least planning and installation. This lead market also includes the technologies and services required for successful execution of the Energiewende (market segment "intelligent energy systems and networks"). The distributed character of many green energy installations, regional disparities between generation potential and concentrations of population and industry, and availability-related fluctuations[3] demand a comprehensive expansion of the networks for transmission (long-distance high-voltage lines) and distribution (regional supply to industry and households). The energy system also needs to be overhauled to equip it for future requirements such as smart grids and electromobility, and storage technologies (electrochemical, mechanical and thermal) will be needed to deal with fluctuations.

3 In simplified terms this means the theoretical volume of power generation permitted by the weather situation. "Supply" refers to the actual amount of electricity fed into the grid.

The energy efficiency lead market (EEF) comprises energy-efficient buildings and production technologies. It principally concerns the construction industry, with manufacturers and service providers from the machinery and plant engineering, digital ICT, and electrical/energy engineering sectors also playing a role. Key technologies here include heating, ventilation and air conditioning; insulating materials; CHP; and smart home systems, as well as automation, networking and control of industrial processes.

The green mobility lead market (KMO) comprises the technologies and services required for climate-friendly movement of people and goods. It subdivides into three market segments: green mobility und drive technologies (including alternative drive concepts such as electromobility and biofuels), climate-friendly logistics and mobility services (including local public transport and carsharing), and intelligent traffic management systems and infrastructure (including flow optimisation and infrastructure for pedestrians, cyclists and public transport).

The envigos model identifies these activities by branch and product in the statistical classification systems and as such enables the use of official statistical data (employment statistics, VAT statistics) to analyse employment impacts.

THE ENVIGOS MODEL

The envigos model for environmental industry, goods and services is a proven analysis tool capable of investigating all relevant technologies and products across the environmental economy on the basis of official economic statistics at a granular level of detail. The lead markets for climate protection technologies and services form a central component. By combining functional and sectional approaches the model takes direct and indirect value creation activities into account.

Functional approach: The functional representation of renewable energy generation/storage and energy efficiency technologies forms the basis for the analysis of flows of goods and international trade links. On the basis of a method developed by the OECD and Eurostat, the function of each of the product groups (of which there are more than seven thousand) is examined. This permits all relevant products and services to be handled with granular precision. The method also uses a weighting procedure to take into account multifunctional dual-use goods. For example nonwovens are used both for insulation and for other purposes.

Sectoral approach: The basis for assessing the economic potential of the various areas of the environmental economy, such as technologies for generating and storing renewable energy or improving energy efficiency, is a branch-based model, linked to the functional model by assignment keys. This approach can be used to assess the economic significance of energy-related goods with respect to variables such as working population and gross value added.

The model thus provides a supply-oriented approach for determining employment effects. The analysis is based on official statistical data (including employment statistics, VAT statistics) and therefore creates a more comprehensive and more valid picture than for example survey-based approaches. It also possesses decisive advantages over demand-based approaches, which estimate employment and value creation effects indirectly on the basis of investment. The underlying datasets are updated more frequently (employment for 2018) and detailed figures are given for various value-adding sectors.

2.2.2 EMPLOYMENT TRENDS IN THE LEAD MARKETS FOR CLIMATE PROTECTION TECHNOLOGIES AND SERVICES BETWEEN 2003 AND 2018

The top-line finding of the model-based analysis is that climate protection already represents a significant employment factor today. In 2018 the three lead markets gave work to more than 1.2 million people, or almost 3 percent of total employment.[4] The strongest employment impact comes from the green mobility and energy efficiency lead markets (see Figure 1).

Altogether a strong employment trend has been observed since 2003,[5] with growth trajectories differing observably between lead markets. Renewable energy experienced a phase of very strong growth between 2003 and 2010, but slowed significantly thereafter. The energy efficiency lead market by contrast remains on a path of uninterrupted expansion. Strong growth in the 2003 to 2010 period was followed by even stronger growth. In the green mobility lead market there was already significant employment in 2003, partly because of employment in public transport. This grew only slowly until 2010 but has accelerated noticeably since then.

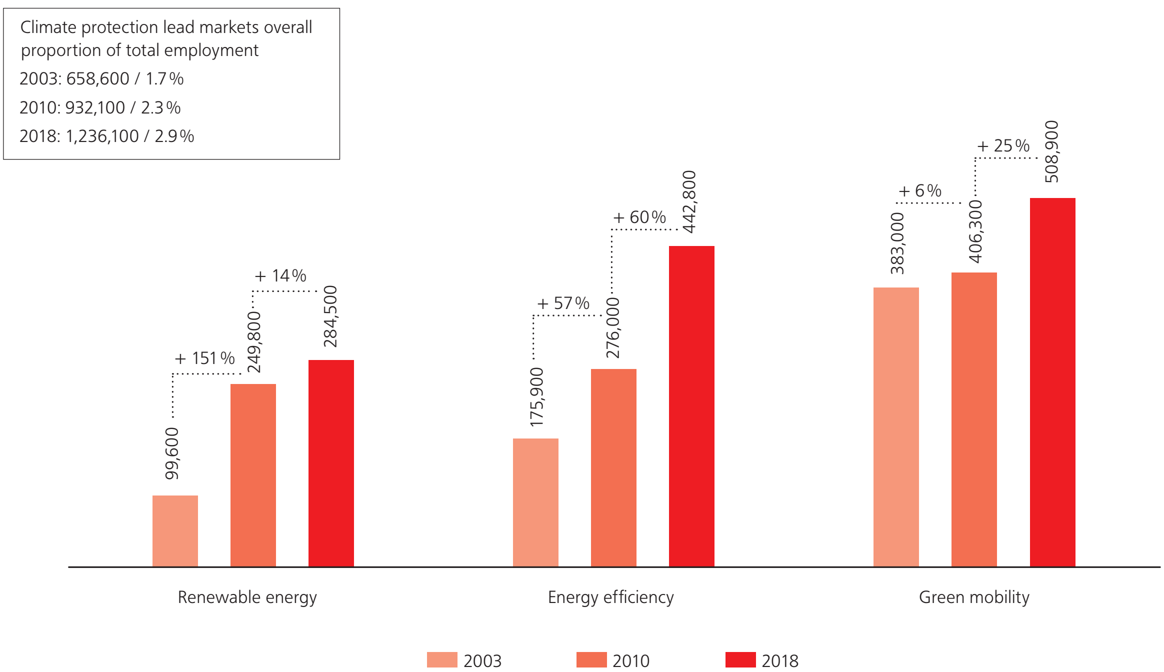
Closer scrutiny of the three lead markets underlines the respective significance and different trajectories of the various market segments. Employment in the renewable energy lead market is strongly influenced by the development of the renewable energy generation market segment. As Figure 2 shows, it was responsible for most of the strong growth between 2003 and 2018. But from 2010 to 2018 the trend stagnated (see next section). Employment in the intelligent energy systems and networks market segment by contrast rose continuously, to almost 75,000 in 2018. This development is associated above all with a significantly increased share of renewable energy in gross electricity generation and the demands this places on the performance and the expansion of the energy system. The employment impact of storage technologies remains small.

The dynamism of the renewable energy market segment is very visible in relation to the different technology sectors (Figure 3). Solar power is central, with a boom between 2003 and 2010 and for a time more than 100,000 employ-

4 For a comparison with other key branches see 3.2.2.

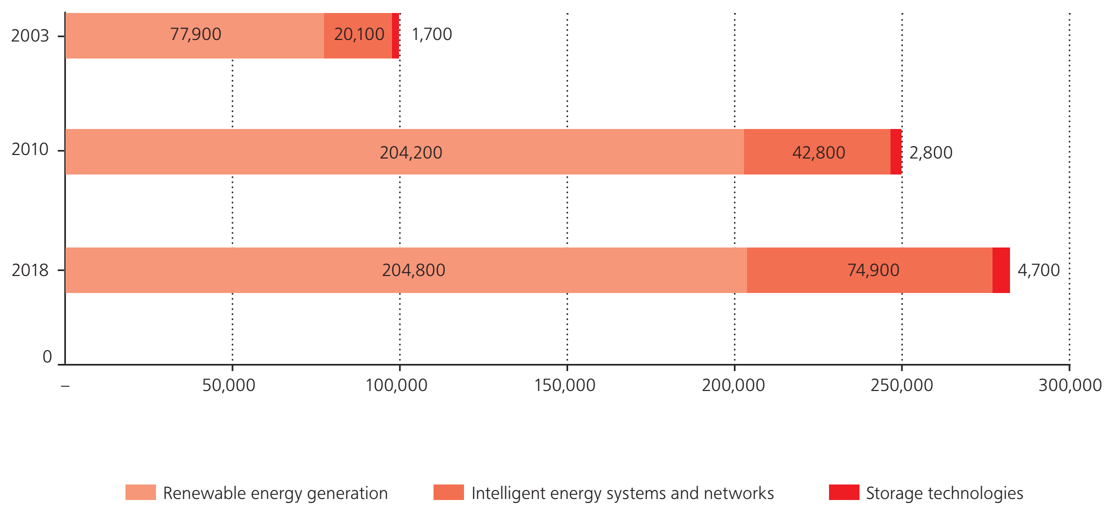
5 The analysis commences with 2003 for reasons of data availability. While the years 2000 to 2002 were also relevant in relation to the introduction of the Renewable Energy Law, the relevant statistical agencies supply data only for an older version of the classification of branches (Wirtschaftszweigklassifikation), which is not compatible with this analysis.

Figure 1
Employment in the lead markets for climate protection technologies and services, 2003 to 2018



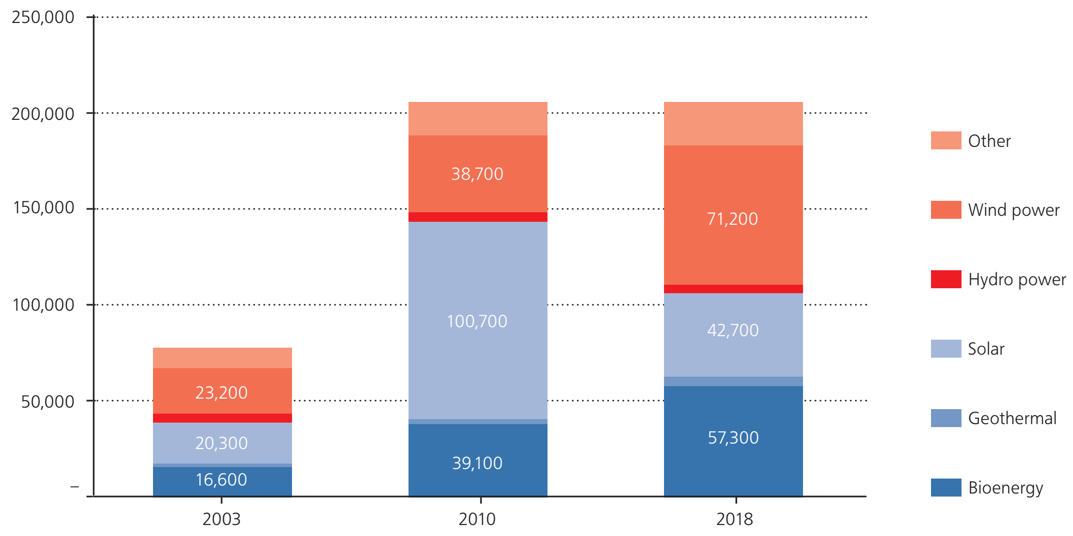
Source: Authors' calculations using data from Bundesagentur für Arbeit and Statistisches Bundesamt 2019a.

Figure 2
Employment in the renewable energy lead market



Source: Authors' calculations using data from Bundesagentur für Arbeit and Statistisches Bundesamt 2019a.

Figure 3
Employment in renewable energy generation



Source: Authors' calculations using data from Bundesagentur für Arbeit and Statistisches Bundesamt 2019a.

ees. In subsequent years the workforce declined noticeably, partly due to increasing international competition in the manufacturing of PV modules. The pace of PV expansion also declined noticeably, in the context of a squeeze on subsidies (so-called PV reform in the Renewable Energy Law). By 2018 there were just 43,000 employees left in the solar industry. The significance of the wind power branch, on the other hand, has increased continuously. In the meantime it has become the most important form of green energy in Germany, with the strongest employment impact (more than 71,000 employees in 2018). But the more recent trend in wind power gives grounds for concern, with a dramatic collapse in construction of new onshore installations: The figures for newly installed capacity were 5.3 GW in 2017, 2.4 GW in 2018, and less than 0.3 GW in the first six months of 2019 (Deutsche WindGuard/BWE 2019). One reason for the slump can be seen in the privileges for citizen-owned energy companies introduced together with tendering in 2017, which have created massive delays in realising new projects. But the rules were corrected in 2018 with an amendment to the Renewable Energy Law and the effect should begin to weaken going forward. Problems also exist in the approval procedures for new wind parks, where legal action has an increasing impact on approvals and thus also on the time and expense involved in realisation.

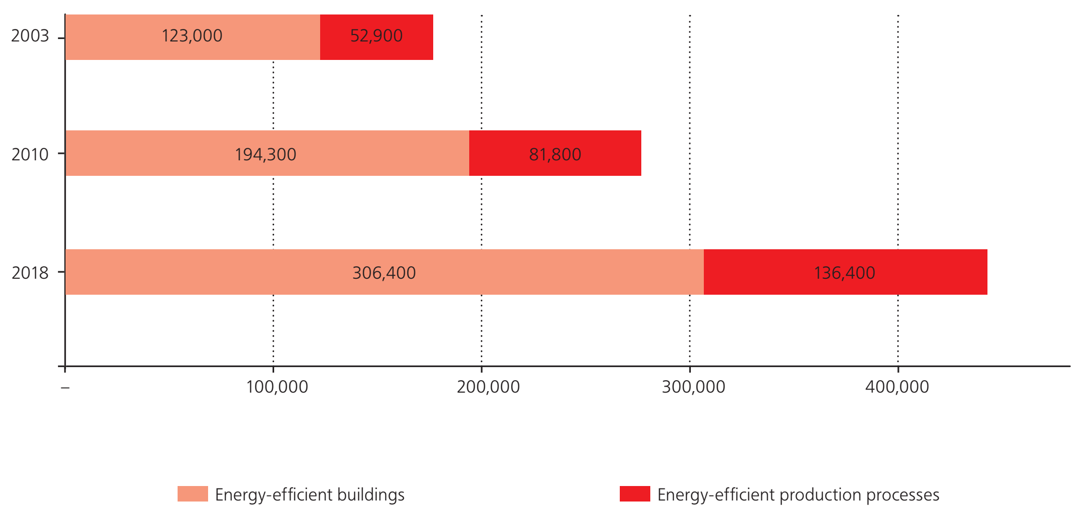
Beyond those spheres, bioenergy has also seen very strong growth and currently employs more than 57,000 (including production of biogas und biomass for heating and biofuels for mobility). The number employed in this sector has more than trebled since 2003.[6] Hydro power and geothermal are economically less significant with about 11,000 employees between them. There are also about 22,000 persons classified under "other", which includes consulting.

In the energy efficiency lead market both segments show strong and relatively stable growth since 2003 (Figure 4). The energy efficient buildings segment has an especially strong employment impact, with more than 300,000 employees in 2018. This is largely attributable to the employment-intensive nature of construction and modernisation work.

