Successfully shaping structural change

TOWARDS A GREEN ECONOMY

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German Environment Agency
Section I 1.4
PO Box 14 06
D-06813 Dessau-Roßlau
Tel: +49 340-2103-0
buergerservice@uba.de
www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt
/umweltbundesamt
/umweltbundesamt

Supervision:
German Environment Agency, Department I 1.4,
Dr. Andreas Burger, Dr. Björn Bünger;
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Department G I 4,
Dr. Simon Marr, Elisabeth Guß, Malena Knauth

Authors:
Dirk Arne Heyen (Oeko-Institut e.V.), with the collaboration of Carl-Otto Gensch, Martin Gsell, Florian Hacker, Katja Hünecke, Cara-Sophie Scherf (all Oeko-Institut);
Dr. Katrin Ostertag, Dr. Claus Doll, Anna Grimm, Dr. Frank Marscheider-Weidemann,
Dr. Dr. Christian Sartorius (all Fraunhofer Institute for Systems and Innovation Research ISI (Fraunhofer ISI), Karlsruhe)

English proof-reading & editing:
Kerstin Borkowski & Michelle Monteforte

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TOWARDS A GREEN ECONOMY

Foreword

The results of the new report of the Intergovernmental Panel on Climate Change show how great the pressure to act on climate protection is, as do – quite tangibly and to a certain extent on our own doorstep – the catastrophic floods of 2021 in North Rhine-Westphalia, Rhineland-Palatinate and Bavaria.

In order to slow down climate change and still achieve the goals of the Paris Climate Agreement, rapid and consistent action is required. This decade will determine whether we can still limit climate change to a manageable level or whether tipping points of ecological systems will be exceeded with unforeseeable consequences. It will not be individual measures that will provide a remedy. Rather, a transformation of our entire economy is required. This will require far-reaching changes within industries and value chains, and in some cases will also give rise to entirely new markets.

This ecological structural change is necessary to secure the natural foundations of economic activity and to maintain prosperity for future generations. “Business as usual” is not an alternative. Incidentally, it is not only the climate crisis that makes this structural change necessary, but also the pollution of air, water and soil, the overuse of natural resources and the dramatic loss of biodiversity.

The changes required are very diverse: just as the industries differ, so do the changes required. These differences are exemplified in this brochure by case studies on the automotive industry and the basic chemicals sector. In some cases, production processes need to change, in others it is the products. In still other cases, entirely new business models are needed.

In most cases, small steps are not enough. Many times we are facing major challenges that require the development and market diffusion of leap innovations. The earlier we act, the greater the scope for action and freedom we have and the greater the chances for gentle, socially acceptable change instead of a hard break with social distortions.

The various economic sectors are at different stages of the socio-ecological transformation. In some sectors, the pathways to solutions have already been clearly mapped out; in others, solutions are still in the early stages of development. In order to identify at an early stage sectors that will come under massive pressure to change, a screening process was carried out in the project “Ecological Structural Change”. In order for such an early warning system to be effective, the researchers recommend that it be further developed and carried out on a regular basis. In my view, this is an important instrument for giving the economy

and society enough time to prepare sufficiently for the necessary structural change.

In addition to the economic challenges for companies and regions, there is also a need to avoid or at least cushion social hardship through forward-looking planning and action. This applies in particular to regions severely affected by change. Especially in these cases, it is important that policy creates favourable conditions for the development of new value chains and jobs.

Ecological structural change is also a global issue. This arises directly from the international networking of the German economy, from upstream supply chains, from imports and exports. In addition, successful ecological structural change can also serve as a model for other countries facing similar challenges.

In order to manage ecological structural change, cooperation is needed at all levels. For example, in order to develop the roadmap for structural change in the chemical industry proposed in the brochure, environmental associations and actors in international cooperation must also help, in addition to politicians, employers and trade unions. Generally speaking, only if business and civil society, politics and research work together ecological structural change will succeed.

Prof. Dr. Dirk Messner
President of the German Environment Agency

Key messages

1

The climate crisis and other ecological challenges of our time require a profound transformation of our society and economy toward a climate-neutral, resource-efficient and waste-avoiding Green Economy.

2

As with every process of economic structural change, this “ecological structural change” will be accompanied by new, in this case more sustainable business models, with others losing relevance.

3

Business sectors whose production processes or products have a high environmental impact will face considerable pressure to adapt as a result of the transformation. In addition, companies will have to deal with ecological megatrends such as climate change and resource scarcity as well as technical-economic trends such as digitalisation.

4

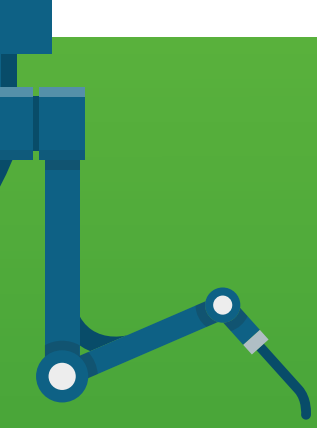
Three types of structural change can be distinguished, depending on the focal point of pressure to change: resource-related, production-related and product-related structural change.

5

A “sector screening” shows that energy supply, automotive manufacturing, the chemical and pharmaceutical industries as well as agriculture are particularly facing profound change.

6

The automotive and chemical industries examined in depth here, reveal similarities – but also differences, for example with regard to the type of structural change, or the key drivers and dynamics of change.



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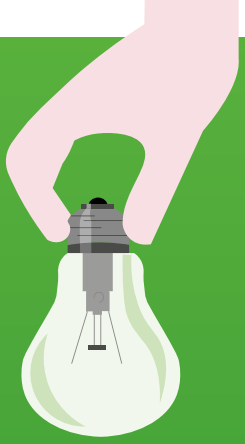
The key challenge in ecological structural change is to shape it in such a way that the environmental policy goals are achieved and at the same time value creation and jobs are maintained in Germany, at least across all sectors.



8

Successful governance of structural change fundamentally requires a forward-looking and proactive approach that is also participatory and cross-sectoral.

9

The climate and environmental policy mix must be ambitious, coherent and long-term, but at the same time capable of being adapted to new developments and findings.

10

A climate-neutral economy requires substantial amounts of electricity and hydrogen based on renewable energies. This requires both a greater expansion of renewable energies in Germany and international cooperation with regions that are favourably located to provide renewable energy.

11

Companies, employees and regions that are strongly affected should be supported in the change process. The focus should not be on compensation for declining revenues from past business models, but rather on investments in new technologies and products, essential infrastructure, and qualification demands.

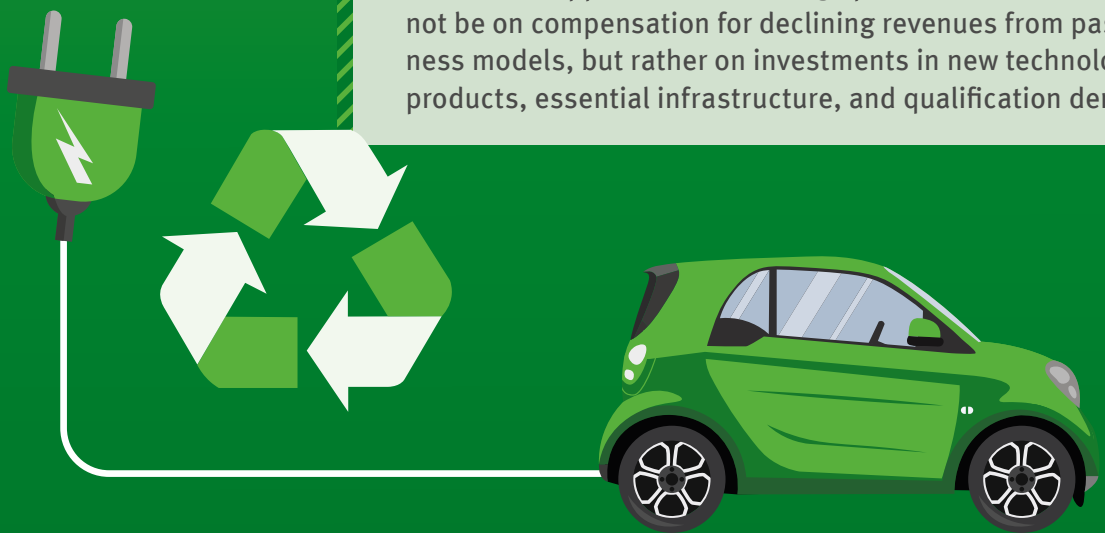
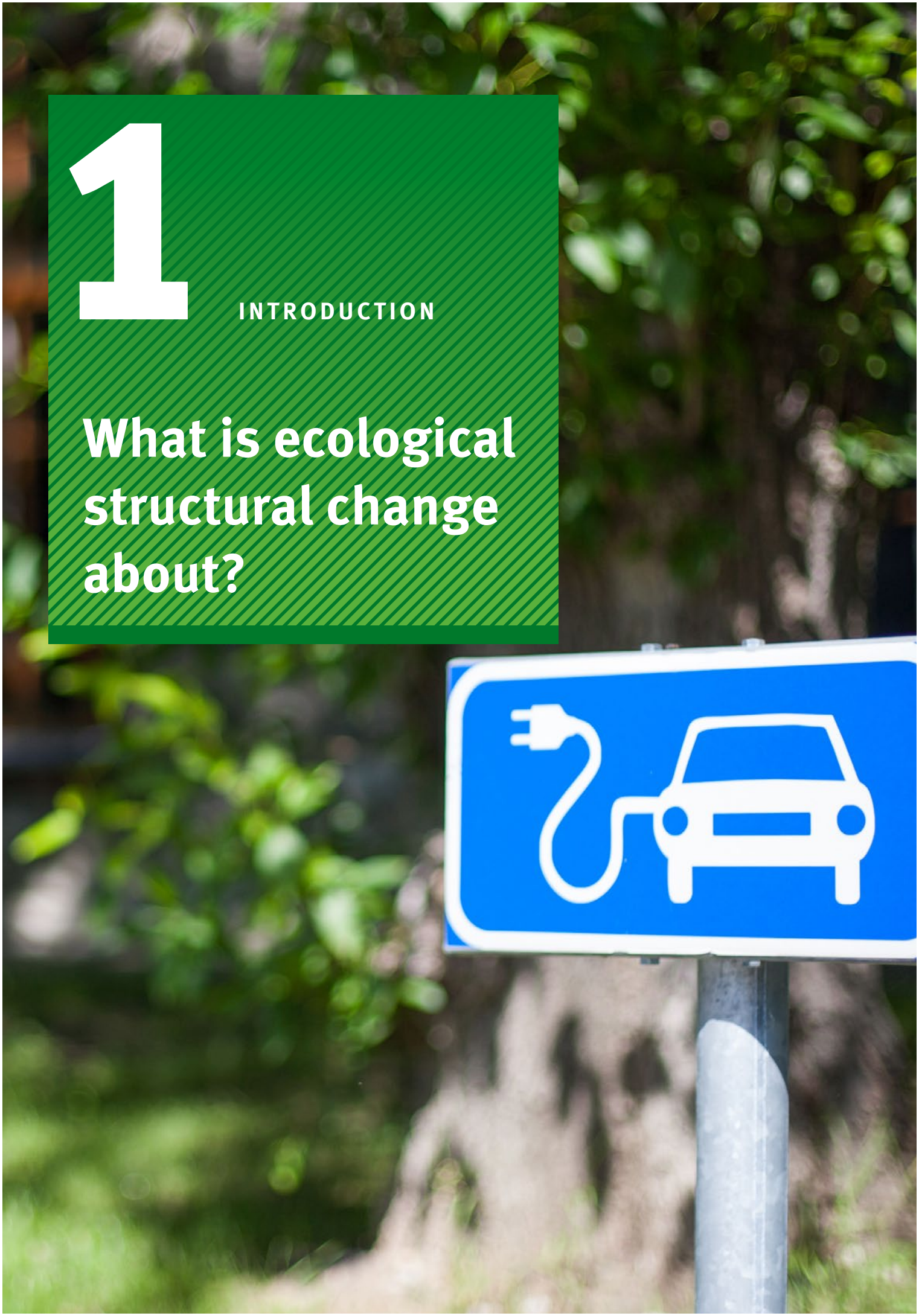


Table of contents

1

INTRODUCTION

What is ecological structural change about?



