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Germany's turning point

Accelerating new growth on the path to net zero

October 2021

MAKING AN IMPACT THAT MATTERS since 1845

Transformations are always complex. But the European continent can achieve new growth as it accelerates to net zero.

Deloitte Economics Institute

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Foreword

We have known for a long time that our choices are harming the environment and the climate. Our experience of natural disasters – floods, droughts, and record-breaking heat waves – increasingly shows us the worsening impacts of our choices.

All these changes to our physical environment are taking place during a global pandemic when we have seen our systems tested and sometimes fail. We are now waking up to the consequences of our global connectedness, just as we are appreciating the depth of our mutual dependence. And we are taking stock of what we are personally willing to sacrifice to protect the shared assets on which we rely.

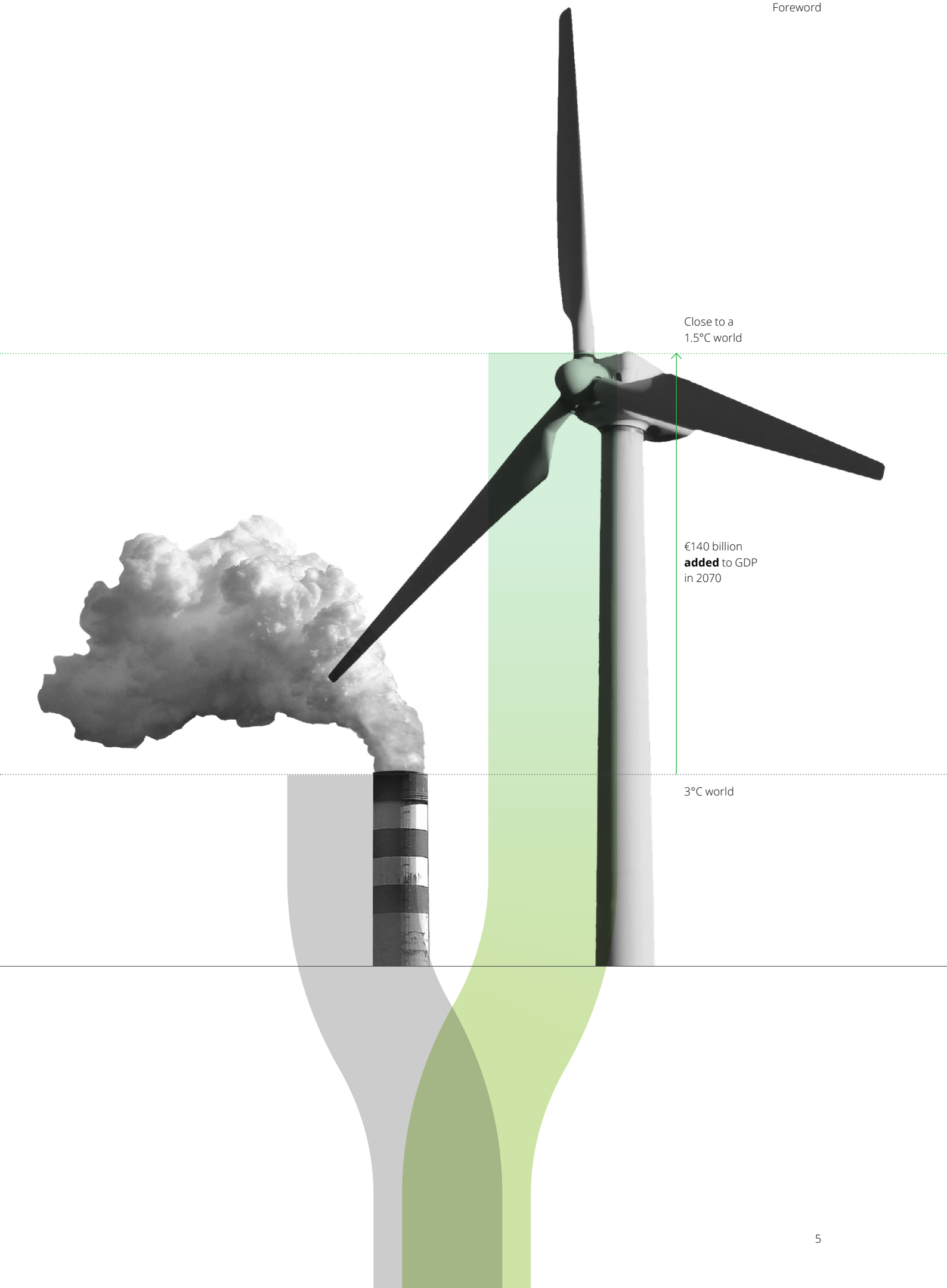
When world leaders meet at COP26 in Glasgow in the UK, they – and we – know that the world must choose between two paths: one of insufficient action, and one of bold, rapid investment in decarbonising the global economy, a monumental transformation that needs to be completed at an unprecedented pace.

Using new data from the Deloitte Economics Institute's D.CLIMATE model, this report provides a persuasive view of this monumental transformation. The analysis accounts for the costs of global climate change within Germany's growth projections to offer a clearer portrait of what the future economy could look like. It also projects the potential economic benefit if Germany – and the world – choose the path of accelerated action to achieve their low-carbon turning point by mid-century.

Germany and the world have what it takes to do it, if we get to global action. Germany has the technologies, much of the regulatory frameworks and the opportunity to reach net zero emissions before 2050 because it has been investing in clean energy for decades. The net cost of this transition, which has been a main barrier for climate action, is less than 0.5% of GDP each year to 2038. By then, Germany is reaching its turning point. For Europe and the world, this is among the fastest pathways to net benefits from an accelerated decarbonisation transition.

Fighting climate change is not just the work of governments, utilities or financiers, though. It is a job for all of us. Yet there is a real and measurable economic opportunity here. It is more than a societal imperative. The choices we make over the next decade will have an impact on the future of today's and tomorrow's generations that can only be measured in superlatives. It is time for us all to choose a better way.

Dr. Thomas Schlaak
Partner, German
Sustainability Leader


Close to a
1.5°C world
€140 billion
added to GDP
in 2070
3°C world

Summary of key insights

In this study, the Deloitte Economics Institute (DEI) applies model-based scenario analyses to shed light on two pressing questions in the climate policy debate. First, what would be the economic costs of climate inaction for Germany? Second, what are the economic benefits of limiting global warming to close to 1.5°C for Germany?

At the center of our research is Deloitte's uniquely calibrated Regional Computable General Equilibrium Climate Integrated Assessment Model, the D.CLIMATE model. This model integrates the economic impacts of physical climate change into a baseline economic trajectory to overcome the myopia of many current economic models. By factoring in the costs of climate change into the baseline, our framework reveals the tremendous economic harms of inaction or inadequate action, as well as the significant opportunities that present themselves in remaking the global economy.