The construction, construction materials and building technology sectors account for the bulk of this market segment, along with energy consulting and energy management services. Its dynamism coincides with the continuous expansion of efficiency efforts in the building sector. The energy-efficient production processes und technologies segment is also a large employer (more than 135,000 in 2018). This includes services and technologies designed to enhance efficiency in economy-consuming processes, especially in industrial production. The fields involved include

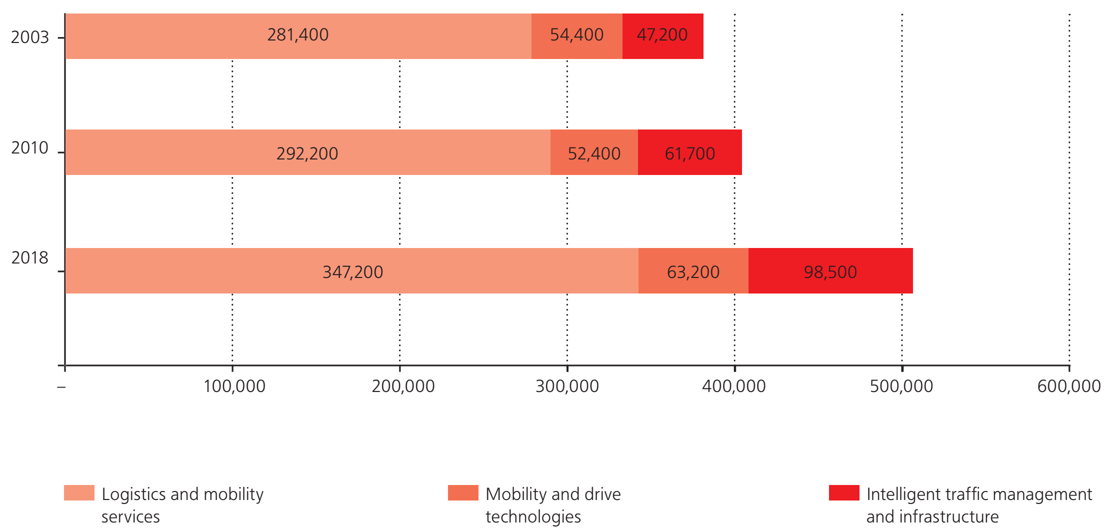
6 The development of bioenergy is a matter of growing controversy, in particular on account of its extensive land use needs and competition with food production.

Figure 4
Employment in the energy efficiency lead market



Source: Authors' calculations using data from Bundesagentur für Arbeit and Statistisches Bundesamt 2019a.

Figure 5
Employment in the green mobility lead market



Source: Authors' calculations using data from Bundesagentur für Arbeit and Statistisches Bundesamt 2019a.

automating and improving process control, control engineering, digital networking (Industry 4.0), and heat recovery and waste heat reutilisation.

Figure 5 shows developments in the green mobility lead market. With almost 510,000 employees in 2018 this is the largest of the three lead markets. It represents about 15 percent of total employment in mobility in Germany.[7] Almost all of this is attributable to the market segment of climate-friendly logistics and mobility services (almost 350,000 employees in 2018). It includes personal and commercial mobility services that represent green alternatives to the private motor car and/or goods transport by road, including in particular local public transport, long-distance rail and coach services, and rail and water-borne freight transport. These already had a strong employment impact in 2003, which has increased since then. The mobility and drive technologies segment ranges from improvements to conventional drive systems (such as hybrid motors) through alternative fuels (biofuels for mobility, hydrogen) to alternative drive concepts (e-vehicles, fuel cells).[8] Here employment growth between 2010 and 2018 was comparatively weak. In 2018 almost 100,000 people were employed in the intelligent traffic management und infrastructure segment, which includes in particular the expansion of green mobility infrastructures such as walkways, cyclepaths, the rail network and charging infrastructure for e-vehicles. The importance of this area has grown strongly since 2010.

2.3 NET EMPLOYMENT EFFECTS IN THE ECONOMY AS A WHOLE

In order to describe the aggregate net employment effects of the Energiewende, the actual development of employment was compared with a counterfactual scenario "without Energiewende" on the basis of a study by GWS et al. ("Gesamt-

7 To account for total employment in mobility the figures for branches WZ 49–53 (Section H, transportation and storage) and WZ 29–30 (manufacture of vehicles and other transport equipment) were added. Note that the residue (difference between overall employment in mobility and employment in the green mobility lead market) cannot be equated with employment in conventional mobility. This is because the definitions of climate-friendly technologies were drawn very tightly; for example, electric cars are not included in their entirety (see next footnote).

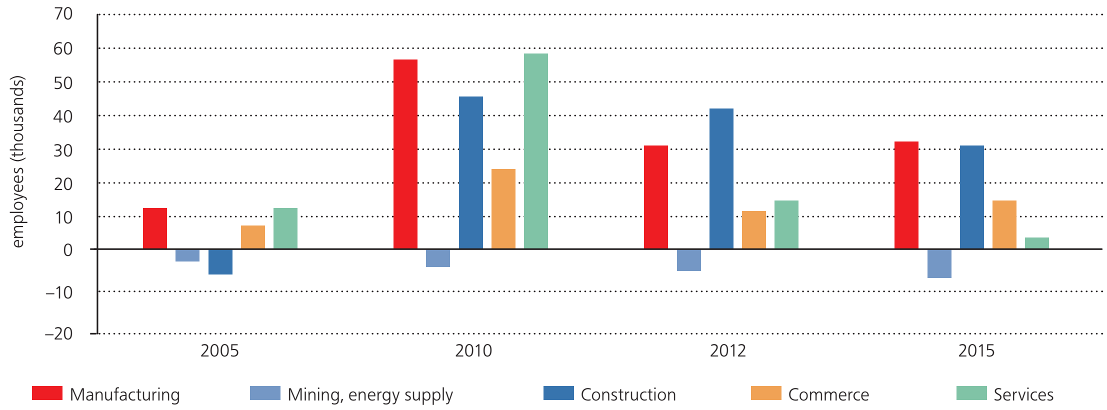
8 The focus here is on the drive technologies themselves and does not include the manufacture of electric vehicles. Otherwise, in light of expected developments under the given assumptions, by 2050 the entire car industry would have to be included. Instead we focus here on the actual decisive technologies, under the assumption that the German car industry remains competitive in the electromobility market. Especially in relation to the production of drive technologies this represents a challenge for industrial and employment policy.

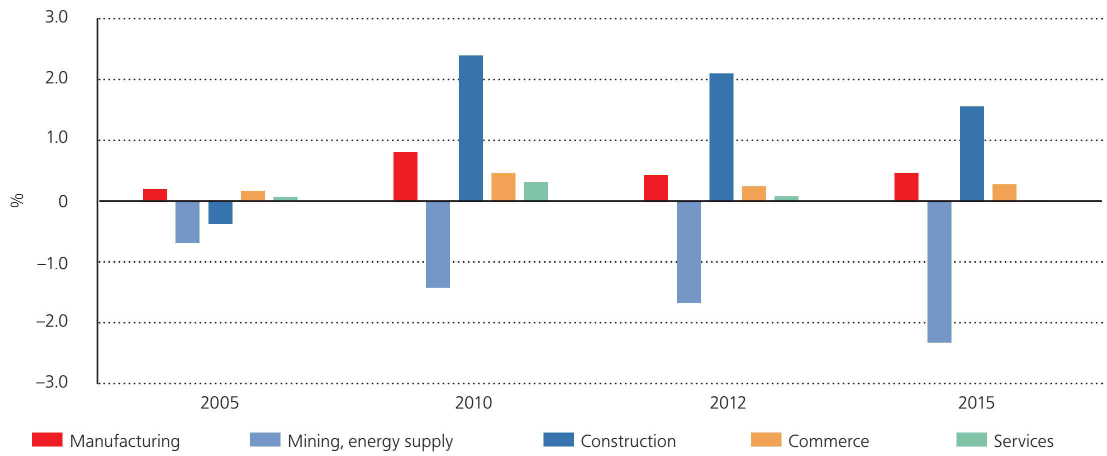
wirtschaftliche Auswirkungen der Energiewende": GWS et al. 2018).[9] The GWS study compares the actual development of the economic system "with Energiewende" with a so-called counterfactual scenario for the period 2000 to 2015 describing a development without the Energiewende.

The counterfactual scenario for example excludes changes in legislation and other forms of support, leading to a slower penetration of renewable energy and efficiency developments compared to the actual observed trend. Here it must be remembered that in green electricity has been supported since 1991 (through the then Electricity Feed-In Law), and in the starting year of the present analysis (2003) the system already contained a clearly visible volume of onshore wind power and electricity produced using biomass. There is therefore practically no further expansion of renewables in the counterfactual scenario and coal-fired generation continues; but the phasing out of nuclear power as decided in 2011 is included. Developments in the electricity market (construction and use of power stations) are governed instead by the rules introduced for the wholesale electricity market ("energy only market", merit order based on marginal costs). The counterfactual scenario assumes the same underlying circumstances for the "reality with Energiewende" scenario (for example population, number of households, GDP growth, branch structure), but final energy demand is higher because there are fewer policy instruments addressing energy efficiency.

9 These developments relating to gross value added and employment were determined by GWS on the basis of the energy scenarios and differential investments calculated by Prognos using energy system modelling, and using the Panta Rhei modelling tools applied by GWS. They supply the net employment effects in aggregated form.

Figure 6
Energiewende scenario vs. counterfactual scenario: employment deviation by sector (thousands/%)





Source: GWS, Prognos, FHG ISI, DIW 2018.

In the world of the Energiewende – compared to the counterfactual scenario – there is more investment in energy efficiency (buildings, industrial processes, mobility) and in renewable energy. This cost is offset by less investment in conventional power stations and savings in fossil fuel imports. The investments are associated with the development and production of the corresponding technologies, such as renewable energy equipment, insulating materials, energy-efficient pumps and motors etc. Their production leads to corresponding increases in value creation and employment in the associated branches, above all in machinery and plant engineering and in the construction industry. "Second-round effects" lead to a complex picture of gains and losses for households and branches.[10] The trajectories of the two scenarios differ correspondingly. In the counterfactual scenario primary and final energy consumption fall only slightly. Greenhouse gas emissions remain largely unchanged. The Energiewende scenario sees falls in primary and final energy consumption.

The findings (Figure 6) show that the overall net employment effects of the Energiewende have been positive. The Energiewende has created more employment overall than the counterfactual scenario (about 71,000 in 2015). But the effects vary enormously between branches. In the period 2000 to 2015 the biggest positive employment impacts were in construction industry, in manufacturing and in services. The employment impacts were negative in the mining and energy supply sectors.

10 For example if income rises on account of an increase in employment, this can potentially cause an increase in consumption. This in turn leads to positive effects for businesses producing the respective consumer goods.

3

FUTURE EMPLOYMENT CHANGES ATTRIBUTABLE TO THE ENERGIEWENDE

3.1 STARTING POINT: THE BDI CLIMATE PROTECTION SCENARIOS

The starting point for the following analyses is the G95 scenario from the "Klimapfade für Deutschland" study which was prepared in 2018 by Boston Consulting Group and Prognos for the Bundesverband der Deutschen Industrie (referred to in the following as "the Climate Paths study").

The objective of the Climate Paths study was to demonstrate consistent and macroeconomically cost-effective paths for achieving Germany's emissions reduction targets across the entire national energy and greenhouse gas system. In the course of a complex stakeholder process three scenarios were developed and – above all for the energy system – modelled in detail:

– A baseline scenario assessing the implementation of current energy und climate measures and instruments and – assuming a moderate tightening of the instruments as permitted by technical progress – extrapolating it to 2050. This assumes that there are no fundamental changes in the policy frameworks for energy and mobility. At the international level emissions trading remains restricted to the existing participants (the energy sector and major energy-intensive industries) and is not meaningfully expanded. There are no major changes in the EU's Emission Trading System (ETS), despite the need to reduce the supply of certificates if ambitious targets are to be set. This "no change" scenario represents the baseline against which efforts to achieve more ambitious climate targets are measured.

– A so-called target scenario, in which the upper limit of the Paris target corridor (for GHG emissions) is achieved, a reduction in GHG emissions by 80 percent by 2050 (compared to 1990) ("80 % climate path", "N80 climate path").

– Another target scenario, in which the lower limit of the Paris target corridor is achieved – a reduction in GHG emissions by 95 percent by 2050 (compared to 1990) ("G95 climate path").

The scenarios are calculated according to international accounting conventions, within the accounting limits of the GHG inventory.[11] Although international aviation is not yet one of the political objectives, it is included here as we assume that this will change within the course of the period under consideration.

Each of the two target scenarios is embedded in two international frameworks:

– Framework "N" assumes that climate protection is approached and implemented instrumentally and essentially at the national level, with countries acting alone. Alongside the EU with its ETS and agenda-setting mobility and energy efficiency initiatives, other countries like South Korea and other Asian and possibly South American states will also gradually begin to adopt ambitious climate targets. But there is no globally coordinated multilateral cooperation with binding targets and burden-sharing. For example it is assumed that the United States and Australia will not step up their climate efforts. There is no global CO_2 trading and no global steering tool.

– Framework "G" assumes that global climate cooperation emerges over the course of the coming decade, global CO_2 trading with functioning price formation is established and an ambitious technological trajectory can make full use of the international division of labour.

In consultation with FES it was assumed for this study that a global consensus will coalesce in the medium term to pursue and achieve the (ambitious) emissions targets needed for effective climate protection through joint efforts.

Framework "G" – in which countries collectively commit to the global climate targets and pursue national implementation strategies in a context of global burden-sharing – was

11 This convention means that sources are accounted for territorially within the country's geographical borders, including direct emissions from combustion of fossil fuels, process emissions, emissions from agriculture, diffusion of coolants, etc. There is no lifecycle accounting and upstream data.

therefore selected for this study. The framework is based on the following political assumptions (BCG/Prognos 2018):

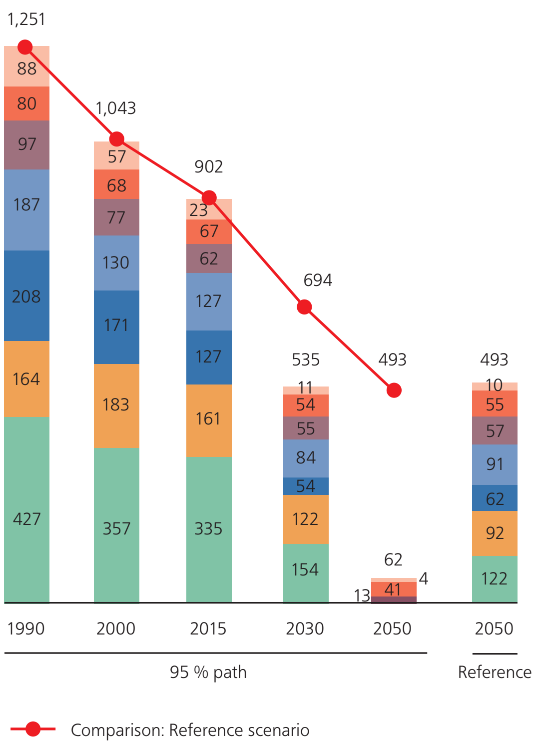
– States commit to an appropriate contribution to the global 2°C target;
– Climate instruments are internationally coordinated;
– Growth and open markets are assumed;
– Investment in climate technologies accelerates innovation;
– Prices for fossil resources remain low;
– Countries are generally willing to pay for climate protection.

One of the central findings of the Climate Paths study is that a GHG reduction of about 61 percent by 2050 (compared to 1990) is plausible if current efforts continue (baseline path: existing GHG reduction measures, political and regulatory frameworks already adopted, foreseeable technological developments). This is still 19 and 34 percentage points short of the German climate targets for 2050. In other words, even an 80 percent target will not be achieved through current efforts.