The economy is subject to constant structural change (see textbox) – driven in particular by technological innovations and changes in demand. However, ecological challenges and environmental policy goals are increasingly becoming a further driver and demand an "ecological structural change" in the coming years.

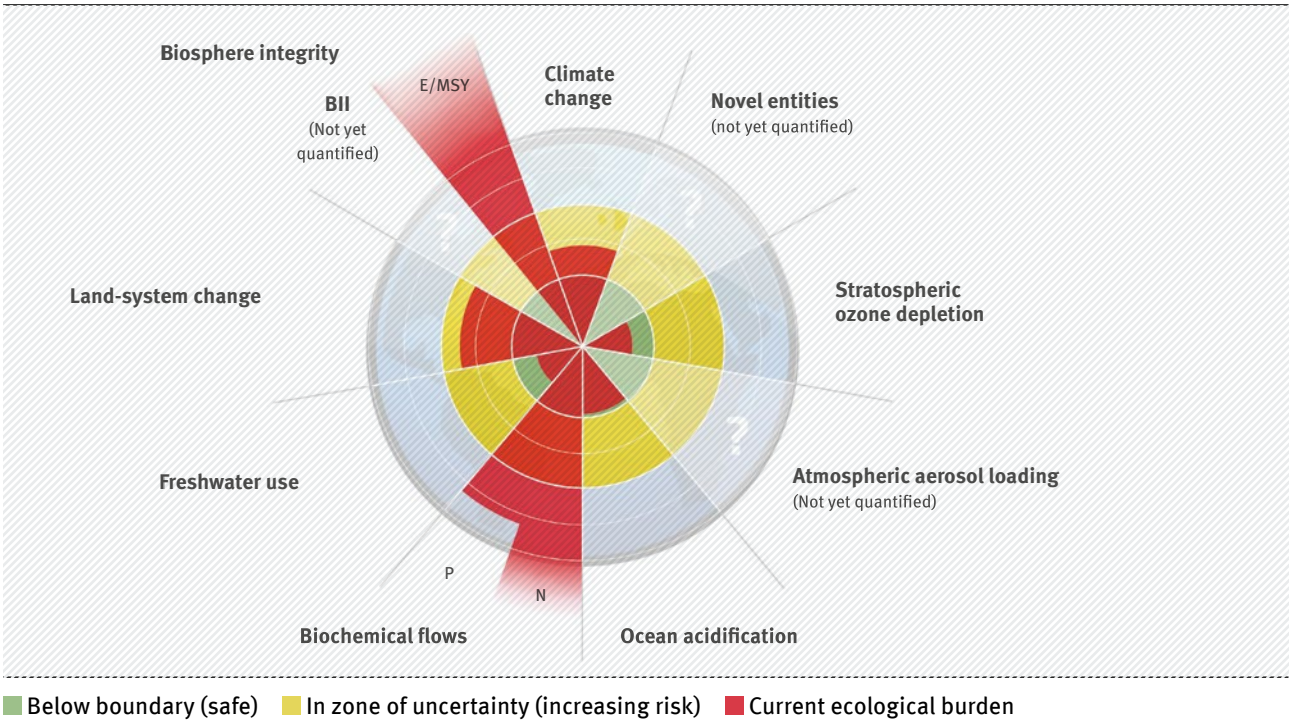
The ecological challenges of our time are immense – and with them the risks for humanity. In particular, the consequences of accelerating climate change and massive biodiversity loss threaten the prosperity and peaceful coexistence of present and future generations. We are consuming vast amounts of resources in a short period of time and are polluting our soil, rivers and oceans with high inputs of nitrogen and (micro-) plastics. In many cases, we are exceeding the planetary boundaries (Steffen et al. 2015) and might throw the Earth out of balance (cf. Figure 1).

Structural change, in its original definition by French economist Jean Fourastié (1907–1990), meant the shift from the so-called primary sector (agriculture and forestry) towards industry as the secondary sector and finally services as a third sector. Since then, however, the term has come to further encompass (macroeconomic or regional) shifts between more specific economic sectors and industries, such as the change from a fossil-fuel- to a renewable-based energy system.

In this brochure, structural change is understood even more broadly to also include fundamental changes in production processes or products within a sector.

Figure 1

Earth's planetary boundaries and extent of their exceedance



Source: Own figure based on illustrations from Felix Jörg Müller and J. Lokrantz/Azote, with content based on the work of Steffen et al. (2015).
(BII = Biodiversity Intactness Index; E/MSY = extinctions per million species-years; N = Nitrogen; P = Phosphor)

Definition of a **Green Economy** according to Germany's Federal Environment Ministry and Federal Environment Agency (BMUB & UBA 2012) (English translation from Renault et al. 2016):

"The Green Economy characterises an innovation-oriented economy in harmony with nature and the environment which

- avoids damaging emissions and the input of pollutants in all spheres of the environment;
- is based on the further development of the circular economy and closes regional materials cycles as much as possible;
- decreases the net use of non-renewable resources, especially by a more efficient utilisation of energy, raw materials and other natural resources and the substitution of non-renewable resources with sustainably produced, renewable resources;
- attains an energy supply exclusively based on renewable energy sources in the long-term and
- maintains, develops and restores biological diversity and ecosystems and their performance.

This concept of the Green Economy is embedded within the greater concept of sustainable development and concomitantly also helps to specify it. The relationship between economy and ecology is at its centre, but also societal consequences such as a fair and socially responsible transition to the Green Economy, effects on employment and qualification aspects are addressed."

Against this backdrop, the global community, the European Union (EU) and the Federal Republic of Germany have set ambitious targets, particularly to halt climate change. For example, the Paris Agreement of 2015 envisages limiting the global temperature increase to below 1.5°C compared to pre-industrial levels. This requires a massive reduction in greenhouse gas emissions as quickly as possible. Within less than thirty years, the EU (2050) and Germany (2045) want to achieve climate neutrality. This means living largely without emitting climate-damaging greenhouse gases such as CO_2 and methane – and capturing and storing additional greenhouse gases or removing them from the atmosphere.

Further ambitious environmental goals include, for example, reducing the pollution of air, soil and water, reducing land consumption by settlements and traffic areas, and halting the loss of species. With its European Green Deal, the EU has declared biodiversity and "zero pollution" to be priorities alongside climate change mitigation.

To achieve these goals, it is not enough to make existing production processes and products slightly more environmentally friendly, for example by increasing efficiency. Rather, a far-reaching ecological structural change toward a Green Economy (see textbox) is needed that fundamentally changes many production and supply structures and also encompasses consumption patterns in industrialised countries. In particular, the Paris Agreement requires rapid, far-reaching and unprecedented changes (IPCC 2018).

A shift to a Green Economy is expected to bring huge environmental and public health benefits as well as overall positive effects on the economy and employment (ILO 2018; NEC 2018; OECD 2017). In addition, it is economically cheaper in the long term to avoid significant climate change than to have to deal with its effects (IPCC 2014; Stern 2006).

However, structural change processes are also associated with economic challenges. In the case of ecological structural change, resource- and/or emissions-intensive industries come under pressure: i.e., those industries that – in absolute terms and/or relative to their value added – have an high environmental footprint. Depending on where the pressure for change is localised, three types of (ecological) structural change can be distinguished:

- **Resource-related structural change:** The pressure to change arises from the scarcity or increase in price of the raw materials and energy required. The scarcity or price increase may be (partly) caused by policy instruments introduced to reduce ecological problems (e.g., coal phase-out, eco tax, restrictions of certain chemical substances). The mere risk of a shortage or increase in price can also generate pressure for change.

- **Production-related structural change:** Pressure to change arises from new, better and more efficient production processes or from ecological problems of previous production methods (e.g. methane emissions in cattle farming, process-related CO_2 emissions in cement production). In addition, changing environmental conditions (e.g. water scarcity) may render certain production methods obsolete and require new ones (e.g. adapted irrigation systems in agriculture).

- **Product-related structural change:** The pressure for change manifests itself at the level of the end product. Ecological factors for this type include emissions in the use phase (e.g., car emissions). The affected industries are often located at the end of the value chain.

Not only companies, but also their employees and the regions, which are strongly dependent on the respective industries, are confronted with challenges. In terms of a fully sustainable development, the aim of government action should be to shape change in such a way that (regional) economic adjustment processes are facilitated, social hardships are avoided or cushioned, and the economic and social opportunities of a Green Economy are exploited. The United Nations (UN) Agenda 2030 and the European Green Deal also speak of a "just transition" that "leaves no one behind". This also reduces social resistance and political blockades.

This brochure focuses on the challenges and opportunities surrounding ecological structural change. It is based on a research project conducted by Oeko-Institut and the Fraunhofer Institute for Systems and Innovation Research ISI from 2018 to 2020 on behalf of the German Environment Agency and the Federal Environment Ministry (for detailed results, see Heyen et al. (2021) and Hünecke et al. (2021)).

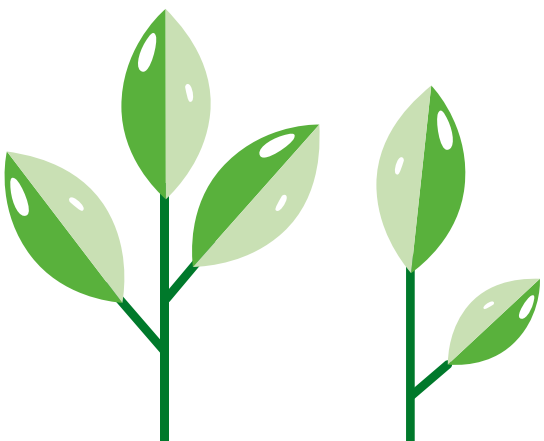
The brochure is structured as follows:

- Chapter 2 asks which sectors are particularly facing structural change for ecological reasons.