Specific to Germany, results from the D.ClLIMATE model, looking at a time horizon from now until 2070, suggest the following:

- **Structural adjustment:** Overall, fighting climate change and achieving a 1.5°C goal requires a long-term strategy. Early in the transition period, Germany would experience upfront costs associated with adjusting its economy and shifting to a low-emission stance. Structural change inevitably comes with a cost. However, over time, the benefits — in avoided damage and new economic opportunities — would result in net economic gains from decarbonisation.
- **Baseline scenario of climate inaction:** Our starting point demonstrates that in the case of climate inaction, temperatures would rise by 3°C until the end of century. This is the baseline scenario and trend outlook for Germany and the world. The economic damages of this trajectory are rarely considered in scenario analyses and long-term growth forecasts.
- **Costs of inaction:** To include these damages, the report analyses six impact channels, ranging from lost land and agricultural losses to stalling productivity. These projections show that climate change-induced losses for Germany would amount to €730 billion over the next 50 years. We estimate that the average yearly GDP loss would be 0.6 percent relative to a world without climate change. A lower growth rate due to climate change would result in job losses and a workforce reduced by 470,000 due to unmitigated climate change.
- **Upfront transition costs:** If Germany takes decisive action, contributes to the global 1.5°C goal and reaches net-zero by 2050, the economic benefits are substantial. In this scenario, Germany needs to invest substantially in the transformation of its economy in the coming years. Initially, GDP will be 0.5 percent lower each year than in the climate inaction scenario. However, there is a turning point in the sense that the worst effects of climate change are avoided, and the economic benefits offset the transition from an emissions-intensive production processes.

- **Reaching the turning point:** For Germany, the turning point - the time at which Germany is better off due to a net-zero transition compared to a state of inaction - comes in 2038. Germany will be one of the first countries in Europe to reap the economic benefits of decarbonisation, due to its early adoption of climate policies.
- **Accelerating economic dividends:** After the turning point, economic dividends will accelerate. GDP in the decade after 2040 will be initially 0.8 percent higher each year than in a world of climate inaction and the growth dynamic will accelerate. In 2070, Germany's net benefit of transition will have grown to 2.5% of GDP. In this scenario the country will be €140 billion better-off in 2070, and this benefit grows with every subsequent year. Also, the workforce will experience a growth of nearly 830,000 more jobs, with job growth especially pronounced in the clean electricity and the services industries.
- **Greening energy supply:** Behind the transition in the 2020s are decarbonisation adjustments in industry, as well as a shift to clean energy (primarily renewables like wind and solar), including the significant expansion of 'zero carbon' hydrogen. This transition will take time but can result in 100% clean electricity by 2050.
- **Strategic policy approach:** The analysis confirms the need for a strategic policy approach, in two dimensions. First, most economic benefits only materialize when international emitters follow a similarly bold approach, driving the need to align trade and foreign policy with climate diplomacy. Second, the wide difference in the timing of benefits across European nations will likely demand a joint solution. A proposal on how to mitigate transition discrepancies will be demanded from the biggest economy in Europe.
- **Now what:** Policy makers have to address the need for a strategic approach now. Moreover, industry and policy makers need to come up with solutions on how to mitigate economic transition costs in the most affected sectors. It is hard to see that financing through private investors for getting to the turning point will be available at required levels without a backstop offered by public hands.

Notes on the analysis

Since the Industrial Revolution, global economic growth has occurred in near lockstep with rising greenhouse gas (GHG) emissions. Even as we burned fossil fuels and converted land to intensive agriculture, living standards and quality of life improved. While growth has not been constant or even—across countries or individuals—GDP growth per capita expanded at a rate of about 1.5% per year from 1750 to present.[1][a]

This growth model is now running up against an overwhelming scientific consensus—and increasingly our own lived experiences—which indicates that the current system of economic production is rapidly generating untenable changes in the climate.[2]

In this report, the Deloitte Economics Institute presents scenario analyses from the D.CLIMATE framework that models the economic impacts of climate change if carbon emissions go largely unchecked, and what could happen—and when—if we transform our systems to achieve net-zero emissions. This model is based on significant research on region-specific climate and economic impacts across Europe and Germany, which are used as inputs for Deloitte's D.CLIMATE model (refer to the technical appendix for more detail). Given the many uncertainties that come with a 50-year time horizon, scenario analysis allows for comparisons of alternative futures. This exercise is not one of prediction or forecast, but rather seeks to answer the question, 'What If?'.

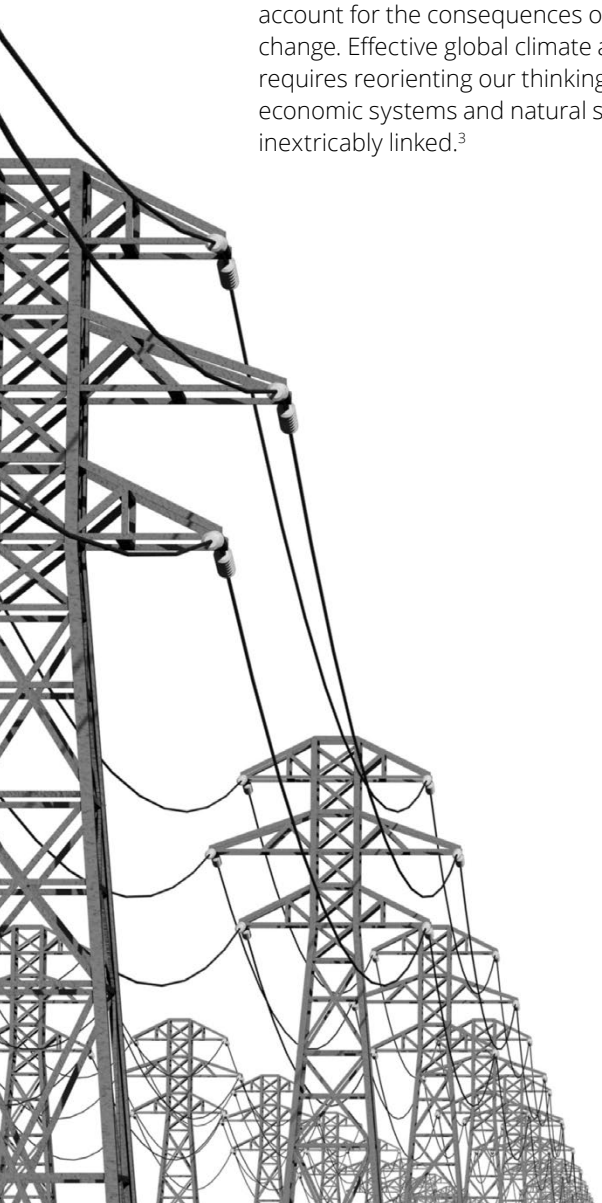
This analysis establishes a better starting point for the global discussion on climate change. Currently, climate change impacts are not typically included in economic analysis, so governments, business and pundits alike have assumed a starting point where the economy will grow unaffected by the changes to our physical environment. If we don't include climate change in our modelling, though, it's hard to understand the economic impacts of different climate policy options, such as net-zero. Despite the limitations that come with any model, D.CLIMATE provides a better starting point by accounting for the inherent cost of global inaction.

The results reveal the magnitude of the challenge, as well as the choices that the world can still make to drive prosperity through a low-emission industrial revolution. The modelling also identifies the moment when the benefits of decarbonisation start to outweigh the costs of action. This is what we call the net gain or the turning point.

a. Economic growth as measured by Gross Domestic Product (GDP), and improved standards of living as measured by increasing GDP per person.