Efforts to reduce GHG emissions by 80 percent apply known technologies extrapolating known learning curves and appear technically realistic. On account of diffusion speeds and the fundamental "similarity" of the required energy services to the current state of affairs they also appear socially acceptable. Achieving the target will require a considerable intensification of existing efforts and a sharp change of po-

Figure 7
Emissions by sector in the G95 scenario, 1990–2050
GHG emissions and sectoral reductions in Germany

GHG emissions Germany 1990–2050 (Mt CO_2eq)



Sectoral reductions (%)

	1990 – 2015	1990 – 2030	1990 – 2050	2015 – 2050
Other*	–74 %	–87 %	–96 %	–85 %
Agriculture	–16 %	–32 %	–49 %	–39 %
Process emissions	–36 %	–43 %	–87 %	–79 %
Industrial energy emissions	–32 %	–55 %	–99 %	–98 %
Households and industry/ commerce/ services	–39 %	–74 %	–100 %	–100 %
Mobility	–2 %	–26 %	–100 %	–100 %
Energy/ conversion	–22 %	–64 %	–100 %	–100 %
All sectors	**–28 %**	**–57 %**	**–95 %**	**–93 %**

* Including waste management, fugitive emissions and the military

Source: BCG, Prognos 2018.

litical course. So reducing GHG emissions by 95 percent is an even more ambitious endeavour for Germany (BCG/Prognos 2018). A 95 percent reduction in Germany is only possible within a globally coordinated framework. Yet the larger reduction is – according to the current discussion – what is in fact required in order to achieve the 2°C target by 2050 within a framework of global burden-sharing in which developing countries and emerging economies in particular still have emissions budgets at their disposal for bringing prosperity to their populations through economic development. For that reason this study concentrates on assessing the 95 percent climate path.

3.1.1 ASSUMPTIONS IN THE BDI CLIMATE PROTECTION SCENARIOS

G95 scenario
If a 95 percent reduction in GHG emissions is to be achieved by 2050, annual CO_2 emissions must be reduced from 902 million tonnes in 2015 to 62 million tonnes in 2050 – with a reduction to almost zero required for a large proportion of the German economy (BCG/Prognos 2018). Because investment cycles and rationales differ widely between emission sectors, the implementation of corresponding cost-effective measures is not uniform across sectors but follows the investment logic of the respective sectors and branches.[12] The model predicts the following developments in sectoral GHG emissions, if a 95 percent reduction target is to be achieved by 2050 (Figure 7):

As things stand at present, this reduction target is ambitious both for the population (buildings, mobility) and for industry. In particular the "last percentage points" between 2030 and 2050 will demand great effort and technological competence.

Achieving the target of the G95 scenario in Germany will require implementation of the following technical measures (BCG/Prognos 2018):

– Comprehensive electrification of mobility (electric cars and light commercial vehicles, hybrid goods vehicles using overhead wires for freight haulage) and heat (heat pumps, direct electric heating; electric storage heaters no longer needed);

– Thorough energy modernisation of existing buildings to very high standards, new buildings zero-energy from about 2025;

– Comprehensive application of all efficiency technologies in electrical devices and in all industrial processes;

– Zero emissions in the electricity system by covering the need for back-up and balancing capacity with synthetic gas;

– Concentration of nationally available biomass in industry for generating process heat (both solid fuel and biogas; possibly also synthetic gas produced using green electricity in power-to-gas processes);

– Significantly accelerated expansion of renewable energy, in order to achieve complete coverage of electricity demand. Back-up capacities also operated using synthetic gas produced using green electricity;

– Greater flexibility in electricity generation, to allow bridging of severe short-term fluctuations;

– Import of power-to-liquid and power-to-gas fuels from countries with best renewable energy conditions;

– Introduction of carbon capture and storage (CCS) will be required to eliminate emissions from cement production, steel production (where direct reduction is not used) and waste incineration;

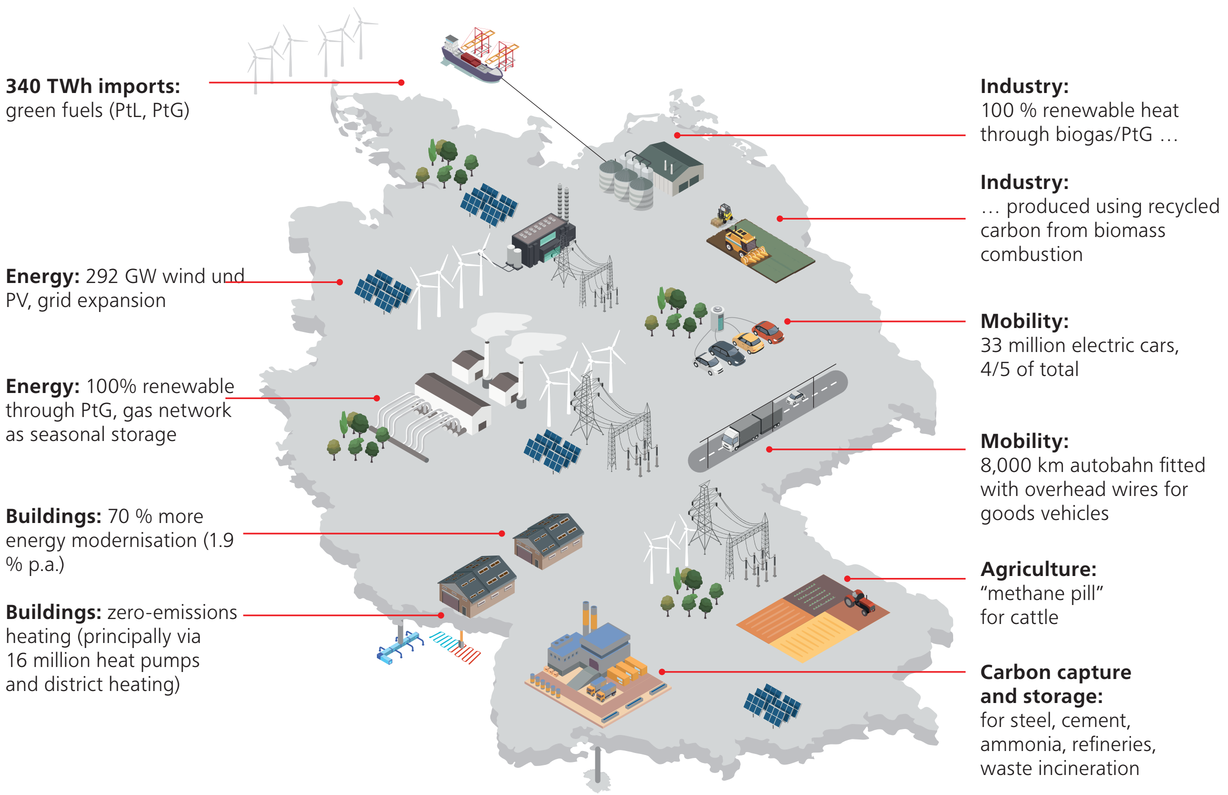
– Significant reduction in emissions from livestock (especially ruminants) and fertilisers.

Figure 8 illustrates in schematic form what it will mean for Germany to implement the measures required for a 95 percent reduction in GHG emissions by 2050 and summarises the central quantitative preconditions. In this scenario the pace of energy modernisation for buildings is almost doubled, buildings in densely populated areas are supplied with green heat via district networks. The energy needs of industry (both electricity and heat) are significantly reduced through efficiency improvements and covered entirely by renewable energy; certain processes in the chemicals industry use hydrogen produced using green electricity. In the mobility sector 8,000 kilometres of German autobahn are fitted with overhead wires for lorries and about four-fifths of the entire vehicle fleet is electric.[13] Where vehicles do use liquid fuels these are produced synthetically using renewable energy (part domestic, part imported). In agriculture efficient fertiliser strategies will need to be implemented and cattle numbers reduced. The "methane pill" will need to be

12 Long planning and investment cycles are found for example for buildings (where the renovation cycle is typically 30–50 years but frequently prolonged beyond that) and for the network expansion (energy/conversion sector, both for electricity and heating networks) that represents a fundamental prerequisite for expanding renewables and therefore needs to be tackled correspondingly rapidly. In the case of energy-efficient lighting (households, industry/commerce/services and industrial buildings) the (re-)investment cycles are a great deal shorter on account of the shorter technical service live of the products.

13 Optimisation of economic efficiency in the scenarios led to the inclusion of the overhead wires option for goods transport. It is considerably cheaper and more energy-efficient than the production and comprehensive use of alternatives such as hydrogen or synthetic fuels produced using electricity. Because of efficiency losses, the use of domestically produced hydrogen for example would require twice as much renewable electricity as the same unit of mobility powered directly via overhead wires. For that reason in this scenario green hydrogen is used principally in industrial processes and only to a small extent for mobility.

Figure 8
Germany in 2050 after 95 percent GHG reduction
Measures to achieve emissions targets in the G95 scenario



PtL = power-to-liquid, PtG = power-to-gas, PV = photovoltaic; all figures for 2050.

Source: BCG, Prognos 2018.

introduced to cattle feeding strategies in order to reduce methane emissions.

As already mentioned, implementation of the G95 scenario will need to begin very quickly and proceed with a very determined dismantling of obstacles to implementation (for example user/investor dilemmas in building modernisation, questions relating to acceleration of network expansion, green energy expansion and CCS). For that reason the scenario with an 80 percent GHG emissions reduction is also briefly presented here.

G80 scenario
Achieving an 80 percent emissions reduction target will naturally require a less rigorous implementation of efficiency measures and of the introduction of renewable energy in all sectors. The last 20 percent will, however, be concentrated in those sectors where it is most difficult to achieve progress. In

the 80 percent path for example there is no need to introduce the CCS technologies that are vital for achieving the targets of the G95 scenario. The following aspects of the 80 percent path are significant (BCG/Prognos 2018):

– Compared to the baseline path intensified sector coupling of mobility and heat to reduce emissions;

– Exploitation of efficiency potentials, above all in industry, households and industry/commerce/services), but with less complete penetration than in the G95 path;

– Compared to today significantly accelerated pace of energy modernisation of buildings (by about 50 percent) and accelerated penetration of green heating (above all heat pumps and district/neighbourhood heating using renewables);

– Biomass in industrial applications to generate medium and low temperature heat;

– Acceleration of Energiewende in electricity sector: 88 percent of German electricity generation renewable by 2050 (back-up capacities still use [fossil] natural gas).

In the G80 scenario these measures have the following consequences:

– Increase in volatility of electricity supply as result of switch to renewables. Cushioning through improved flexibility of new consumers (electric vehicles, heat pumps);

– "Electricity surpluses" not prevalent, reducing potential for domestic Power-to-X applications using surplus;

– Heterogeneity of sectors for achieving 80 percent target: individual sectors make very different contributions. In some sectors the sectoral targets for 2030 will be missed (mobility in particular); greater national investment would be required to achieve sector-specific targets.

Concretely, in the 80 percent path in 2050 for example about two thirds of vehicles in Germany will be electrically powered, 4,000 kilometres of German autobahn will be fitted with overhead wires for lorries, and emissions in agriculture will be reduced by more efficient use of fertiliser. Livestock numbers will not be reduced and feed strategies will remain unchanged.

3.1.2 GROSS VALUE ADDED IN THE G95 SCENARIO

Under assumptions used in the G95 scenario, the model predicts an average annual growth rate of 1.2 percent for real gross value added (GVA) in 2050 in Germany (BCG/Prognos 2018). The decisive factors for this rather modest development are above all a global weakening of economic growth because of declining global population growth and convergence processes in the emerging economies which lead – despite increased per capita GDP – to a flattening of growth trends in those countries. This applies in particular to China. This set of conditions was used as the framework for calculating the baseline scenario and as the basis for calculating climate paths, in order to guarantee comparability: the same level of value added should be achieved (with climate protection) and the resulting demand should be covered. Reduction through relocation of (energy- or emissions-intensive) businesses ("carbon leakage") is explicitly excluded. It is one of the conclusions of this study that this needs to be ensured through corresponding political frameworks and compensatory processes.

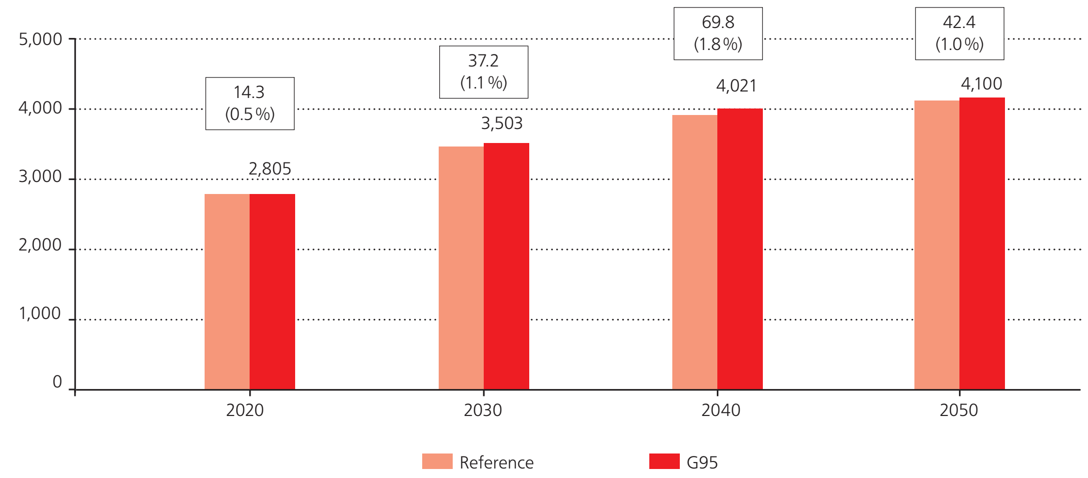
The emissions reductions are achieved by implementing technical measures, partly also through technological changes (such as for example strong penetration of heat pumps and electric vehicles, green electricity). This requires investment. In the G95 path cumulatively about €2.3 trillion in additional energy-related investment will be needed over and above the baseline scenario in the various sectors by 2050. That corresponds to about 3 percent of the investment in plant and buildings already factored into the baseline scenario. This spending on investment is balanced by savings in imports of fossil fuels. The resulting net expenditure is thus a good deal lower, with a cumulative figure of just under 1 trillion by 2050.

The investments at stake here are in plant and buildings (for example heating technology, energy systems, efficiency technologies, materials), much of which are produced in Germany rather than imported. These domestic investments lead – through growth in the corresponding branches and businesses – to (positive) knock-on effects in industryoriented services (for example planning and engineering firms), trades (for example building trades, heating installation, servicing etc.) and also in private consumer spending. Altogether therefore all scenarios find a small but positive added value effect compared to the baseline scenario on account of additional investment and a reduction in energy imports.

Figure 9 shows the development of total real gross value added in Germany in the G95 and baseline scenarios. In all years illustrated the gross value added in the G95 scenario is slightly higher than in the baseline scenario. The reason for this is that the required investments in plant and buildings are implemented above all by efficient domestic sectors. On the one hand imports of fossil fuels are substituted by domestic investment. On the other, these investment lead in turn – through slightly increased GVA and the associated employment – to indirect effects in industry-oriented services and through consumer spending by workers. Additional GVA to the tune of about €42.4 billion has accumulated by 2050, above all because of the climate protection measures.