- Chapter 3 analyses the drivers and challenges of structural change, taking the automotive and chemical industries in Germany as examples.

- Chapter 4 presents a governance approach for ecologically and socio-economically successful structural change processes.

- Chapter 5 provides a brief conclusion.



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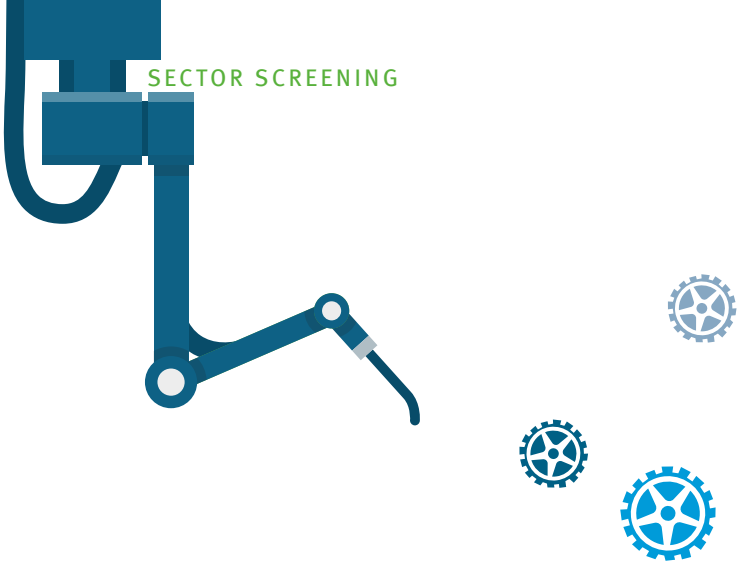
SECTOR SCREENING

Which sectors face ecological structural change and why?



It is undisputed that the energy sector is undergoing a profound transformation with the energy transition (Energiewende). There are also a lot of discussions these days about the transformation of the automotive industry in light of electrification and automation. But what about other sectors? Which business models are facing significant change, not only in view of climate change? This knowledge is important in order to be able to shape structural change processes in a forward-looking and proactive manner (in line with the recommendation in Chap. 4).

In the UBA project, these questions were answered in the context of a sector screening on ecologically induced pressures for structural change using the following guiding questions and taking into account numerous environmental dimensions and megatrends (cf. Hünecke et al. 2021):

1. Which sectors have particularly high environmental impacts? (high-impact sectors)
2. Which sectors are particularly affected by environmental megatrends?
3. What are opportunities and risks for the sectors arising from socio-economic megatrends?
4. Are alternative sustainable business models on the horizon for the sector?

Methodological approach in the UBA project "Ecological Structural Change"

Two methods were used to answer the first guiding question about environmental impacts:

- a qualitative, literature-based analysis of 20 pre-selected sectors, which were assessed along five ecological dimensions (greenhouse gas emissions, air pollutants, raw-material-, land- and water consumption) (very relevant / moderately relevant / not relevant)
- a quantitative analysis based on EXIOBASE, whereby the ecological impacts of 200 product groups were calculated along 15 environmental dimensions (various greenhouse gases, various air pollutants, resource/material consumption, land use), taking into account impacts along the entire value chain.

With each method, the most relevant sectors were identified based on the various environmental criteria (equally weighted). Subsequently, the results from both methodological approaches were merged, resulting in a list of "high-impact sectors" (see Figure 2).

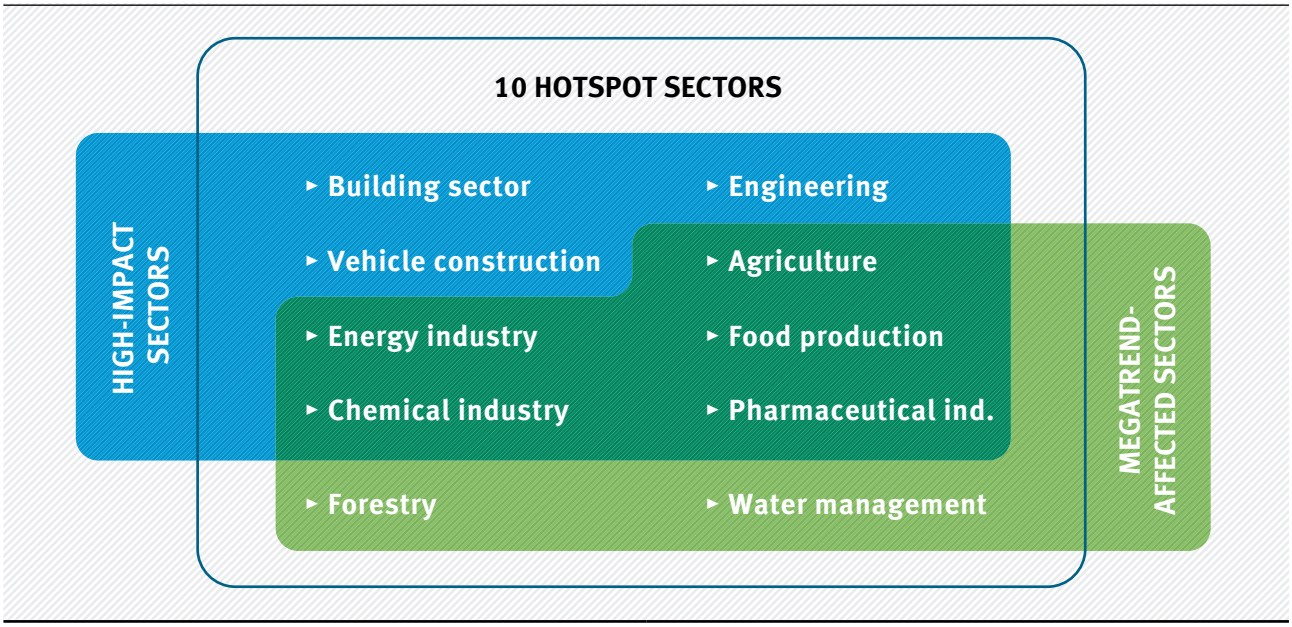
The second guiding question on vulnerability to environmental megatrends was answered purely on the basis of a qualitative, literature-based analysis of the 20 sectors from the first step – looking at direct impacts from the following megatrends: climate change, resource scarcity, freshwater scarcity, biodiversity loss, and deforestation.

For the "hotspot sectors" identified in both steps (see Figure 2), additional qualitative analyses were conducted on guiding questions 1-4 to ultimately determine the extent to which these sectors are facing structural change.

The detailed report on the results addresses the strengths and weaknesses of the approach and also specifically of the qualitative and quantitative methods used (Hünecke et al. 2021).

Figure 2

"Hotspot sectors" due to strong environmental impact and/or being strongly affected by environmental megatrends, in each case in several environmental dimensions



Source: own figure, based on Hünecke et al. (2021)

The analysis conducted on the first two guiding questions led to the identification of

- eight "high-impact sectors" (see Figure 2) with strong impacts in several environmental dimensions, in most cases greenhouse gas emissions, but often also raw material and/or land use, as well as
- seven sectors that could be strongly threatened by environmental megatrends (see Figure 2), with resource scarcity and climate change (effects) playing a particularly frequent role.

Five of the sectors considered even have both a high environmental impact and are highly affected by environmental megatrends: the energy sector, the chemical and pharmaceutical industries, as well as the food and agricultural sector.

A prioritisation based on an assessment in several (equally weighted) environmental dimensions has advantages, especially for the identification and analysis of relevant sectors beyond the climate change dimension, which is often considered alone, as well as for the avoidance of later problem shifting.

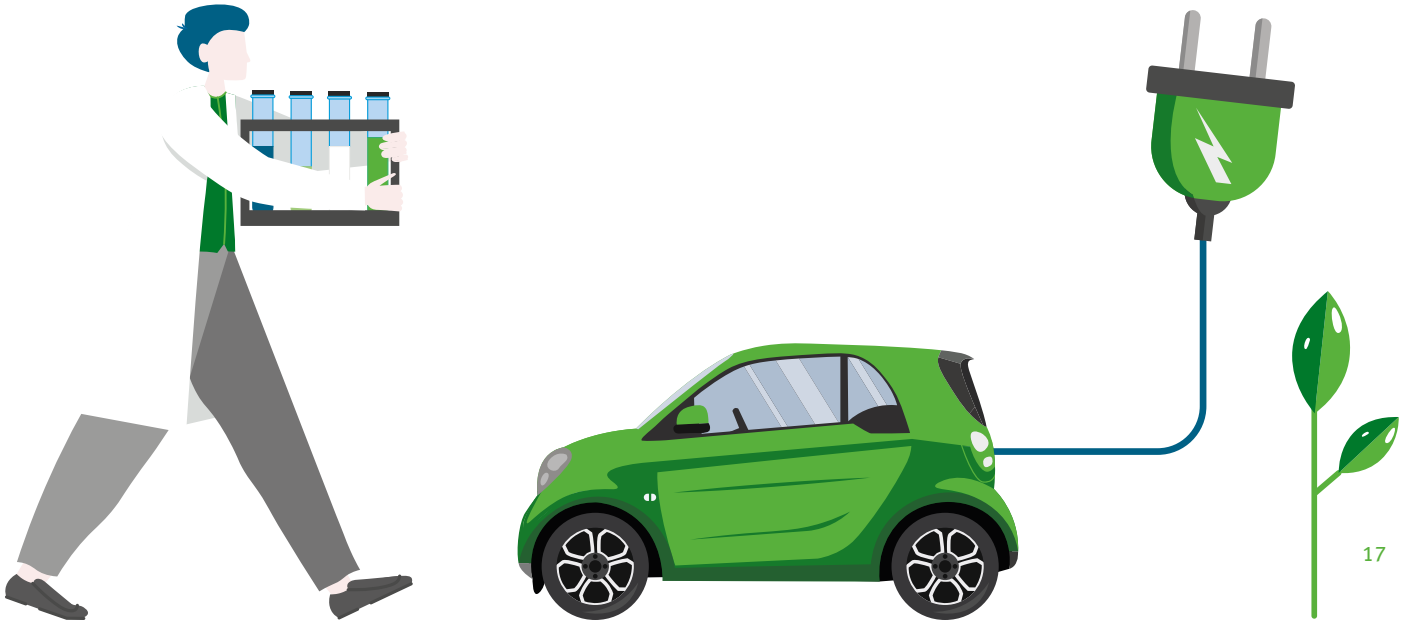
However, a sector such as air travel, which is almost "only" relevant in terms of greenhouse gas emissions, is not prioritised in this methodology, but may nevertheless face significant structural change, for climate change reasons alone. The same applies to other energy-intensive basic material industries beyond the chemical industry (e.g. steel, cement). It is thus necessary to also look at individual environmental issues.