Throughout the report, there is reference to several assumptions, scenarios, and specialised terms. The following provides a shorthand description of these ideas to support the understanding of the insights in this report:

- **Climate change is the new normal:** Unless the world takes rapid and coordinated action, an increasingly climate-damaged economy will become the new normal. When evaluating the costs and benefits of mitigation, business leaders and global decision-makers should account for the consequences of climate change. Effective global climate action requires reorienting our thinking to consider economic systems and natural systems as inextricably linked.[3]



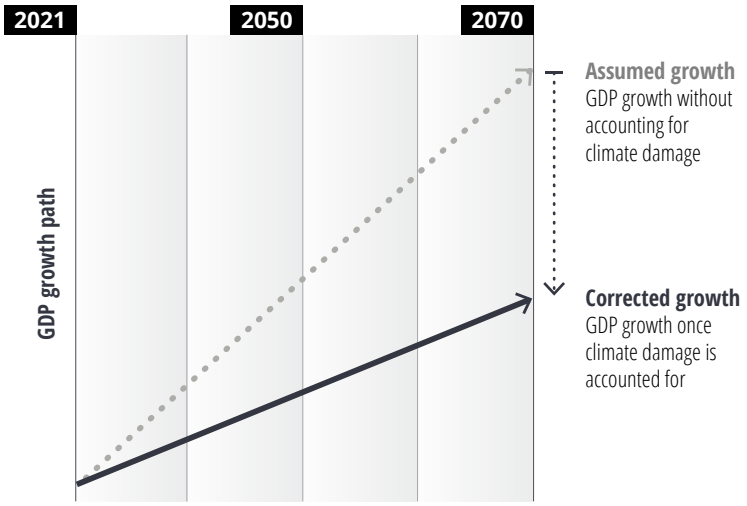
- **Without global action, carbon emissions and temperatures will continue to rise:** Without rapid, systemic change, the outcome would be increasing global average warming toward the end of the century. In this world, insufficient action on climate change would be the baseline path for the economies of Germany and the world (refer to the Technical Appendix for a detailed discussion).
- **Rapid, coordinated global decarbonisation would not only limit the worst effects of climate change, but could bring an economic and climate *turning point*:** Transitioning to a net-zero world and limiting warming as close to 1.5°C requires an industrial and economic transformation. The turning point concept highlights that choosing transition will mean that, despite initial costs, countries and industries could see dividends in terms of avoided costs from climate damage and in the form of new industries and technologies.

In this report, the Deloitte Economics Institute presents two scenarios. The first describes what could happen if the countries of the world allow the planet to warm on a path to 3°C by the end of the century. The second reveals the economic opportunities for Europe if the world limits global warming to as close to 1.5°C by mid-century.

1. **We do nothing further and global emissions rise ("Around 3°C world"):** This economic path represents a future with a higher rate of global GHG emissions, where there are no significant additional mitigation efforts and the global average temperature increases to around 3°C by 2100. This scenario reflects a widely adopted set of emissions, economic, and population assumptions, referred to as SSP2-6.0. The results of this scenario are presented as a deviation, a comparison to a world that does not have climate change impacts modelled.
2. **We act decisively and quickly to hit global net-zero by mid-century ("Close to 1.5°C world"):** This economic path represents a sequencing of efforts—by government, business, and citizens—to achieve net-zero emissions by 2050. This scenario would make it possible for us to limit warming to as close to 1.5°C—well below 2°C. Within this report, this scenario is regionalised to the European continent. The results of this "close to 1.5°C" scenario are presented as a deviation, a comparison to the "3°C world".

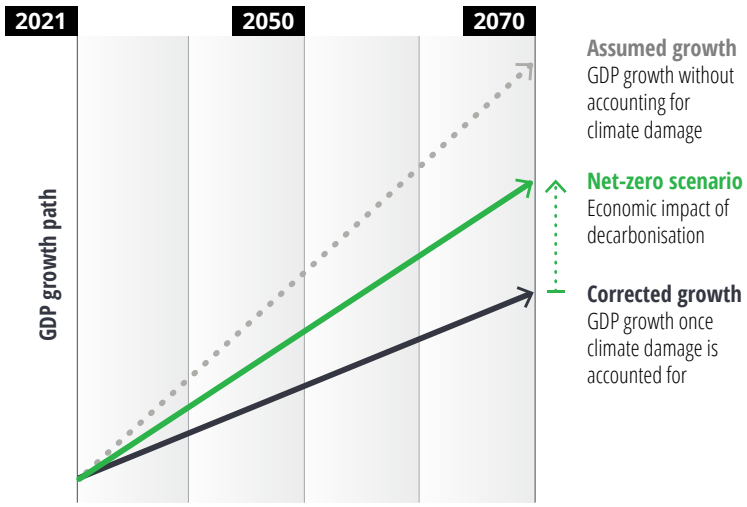
Under each scenario, the rate of economic growth is impacted (deviates from trend) based on different climate and decarbonisation effects.

The impact of accounting for climate change on Europe's growth path



Source: Deloitte Economics Institute.

The opportunity of new economic growth under a net-zero scenario



Source: Deloitte Economics Institute.

Additionally, the following references and terms are defined for specific purposes in the context of this report.

Climate change: Changes in the regional and global climate brought about by increased greenhouse gas (GHG) concentrations in the atmosphere.

Turning point: The economic point where the benefits of decarbonisation start to offset the combined costs of "locked in" climate change and the costs to transition the economy to net-zero.

Net-zero emissions: A state in which GHG emissions from human activities are balanced by the emissions taken out of the atmosphere. The technical definition of this concept can be found in the Technical Appendix.

Close to 1.5°C world: This pathway describes a net-zero economy by 2050 in which global average warming is limited to well below 2°C and as close to 1.5°C as possible, compared with pre-industrial levels.

Around 3°C world: An economic scenario that relates to a pathway of climate inaction, where the implied temperature change is 3°C above pre-industrial levels toward the end of the century.

Representative Concentration Pathway (RCP): A greenhouse gas concentration (not emissions) trajectory adopted by the Intergovernmental Panel on Climate Change (IPCC).

Shared Socioeconomic Pathway (SSP): A set of pathways adopted by the IPCC Sixth Assessment that explore how the global economy, society and demographics might change over the next century.

The economic impacts of two climate change futures

The economic impacts of two climate change futures

Of all the regions of the world, Europe has made some of the most ambitious commitments and plans to tackle climate change. From investment in renewable energy at scale to the European Green Deal, the region has long demonstrated its commitment to reducing its carbon emissions in line with our planetary boundaries.

Germany has often been at the frontier of this ambition – recently accelerating the country's greenhouse gas emissions reduction ambition to 'net-zero' by 2045.

But despite the accelerated ambition, more work needs to be done to get the pace and scale of the transition to net-zero right, and the latest science suggests that we don't have much time. According to the 2021 IPCC Sixth Assessment Report (AR6), the world is very likely to pass 1.5°C in the early 2030s in the absence of rapid emissions mitigation.[4]

As this report was being written, climate change can be attributed to the devastation wrought by the floods of July 2021 across Germany, Belgium, and the Netherlands.[5] Already, climate change is showing up in increasingly visible ways across Europe. Recent frost blights have caused billions in damages for winemakers in France.[6] Sea level rise is constantly threatening the low-lying nations of the Benelux, who are at risk despite their leading dike technology. The glaciers in the arctic regions of Scandinavia are melting. Warmer air in Europe is generating heavier rainfall, increasing the risk of flooding.[7]

Based on existing levels of warming, the next 30 years will bring similar extreme weather events that will put severe stress on our systems—agricultural, healthcare, manufacturing, infrastructure, and financial. Without significant change, we're heading toward a climate-damaged global economy.