It should also be mentioned that growth varies between individual industrial and service branches. While growth in

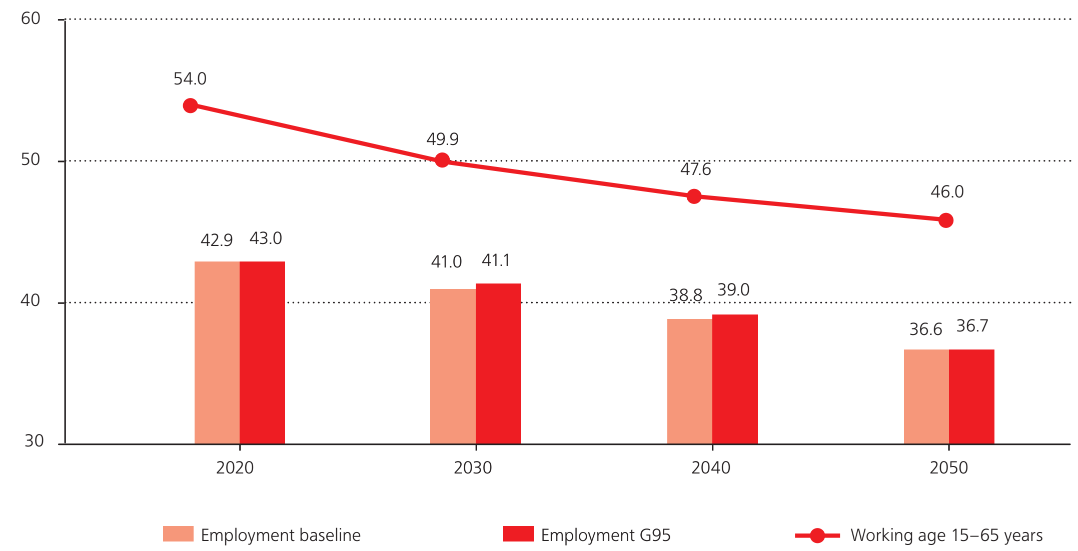
Figure 9
Gross value added in Germany (total)
Baseline and G95 scenarios, 2020–2050 (volume, base year = 2010)



Explanation: In 2050 the gross value added in the G95 scenario is approx. €4,100 billion. In comparison to the baseline situation that represents a positive difference of approx. €42.4 billion or a deviation of 1.0 percent.

Source: BCG, Prognos 2018.

Figure 10
Working-age population and employment
Population aged 15 to 65 years and total employment in the baseline and G95 scenarios, 2020–2050 (millions)



Source: Authors' calculations using data from BCG, Prognos 2018.

energy-intensive branches such as vehicle manufacturing will tend to slow, mechanical and electrical engineering will be boosted. These developments correspond largely to the trends of previous years and are essentially also reflected in the G95 scenario (BCG/Prognos 2018).

3.2 EMPLOYMENT IN THE G95 SCENARIO

3.2.1 DIFFERENTIATED BY BRANCH

Demographic change and further advances in productivity mean that employment in Germany will fall significantly by 2050 regardless of which climate paths are adopted and when. Figure 10 shows the development of working-age population (15 to 65 years) and employment in the baseline and G95 scenarios. It reveals that in 2050 the population between 15 and 65 years of age amounts to about 46 million, corresponding to a decline of about 8 million compared to 2020. One consequence of this demographically driven reduction in labour force potential is that employment falls noticeably in both scenarios (baseline and G95). At the same time employment in the G95 scenario is always higher than the corresponding figure in the baseline scenario.

In aggregate terms the differences in employment between the G95 scenario and the baseline are thus comparatively small: in 2020 about 26,000 more in the G95 scenario than in the baseline scenario; by 2050 the figure is about 43,000. Small positive effects of climate protection on employment have already been demonstrated in the past. In section 2.3 it was shown that overall positive net employment effects occurred between 2003 and 2018 because of energy policy instruments and measures (including the Renewable Energy Law). These were observed especially in the individual lead markets for climate protection technologies and services.

In order to identify the branch-specific differences between the G95 scenario and the baseline scenario we begin in the following by describing the branch-specific developments in the baseline scenario. Figure 11 illustrates the average relative and absolute annual change in employment in selected branches in the baseline scenario over the period 2020 to 2050. This shows firstly that the demographic trend causes a decline in employment in every branch. Secondly it shows that even in the baseline scenario the branches that record the largest percentage losses tend to be those classically associated with high GHG emissions and involved in the extraction or processing of fossil fuels (for example “coal mining” and “crude petroleum and natural gas”). The smallest declines in percentage terms are found in the branches “accommodation and food service activities” (–0.2 percent) and “manufacture of computer, electronic and optical products” (–0.2 percent).

In terms of its relevance for the economy as a whole, absolute change in employment is more important. In larger branches a small percentage change can cause large effects in absolute terms. For example the largest absolute decline is found in the branch “professional, scientific and technical activities” where the annual percentage decline is just –0.3 percent.

As mentioned at the beginning of this section, the differences in aggregate employment are relatively small between the G95 and the baseline scenario. But at the level of individual branches clear (relative) differences are found: not all branches profit equally from investment in climate protection. There are naturally “winners” and “losers” above all on account of the structural transformation in the energy system.[14] Out of the forty-nine branches investigated in all, only nineteen show a negative overall average deviation from the baseline path in employment, both annually and overall.

Figure 12 identifies the branches in Germany where the difference between the G95 scenario and the baseline exceeds 1 percent in 2050. Although the branch “wholesale and retail trade and repair of motor vehicles and motorcycles” does not fall into this category, it is also examined in greater detail because of the large absolute effect involved.

The largest relative employment gains in comparison to the baseline path are recorded by the branches “electricity, gas, steam and air conditioning supply” (+ 4.5 percent), “manufacture of gas; distribution of gaseous fuels through mains” (+ 2.4 percent) and “manufacture of glass and glass products” (+ 2.2 percent). In absolute employment terms the branch that profits most from an ambitious 95 percent climate path is “specialised construction activities” with a positive effect of 21,000 employees in 2050 compared to the baseline scenario. The reason for this is primarily the high level of investment in construction associated with building modernisation in this scenario, and to a lesser extent higher standards for new buildings. The other construction branches – construction of buildings + 2.2 percent) and civil engineering (+ 2.1 percent) – also profit from this development and other infrastructure investment.

The most negatively affected branches are those based on the handling, processing and transport of fossil fuels: crude petroleum and natural gas (– 26.4 percent), manufacture of coke and refined petroleum products (– 15.7 percent) and coal mining (– 12.4 percent). These branches, which are set to experience great change in connection with conversion of the energy system, have comparatively small employment and gross value added in comparison to the other industrial branches. In terms of absolute figures considerably larger differences are therefore visible in other branches. For example the service branch “wholesale and retail trade and repair of motor vehicles and motorcycles” records an

14 Here it must be remembered that even the baseline scenario includes a certain level of change in the energy system: efficiency increases and the proportion of fossil fuels falls, while the proportion of renewables (for electricity, heating and propulsion) increases.

Figure 11
Branches with the largest and smallest declines in employment in the baseline scenario
Decline in employment in the baseline scenario between 2020 and 2050 (in % p.a. and absolute in thousands)

Source: Authors' calculations using data from BCG, Prognos 2018.

absolute difference of about 47,000 employees – with a percentage deviation of just –0.9 percent. This is the branch where the absolute number of employees in a 95 percent scenario falls furthest short of the baseline figure.

Figure 12 shows clearly that the employment effects in the branches associated with the car industry are not especially large. At the same time it is of central importance to the German economy. For that reason the developments modelled for this branch in the G95 scenario are described in greater detail in the text box.

Figure 12
Branches with the largest employment effects
Difference in employment between G95 scenario and baseline scenario in 2050 (in % p.a. and absolute in thousands)

Source: Authors' calculations using data from BCG, Prognos 2018.

3.2.2 DIFFERENTIATED BY THE LEAD MARKETS FOR CLIMATE PROTECTION TECHNOLOGIES AND SERVICES

The employment trends in the G95 scenario can also be viewed through the lens of the lead markets for climate protection technologies and services (see Chapter 2). Using the envigos model we projected the branch-related scenario trends and the underlying technological assumptions onto the lead markets.

EMPLOYMENT IN THE CAR INDUSTRY IN THE G95 SCENARIO

In the BDI Climate Paths study the mobility sector and thus also the car industry are especially affected by the reductions in GHG emissions. A scenario extrapolating existing trends will see a significant shift to bus and rail. Additionally efficiency improvements in internal combustion engines and a shift to 35 percent electric cars and 5 percent gas-powered will ensure a reduction in GHG emissions.

In the G95 path by contrast the mobility sector will have to achieve zero emissions by 2050. For that to happen a further penetration of alternative drive concepts and synthetic fuels will be needed over and above the baseline. Altogether about 80 percent of passenger vehicles will be electric. Most goods transport will also be electrically powered with 8,000 kilometres of overhead wires and 69 percent of goods vehicles electric.

Developments in the mobility sector, in particular the expanded use of electric cars and lorries, create great pressure of change in the German car industry. Climate Paths study assumes that the German car industry will be able to adapt to the new challenges and will largely succeed in upholding its competitiveness.

For the branches "manufacture of motor vehicles, trailers and semi-trailers" and "manufacture of other transport equipment" the BDI Climate Paths study identifies an average annual rate of growth in gross value added of 1.2 percent and 1.4 percent by 2050. The relative differences in employment between the G95 scenario and the baseline are relatively small in these branches in 2050.

However the assumptions made in the scenarios for the mobility sector do not only affect the manufacturing side of the car industry. For example in 2050 in the branch "wholesale and retail trade and repair of motor vehicles and motorcycles" there will be about 47,000 fewer employees (or –0,9 percent) in the G95 path than in the baseline. One reason for this is that considerably fewer employees will be required to sell and repair vehicles.

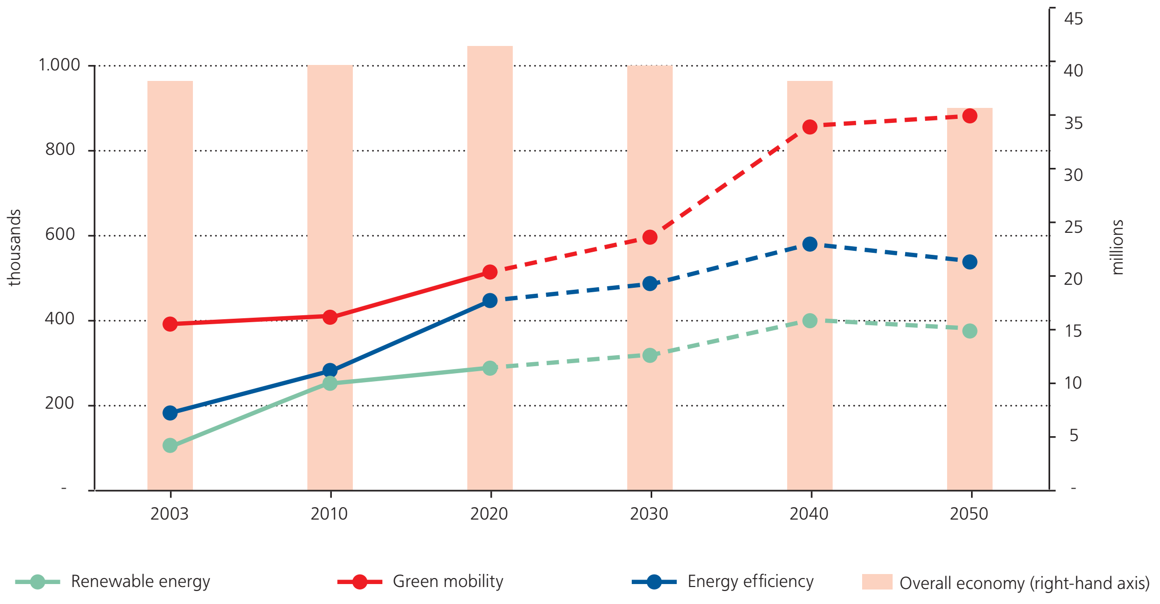
Figure 13 shows the development of the climate protection lead markets until 2050 in the G95 scenario. As would be expected, employment is again boosted in the three lead markets. In the G95 scenario the available technologies and services play a decisive role in achieving the corresponding climate targets. Demand rises accordingly, and with it the employment impact. Gross employment actually rises in absolute terms in the climate protection lead markets amidst a general, largely demographic decline in employment in the economy as a whole.

As in the ex-post analysis, however, different growth paths are expected in the lead markets. Employment in renewable energy and energy efficiency initially grows steadily and peaks around 2040. It can be assumed that a large part of the energy conversion has been concluded by this point (including the expansion of renewable energy and energy modernisation of buildings), and as a result a slight decline is then expected in the phase 2040 to 2050. Altogether however, employment in the two lead markets grows significantly more strongly until 2050 than in the status quo scenario (REW by 0.9 percent p.a.; EEF by 0.6 percent p.a.).

The green mobility lead market grows most strongly overall. Until 2050 employment grows by 1.7 percent p.a. This underlines the centrality of the mobility sector when it comes to achieving the 95 percent target. The phase of strongest growth is expected between 2030 and 2040, when it is assumed that a large part of the electrification and/or decarbonisation of mobility will occur.

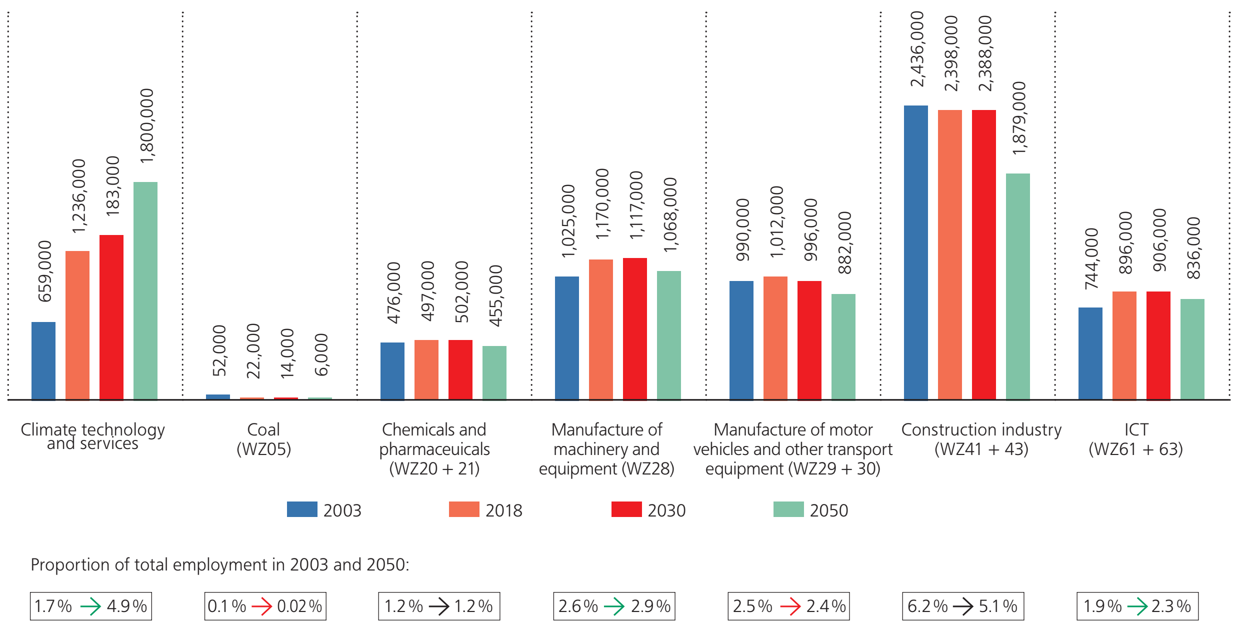
The economic significance of climate protection technologies and services can be illustrated by way of a comparison with other key branches. Here it must be remembered that the climate protection lead markets themselves include particular parts of these key branches. Figure 14 compares developments in the climate protection lead markets with those in coal mining, in the chemicals and pharmaceuticals industries, in mechanical engineering, in vehicle manufacturing, in the construction industry and in the ICT sector.