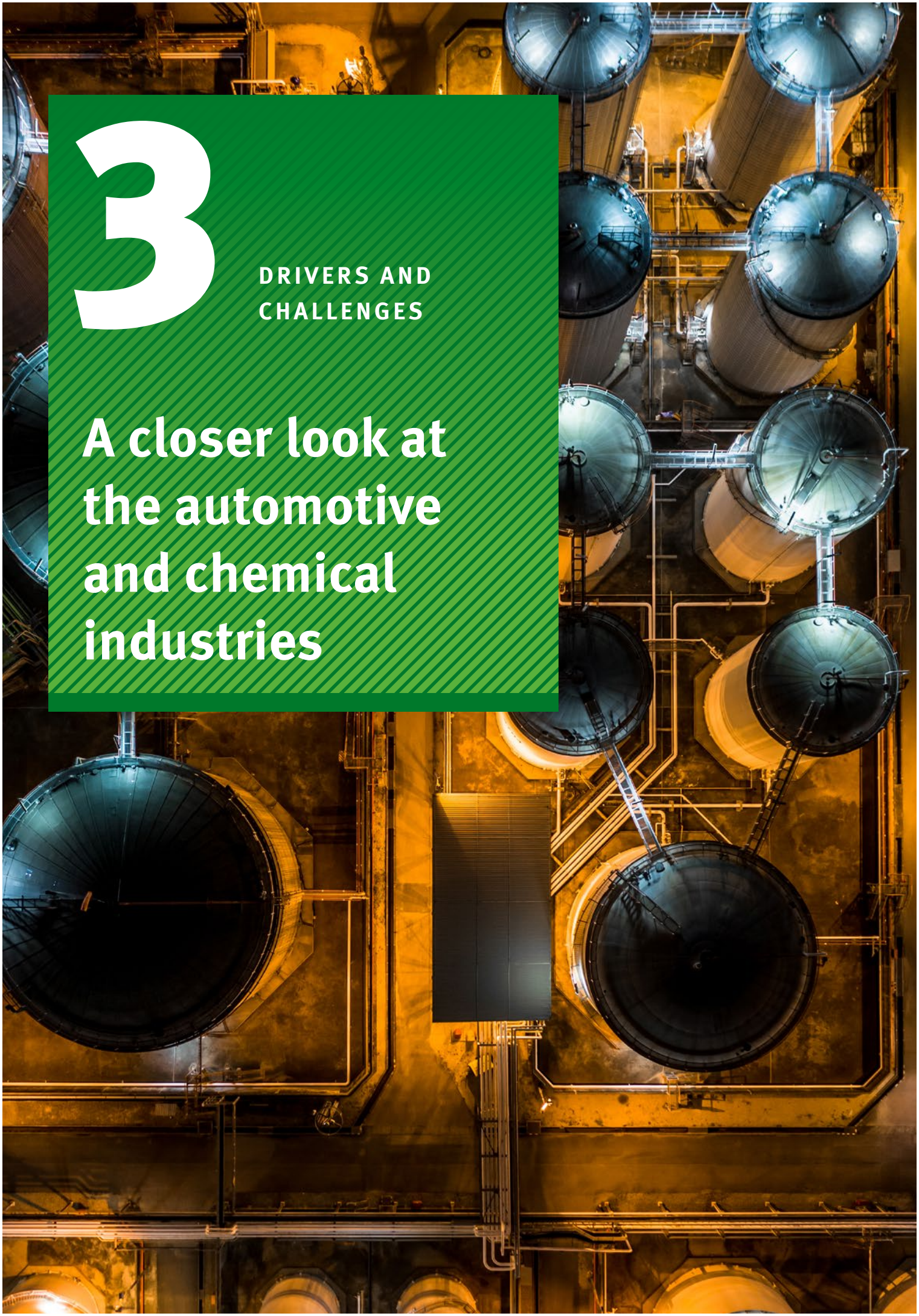
In addition, the analysis of economic megatrends and alternative business models is important for assessing whether an ecologically relevant sector is actually on the verge of profound structural change that may also jeopardise its business model (see guiding questions 3 and 4). The ten "hotspot sectors" identified here (see Figure 2) were therefore subjected to a more extensive analysis (see Hünecke et al. 2021). This revealed, among other things, that the ten cases most frequently involve "resource-related structural change" (see Chapter 1), while sometimes also involving pressure for change elsewhere.

Of the ten sectors examined in more detail, the following are ultimately facing change to a greater extent:

- the **energy sector**, especially with regard to its fossil resource consumption and its greenhouse gas emissions in production;
- the **automotive industry**, especially with regard to the fossil resource consumption, land use for infrastructure, and greenhouse-gas- and air-pollutant-emissions in the use phase;
- the **chemical and pharmaceutical industries**, especially with regard to their fossil resource consumption, water consumption and greenhouse gas emissions in production, and in the case of the pharmaceutical industry also with regard to their vulnerability to biodiversity loss;
- **agriculture**, especially with regard to its greenhouse gas and air pollutant emissions, soil and water pollution, land use and biodiversity impacts, as well as its own vulnerability to biodiversity loss, climate change and water scarcity.

However, a screening is no substitute for an in-depth analysis of individual industries and their challenges. Therefore, the following chapter takes a closer look at two of the sectors mentioned.



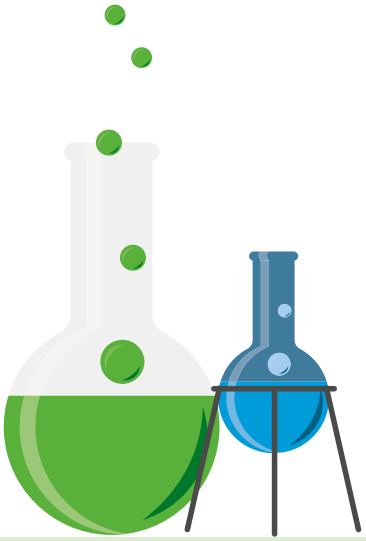


3

DRIVERS AND CHALLENGES

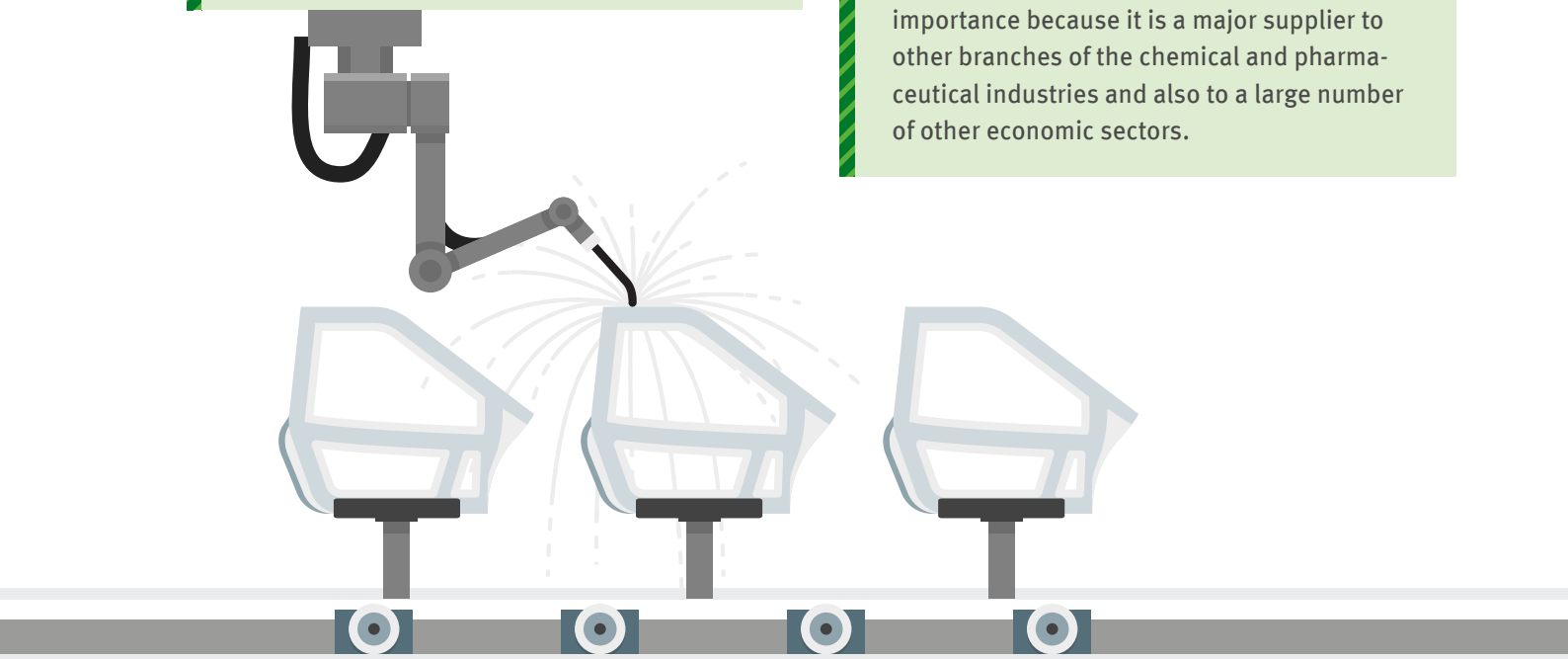
A closer look at the automotive and chemical industries

Drivers, possible developments and challenges of structural change processes can differ between sectors. This chapter looks at two industries with high climate and environmental relevance and, at the same time, high economic importance in Germany, both of which are facing considerable structural change: the automotive and chemical industries (the latter with a focus on "basic chemicals", see textbox).



In 2017, **the automotive industry** generated gross value added of just under 138 billion euros, or 4.7% of Germany's total gross value added. With around 830,000 employees in 2019, it is one of the largest employers in Germany. If upstream industries are included, a total of as many as 1.75 to 2.2 million gainfully employed persons can be directly and indirectly linked to the automotive industry, which is also an important customer for a wide range of components and materials.

The **chemical industry** (excluding pharmaceutical products) generated gross value added of approximately 49.7 billion euros in 2017, corresponding to a 2% share of total gross value added in Germany. It has around 340,000 employees. Basic chemicals, which are the focus here, are responsible for over half of the employees and almost two thirds of the sales. **Basic chemicals** refer to basic materials produced such as the organic primary chemicals ethylene and benzene, fertilisers or plastics in primary form. The manufacture of these "platform chemicals" is characterised by mass production and a low degree of product differentiation. The industry is of particular importance because it is a major supplier to other branches of the chemical and pharmaceutical industries and also to a large number of other economic sectors.



3.1 Causes and drivers of change

In the case of "ecological structural change," ecological and environmental-policy pressure for action coincide with economic and technical developments.

Environmental pressure to act

A key driver of change in both industries considered here is climate change and the reduction of greenhouse gas emissions that cause it. To become climate-neutral by 2045, mere efficiency improvements and slight emission reductions in existing technologies, as in the past, are no longer sufficient.