Accounting for climate inaction

Despite these climate events and scientific research, dominant economic projections tend to assume that economies will continue to grow as they traditionally have, completely unaffected by the damages caused by climate change. When they do consider climate change damage and mitigation policy, it's often in scenario analyses that compare alternative future states against an erroneous "business as usual" trend that assumes unconstrained economic growth via emissions-intensive economic production. This is the economic baseline that informs how most decisions and investments are made for governments and businesses alike—and this economic thinking is wrong.

If the economic impacts of a changing climate are left out of economic baselines, the result is likely to be poor forecasts, poor risk management, and dangerously inadequate efforts to address the global climate crisis. A growing chorus of voices recognises the challenge and, in 2020, the Network for Central Banks and Supervisors for Greening the Financial System, made up of 92 central banks, released guidance on the need to solve this very issue.[8] If we're serious about shifting the global economy toward a low-carbon footing, it's critical to understand and account for the longer-term effects of climate change on productivity, output, and economic growth.

To fully assess the costs of climate action, Deloitte has developed a framework that integrates the economic impacts of physical climate change into a baseline economic trajectory. Factoring in the costs of climate change reveals the tremendous harms that could befall the economies of the world if climate change goes largely, or wholly, unchecked. On the other side are the significant opportunities that could arise if we transform our systems to achieve net-zero emissions by 2050. Our model also identifies the turning point, or the pivotal moment when the benefits from decarbonisation will outweigh the upfront investments.

Creating Europe's turning point

Most countries in Europe – including Germany – have already made considerable strides toward shifting their energy systems to renewables. Doing so has required the deployment of multiple proven and mature technologies at scale, supported by policy settings that have been increasingly shifting in the direction of renewable energy production.

If Germany stays on track—which requires picking up the pace to meet net-zero—Deloitte's model shows that it will be one of the earliest regions in Europe to reap the economic benefits of decarbonisation. From this economic and climatic turning point, our model shows that Germany's economy will not only be growing but will grow more than it otherwise would if it does not act. In 2070, Germany's benefit of transition has annually made GDP 2.5% larger. It is €140 billion better off in 2070 relative to a world of inaction - and this benefit grows with every subsequent year in a low-emission economy.

Carefully coordinating the transformation of its systems could not only prevent the worst effects of climate change, but could strengthen the German economy by increasing the quality of its economic growth. The transition from traditional manufacturing to modern, emissions-free production could create new value in the form of professional services, technology solutions, and opportunities for industry diversification. This increased value-adding activity can make Germany's economy more resilient, an important metric of success in a low-emission future.

The scale of Germany's decarbonisation task

Industry has been integral to Germany's growth story, but it has also been a driver of Germany's emissions.

Overall, emissions have reduced significantly in Germany over time. The country has been able to make significant strides towards decoupling growth from emissions. As of 2020, Germany was able to reach its goal and cut emissions to 40% below 1990 levels.[9] However, this target was only just barely reached, largely as a result of the pandemic reducing vehicle and electricity usage. Germany's struggle to reduce greenhouse gas emissions stems largely from its transportation sector. Compared to 1990 levels, sectors of electricity and heat producers, residential, industry and commercial and public services have been able to cut emissions by between 23% and 49%.[10]

Germany has made significant shifts towards its emissions targets, especially in its electricity sector. The 'Energiewende' plan represents a fundamental reorientation of policy towards renewable energy and away from Germany's traditional conventional energy basis. This transition towards renewable energy has been effective in certain measures within the electricity sector, with the country surpassing its 35% renewable energy goal for 2020 and achieving 44% renewable energy by 2019.[11] This ambition is planned to extend into the future, with the share of renewables in electricity to increase to 50% by 2030, 65% by 2040 and 80% by 2050.[12]

Beyond electricity, Germany's heating and transportation sectors require acceleration of technological effort to meet net-zero emissions. Its transportation sector will need to see significant policy support to transition to net-zero. However, Germany is well placed to seize the opportunity to lead the world in this sector. As global leaders of innovation in the automobile industry, Germany can work towards revolutionising the transportation industry, not just through electric and hydrogen vehicles, but by structurally changing mobility patterns.[13]

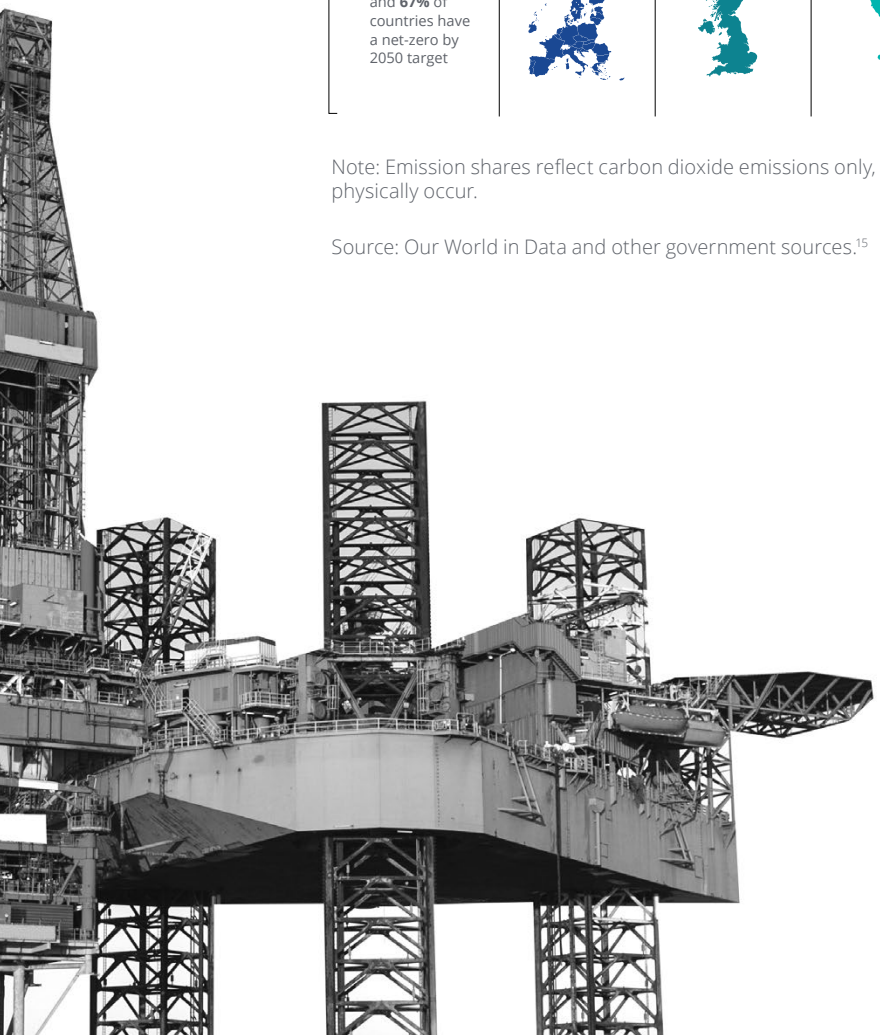
Germany's current target for transportation emissions reduction is 40-42% by 2030. Reductions so far, 0.6% from 1990 to 2019, means action needs to accelerate.[14]

Europe's largest emitters have commitments to reduce emissions

	Europe	European Union (EU-28)	United Kingdom	Italy	France	Germany
Share of global carbon emissions	15%	9%	1%	0.9%	0.9%	1.9%
Target	Of European countries with interim 2030 and net-zero 2050 targets, the implied reduction in emissions on 1990 levels is **45%** at 2030 and **67%** of countries have a net-zero by 2050 target	Cut emissions by at least **55%** by 2030 All members must reduce emissions by at least **40%**	The UK has an interim target of reducing emissions by **68%** by 2030, and **78%** by 2035 compared to 1990 levels	Italy has an interim target of reducing carbon emissions by around **60%** by 2030	France has an interim target of reducing emissions by **40%** by 2030	Germany has an interim target of reducing emissions by **65%** by 2030

Note: Emission shares reflect carbon dioxide emissions only, attributed to the country in which they physically occur.