Figure 13
Employment in the lead markets for climate protection technologies and services 2003 to 2050



Source: Authors' calculations using data from Bundesagentur für Arbeit, Statistisches Bundesamt 2019a and BCG, Prognos 2018.

Figure 14
Employment in the lead markets for climate protection technologies and services in comparison to other key branches



Source: Authors' calculations using data from Bundesagentur für Arbeit, Statistisches Bundesamt 2019a und BCG, Prognos 2018.

What it reveals is that already under the status quo the climate protection markets have a strong employment impact, which is felt beyond the many classical key branches. In the stricter G95 scenario the lead markets gain in significance and expand their share of overall employment to almost 5 percent. Only mechanical engineering and ICT gain in overall importance in relation to employment over the period under consideration.

3.3 COMPARISON: EMPLOYMENT IN THE G80 SCENARIO

Reducing GHG emissions in Germany by 95 percent by 2050 is an ambitious undertaking. A reduction of 80 percent by 2050 is associated with fewer deep changes because certain drastic reduction measures do not yet need to be introduced (zero use of fossil fuels, substitution of the last natural gas applications with synthetic gas, CCS for process emissions).

The differences between the G95 and G80 scenarios lie above all in the "last tonnes" which require very rigorous implementation of technologically demanding measures, but have relatively little impact on employment. One reason for this is that the G95 scenario initially involves "only" more rigorous realisation of numerous measures implemented in the G80 scenario; part of the additional emissions reduction comes through imported synthetic fuels, which have no employment effects in Germany, while the application of CCS, which is needed for the last megatonnes of process emissions, is only partial and does not require coverage or conversion of entire branches.

The aggregate employment effects in a scenario with an 80 percent reduction are therefore similar to those in the G95 scenario. So employment in 2050 in the G80 scenario is about 36.68 million, or nearly 50,000 more than in the baseline scenario. The finding that the aggregate employment effects expected in the course of the Energiewende are negligible (as in the G95 scenario) remains valid even if "only" the G80 scenario is implemented.

At the same time, as in the G95 scenario, there are also differences between branches in the G80 scenario. Differences between the G95 and G80 scenario are found in particular in branches where the underlying assumptions differ. For example employment in the car industry under the G95 assumptions is somewhat lower than in the G80 scenario. At the same time the technologies already employed in the G80 scenario (such as building modernisation, electric vehicles, heat pumps and energy-efficient cross-cutting technologies in industry) are applied more extensively and consistently in the G95 scenario. As a result in some cases the associated branches show slightly stronger employment than in the G80 scenario. Because the differences in employment effects between the G80 and G95 scenario are so small, and therefore partly masked by second-round effects, we do without a more detailed breakdown of branches.

4

FUTURE EMPLOYMENT DEVELOPMENTS AT REGIONAL LEVEL

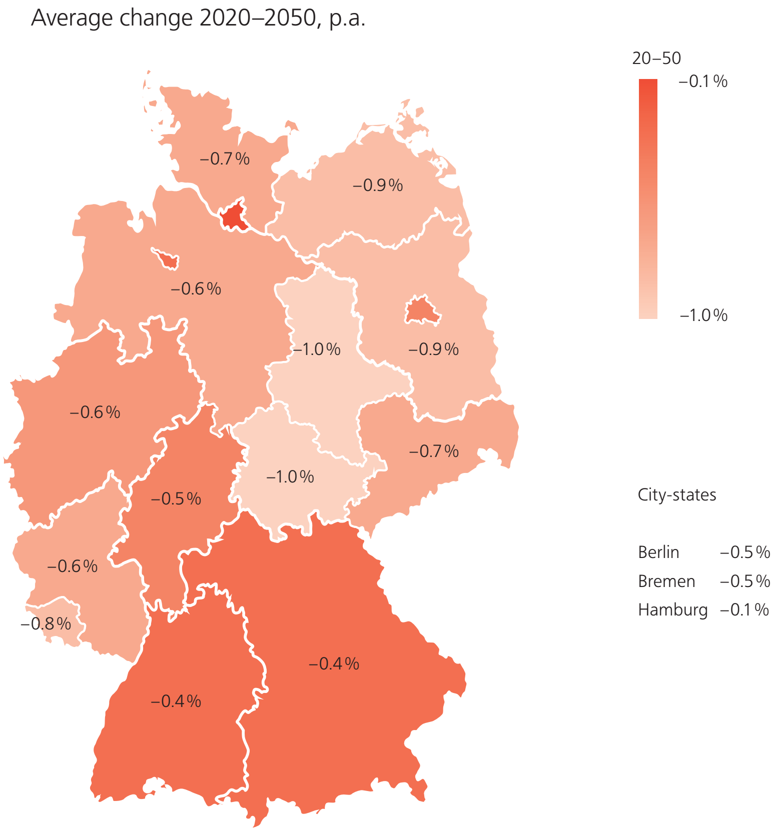
4.1 BY STATE

The employment developments calculated at national level for the G95 scenario can be broken down to the level of the states by means of a suitable modelling configuration. This was done by combining the national findings with a branch-wise employment forecast for all states prepared in conjunction with the Deutschland Report 2025 – 2035 – 2045 (vbw/Prognos 2018).

As already demonstrated, the demographic trend in all the Climate Paths scenarios considered in this study produces a clear decline in employment between 2020 and 2050, at a level of about 0.5 percent p.a. (see 3.2). Because the expected future demographic trend differs widely between individual states, where a scenario is considered in isolation a large part of the specific differences between states – in other words a large part of the state-specific differences in employment trends – can be explained in terms of demographic change.

Figure 15
Employment in the G95 scenario
Comparison 2020 and 2050 (in thousands and %)

	2020	2050
Baden-Württemberg	6,085	5,433
Bavaria	7,405	6,632
Berlin	1,863	1,615
Brandenburg	1,047	799
Bremen	442	384
Hamburg	1,231	1,179
Hesse	3,322	2,883
Mecklenburg-Vorpommern	717	541
Lower Saxony	3,951	3,274
North Rhine-Westphalia	9,120	7,707
Rheinland-Pfalz	1,966	1,641
Saarland	506	394
Saxony	1,965	1,604
Saxony-Anhalt	968	717
Schleswig-Holstein	1,362	1,101
Thuringia	1,020	750
Germany	42,971	36,653



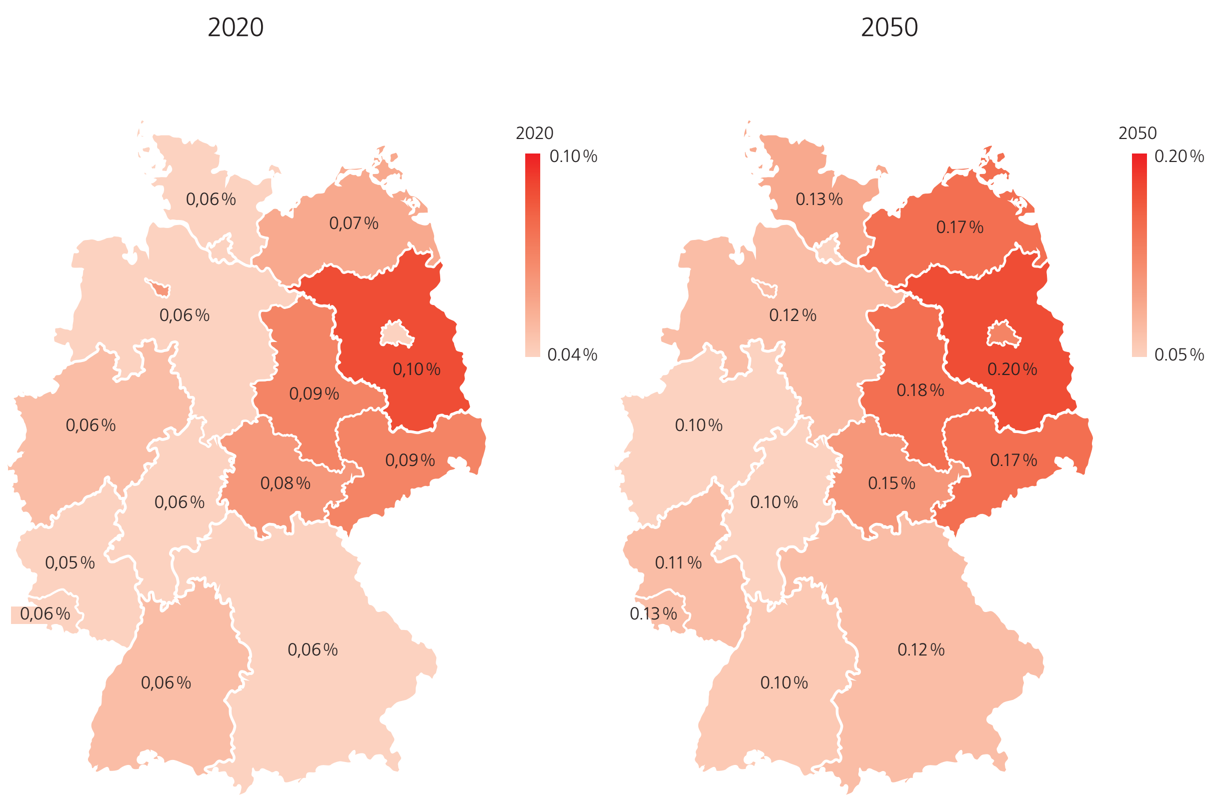
Source: Authors' calculations using data from BCG, Prognos 2018.

So if employment developments in the G95 scenario are considered in isolation, it is seen that the decline in employment in the eastern German states (measured against the figure of −0.5 percent p.a.) is higher than average (Figure 15). This applies in particular to Saxony-Anhalt and Thuringia with a decline of about 1.0 percent p.a. In the southern states (especially Baden-Württemberg, Bavaria and Hesse) and in the city states Berlin, Bremen and Hamburg the decline is considerably smaller than the national average (decline by 0.5 percentage points, 0.5 percentage points and 0.1 percentage points respectively). Because regional differences in demographics so strongly influence the findings, where the G95 scenario is considered in isolation nothing can be said about the strength of the specific effect of the Energiewende on employment in individual states.

In order to roughly estimate the specific effect of the Energiewende on the regions, in the following the percentage deviation between the G95 and baseline scenarios is therefore examined for each of the states. It is found that already in 2020 in all sixteen states the G95 scenario shows a (small) positive effect for employment in comparison to the baseline situation (Figure 16). So according to the calculations, all the states profit from the small but positive aggregate employment effect associated with the Energiewende, as described in 3.2. The effect grows over time until 2050.

But the increasingly positive employment trend in the G95 scenario in comparison to the baseline is not uniform across all the states. The employment effects in the eastern German states are somewhat stronger. For example in the G95 scenario in 2050 Brandenburg has the strongest relative growth in employment in comparison to the baseline (+0.20 percent), followed by Saxony-Anhalt (+ 0.18 percent) and Saxony (+ 0.17 percent).

Figure 16
Regional comparison of difference in employment between the G95 and baseline scenarios. 2020 and 2050
Percentage difference by state



Explanation: In 2050 employment in Bavaria in the G95 scenario is 0.12 % higher than in the baseline scenario.

Source: Authors' calculations using data from BCG. Prognos 2018.

At this point we refrain from describing absolute differences because they reveal little. Effects in the absolute differences are attributable largely to the different population sizes of the states. It must also be remembered when interpreting the findings that these are very small differences of less than 1 percent and their robustness is therefore limited. At the same time the finding that the effects in the eastern German states are somewhat stronger is in line with the findings of the GWS study on renewables and employment (GWS 2018).

4.2 TWO EXAMPLES

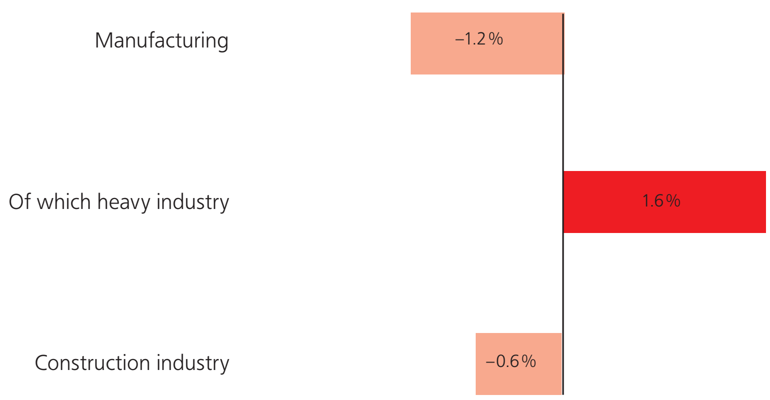
In order to illuminate the regional differences we examine the cases of North Rhine-Westphalia and Brandenburg. These two states are found, as shown in the preceding section, at opposite ends of the ranking of states in terms of the comparison of employment effects of the G95 and baseline scenarios. North Rhine-Westphalia is characterised by a high density of population and businesses, in stark contrast to Brandenburg. But both states face similar structural challenges in association with winding up their lignite mining sectors (Lausitz and Rheinisches Revier). These two states can serve as examples for different regional development paths.

4.2.1 NORTH RHINE-WESTPHALIA

North Rhine-Westphalia (NRW) is the state with the largest population and the highest GDP, the highest gross value added in services and the third-highest gross value added in manufacturing. It has an area of 34,122 km^2, almost 18 million residents and currently about 9.5 million workers. Of these more than 2.14 million work in the secondary (industrial) sector; it thus has more employees in this sector than any other German state (Baden-Württemberg 1.97 million, Bavaria 2.09 million) (Statistisches Bundesamt 2019a). Energy-intensive branches are over-represented, especially in industry (for example basic chemicals, chemicals, rubber and plastics, steel).

In the coming years the baseline scenario predicts a small decline in employment for NRW, a cumulative reduction by 2050 from currently 9.5 million to 7.7 million employees. In the G95 scenario the change in employment in NRW is – as for the other states – more positive, but in this case does not differ significantly from the baseline. The significance of heavy industry (meaning manufacture of coke and refined petroleum products (WZ19), the metal industries (WZ24 + 25) and chemicals (WZ20) exceeds the national average (Figure 17). These branches are among the losers in the G95 scenario. At the same time the share of employment in the construction industry – which profits from the extensive climate

Figure 17
Economic structure in North Rhine-Westphalia in comparison to national average
Share of total employment for selected sectors* in North Rhine-Westphalia (2018) and difference from national average



* The sectors are based on the Classification of Economic Activities: Manufacturing = Section C; Heavy industry = manufacture of coke and refined petroleum products (WZ19) plus metal industry (WZ24+25) plus basic chemicals (WZ20); Construction industry = Section F.