- The **chemical industry** is one of the most energy- and emissions-intensive industries. The production of "platform chemicals" (see textbox on the chemical industry) alone accounts for about two-thirds of all greenhouse gas emissions in the sector. According to a roadmap drawn up for the German Chemical Industry Association, total emissions from energy requirements, processes and products in the chemical industry were estimated to be just under 113 million metric tons of CO_2 in 2020. Fossil raw materials (primarily crude oil, but also natural gas and, to a lesser extent, coal) are used in the industry for energy and materials. The share of fossil raw materials (87%) is currently significantly higher than the share of biogenic raw materials (13%) regarding the raw material base of organic basic chemicals. With regard to emission reductions, those emissions that originate from the use or combustion of chemical products (so-called "Scope 3 emissions") must also be taken into account, in addition to energy and process-related emissions. Basic chemicals production is thus also facing a fundamental change in its raw material base.

- In the **automotive industry**, greenhouse gas emissions also occur in production, especially in metal-processing stages of the value chain. However, the greatest pressure for change to reduce emissions is at the level of the vehicles produced: Road traffic is responsible for 26% of final energy demand and 24% of fossil CO_2 emissions worldwide. In addition, the emission of air pollutants is harmful to human health. Vehicles powered by fossil fuels are therefore subject to increasingly strict government regulations in many countries around the world (e.g. through efficiency/emission standards, air pollutant limits, inner-city driving restrictions, and in some cases bans on new registrations in the long term), while the spread of electric cars is being promoted (e.g. through purchase premiums, tax privileges, and in some cases sales quotas for manufacturers).

In recent years, political and regulatory pressure on the automotive industry in terms of climate change mitigation and air quality has been more pronounced globally than for the chemical industry. This is presumably due on the one hand to the fact that the technical, (locally) pollutant-free alternatives for vehicles are more mature and proven than for many chemical processes and products. On the other hand, global market developments and national interests in the sales markets also play a role, as will be explained in more detail below.

Global market developments and regulations in sales markets

Both the automotive and chemical industries have strong global linkages through their value chains. The trade intensity of both industries in Germany is above the national average for the manufacturing sector. This basically results in a high sensitivity to the global economic environment and international competition.

In addition, demand in both sectors has grown strongly in recent years, mainly in Asia, especially China. For example, the Chinese market share of global passenger car sales almost quadrupled between 2005 and 2017 from 9% to 35% (2019: 33%). The same applies to the Chinese share of global chemical sales, which rose from 11.6 % in 2005 to almost 41% in 2019. Accordingly, German companies are exporting a lot to this region, while also building up additional local production capacities.

However, China and other growing economies have also massively expanded their own production capacities in recent years. This is putting German companies in the two sectors under pressure in different ways:

- The German and also European **basic chemicals** industry is exposed to increasing pressure from non-European competitors who have significantly expanded their capacities in view of production cost advantages. US producers, for example, have benefited from low energy and raw material costs due to shale gas production. However, commodity-related production capacities have also been expanded in the Middle East. Production in these resource-rich countries is exceeding domestic demand and increasingly serving world markets. In addition, overcapacities are believed to have developed in China. The German basic chemicals industry, with its relatively high raw-material- and energy costs, is therefore threatened with fewer export opportunities, increasing import pressure and, overall, lower growth.

- The European **automotive industry** is facing, particularly in the important Chinese market, increasing competition from domestic manufacturers – especially in the electric car segment which the Chinese government is increasingly prioritising over cars with internal combustion engines. In addition to environmental- and health-policy reasons, industrial-policy considerations also play a role here. While Chinese companies had a technical competence gap in the development of combustion engines, they have a large lead over the German automotive industry in battery technologies and especially in their mass production. Another factor is China's interest in being able to reduce its high dependence on oil imports through electromobility.

Technological change

A prerequisite (and in some cases also a driver) for structural change is the progress made in new alternative technologies that can replace existing ones:

- In the case of **electromobility**, this is primarily the continuous development of battery systems (initially in other application areas and industries), which has resulted in increased energy density and reduced costs per storage unit. This is the result of high investments in research and development (R&D) as well as of increased production volumes over the last 25 years.

- In the case of **basic chemicals**, the structural change is about a CO_2-free energy supply, for example, to provide process heat for chemical reactors, and about the use of non-fossil or secondary carbon sources: i.e., electricity-based raw materials such as "green hydrogen" and its derivatives in particular, but also biomass or plastic waste. Both goals are facilitated by the increasing expansion of renewable energies for the provision of electricity. Here, too, technologically advanced solutions already exist, but a broad market launch of climate-neutral processes is still pending, as high investments have to be made under difficult economic conditions (worldwide overcapacities of conventional production).

In addition, ongoing digitalisation and automation are driving structural change in many industries. This is also impacting production processes, products and business models in the automotive and chemical industries. Road vehicles are likely to be particularly affected. Connected and automated driving requires new competencies in automotive engineering; at the same time, new mobility services are emerging. New players with high innovative strength and a focus on digitalisation and automation are playing an increasing role and putting additional pressure on classic manufacturers.

3.2 Potential sector developments and their consequences

A broad direction of change can be seen in both the automotive and chemical sectors, but a precise forecast of their further development is always fraught with uncertainty. Instead, various scenarios are conceivable and are also considered separately and compared in well-founded studies.

Automotive industry

In the automotive industry, the exponential growth in the number of electric cars is expected to continue worldwide in the coming years and decades. However, the magnitude of the growth and the temporal dynamics vary between scenarios (cf. Figure 3).

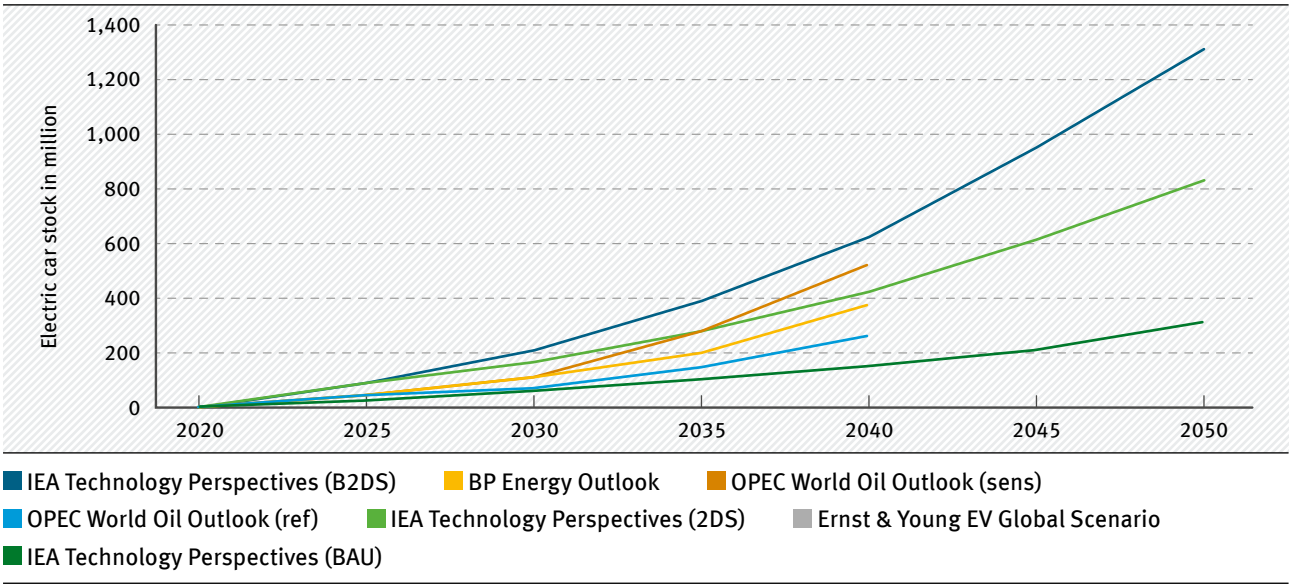
In addition, other trends such as digitalisation, automated driving and new mobility services play a role, but their precise effects are also uncertain. For example, it remains to be seen how the market will be divided between established manufacturers and new players (from the ICT sector, among others), and what role(s) the established manufacturers will assume in the future. One possibility is that they will become "hardware" suppliers of module vehicles for ICT actors. However, they can also become stronger providers of mobility services themselves beyond vehicle sales. There are differing assessments and recommendations on this among industry actors.

Despite past successes and attractive returns on the sale of diesel and gasoline vehicles, the German automotive industry must face up to change. Both electrification and digitalisation require major investments by manufacturers and suppliers. Moreover, in the case of purely battery-electric vehicles, German companies have so far tended to lag behind. The chances of success for German manufacturers and large, broad-based suppliers are quite good, given their expertise, which will continue to be needed in many respects, their global network, and, in the case of the premium segments, their higher margins. In view of the uncertainties about the exact course of structural change, diversification and flexibility, including of production lines, are important criteria for success.

The situation is considered to be more difficult for those (medium-sized) suppliers who have so far specialised in components related to combustion engines. They will have to fundamentally reorganise their product portfolios with the foreseeable breakthrough of battery-electric drives and analyse the strengths of their production and manufacturing expertise. It is to be expected that some of these companies will disappear from the market completely. The regional concentration of such companies could also affect entire regional economic clusters.

Figure 3

Global fleet of electric cars according to different scenarios



Source: own figure, based on the scenarios mentioned

Job losses in the automotive industry?
Studies and sector experts differ in their assessments of whether the structural change in the automotive industry will result in extensive job losses for the economy as a whole. What is widely undisputed is that the development and production of the electric powertrain requires fewer workers than that of the classic combustion engine vehicle. The vehicle manufacturing industry and its suppliers must therefore expect a certain decline in employment, depending on the further development of the respective market shares. Trade unions also fear that the disruptions could be used by companies to relocate and withdraw from collective agreements. The extent to which losses in vehicle construction can be compensated for within the automotive industry or in other segments of the transport sector (rail, local public transport, new mobility services) – with partly changed skills profiles – is under discussion. Overall, positive employment effects are also considered possible (cf. Heyen et al. 2021).

Basic chemicals

So far, the German basic chemicals industry has mainly felt the effects of increased international competition due to growing production cost advantages and capacities in Asia and the USA. Major growth in export opportunities and production volumes is not expected for the domestic industry. It can however continue to produce for the European market thanks to geographical proximity and integrated production if the economic conditions (such as the overall state of the economy and electricity prices in particular) do not deteriorate further. In a pessimistic scenario, on the other hand, production declines and interrupted value chains could have a negative impact on German industry as a whole.

At the same time, the chemical industry must embark on a path toward climate neutrality, which cannot be achieved through pure efficiency improvements but requires new raw materials and production processes. This involves electricity-based heat and steam generation, hydrogen production based on renewable energies, and the use of non-fossil carbon sources (electricity-based raw materials, biomass, plastic waste). The technical options for this are largely available, although some technologies have yet to be developed to market maturity and, above all, have yet to be applied on a broad scale.