Source: Our World in Data and other government sources.[15]



The economic costs of climate inaction

The economic costs of climate inaction

Trend without change comes at a high price

If Europe, Germany and the world doesn't take significant action to fight climate change, and global emissions continue to rise with economic growth, the result will be global average warming of around 3°C by the end of the century, according to the Deloitte analysis. This is the baseline and trend outlook for Germany and the world.

The Deloitte Economics Institute has modelled the economic impact of 3°C global warming. As the planet warms, economic outcomes are influenced through six impact channels, namely: heat stress, capital damage, tourism expenditure flows, lost agricultural land due to sea level rise, agricultural yield changes, and tolls on human health.

Source: Deloitte Economics Institute

In this climate-damaged world, warming would reduce Germany's economic potential. Productive capital and knowledge would be concentrated on repairing damages instead of investing in new, value-adding innovations and infrastructure. Meaningful participation in the workforce and living fulfilling lives would be limited for those who would face human health and well-being impacts in a changed climate.

Economic impact associated with climate change

Heat stress
Lost labour productivity from extreme heat

Sea level rise
Lost productive land, both agricultural and urban

Damaged capital
Stalling productivity and investment

Human health
Increased incidence of disease and mortality

Tourism loss
Disrupted flow of global currency

Agriculture loss
Reduced agricultural yields from changing climate patterns

Source: Deloitte Economics Institute.

Modelling climate change impacts

Global emissions will continue to rise if no further significant action is taken to mitigate climate change. The outcome would be increasing global average warming toward the end of the century. In this world, inaction on climate change would be the baseline path for Germany and the world. This baseline scenario would negatively impact economic growth, when compared to a world without climate change (refer to the Technical Appendix for a detailed discussion).

To quantify this conclusion, Deloitte modelled the economic impacts of a changing climate on long-term economic growth in Germany, using the following stepped process:

1. The model projects economic output (as measured by GDP) with emissions reflecting a combined Shared Socioeconomic Pathway (SSP)-Representative Concentration Pathway (RCP) scenario, SSP2-6.0, to the year 2100.[b] The socioeconomic pathway, SSP 2, is the 'Middle of the Road' among five broad narratives of future socioeconomic development which are conventional in climate change modelling. The climate scenario, RCP 6.0, is an emissions pathway without significant additional mitigation efforts (a baseline scenario).[16] This results in a projected emissions-intensive global economy.[c]
2. Increased atmospheric GHGs cause average global surface temperatures to continue rising above pre-industrial levels. In the SSP2-6.0 baseline scenario, global average temperatures increase more than 3C above pre-industrial levels by the end of the century according to the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC).[d] (Note that present-day temperatures have already risen more than 1.0C above pre-industrial levels.)
3. Warming causes the climate to change and results in physical damage to the factors of production. The Deloitte model includes six types of economic damage, regionalised to the climate, industry, and workforce structure of each defined geography in Europe.
4. The damage to the factors of production is distributed across the economy, impacting GDP. Any change in emissions - and, correspondingly, temperatures - over time results in a change to these impacts and their interactions. The economy impacts the climate, and the climate impacts the economy.
5. The key variables of time, global average temperatures, and the nature of economic output across industry structures combine to offer alternative baseline views of economic growth. Specific scenario analysis is then conducted, referencing a baseline that includes climate change damage. Scenarios can also include policy actions that either reduce or increase emissions and global average temperatures relative to the current SSP2-6.0 baseline view.

This modelling framework involves significant research on region-specific climate and economic impacts across Germany, which are used as inputs for Deloitte's D.CLIMATE model (refer to the Technical Appendix for more detail).

b. IPCC-adopted emission scenarios vary widely, depending on socioeconomic development and climate mitigation policy settings. SSP2-6.0 is chosen as one of the most frequently used 'baseline' scenarios in the literature. It describes an intermediate baseline scenario as it carries historical social, economic and technological trends forward and includes no specific or significant climate mitigation policy effort, making it an appropriate baseline for reference. For more detailed description of SSP2-6.0 and rationale for its adoption, see Technical Appendix.

c. Pre-industrial is defined in IPCC assessments as the multi-century period before the onset of large-scale industrial activity around 1750.

d. The associated climate data (like annual temperature increases and atmospheric concentrations) are estimated using MAGICC as described in Meinshausen et al. (2011) and Meinshausen et al. (2020), and configured by Nicholls et al (2021). See the Technical Appendix for further detail.

Industry damage results

Industry	GDP impact 2020–2070 (€ billion, net present value)
Private and public service sectors	**-380**
Manufacturing	**-180**
Retail and tourism	**-60**
Construction	**-40**
Transportation	**-30**
Conventional energy	**-20**
Clean energy	**-10**
Water and utilities	**-10**
Natural resources and mining	**-5**
Agriculture and forestry	**5**

Note: Net Present Value of deviation loss to GDP in Germany over the period to 2070 at a 2% discount rate. Refer to Technical Appendix for a discussion on the selection and application of the discount rate.

Source: Deloitte Economics Institute.

The economic cost of climate inaction

In the economic future modelled, Germany and the rest of the world do not significantly reduce emissions relative to current levels. This future has an emissions pathway that leads to global average warming of more than 3°C by 2070.[e]

The impacts of climate change on Germany are already burdening the economy and society. Over the last few decades, summers have been getting warmer and the number of days where temperatures exceeded 30°C have risen from three times per year to eight.[17] Further, in 2019 Europe experienced severe heatwaves, with Germany seeing temperature rise above 40°C. This not only had health impacts, as the population is typically unprepared to deal with such high temperatures, but also impacted productivity as the German government asked employers to provide a day off to workers due to the persistent heat.[18]

Even more recently, Germany has experienced deadly flooding across large areas of the country. The extent and scale of severe flooding has been largely unseen in previous years and has led to severe destruction and impacts to community wellbeing.[19]

The result over the next half-century, by Deloitte's estimates, would be climate change–induced economic losses to Germany of approximately €730 billion in present value terms.[f] In a future of inaction, Germany loses 1.2% of GDP – or €70 billion – in 2070 alone.

For comparison, the regional GDP of North Rhine-Westphalia was approximately €697 billion in 2020.[20] The economic cost of unchecked climate change to Germany in 2070 would be roughly equivalent to removing the biggest of Germany's states from its economy.