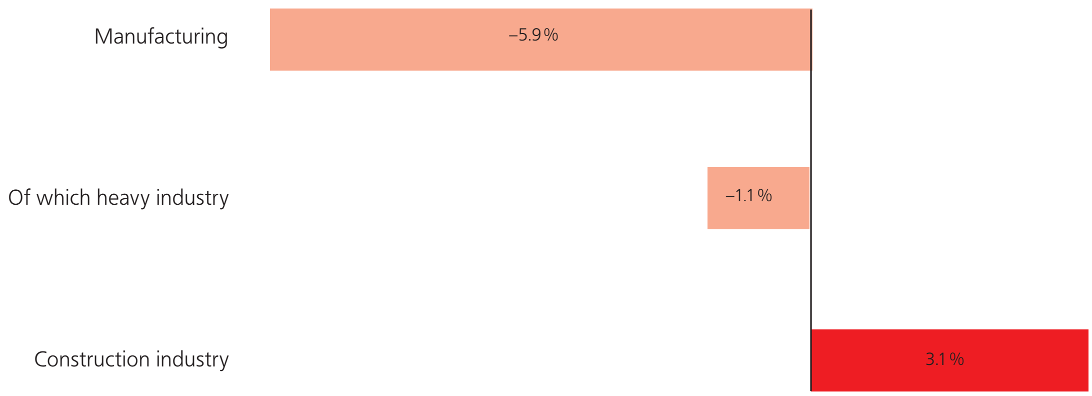
Source: vbw, Prognos 2018, calculations by Prognos.

investments – is below the national average. Changes driven by structural transformation are therefore more prominent in the economic structure of NRW than in other states. As a consequence the positive development associated with the G95 scenario is weaker there (see Figure 16).

NRW is regarded as Germany's "top energy state", generating 30 percent of the country's electricity and about 40 percent of its industrially used electricity. Structural transformation in the energy sector faces NRW with special challenges. Its structures are still strongly anchored in the classical energy system: more than half its electricity is produced using coal and lignite. Renewables to date account for only a small proportion. The Rheinisches Revier is especially affected by the phasing out of mining. In 2018 RWI published a comparative indicator-based review about the lignite-mining regions in Germany. It defines the "lignite sector" as the (open-cast) mines, the lignite-fired power stations and the local enterprises processing lignite. Although the lignite sector in NRW represents only a small proportion of the state's economy as a whole, it is strongly concentrated in the Rheinisches Revier, where those employed directly in the lignite sector represent 1.2 percent of employment subject to social security contributions. If indirect employment and "induced employment" (through intermediate goods, industry-oriented services and workers' consumption spending) are included the proportion grows to 1.8 percent of total employment subject to social security contributions and 10.2 percent of employment in manufacturing (2016) (RWI 2018). NRW has been dealing with the challenges of ending of coal mining in an orderly fashion for decades, and the decision to end mining can certainly be expected to have further repercussions in the state. But the Rheinisches Revier is geographically close to the conurbations of Cologne, Düsseldorf and Aachen, where there are major concentrations of manufacturing that in principle allow the loss to be cushioned. Another branch of industry facing special challenges in connection with the Energiewende is classical vehicle manufacturing, where North Rhine-Westphalia has significant employment. As a consequence structural change must be expected here too.

In order to address these challenges, North Rhine-Westphalia has in the meantime moved to advance the expansion of renewable energy and has also begun promoting the development in the other lead markets for climate protection. NRW was one of the first states to pass its own state climate law with ambitious CO_2 reduction targets. Beyond this the environmental economy, which also comprises the lead markets for climate protection discussed here, enjoys strong political support. To this end a broad set of instruments has been initiated (comprising an environmental economy strategy, a master plan and an excellence network).

Figure 18
Economic structure in Brandenburg in comparison to national average
Share of total employment for selected sectors* in Brandenburg (2018) and difference from national average



* The sectors are based on the Classification of Economic Activities: Manufacturing = Section C; Heavy industry = manufacture of coke and refined petroleum products (WZ19) plus metal industry (WZ24+25) plus basic chemicals (WZ20); Construction industry = Section F.

Source: vbw, Prognos 2018, calculations by Prognos.

4.2.2 BRANDENBURG

Brandenburg is the largest of the eastern states (former GDR) and with ca. 2.5 million residents has a low population density. Brandenburg is characterised by small and medium-sized enterprises: both in terms of GDP and gross value added it is in the bottom third of German states. Like NRW Brandenburg possesses a significant mining region in the shape of the northern part of the Lausitz coalfield (open-cast lignite). According to RWI (see previous section) direct employment in the lignite sector accounts for 2.5 percent of employment subject to social security contributions. If indirect and induced employment are included the proportion grows to 3.8 percent of total employment subject to social security contributions and 17.5 percent of employment in manufacturing in the Lausitz lignite-mining region in 2016 (RWI 2018). The closure of the lignite mines and associated power stations faces the state with special challenges.

At the same time Brandenburg profits in the climate protection scenario, which is a good deal more positive than the baseline scenario (see 4.1). One of the reasons for this is the state's economic structure (see Figure 18). Brandenburg has about 1.1 million employees, 75 percent of whom work in the service sector. Manufacturing is underrepresented, as is heavy industry, which is among the losers in the G95 scenario.

The construction sector is overrepresented in relation to the national average, employing 9 percent of the state's workforce (about 50 percent above the national average). In view of the investment required in energy and mobility infrastructure, construction occupies a key function in the Energiewende and profits especially under the G95 scenario. Alongside expansion of climate-friendly energy and transport systems, it has a decisive role to play in improving energy efficiency in the building sector. Construction firms in Brandenburg can expect to profit from their proximity to Berlin. The construction industry also generates positive employment effects in services, for example in connection with site services, structural and civil engineering and electrical installation.

About 22,000 people work in mining, energy, water and waste management in Brandenburg (about 4,500 of them in the Lausitz region). Lignite remains the principal source of electricity in the state, accounting for about two-thirds. One-third originates from renewable sources. Expanding renewables, especially wind power, is a central component of the state's energy strategy. With 7,104 MW Brandenburg is the second ranked state for installed capacity of onshore wind power. Brandenburg also holds second place for newly installed photovoltaic per km^2. In the case of the share of renewables in primary energy consumption Brandenburg occupies fourth place nationally. Because Brandenburg has plenty of space, comparatively few inhabitants and good conditions for wind and solar power, it will presumably continue to play a leading role in the expansion of renewable energy.

5

FUTURE CHANGES IN TYPE OF EMPLOYMENT

This chapter examines the employment developments that emerge in connection with the Energiewende at the level of occupational and qualification profiles (and on the basis of particular indicators for the quality of jobs). Its methodology builds on a labour force model from Prognos (see info box). Put in simple terms, three steps are required for the analysis. In a first step, a special analysis of the microcensus (from the work landscapes model) identifies the distribution of occupations of those working in each branch of the economy.[15] This permits the effects on occupations of changes at branch level to be inferred directly.

In a second step we infer employees' qualifications from their occupations. The model on which the "Work Landscapes" model is based also records the vocational qualifications possessed by employees within the occupational groups. This means it is also possible to distinguish between academic and vocational qualifications (as well as individual disciplines).

In a third step we infer on the basis of particular branch-specific indicators differences between the quality of the new jobs and that of those lost.

In the following we describe our findings concerning future demand for occupations and qualifications established using this method.

15 The model dynamises the dependencies between branches and occupations, as these are not static over time.

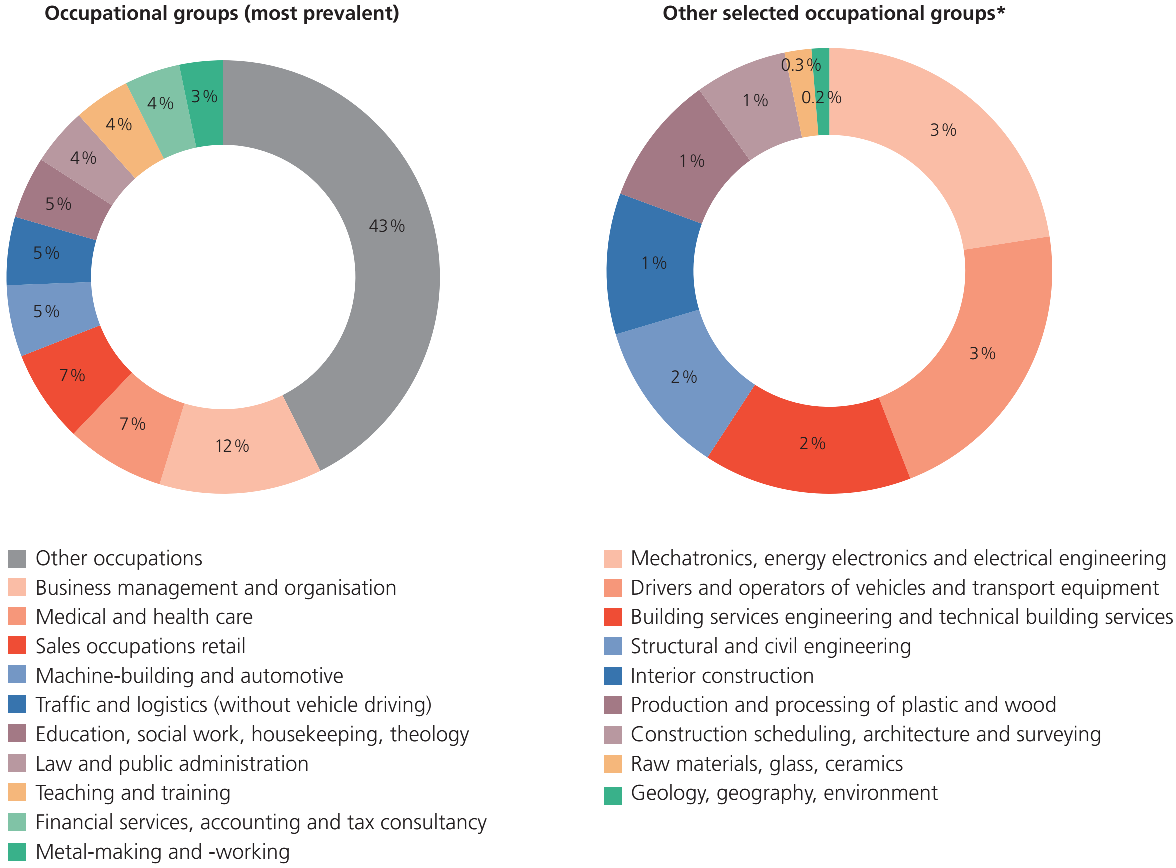
THE PROGNOS LABOUR FORCE MODEL ("WORK LANDSCAPES" MODEL)

In its "Arbeitslandschaften" (work landscapes) series Prognos has been investigating developments in labour demand, labour supply and the potential resulting labour shortage in Germany at regular intervals for more than ten years. The developments can be described at the level of branches, occupations, qualifications and functions.

In simplified terms forecasts of labour demand and supply are first prepared in the underlying model. These are differentiated by occupation, main subject of most recent educational qualification, exercised function, and branch. The potential labour shortage is then determined by comparing supply and demand. The model can also be used to estimate the extent to which the potential labour shortage identified in this way can be reduced through defined options for action.

The model was last fundamentally updated in February 2019. A study using that data, "Arbeitslandschaft 2025" prepared on behalf of the Vereinigung der bayerischen Wirtschaft (vbw), was recently published. The data is thus absolutely up-to-date.

Figure 19
Employment by occupational group in Germany
Selected occupational groups in 2016 (percent)



* In the interests of clarity, not all the other occupational groups are shown here. For that reason the figures do not add up to 100 percent.

Source: Statistisches Bundesamt 2018, calculations by Prognos.

Changes in employment by occupational main group
In 2016 the largest occupational main group in Germany was "business management and organisation" (12 percent).[16] "Medical and health care" and "sales occupations in retail trade" follow with 7 percent each (Figure 19). On the other hand many occupational groups that could be especially affected by the specific conditions of the G95 scenario are much smaller, with shares of sometimes less than 1 percent. This applies for example to "construction scheduling, architecture and surveying" or the occupational group that covers the field of resource extraction. Other occupational groups that are especially relevant in the context of this study are listed on the right in Figure 19.

In terms of belonging to – and thus also depending on – specific branches, there are clear differences between the occupational groups. The types of occupational group involved vary very strongly between branches. Given that a G95 scenario produces "winners and losers" among branches (see 3.2.1), this also has immediate consequences for future demand for particular occupational groups.

For example reducing emissions in the building sector represents one of the central conditions of the BDI Climate Paths study. The pace of energy modernisation of buildings

16 According to the German Klassifikation der Berufe 2010 (classification of occupations, KldB 2010). The granularity of differentiation applied here comprises thirty-seven occupational groups (two digits in the classification scheme).

needs to be stepped up by about 70 percent through 2050, compared to today's implementation rate, and a completely zero-emissions heat supply needs to be established. This is associated with significantly higher demand for employees from occupational groups whose core activities consist in carrying out these tasks. Energy modernisation of buildings is conducted principally by bricklayers, window fitters and skilled building workers. The principal occupational groups in which these employees will be found are "building services engineering and technical building services", "construction scheduling, architecture and surveying" and "interior construction". Smaller photovoltaic installations may for example be installed by electricians ("mechatronics, energy electronics and electrical engineering"). By 2050 these occupational groups employ more people in the G95 scenario than in the baseline without climate action.

Figure 20 shows a selection of occupational groups that will be subject to especially low or high demand under the assumptions of the G95 scenario. This reveals that there are more occupational groups where employment will increase than where it will decrease. The branch "electricity, gas, steam and air conditioning supply" is one of the winners with growth of 4.5 percent (approx. +6,000 employees). More than one-quarter of the employees in this branch work in energy and electrical occupations, making this another of the groups for which demand will increase in a G95 scenario. Building construction (+6,000) and civil engineering (+4,000) also demonstrate clear growth in employment in the G95 scenario. In these branches too the occupational groups that comprise the largest share are also growing. In structural and civil engineering in 2050 about 8,000 more will be employed in the G95 scenario than in the baseline scenario.