Detailed analyses of the consequences of a far-reaching conversion of the energy and raw materials base are rather at their beginning but point to a profound change with complex challenges. The close interrelationships and dependencies between the chemical industry and other sectors play a role here. These could become even stronger if the demand for renewable energies, hydrogen and alternative carbon sources also increases in other sectors of the economy – such as the steel industry and the transport sector. The investments required, some of which are outside the chemical industry, are enormous in an ambitious climate neutrality scenario. Production costs for many platform chemicals would be two to five times higher compared with fossil-based products to date. In addition, the electricity demand of a defossilised chemical industry would exceed the production potential of renewable energies available in Germany. This would make it necessary to import electricity-based basic materials – or raise the question of relocating production to favourable locations. This would in turn have an impact on national employment, although detailed forecasts of employment effects in the chemical industry are lacking to date.

3.3 Interim conclusion

Both industries under consideration are facing fundamental structural change. As drivers, ecological pressures and corresponding environmental policy measures are coinciding with global technological and economic developments. However, the two sectors differ in terms of various characteristics of their structural change:

- **Strength of environmental policy pressure:** In recent years, global political and regulatory pressure on the automotive industry in terms of climate change mitigation and air quality has been more pronounced than for the chemical industry. This is due not only to ecological but also to different national economic interests. However, this does not change the fact that the chemical industry must also become climate-neutral by 2045.

- **Core / type of structural change:** While in the automotive industry it is primarily the end product (vehicle) that is facing disruption, in basic chemicals it is primarily the fossil raw material and energy basis of production. Thus, structural change in the automotive industry is mainly "product-related" and that in the chemicals industry is mainly "resource-related."

- **State and dynamics of change:** In the case of the automotive industry, technological disruption is already underway with a high degree of momentum and will probably affect the entire industry in the next few years. In the case of the chemical industry, the transformation is still in its infancy, and the further dynamics are highly dependent on the concrete design of the climate and energy policy framework conditions.

- **Pioneer vs. laggard role of German companies:** In the case of electromobility, established German manufacturers have so far tended to be laggards compared with foreign, and in some cases new, market players. In the field of climate-neutral (basic) chemicals, German producers and – upstream – German plant-engineering companies could become technological pioneers. Both roles involve economic opportunities and risks. Doing nothing, however, would not be a sensible option either ecologically or economically in both industries.

- **Role of new vs. established companies in structural change:** In the automotive industry, electromobility and, to an even greater extent, connected and automated driving are bringing new players into the market. This is putting pressure on traditional manufacturers on various fronts. Suppliers specialising in components for the internal combustion powertrain are in danger of disappearing from the market altogether. In basic chemicals, the market entry barriers are traditionally high due to the specifics of the process industry and the advantages of integrated production by established companies. As this is about physical interdependencies, neither the shift to a climate-neutral energy- and raw-material base nor digitalisation is likely to change this much. It is therefore unlikely that the transformation of the chemical industry in Germany or the EU will be accelerated by the emergence of new players in the domestic market.

- **Interests along the value chain:** Looking at the value chain of an industry under pressure, the question arises as to whether there is a common interest in change along the entire value chain. The players in the automotive industry partly differ fundamentally in terms of their interests, depending on what opportunities they see for themselves against the background of their technological competencies. For the basic chemicals industry, a common interest could also exist beyond the industry due to the pronounced economies of scope within the chemical industry and the advantages of close manufacturer-user relationships with downstream sectors.

4

Shaping structural change successfully

How can ecologically necessary structural change be designed in such a way that it helps to achieve climate and environmental policy goals, and at the same time is economically successful and socially just?

Economic success is primarily to be understood in macroeconomic terms. Not every company will survive structural change processes, and not every job will be saved. Overall, however, macroeconomic and regional economic disadvantages as well as negative effects on the quantity and quality of employment should be avoided. And at the same time, the socio-economic opportunities of a Green Economy must be exploited: in other words, new business models fit for future must be developed and new jobs created.

Social justice also means that positive employment effects are not only created in the aggregate, but that all population groups – regardless of age, gender and level of education, for example – have the opportunity to benefit from the change and are supported in doing so, if necessary. This also applies to regions whose economic structure is strongly characterised by a shrinking industry, such as lignite extraction in the German region of Lusatia.

Business and political actors are both called upon in this task.

Necessity and ability to politically govern structural change processes

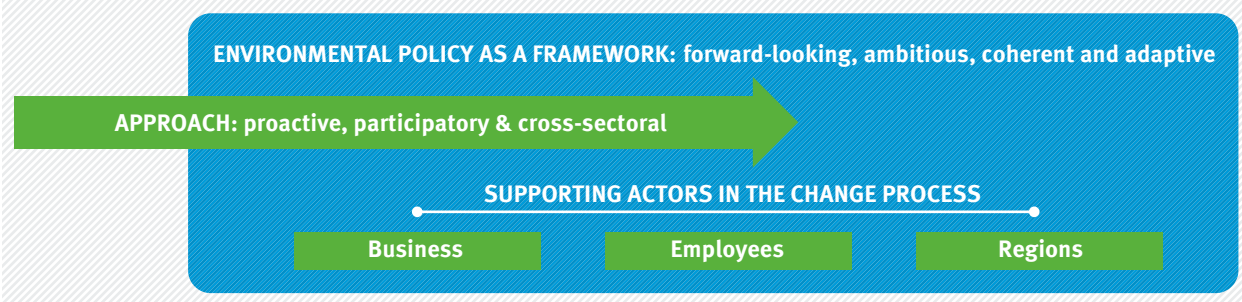
It is in the nature of economic development that once established structures have a tendency to persist. To break out of them, external pressure is often needed. If change is needed with a view to longer-term sustainability goals, but is not sufficiently driven by economic competition or changed consumer behaviour, political incentives and governance are needed.

Past processes of structural change show that policy can in principle address all the influencing and success factors identified in the literature. On the other hand, economic prosperity cannot be simply planned and implemented in the short term. The political ability to steer the economy and society has its limits; public budgets have limits, too. Therefore, politics, business and society must work together as much as possible. Politics has a moderating role as well as a shaping one.

This chapter looks at which basic principles and measures are promising for the governance of ecological structural change, with a focus on political action. The recommendations are based on a literature review of factors influencing previous structural change processes in Germany and abroad as well as on stakeholder discussions within the case studies of the UBA project "Ecological Structural Change" (Heyen et al. 2021).

Figure 4

Overview on recommendations



Source: own figure, based on Heyen et al. 2021

4.1 Approach: proactive, participatory and cross-sectoral

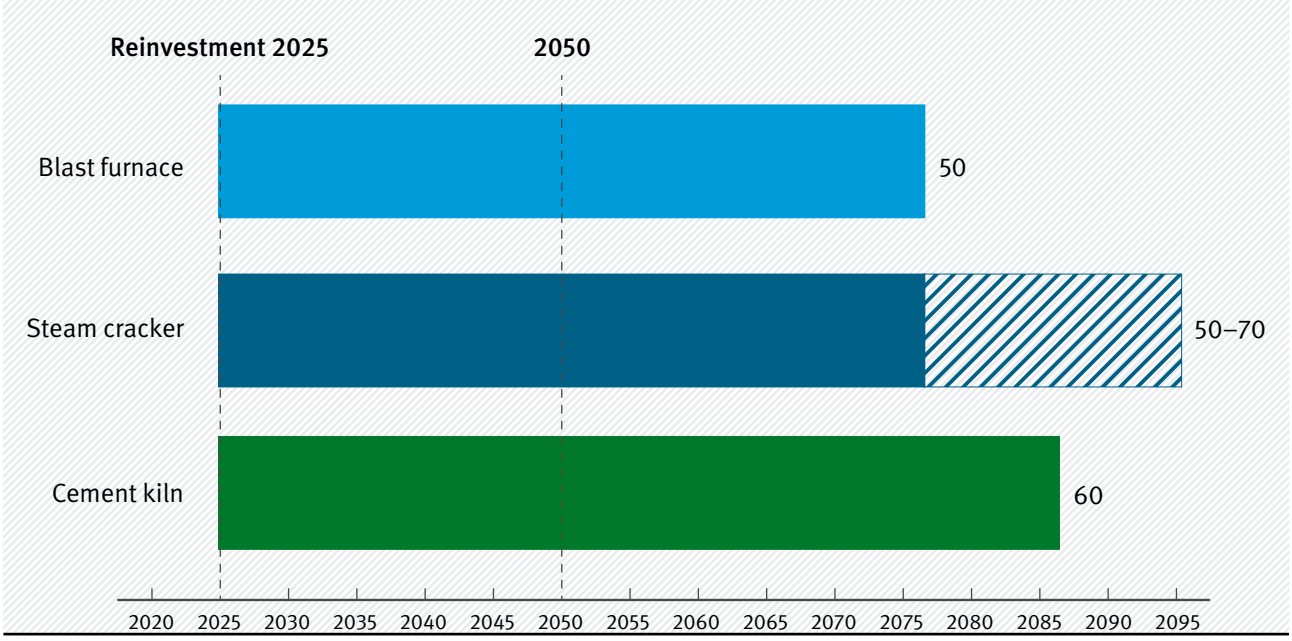
Past processes of structural change have been more successful when challenges had been identified **early** on and addressed **proactively**. This gives companies and employees more time to adapt to new business models and changing job requirements and qualifications. It further avoids structural breakdowns in the long term and the wrong investment decisions in the short term.

Foresight is particularly important in **sectors with long planning and investment cycles**, such as the automotive and chemical industries. The planning lead time for passenger car models is several years, with vehicles subsequently on the road for ten to twenty years. Large production plants in the chemical industry and other energy-intensive sectors have a service life of several decades (cf. Figure 5). It is therefore crucial which technologies are invested in over the next few years.

Regular sector screenings:
To be able to act forward-looking and proactively, policymakers and industry must anticipate risks to individual sectors at an early stage. To do this, they should regularly conduct in-depth analyses to clarify which industries could come under pressure because they cause high environmental impacts and/or because megatrends such as climate change require adjustments to production processes or products. Good analyses can also uncover ecological risks that are not yet broadly discussed. In this context, it is possible to build on the approach taken in the UBA project "Ecological Structural Change" (see Chapter 2 and, in detail, Hünecke et al. 2021).

Figure 5

Technical lifetime of selected production plants in the steel, chemical and cement sectors with reinvestment in 2025



Source: Agora Energiewende & Wuppertal Institute (2019) (CC-BY licence)

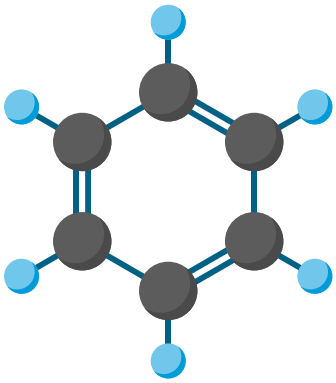
This means that policymakers must formulate clear long-term goals and reliable framework conditions (see section 4.2). The companies themselves must also adapt to the change at an early stage and formulate a clear strategy. **New competencies and possibly new business areas as well as reliable supply chains must be established in good time.**

In view of the combined ecological, economic and social challenges, it is important that politics, business, trade unions, regions and civil society actors **jointly and constructively** discuss how best to shape structural change processes in different industries. Evaluation of past processes shows that transformation strategies with a high degree of consensus are more effective and robust.