Over the next 50 years, the top five most impacted industries in terms of economic activity comprise 89% of the country's current output. These industries—services (government and private), manufacturing, retail and tourism, transportation, and construction—are economic powerhouses and major sources of employment in Germany. Together, they form the basis of the country's contemporary economic engine.

If substantial actions are not taken, climate change would, in average annual terms, reduce Germany's economic potential by 0.6% per year over the next 50 years. As a result of this smaller future economy, there are fewer job opportunities. Climate inaction means a German workforce that is 0.7% smaller, 470,000 fewer jobs, in 2070 compared to a world without climate damages.[g]

e. IPCC-adopted emission scenarios vary widely, depending on socioeconomic development and climate mitigation policy settings. RCP 6.0 is chosen as an intermediate baseline scenario as it includes no specific or significant climate mitigation policy effort, making it an appropriate baseline for reference.

f. Total NPV of deviation loss to GDP in Germany over the period to 2070, at a 2% discount rate. Refer to the Technical Appendix for a discussion on the selection and application of the discount rate.

g. Jobs are measured in full-time equivalent units (FTE).

A significant share of employment losses occurs in Germany's public and private service sectors. Overall, service sectors – like education, health, real estate, professional services – are expected to have almost 262,000 fewer jobs in 2070 compared to a world without climate damage. Service sectors are the largest shares of current and future employment in Germany and are highly exposed to losses from heat stress and the compounding impacts of damages to the broader economy. Heat stress represents a significant loss in the ability of workers to both go to work and complete their work effectively. Over the 50-year period to 2019, two heatwaves accounted for 80% of deaths resulting from weather, climate and water-related disasters in Europe.[21] The impacts of heat stress on workers due to climate change is a significant risk to the future of work.

Core sectors, such as heavy manufacturing, are also highly exposed to the impacts of climate change. Manufacturing is a sector reliant on large capital investments and in a climate-damaged world the industry is expected to lose 121,000 jobs by 2070.

Opportunities for Germany in a net-zero future

Opportunities for Germany in a net-zero future

A new economic climate

The temperature changes and costs described above are not fixed. Although some degree of global temperature increase and climate impact are already 'locked in' due to historical emissions, there is an opportunity to take bold action to enable economic prosperity and avert the worst impacts of an altered climate. Supported by the right economic framework, these actions can put Germany—and the world—on a path to realizing strong, equitable, and shared growth.

Germany is at the frontier of a new economic era and has the potential to seize this opportunity and lead the world through its advanced manufacturing and automotive industries. There is an opportunity to build on recent momentum and take bold action to decouple economic prosperity from emissions. **A new economic climate not only emphasises the quantity of economic growth, but also its quality.**

But time is of the essence. Policy and investment decisions made in the next several years will largely shape the economy and climate that Germany and the world inherit. That narrow window makes it even more vital to understand the economics of a warming world and incorporate these factors into decision making that addresses the multiple market failures of climate change.

The turning point

By contributing to the European and global efforts to keep warming to as close to 1.5°C, Germany is investing in its future. Such an investment produces a significant economic dividend.

Deloitte estimates that the he economic gains of decarbonisation occurs in sectors and industries that will be the future of Germany's comparative advantage. Rapid decarbonisation creates structural adjustment costs, but ambitious, early action means that these lower than would have been from a later and more abrupt decarbonisation acceleration.

In 2070, Germany's net benefit of transition has grown to 2.5% of GDP. It is €140 billion better-off each year by 2070, relative to a world of inaction and this benefit grows with every subsequent year.

Early in the transition period, Germany would experience costs associated with adjusting its economy and shifting to a low-emission stance. But over time benefits—in avoided damage and new economic opportunities—would result in net economic gains from bold climate policy decisions made early, delivering rapid investment and technology development consistent with limiting global average warming to 1.5°C by 2050.

A new economic climate not only emphasises the quantity of economic growth, but also its quality.

In 2070, there are almost 830,000 more jobs within Germany – or a 1.2% larger workforce – compared to a climate damaged world without action.

This gain to employment is underpinned by surges in employment growth in the clean electricity and services industries. These two industries benefit greatly from a decarbonised Germany and are able to expand significantly towards 2070. As such, while industries such as conventional energy and some manufacturing sectors see lower employment – due to improved technical efficiency – as they transition, the economy overall will benefit from growth in other industries.

Decarbonisation means more than generating larger quantities of economic output. It also fundamentally changes the quality of activity, in terms of its sustainability, resilience and inclusivity. A rapid, coordinated and effective transition to a climate neutral economy will generate a diverse range of benefits for Germany.

Germany in a climate-neutral continent

The Deloitte Economics Institute modelled path for Europe's turning point represents a sequencing of efforts – by government, business, and citizens – to collectively move to net-zero emissions by 2050 and limit warming to around 1.5°C.

The modelled effort reflects the crucial interplay of systems and decision makers in Europe – and the rest of the world – as it decouples emissions from economic growth. (See Technical Appendix for more details on the mechanisms that drive decarbonisation to reach Europe's turning point in the scenario).

The economic gains of decarbonisation occur in sectors and industries that will be the future of Europe's global comparative advantage. Rapid decarbonisation creates structural adjustment costs, but ambitious, early action means that these are lower than would have been from later and more abrupt decarbonisation.

There are several core features to Europe's rapid decarbonisation, spanning production systems, policy, finance, and consumer behaviour.

In the Deloitte modelled scenario, clean energy (primarily renewables like wind and solar) underpin the early and rapid transition, including the significant expansion of 'green' hydrogen using electrolysis to support harder to abate industries. This transition – from the renewable shift in electricity generation to the electrification of industrial and other processes – takes time, but results in 100% clean electricity by 2050. Alongside renewable shifts, additional technologies such as storage, firming and distribution services develop together with the generation component of the sector.

The drivers of economic change from decarbonisation in a 'close to 1.5°C world'

Change is valued

- Decarbonisation policies, investments and new technologies structurally change economies
- The coverage and the value of explicit and implicit carbon prices rise
- Estimates of future economic costs of climate change provide a market signal for action
- Consumer behaviour changes

Energy transforms

- Renewable and clean electricity transform Europe's energy system
- Renewables become cheaper compared to fossil fuels, increasing substitution in favour of renewables
- Overall energy use becomes significantly more efficient