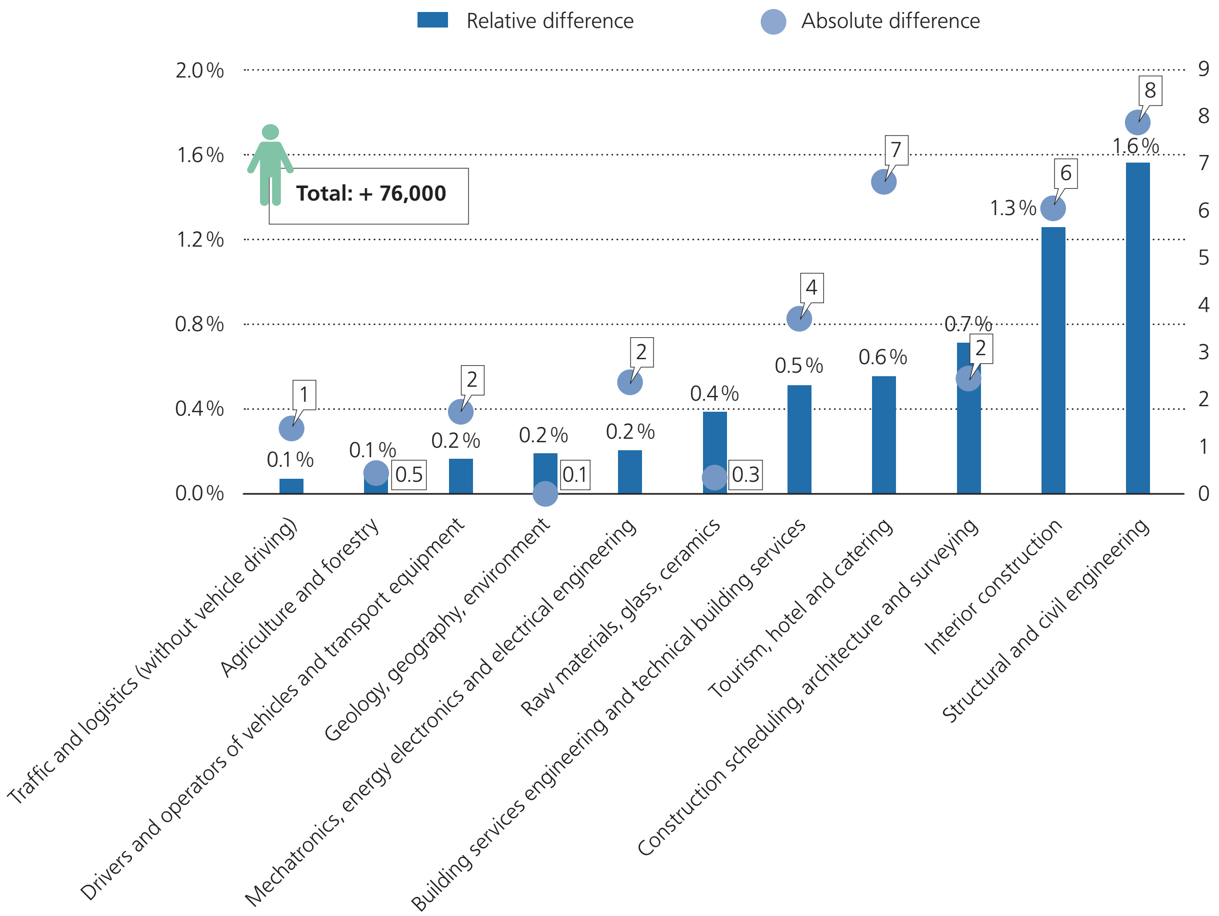
In the metal-making and -working occupations there are almost no discernible differences between the G95 scenario and the baseline. At the same time the branch "manufacture of basic iron and steel and other products of first processing of steel", to which many members of the metal-making and -working occupational group belong, records a fall in labour demand of 2.2 percent. The reason for this is that a decline in employment in a branch rarely restricted to individual occupational groups. For example if employment declines fewer administrative staff are required too.

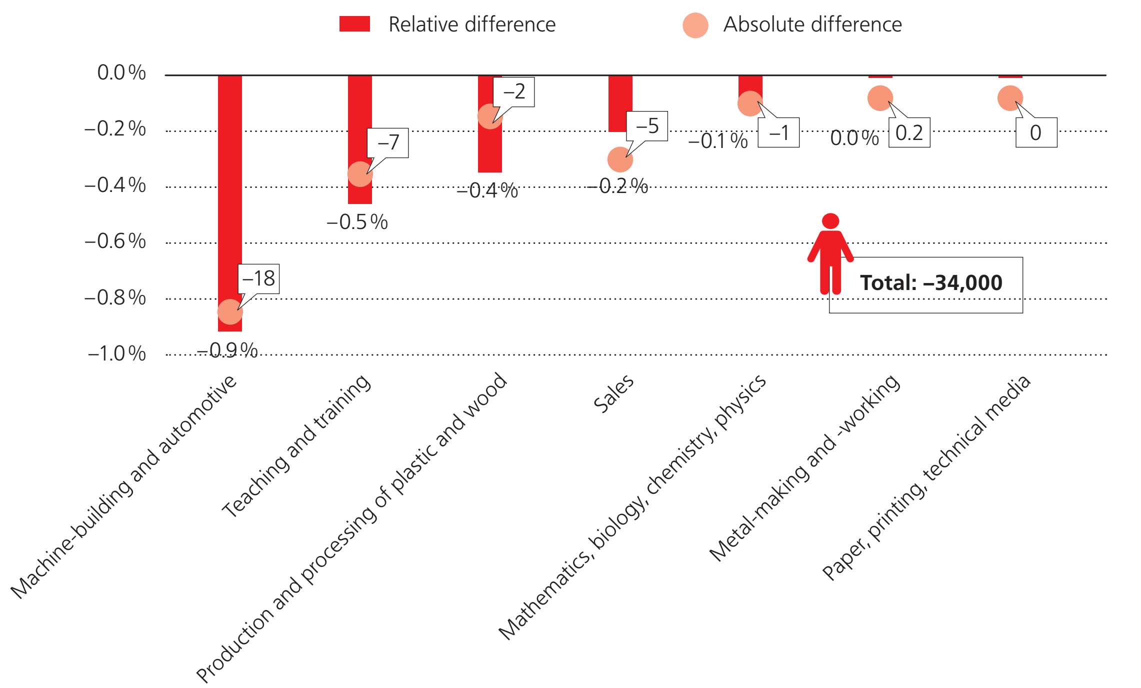
Altogether a G95 climate path does not decisively change the distribution of working population across occupational groups for the country as a whole. But the strict conditions of the BDI Climate Paths study, in particular in the sectors of mobility, buildings and industry, do influence demand for labour. Building services and ancillary occupations are urgently required for the major restructuring works involved. In both relative and absolute terms these occupational groups therefore record the largest increase in employment in 2050 compared to the baseline scenario (see Figure 20, upper part). The strong emissions reductions in the mobility sector mean that workers will almost cease to be needed to produce internal combustion engines for passenger cars. And the introduction of a total of about 33 million electric cars – whose production is considerably more flexible, more resource-efficient and less complex – leads in particular to a reduction in demand for machinebuilding and automotive occupations (see Figure 20, lower part).

Figure 20

Comparison of difference in employment between the G95 and baseline scenarios, by occupational group

Difference in selected occupational groups in 2050 (in % and absolute in thousands)





Source: Authors' calculations using data from BCG, Prognos 2018.

Changes in employment by qualification
In many cases a particular qualification is needed in order to pursue a particular profession. This may reflect formal or legal requirements or simply reflect demand for particular skillsets acquired during a training or degree course. This means that one can approximately infer qualification requirements from employment effects determined at the level of occupational groups. Similarly to the determination of effects at the level of occupations conducted in the previous step, we again use the Prognos labour force model and the special analyses of the microcensus integrated within it.

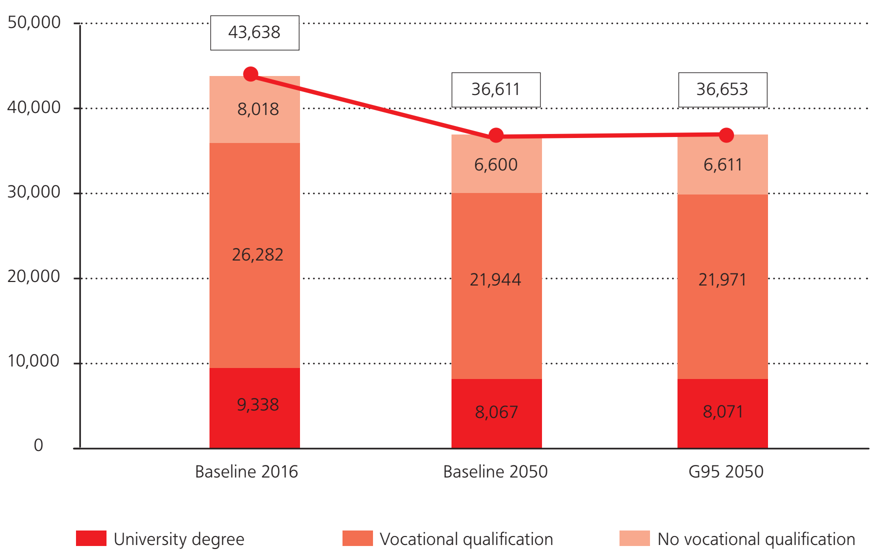
Figure 21 shows the resulting distribution of employees by type of qualification. A distinction is drawn between employees with university degrees, with vocational qualifications and without vocational qualifications. Currently those with vocational qualifications represent the majority in Germany (about 60 percent, see Figure 21). The remaining 40 percent is divided roughly equally between employees with university degrees and those without vocational qualifications. The demographically driven decline in employment as a whole is clearly visible in the baseline scenario.

In the context of the study the differences in 2050 between the G95 scenario and the baseline scenario are especially relevant. Here it is seen that the 43,000 additional employees in the G95 scenario are distributed among all three qualification types. In detail, employment with academic qualification is about 0.1 percentage points higher than in the baseline scenario (4,000 employees). Among employees with vocational qualifications the figure is also about 0.1 percentage points (27,000) and among employees without vocational qualifications 0.2 percentage points (11,000).

This means that the climate scenario causes the smallest absolute difference in relation to employees with university degrees. At the same time individual disciplines may for example profit from rising demand in the area of construction scheduling, architecture and surveying (see 5.1). Because this occupation is almost entirely exercised by university-trained engineers, the demand for this discipline also increases accordingly. Equally, increased demand for energy and electrical occupations could have effects on demand for university-trained engineers.

But the effect of changing demand is greatest in relation to employees with vocational qualifications: altogether 27,000 more are required than in the baseline situation. Employees with vocational qualifications in construction and structural and civil engineering are likely to profit because of the increase in employment in the relevant occupational groups (see 5.1).

Figure 21
Employment by qualification
Comparison between baseline and G95 scenarios in 2016 and 2050 (thousands)



2050: G95-baseline	
University degree:	+ 4,000
Vocational qualification:	+ 27,000
No vocational qualification:	+ 11,000
Total*: approx.	+ 43,000

* All figures rounded to nearest thousand.

Source: Authors' calculations using data from BCG, Prognos 2018.

Table 2
Selected indicators for job quality, by branch

Branch	Proportion of workers in SMEs, in % *	Proportion of workers covered by collective agreements, in % **	Proportion of women, in % ***
Branches with strongest employment growth			
D_35.1, D_35.3: Electric power generation, transmission and distribution; Steam and air conditioning supply	14	85	26
D_35.2: Manufacture of gas; distribution of gaseous fuels through mains	14	85	26
C_23.1: Manufacture of glass and glass products	43	43	27
F_41: Construction of buildings	93	57	14
F_42: Civil engineering	93	63	14
C_23.2 - C_23.9: Ceramics, processed stone and earth	43	43	27
C_24.4: Manufacture of basic precious and other non-ferrous metals	43	67	27
F_43: Specialised construction activities	93	33	14
Averages	**54**	**60**	**22**
Branches mit strongest decline in employment			
G: Wholesale and retail trade and repair of motor vehicles and motorcycles	63	20	50
B_07 – B_09: Ore, stone, earth, other mining products and services	49	42	13
C_17: Manufacture of paper and paper products	43	52	27
C_22: Manufacture of rubber and plastic products	43	29	27
C_24.1-24.3: Manufacture of basic iron and steel and other products of first processing of steel	43	67	27
A_02: Forestry and logging	n.a.	n.a.	n.a.
B_05: Mining of coal and lignite	49	73	13
C_19: Manufacture of coke and refined petroleum products	43	69	27
B_06: Crude petroleum and natural gas	49	97	13
Averages	**48**	**54**	**25**

* Statistisches Bundesamt 2019b. Auswertung auf Ebene von Wirtschaftszweig-Abschnitten.
** Statistisches Bundesamt 2016. Auswertung auf Ebene von Wirtschaftszweig-Abteilungen.
*** Statistisches Bundesamt 2019c. Auswertung auf Ebene von Wirtschaftszweig-Abschnitten.

Source: Authors' calculations using data from BCG, Prognos 2018.

It would seem astonishing at first glance that the group without qualifications profits most in relative terms from a strict GHG reduction scenario. The principal reason for this is that about one-quarter of employees in construction-related branches (including structural and civil engineering) possess no vocational qualification. Because this figure is above the average for all occupations, employees without qualifications are able to profit disproportionately. What this boils down to is that employees at all levels of qualification will be required to implement the Energiewende.

Quality of work

The occupations and qualifications provide first indications as to the quality of the associated jobs. In order to gain further insights a number of selected indicators, which serve to make the differences in quality between the new and lost jobs somewhat clearer, are examined in the following. It is shown how the branches with the strongest employment effects (as described in 3.2.1) vary in relation to the selected indicator.[17] Concretely we rely on the indicators workplace size, collective agreements and gender ratio. Workplace size and collective agreements are included as they play a role for attractiveness from the workers' perspective. The gender ratio supplies pointers concerning equality of opportunities.

Examination of workplace size reveals that the proportion of employees in small and medium-sized enterprises in the branches with the strongest employment growth (54 percent) is somewhat higher than in the branches with the strongest decline in employment (48 percent; see Table 2). Thus there is a tendency for employment to shift to rather smaller workplaces. The reason for this is found in particular in the creation of employment in branches belonging to the construction industry (WZ Section F). In this sector a full 93 percent of employees are in small and medium-sized enterprises. At the same time clear differences are found when the other branches are examined. The proportion of employees in SMEs in the branches associated with energy supply (WZ Section D) is just 14 percent. In the branches associated with manufacturing (WZ Section C) the situation is more balanced with 43 percent.

In relation to the share of workers with collective agreements the mean for the branches with the strongest employment growth is 60 percent, or 6 percentage points above the mean of the branches with the strongest decline in employment (54 percent). With 85 percent the share was highest in the branches associated with energy supply (WZ Section D). In branch F 43 (specialised construction activities), which is important in relation to energy modernisation of buildings, the proportion of workers with collective agreements is just 33 percent. In other words, two-thirds of workers in this branch have no collective agreement.

The proportion of female employees is especially low in the branches with the strongest employment growth (22 percent) and decline (25 percent). This applies in particular to the branches associated with construction industry (WZ Section F), where just 14 percent of employees are female. The big picture here is that the branches most affected by the Energiewende are largely male-dominated. It is largely men who lose their job because of the Energiewende – and new employment is created in branches that to date have tended to lean male.

To draw the discussion together, it can be said that new employment tends to emerge in the area of SMEs and the proportion of employees with collective agreements could also increase somewhat. Although there are clear differences in individual branches, they tend to be rather small when aggregated across all branches. In relation to gender balance there is no meaningful difference between the branches with the strongest employment growth and the strongest decline. In both cases the share of female employees is no more than one quarter.

17 Some of the indicators can also be reflected at the level of occupations (for example gender ratio). At the same time the working conditions of a particular occupational group differ between branches. For estimating the quality of work it therefore appears more meaningful to examine the indicators at the level of the branches.

6

RECOMMENDATIONS FOR A SOCIALLY ACCEPTABLE STRUCTURAL TRANSFORMATION

So far we have demonstrated that the aggregate employment effects attributable to the Energiewende are positive but relatively small. At the same time changes in branch and employment structure emerge. For particular sections of the population these may be associated with significant financial and social privations, especially where structural transformation leads to loss of employment. In order to minimise these negative effects the structural transformation should be made as socially acceptable as possible.

The objective of the present section is to supply a first qualitative outlook on possible recommendations addressing this question. We begin by identifying the branches (and associated occupations) where a need for action is likely to arise. That is the case wherever a disproportionately large loss of employment is forecast. On the basis of suitable literature reviews and published research we consider which fields of action appear promising of success in the context investigated in this study.

So where can a need for action be expected? As shown in section 3.2.1, "crude petroleum and natural gas", "manufacture of coke and refined petroleum products" and "coal mining" are the three most strongly affected branches in relative terms, given a GHG reduction target of 95 percent. In terms of absolute employment effects "wholesale and retail trade and repair of motor vehicles and motorcycles" and "manufacture of rubber and plastic products" are relevant. Because the natural gas/crude petroleum/coal sectors[18] have already been subject to years of structural transformation, experience has already been gathered here concerning how to make transformation as socially acceptable as possible. In the following therefore the experience in this area is discussed first, before moving on to consider the extent to which these measures could be applied to the other areas.