A common understanding of the problem and the goal is an important starting point. This does not necessarily mean agreement on specific policy measures, but rather a **consensus on the need for and direction of change** – and ideally a **shared vision of the future for the sector**, which then also shapes corporate mission statements. Advantages and disadvantages of different technologies, concrete measures, and conflicting goals in achieving the vision can then be openly discussed within the common normative framework. In addition to climate protection, other sustainability aspects should also be taken into account in order to avoid ecological problem shifting.

A cross-sectoral approach is necessary in view of major interrelationships and dependencies between sectors. Furthermore, several parallel and interrelated adaptation requirements may arise along value chains. There may also be competition particularly between energy-intensive basic industries (but also between these and the transport sector) for large quantities of renewably produced electricity and hydrogen. In its 2019 RESCUE study, the German Environment Agency used integrated scenarios covering all relevant sectors to outline ways in which greenhouse gas neutrality can be achieved by 2050 while using raw materials as sparingly as possible (UBA 2019).

Unlike in the energy and automotive sectors, however, the debate on concrete ways to achieve climate neutrality in the chemical industry and other basic material industries is still in its infancy. This is also shown by the comparatively much smaller number of studies that have so far dealt with scenarios and structural change effects in these industries. The discussion of strategies must therefore urgently gain momentum and significance to set the necessary course in good time. The development of a **cross-sectoral roadmap** could be useful here (see textbox).



A cross-sectoral and transnational roadmap for the chemical industry:
A roadmap for a climate-neutral chemical industry must be cross-sectoral and transnational. Among the issues that must be addressed are the required quantities of green electricity and hydrogen, and finding suitable interfaces between domestic and foreign value chains in the future from an energy and material point of view. This is also about international cooperation and domestic employment. Beyond climate protection, other sustainability aspects must be considered, too. In addition to politicians, employers and trade unions, civil society actors working on environment and international cooperation should also participate in the development of the roadmap.

4.2 Environmental policy: forward-looking, ambitious, coherent and adaptive

By formulating **clear, ambitious, medium- and long-term sustainability targets**, policymakers can create planning certainty. This is advantageous for companies, investors and (future) employees alike – for example with regard to investments in R&D or in durable production facilities, the future product line-up, and with regard to career choices or further training. Wherever possible, **targets should be specified at sectoral level** in order to avoid mutual shifting of responsibility between sectors.

It is also important to look beyond individual sustainability goals **to identify and address potential tensions and trade-offs** at an early stage. This helps to reduce the need for corrections at a later stage and strengthens the ability to plan. **Coherence between policy goals of different governance levels and departments** must also be ensured.

When formulating goals and measures, policymakers must allow **sufficient leeway for innovation and learning**, as structural change takes place in a dynamic environment with high levels of uncertainty, especially at the beginning. Therefore, an adaptive policy must include a **regular review of goals and measures** and, if necessary, adjust or specify them (see textbox). An important basis for this is a suitable set of indicators as well as measures for monitoring, evaluation and communication. When adjustments are necessary, it is important that the underlying patterns – e.g. the criteria applied when adjusting instruments – be transparent and comprehensible.

In addition to ambitious targets, shaping ecological structural change also requires **sophisticated climate- and environmental-policy instruments** that ensure the replacement of problematic processes and products with ecologically advantageous ones. It is not possible here to list specific instruments that should be used across all sectors and environmental goals. As a rule, profound change rather requires a "policy mix" that includes not only information and advice but also **financial incentives and regulatory instruments** that promote sustainable practices while restricting or financially burdening unsustainable ones.

Example: climate policy targets

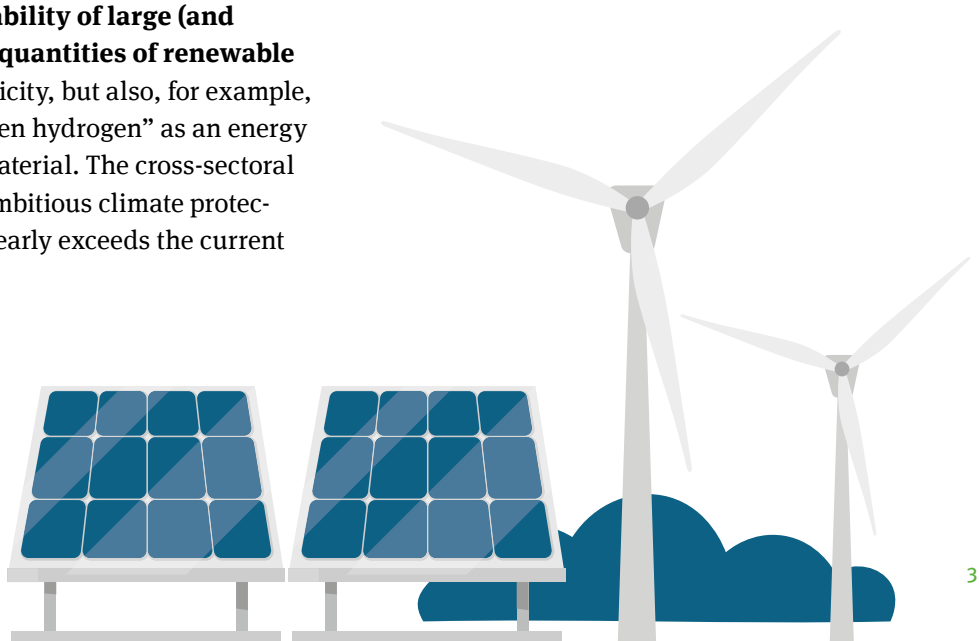
The goal of greenhouse gas or climate neutrality by 2050 at the latest is an example of a long-term goal that has implications for investment decisions today. It is legally established at both the European (2050) and the national (2045) level.

The previous target to cut greenhouse gas emissions by 80-95% by 2050 has since become even more ambitious. This was done in view of the 2015 Paris Climate Agreement which demands limiting global warming to below 1.5°C relative to pre-industrial levels, and an analysis by the International Panel on Climate Change which calculated the emission levels still possible to achieve this (IPCC 2018).

The German government's GHG-emissions-reduction target for 2030 was specified at the sectoral level as part of the German Climate Change Act.

The instruments can be **tightened over time**, especially if appropriate steps are communicated early. Examples of economic instruments include annually increasing CO_2 taxes (or CO_2-based components of energy taxes) and the decreasing number of certificates in the European emissions trading system; examples of regulatory instruments are decreasing emission limits over time (e.g. for manufacturers' passenger car fleets) or increasing sales quotas for passenger cars with alternative drive systems.

A specific framework condition for ecological structural change is the **availability of large (and relatively inexpensive) quantities of renewable energy:** directly as electricity, but also, for example, for the production of "green hydrogen" as an energy storage option and raw material. The cross-sectoral demand resulting from ambitious climate protection scenarios not only clearly exceeds the current ambitions for the expansion of renewable energies, but foreseeably exceeds the total potential available in Germany. Thus, a successful ecological structural change in the short to medium term must be linked to a faster expansion of renewable energies as well as considerations about the prioritised use of hydrogen in various sectors. The medium term must also include international cooperation with countries with greater production capacities for electricity from renewable energies and electricity-based raw materials.



4.3 Supporting business in the transition

An ambitious climate and environmental policy in Germany and Europe must ensure that measures **do not merely result in emissions being shifted abroad** ("carbon leakage"), whether through relocation or the replacement of domestic production with imports. **Internationally binding instruments would be desirable** for the regulation or pricing of greenhouse gas emissions, or the extraction and consumption of resources. These are, however, usually very difficult to implement. A smart alternative could be a European **carbon border adjustment mechanism** (often called "carbon border tax") (see textbox).

In addition, policymakers can support companies affected by structural change through the standard range of instruments for **promoting climate-friendly innovations and investments**, e.g., through direct investment grants, favourable loans, government guarantees, tax-advantageous depreciation schemes – and free advisory services on funding options.

Given the necessity and at the same time considerable investment required for ecological structural change, **public innovation funding should be geared more consistently than before to climate and environmental criteria**. This also applies to economic stimulus programmes worth billions, such as those launched in the wake of the Corona crisis.

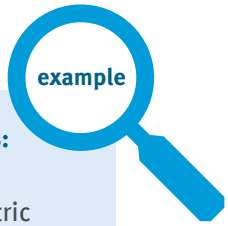
In view of short innovation cycles, bureaucratic processes should be simplified, and R&D subsidies, grants or loans should be less rigid regarding the specification of sub-technologies. One example of good practice is the "innovation vouchers" scheme of the state of Baden-Wuerttemberg. These are programmes that specifically support small and medium-sized enterprises (SMEs) and start-ups in the planning, development and implementation of innovative products, services or production processes in selected high-tech fields.

The needs of SMEs should generally be given special consideration. Some SMEs are specialised in technologies that are losing importance as a result of structural change – the combustion engine, for example. These companies must be supported – also by their customers and social partners – in transferring their production and manufacturing expertise to, in this case, new types of engines and new forms of mobility. Smaller and young companies tend to find it more difficult to finance necessary investments because their costs are higher relative to their size, they have lower absolute surpluses and find it more difficult to obtain loans from banks. They also incur higher relative costs in overcoming bureaucratic hurdles.

Carbon border adjustment mechanism

A carbon border adjustment mechanism considers the emissions associated with the production of goods imported from countries with less stringent climate policies and imposes a corresponding monetary surcharge on these goods. This is intended to ensure equal treatment with goods produced domestically (or within the EU).

The European Commission is currently working on the design of such a system. This involves overcoming methodological, trade-law and trade-policy-related challenges.



Example for the importance of framework conditions for new business models: reuse of batteries from electromobility

Various companies and start-ups are currently testing how batteries from electric vehicles can be reused in stationary storage systems in an economically and ecologically sensible way when their performance is no longer sufficient for a use in vehicles. Policymakers can promote these new business models, for example, by ensuring the mandatory and cost-effective disclosure of certain data from the mobile use of the battery. This is because the data enables the players who reuse the battery to determine its condition and the possibilities for further use with manageable effort.

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However, new business models and start-ups do not automatically benefit those employees and regions affected by the decline of certain industries. Therefore, they often need some support as well. The next two chapters deal with them.

4.4 Supporting employees in the transition

Workers in declining industries or sectors undergoing major change should be supported, in particular through **further training and retraining in promising fields of activity**, taking into account people's existing competencies. The companies themselves are first called upon in this step – in cooperation with works councils, social partners and training centres. After all, companies also benefit from the newly acquired skills of these workers. The German Skills Development Opportunities Act offers additional state support. It provides financial support that companies can use to prepare their employees for future challenges in their field of work through further training.

For far-reaching structural change processes, such as in the automotive industry, there is also a proposal from the German trade union IG Metall for specific **short-time work benefits ("Transformation-skurzarbeitergeld")**. Under this scheme, structural-change related short-time work would be systematically used for training measures in new work areas. The employee would remain employed by the company during the training, with their wages subsidised by the Federal Employment Agency.