Fuels switch

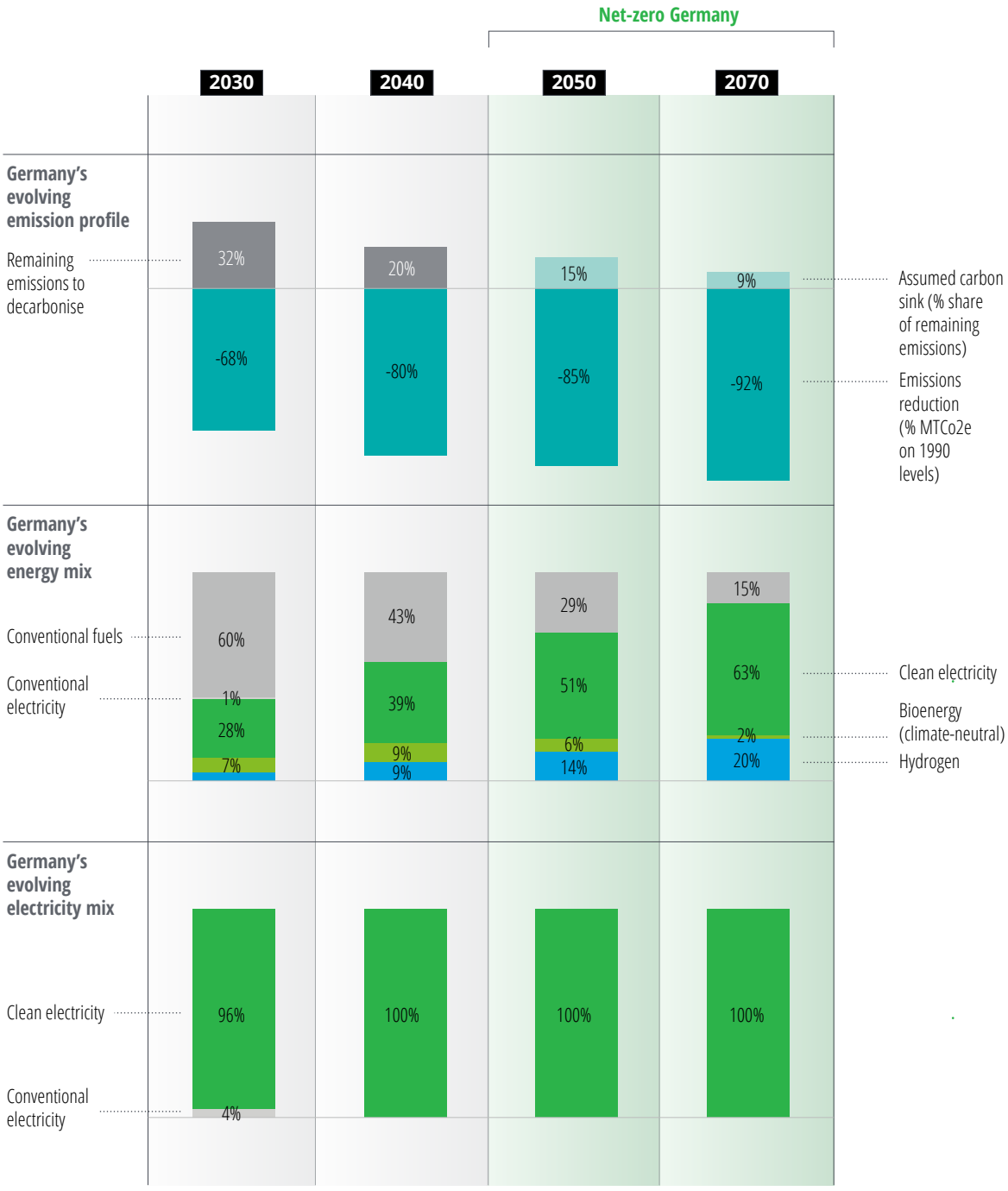
- Electrification and the use of new sources of low-emission fuel powers industry and households
- This transformation links energy-producing and energy-consuming sectors more closely
- Economies have cheaper and cleaner energy, and more productive economic output from it

Just transition

- No place or sector is left behind in transition
- Strategic economic policy meets the challenge and supports workers

Source: Deloitte Economics Institute.

Germany's net-zero transformation

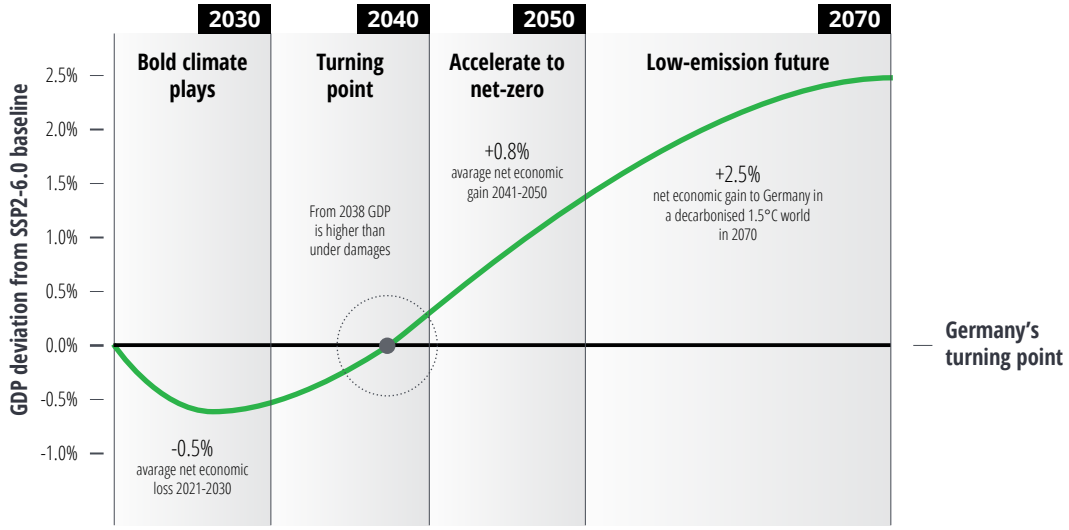


Phases of decarbonisation

The sequencing of the system transformation for a low-emission future in Germany – and the rest of the world – results in four phases of structural economic change. Each phase represents the economic interaction of the choices, investments, technological and industrial changes that create a new low-emission economy.

Deloitte's four phases of decarbonisation show how rapid decarbonisation will create costs, but timing and sequencing of effort can offset these costs by creating positive returns in the capital and technologies that shift the region's economy onto a decarbonised pathway. Germany's overall phases of decarbonisation summarises several individual country transitions playing out at different speeds, but all towards a common goal of net-zero by 2050.

Germany's step change transformation to a 1.5°C world



Source: Deloitte Economics Institute

Industry opportunity

	Industries that are better off under transition at the end of each phase, in level terms	
Bold climate plays 2021 – 2030	Clean energy Construction	Agriculture and forestry
Turning point 2031 – 2040	Clean energy Agriculture and forestry	Construction Water and utilities
Accelerating to net-zero 2041 – 2050	Clean energy Construction Retail and Tourism	Services sectors Water and utilities Agriculture and forestry
Low emissions future 2051 – 2070	Clean energy Manufacturing Retail and tourism Water and Utilities Transportation	Services sectors Retail and tourism Construction

Bold climate plays: From 2021 to 2030

The next several years set the stage for rapid decarbonisation. In accelerating to achieve net-zero emissions, it is not only the date at which net-zero emissions is reached that matters. It is the cumulative amount of emissions produced along the way. Bold climate plays are required to 2030 to not only reduce the transition cost in the long term, but to increase the likelihood net-zero emissions is achieved in a 1.5°C world by 2050.

In this phase, the decisions by government, regulators, business, industry, and consumers reinforce initial progress and create the market conditions to deliver decarbonisation at pace and scale. Accelerated innovation, investment, and R&D in the next decade will deploy the requisite technologies in sectors to achieve the harder reductions after 2030. The coverage of Germany and Europe's Emissions Trading Scheme likely expands, and carbon prices rise, making more of these projects attractive to private finance. These shifts support supply chains to transform and act as the foundation for a structural shift to limit global average warming to around 1.5°C.