Natural gas/crude petroleum/coal

The natural gas/crude petroleum/coal sectors have already experienced deep transformation in the recent past, in particular in connection with the end of coal mining. Coal mining in Germany ceased completely in January 2019, and lignite mining is being successively phased out. Altogether it is assumed that even without a G95 scenario employment in the natural gas/crude petroleum/coal sectors in Germany will fall by about 21,000 between 2020 and 2050.[19] A strict G95 scenario would amplify this effect by about another 4,000 (see 3.2.1, Figure 12). The Ruhr region and the Rheinisches Revier are especially strongly affected by the now completed cessation of coal mining and the planned end of lignite mining.

In the Ruhr region measures were introduced at an early stage to cushion loss of jobs and looming unemployment and to counteract a loss of regional attractiveness to business because of the pit closures. Accordingly we distinguish in the following between measures that affect particular groups of workers and measures that operate more on the economic/structural policy plane.

The measures targeting particular groups include:

– **Financial support measures:** Older coal miners (age 49 and over) were offered early retirement programmes, similar to those offered to East German lignite miners aged 55 and over following reunification in 1990 (E3G 2015; Bundesfinanzministerium 2017). There are also transitional benefits where miners aged 50 and over who lose their job through closure or rationalisation can apply for financial support for five years. The average payout is €13,500 per year and the scheme is successful and established. Transitional benefits totalling €109 million were paid out in 2017 (E3G 2015).

– **Assisting a transfer to a different but similar field of work:** Financial support following loss of employment is not relevant for all employees. Even after the pit closures in the Ruhr region, new employment possibilities were created in similar fields of work. Workers are required for

18 Here and in the following this comprises "crude petroleum and natural gas", "manufacture of coke and refined petroleum products" and "coal mining".

19 The figure relates to employment in the baseline scenario from the BDI Climate Paths study by BCG/Prognos (2018).

example to dismantle and convert mines and equipment. It is also possible for workers to change branches while retaining their occupations (or shifting to a similar occupation). In the Ruhr region it is possible that new gas-fired power stations will be built after coal mining has ceased, to be powered in the long term by synthetic gas produced using green electricity (power-to-gas). For occupational groups like "business organisation and strategy" and "office clerks and secretaries" the activities associated with the occupation make it by nature easier to shift to a different branch.

– **Retraining for qualifications in new occupational fields:** In the ideal case such measures can even counteract skill shortages in other areas (for example with the help of the employment agencies). This is the case where targeted retraining and qualification measures are offered for occupations for which high demand exists or is expected.[20] This is especially relevant for younger people, who often find it easier to settle into a completely new working environment following retraining.

In the Ruhr region the end of coal mining has not only reduced employment in the industry. Above all it has affected the entire region's attractiveness to business. The structural transformation is broader, for example involving the contemporaneous decline of heavy industry, which had been struggling with challenges associated with similar changes in the world market. In order to counteract the structural setback and loss of attractiveness to business and maximise the socially acceptability of the structural transformation, national and state-level governments need to pursue a **forward-looking economic and structural policy** that strengthens both small businesses and municipal budgets. For some years measures and programmes have been being initiated to this end in the regions affected by the successive decline in coal mining (above all Ruhr region and Lausitz).

These economic and structural policy measures include:

– **Promoting educational institutions and innovation projects:** The founding of the Ruhr-Universität Bochum in 1962 was associated with the hope that young people would remain in (or move to) the region, and that this would also strengthen it economically.[21] The city of Gelsenkirchen is also planning to found a new university, hoping to establish itself as a knowledge location and compensate the loss of mining-related jobs in the region (Stadt Gelsenkirchen 2019). The universities attract young students and are involved in numerous innovation projects. Today, the Rhein-Ruhr region has acquired a reputation as a start-up hotspot (KPMG/Bundesverband Deutsche Start-ups 2018). Various national and regional support programmes are available for young entrepreneurs (for example "Initiativkreis Ruhr"). These serve to promote the structural transformation (business, culture, education) and support in particular the start-up scene. Many of the resulting ideas have been successful.[22]

– **Regional and national support programmes:** In the Lausitz there are diverse approaches to implementing a socially acceptable structural transformation. One of these is the founding of Innovationsregion Lausitz GmbH (iRL) to develop new business fields and initiate growth projects in workplaces affected by structural transformation. The top priority is to expand cooperation and networking (Innovationsregion Lausitz 2019). The state government of Brandenburg also plans to relocate the State Ministry for Science, Research and Culture from Potsdam to Cottbus by 2023, with the intention of bringing jobs and money to the region through the new buildings and modernisation projects required for the move. Beyond this many national and EU-wide funds and business development programmes provide financial support to regions affected by the end of coal mining.

The above description of developments in the natural gas/crude petroleum/coal sectors identifies various approaches designed to cushion structural transformation through measures such as financial support (for example early retirement), retraining and placement initiatives, and targeted economic and structural policy measures. In the following we discuss whether these approaches can also be applied in other regions/branches where similar problems are expected in future.

Applicability of experience in the natural gas/crude petroleum/coal sectors to other areas

Even if the natural gas/crude petroleum/coal sectors face the strongest proportional reduction in employment as a result of stricter climate protection and in particular the end of coal mining, other branches are significantly more strongly affected in absolute terms. In the climate protection scenarios wholesale and retail trade as a whole (including repair of motor vehicles and motorcycles) loses about 47,000 employees in comparison to baseline (see 3.2.1, Figure 12). Within this branch "wholesale and retail trade and repair of motor vehicles and motorcycles" (WZ45) is most severely affected in relative and absolute terms, and a need for action may be expected. On the other hand the categories of wholesale and retail trade (excluding motor vehicles and motorcycles) (WZ46, WZ47) in the same branch are not negatively affected in the G95 scenario (see 3.2.1).

20 Demand for labour is especially strong for example in the nursing and care professions, where the Employment Agency (Bundesagentur für Arbeit) offers financial support for retraining. Three-year funding has been secured for nursing training following the recent reforms. It was first introduced in a limited form in 2013, and has been made permanent from 2020.

21 The first pit closure was in 1958, affecting the Minden coal mine in Ostwestfalen (Deutschlandfunk Kultur 2018).

22 The Essen-based start-up Talpasolutions GmbH for example harnesses the region's mining knowledge and combines the mining tradition with digital technologies. Across the world Talpasolutions supports mining companies with data analyses (EWG – Essener Wirtschaftsförderungsgesellschaft mbH 2018).

In contrast to the natural gas/crude petroleum/coal sectors , relevant historical experience is not available for the branch "wholesale and retail trade and repair of motor vehicles and motorcycles". In the following therefore we consider whether and how the potential recommendations described for the natural gas/crude petroleum/coal sectors could be applied to this branch. In relation to measures targeting particular groups of employees, we find:

- **Financial support measures:** The largest group of employees in wholesale and retail trade and repair of motor vehicles and motorcycles are in the occupational group "automotive, aerospace, shipbuilding" (approx. 30 percent). Sales, "business organisation and strategy" and "office clerks and secretaries" form another major group. Almost half the workers subject to social security contributions in the occupational group "automotive, aerospace, shipbuilding" in 2018 were under 35 years of age, so early retirement and transitional benefits for older workers do not appear relevant (Bundesagentur für Arbeit 2019). Employment in other branches and retraining could make more sense.

- **Assisting a transfer to a different but similar field of work:** For employees with service-oriented occupations within the branch "wholesale and retail trade and repair of motor vehicles and motorcycles" there are also options – as in the natural gas/crude petroleum/coal sectors – for switching to a different branch with the same occupation. For "automotive, aerospace, shipbuilding" this is not necessarily an easy matter because this highly specialised occupation is strongly represented in only a few branches. Nevertheless in the branches "manufacture of motor vehicles, trailers and semi-trailers", "manufacture of other transport equipment" and "repair and installation of machinery and equipment" there are also employees with "automotive, aerospace, shipbuilding" occupations. Even if absolute demand is unlikely to increase significantly on account of stricter environmental protections and the growing prevalence of electric vehicles, this may offer opportunities for similar employment.

- **Retraining for qualifications in new occupational fields:** Similar to the natural gas/crude petroleum/coal sectors, another possibility for those affected would be to start targeted retraining for a different occupational fields.

In contrast to the natural gas/crude petroleum/coal sectors, whose strongly regional nature means that entire regions become involved in structural transformation, the risk of loss of a region's attractiveness to business through decline in the branch "wholesale and retail trade and repair of motor vehicles and motorcycles" is small. This branch comprises not the actual car-making, which is highly concentrated in particular regions, but only the post-production side. Assuming that dealers and garages are distributed across Germany, the risk of structurally weakening a whole region through GHG reductions is small. The (regional) economic and structural policy measures applied in the natural gas/crude petroleum/coal sectors are presumably less relevant to "wholesale and retail trade and repair of motor vehicles and motorcycles".

7

CONCLUSION

Building on existing scenario modelling in the BDI Climate Paths study, the present study investigated the potential employment effects of a 95 percent reduction in GHG emissions achieved by 2050 (compared to 1990). Alongside the overall perspective, the study also differentiated by branches, by different lead markets for climate protection technologies and services, and by employment factors (occupations and qualifications). The question of possible regional differences in employment effects was also considered. Finally, on the basis of literature reviews we discuss initial recommendations for a socially acceptable structural transformation.

The findings show that overall climate protection is associated with positive economic effects. Ex-post it is clear that the introduction of climate protection technologies and services generates considerable employment. In 2018 the three lead markets – renewable energy, energy efficiency and green mobility – employed more than 1.2 million (2.2). Additionally, positive net aggregate employment effects can be identified for developments to date in the scope of the Energiewende (2.3).

Turning to the future, it is found that the structural transformation associated with the Energiewende can have a small but positive effect on aggregate employment. For example in the climate protection scenario (G95) there are about 43,000 more employed in 2050 than in the baseline scenario (3.2). Although this figure is very small in relation to total employment, a clear conclusion can be drawn: the widely discussed trade-off between climate protection and jobs is unfounded, at least in the aggregate.

In many areas the Energiewende creates new jobs. At the level of branches this applies to "electricity, gas, steam and air conditioning supply" (3.2.1). Particular branches and occupations associated with the construction industry profit from the investment required for energy modernisation of buildings and other necessary infrastructure investments. As well as specialised construction activities these also include structural and civil engineering. The lead markets for climate protection technologies and services will also profit from these developments (3.2.2). It was also shown that the Energiewende can benefit workers with all levels of qualification (Chapter 5).

Another finding of this study is that the Energiewende is also associated with job losses in specific parts of the economy. In relative terms the most prominent are "crude petroleum and natural gas", "manufacture of coke and refined petroleum products" and "coal" (3.2.1). At the level of occupational groups "machine-building and automotive" tops the list (Chapter 5). Nevertheless the employment effects are comparatively small in relation to the car industry as a whole.

For the parts of the population affected by loss of employment this development can be associated with significant financial and social privation. A survey of possible fields of action shows that a number of approaches are already available with appropriate measures to cushion negative impacts (Chapter 6). A combination of individual and structural/economic policy measures is found to be especially effective.

Contextualising the Findings

The methodology of this study builds on the "Klimapfade für Deutschland" study published in 2018 (Climate Paths for Germany), conducted by Boston Consulting Group und Prognos on behalf of BDI. The findings presented here therefore depend on the assumptions and findings of the Climate Paths study. For the G95 scenario that is central to the present study, these include the preconditions for ambitious, coordinated and binding global climate protection with effective instruments such as global emissions trading and compensation measures to avoid carbon leakage. In a complex stakeholder process in the preparatory phase of the Climate Paths study, the assumptions and findings were subjected to a constructive critical process that led to broad acceptance.[23]

23 At the same time it should be mentioned that the assumptions for the G95 scenario concerning the timeframe for ending the use of coal have changed slightly since the Climate Paths study was published. The latest government decision foresees the end of lignite mining and its use for power generation occurring slightly later than assumed in the Climate Paths study on account of the assumed instrumental framework (CO_2 prices in the expanded ETS). On the other hand small volumes of generating capacity from a handful of coal-fired power stations will remain in the electricity system until 2040 for regulation and back-up. This also means that only small differences are to be expected from the employment effects described here. In the long term and in particular at the macroeconomic level the resulting deviations are marginal. In effect certain changes occur earlier but the overall outcome for 2050 remains the same. The findings of this study therefore retain their validity despite alterations to the timeframe for phasing out coal.

The positive employment effects found between 2003 and 2018 in association with the introduction of the Renewable Energy Law also indicate that a small positive employment effect can certainly occur at the aggregate level (described in section 2.3). This core finding also demonstrates robustness, in that the (small) positive effects are not found exclusively in the G95 scenario. The effects are similar in a G80 scenario and even in an N80 scenario (in which the main climate efforts are pursued by committed industrialised countries and emerging economies and no global consensus is achieved), and the core finding is unchanged. This permits us to conclude that the bulk of the required climate measures can be implemented without significant loss of jobs and without the need for global consensus, and that even the "last tonnes" can be tackled without negative employment effects in an ambitious climate protection scenario. Dealing with the "last tonnes" presupposes global coordination – in both technological and economic/structural terms – on climate protection that is binding and equipped with instruments.

Most of the outlined recommendations for a socially acceptable structural transformation build on historical experience in particular branches. This study also initiates the discussion about the applicability of the described measures to future challenges in other branches. Concrete application of measures generally demands a differentiated and contextualised adjustment of the respective details, in order to ensure precision, efficiency and social acceptance. For example, the usefulness of specific economic and structural policy measures differs widely by region and is dependent on the economic structures on the ground. At the same time, the described experience concerning the recommendations demonstrates that it is possible to make structural transformation socially acceptable.

Abbreviations

BDI	Bundesverband der Deutschen Industrie
BMWi	Bundesministerium für Wirtschaft und Energie
CCS	Carbon capture and storage
CHP	Combined heat and power
EEF	Energy efficiency
EEG	Renewable Energy Law (Erneuerbare-Energien-Gesetz, EEG
envigos	Model for environmental industry, goods and services
ETS	Emissions Trading System
GHG	Greenhouse gas
GVA	Gross value added
GW	Gigawatt
KMO	Green mobility (klimafreundliche Mobilität)
OECD	Organisation for Economic Cooperation and Development
PtG	Power-to-gas
PtL	Power-to-liquid
PV	Photovoltaic
REW	Renewable energy generation (Regenerative Energiewirtschaft)
SMEs	Small and medium-sized enterprises
UBA	German Federal Environment Agency (Umweltbundesamt)
vbw	Vereinigung der bayrischen Wirtschaft
WZ	Branch of the economy (Wirtschaftszweig)

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Jobwende
Effects of the Energiewende on Work and Employment

After the Paris agreement of December 2015 the German government placed the long-term goal of achieving almost complete greenhouse gas neutrality by 2050 at the heart of German climate policy. This presents Germany, as the world's sixth-largest greenhouse gas emitter, with enormous challenges – in the electricity sector, in its building sector and even more so in agriculture and mobility.

Alongside the purely quantitative aspects, the study also set out to explore the qualitative aspects of the employment effects of the Energiewende in the case of a reduction in GHG emissions in Germany by 95 percent by 2050. The study focuses on the lead markets for renewable energy, energy efficiency and green mobility, as well as identifying regional differences. The states of North Rhine-Westphalia and Brandenburg are examined in greater detail. Finally, recommendations for possible action for socially acceptable structural transformation are derived from the findings.

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