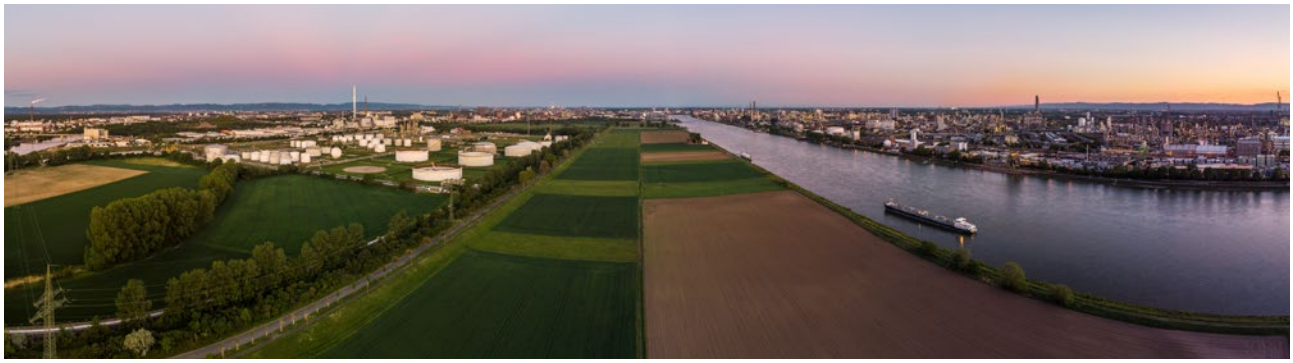
example

Advanced vocational training in the automotive industry

As vehicle power trains and business models in the automotive industry change, skills requirements will change significantly. Support is needed in particular for SMEs specialising in combustion engines and their employees, who will relatively quickly require qualifications related to new drive technologies as well as automated and connected vehicles. If no alternative employment opportunities can be found for workers in the company itself, positions in the field of electromobility outside of passenger car production are also possible, for example in the development and operation of charging infrastructure, local public transport or other mobility services.

If employment in the current company is no longer possible, the usual **job-search support measures** should take effect. These include counselling and placement services offered by the employment agency, relocation assistance, recruitment and employment incentives for companies or support for business start-ups. In the case of major economic disruptions, employment companies ("Beschäftigungsgesellschaften") can also be set up with public funding to provide temporary employment, further training or retraining for those employees affected, and to support them in their job search. For older employees, **early retirement schemes** can be offered.

4.5 Supporting industrial regions in the transition



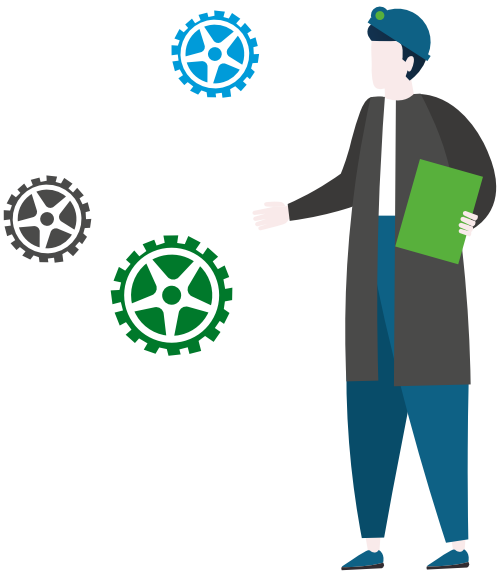
The more regionally concentrated an industry is, and the more pronounced its change or even its decline, the more likely it is that the affected regions will also need support. A current extreme case is the German region of Lusatia with regard to the phase-out of lignite, which has dominated the regional economy for a long time.

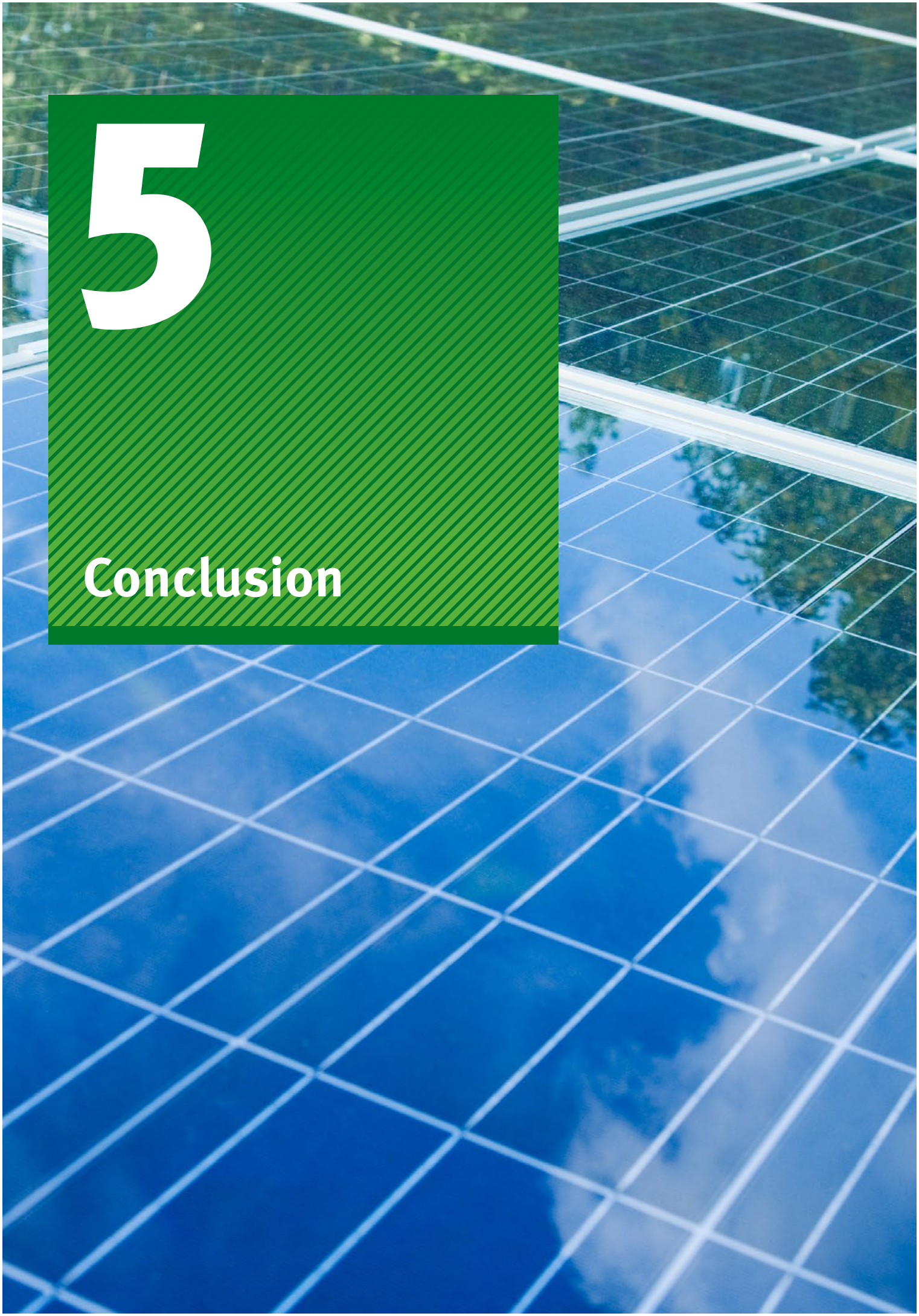
In these cases, the primary objective is to **promote the establishment of new companies** with sustainable business models in order to diversify and green the economic structure. Measures for this can include **investment incentives, start-up support and infrastructure development**. Well-functioning public infrastructures are a fundamental prerequisite for the attractiveness and thus competitiveness and future viability of a location.

In addition, a **well-developed research and training infrastructure** is seen as an important success factor. Together with companies, it ensures the availability of know-how and the innovative capacity in a region. However, research institutions also tend to align themselves with the (application-oriented) needs of the regionally dominant industry. **Diversification of the economy requires diversification of research**, with a focus on sustainable business areas. In this context, strong basic research (initially) has the advantage of being more open in its orientation and usability.

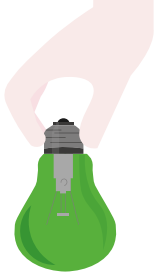
In the case of the automotive and chemical industries, it is not necessarily a matter of regional diversification, but of change within the established industries. But even locations for which the two industries are currently of central importance (e.g. automotive manufacturing in Wolfsburg, Stuttgart and Ingolstadt, or the chemical industry in Leverkusen and Ludwigshafen) can face challenges – especially if new manufacturers settle in completely different locations, as the example of Tesla in Brandenburg shows.

The German government is promoting regional innovation clusters in various ways, such as its support for the automotive supply industry as part of the 2020 economic stimulus package. Regarding research, regional and application-oriented competence centres can focus on new technologies and business models. To counter technological “dead ends” in regional clusters of the German automotive industry, local governments are also called upon to conduct a dialogue and strategy process with all stakeholders on regional adaptation to and governance of the structural change.





5 Conclusion



The climate crisis, the massive extinction of species and other ecological challenges require a profound change of our society and economy towards a climate-neutral, resource-efficient and waste-avoiding Green Economy. In addition to improvements for the environment and quality of life, this change also offers great economic potential for sustainable business models.

Companies whose resources, production processes or products are associated with significant climate or environmental impacts, however, face considerable pressure to change. In addition, many sectors of the economy must deal with environmental megatrends such as climate change and resource scarcity, but also technical-economic trends such as digitalisation.

The "sector screening" conducted as part of the UBA project "Ecological Structural Change" shows that energy supply, automotive manufacturing, the chemical and pharmaceutical industries, as well as agriculture are particularly facing profound change. The in-depth examples of the automotive and chemical industries (focusing on basic chemicals) reveal similarities but also differences, for example with regard to the type of structural change, or the main drivers and dynamics of change.

The key challenge in ecological structural change is to shape the transformation in such a way that ambitious climate and environmental policy goals are achieved while at the same time maintaining value creation and employment in the country, at least across all sectors. To this end, severely affected companies, employees and regions should be supported in the process of change. The focus should not be on compensation for revenue losses from past business models, but rather on investments in new technologies and products, the essential infrastructures and qualifications.

Ecological structural change also requires an ambitious climate and environmental policy with a coherent mix of policy instruments to set the framework conditions for the path to a climate-neutral and resource-efficient economy. Since a climate-neutral economy relies on substantial amounts of electricity and hydrogen based on renewable energies, there is a particular need for greater expansion of renewable energies in Germany – as well as international cooperation with regions that are favourably located to provide renewable energy.

Successfully shaping structural change processes requires a forward-looking and proactive approach that is also participatory and cross-sectoral. This is especially true for industries with long investment cycles and strong linkages with other parts of the economy. Thus, the course must be set in the next few years for the future economy. This also requires further analyses and strategic dialogues regarding some sectors that have been thus far understudied, such as energy-intensive industrial sectors.

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