The impact of this first decade of domestic, as well as global, climate change action is expected to have a considerable effect on Germany's economy. Structural change inevitably comes with a cost, but these bold climate plays are needed for a brighter future.

Germany benefits from being an early mover in decoupling its economy from emissions and progressing towards a net-zero pathway. In line with Germany's newly revised Climate Action Plan 2050, this decade focuses on meeting the interim targets set in the early 2020s, such as reducing emissions by 65% by 2030 compared to 1990 levels.[22]

Within this first decade, Germany's GDP will be an average 0.5% lower than under a future of climate inaction as it accelerates transition and 'locked in' climate damage occurs. Despite this initial impact on GDP, the country benefits from having been an early mover and the costs of transition are not as high as they are for some of its neighbouring regions. This is largely due to the headway Germany has already made in shifting its electricity generation to renewables.

Germany's clean energy sector has significant growth; higher gains during this period than most of its neighbouring economies. This is largely because Germany has already made early investments into renewable energy. By continuing to invest in this area, Germany is setting itself up for an easier transition than will be experienced by other regions.

The majority of this contraction stems from Germany's transportation and heavy manufacturing industries, which see some of the largest declines during this period. These are two of Germany's highest emitting industries and are not as well progressed in decoupling growth from emissions. As such, these two industries shoulder some of the largest burdens as they must quickly make bold climate plays and begin decarbonising.

Similarly, heavy manufacturing, which is the major contributor to Germany's automobile manufacturing industry, sees the largest employment declines amongst all other industries due to higher emissions intensity. However, while this industry feels the pain of structural adjustment, there are many other occupations that gain during this time of transition. For example, in 2030, the industries of agriculture and clean electricity, together, add an additional 132,000 jobs to the economy as these industries grow.

Currently, Germany plans to have seven to ten million electric cars on the roads by 2030[23], having only just reached its 2020 target of one million electric cars.[24] There are more plans, however, to support this transition in the future. For example, the government has increased the bonus that buyers receive when purchasing electric or fuel cell cars by up to €6,000. Since the beginning of 2020, there has also been increased tax incentives for electric vehicles, such as the ability for employees to charge electric vehicles tax-free in their employers' car parks. From 2021 onwards, there will be further funding for charging infrastructure across Germany, helping the country reach its target of one million charging points by 2030.[25]

Turning point:
2031 to 2040

This decade centers on the meeting of interim targets agreed to in the early 2020s. The hardest shifts in industrial policy, energy systems and consumer behaviour are underway. This is a decade where economies, business and industries begin to see the consequences of bold climate plays, with different industries and regions transforming at different paces.

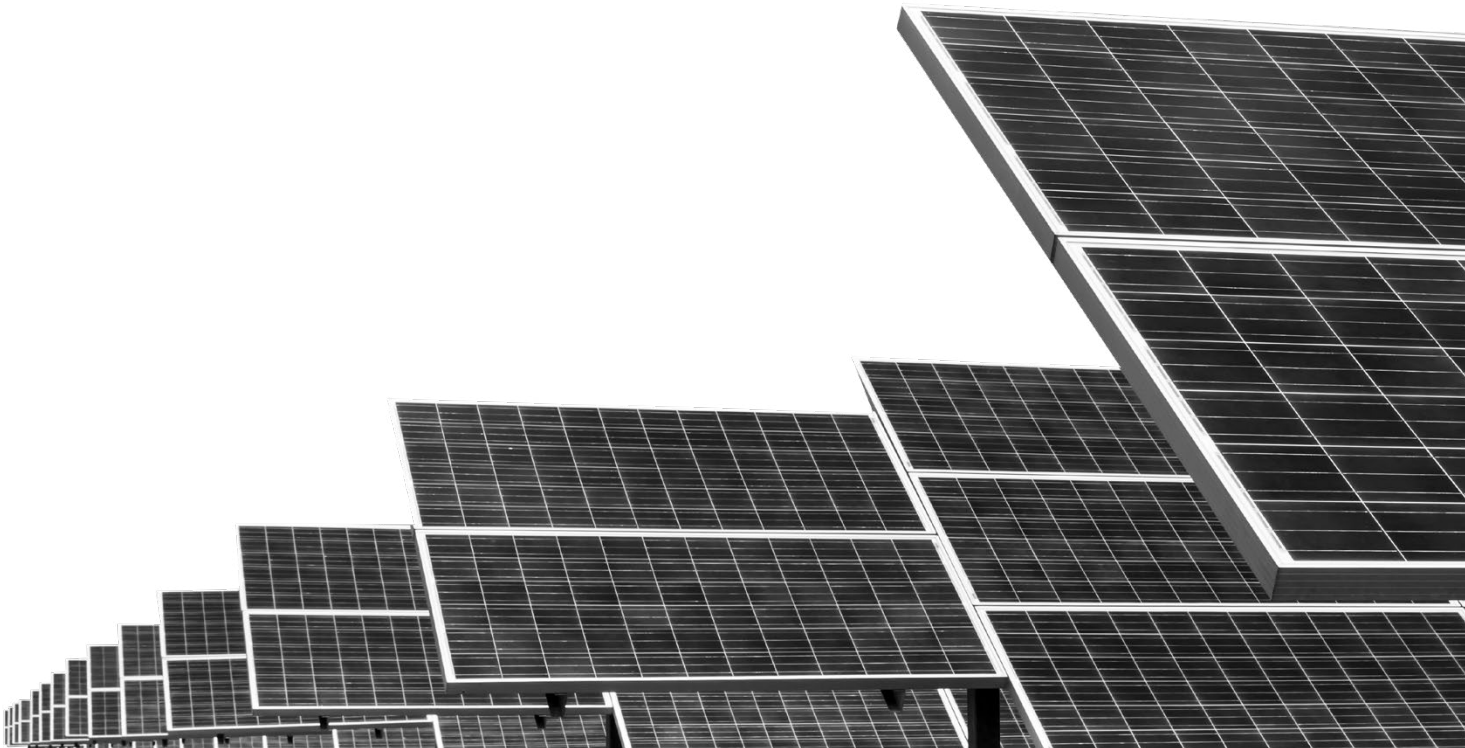
For Germany, this decade is also the climatic and economic turning point that prevents a shift to a 'locked-in' higher emissions pathway and realises the economic dividends of systems-level transformations.

The automotive industry continues to decouple from the internal combustion engine as Germany invests in electric vehicle production to maintain a dominant position supplying the electric vehicle boom across the globe. This sees Germany wellpositioned to continue its export-led growth strategy with a focus on decarbonised, high-value manufacturing.

From 2038, Germany is better off due to a net-zero transition compared to a world of inaction. By the end of this period, the country begins to see economic dividends from transition, with GDP 0.2% higher in 2040 when compared to a climate damaged world.

Whilst this period still sees many industries struggling to decouple growth from emissions, there are industries that see positive gains by 2040. Other than clean energy industries, there are also expected gains in water and utilities and mining essential to renewable technology. For example, manganese, quartz and basalt are all used in batteries and other forms of renewable technology, and all of which can be mined in Germany.[26]

Similarly, while some industries continue to lose employment as they decouple their growth from emissions, there are many new industries that can recapture this employment in growing industries. These include construction, water and utilities, clean energy and agriculture, which are all beginning to surge as a result of early movement. Combined, these industries are able to employ an additional 265,000 workers, compared to a world without climate action, as they benefit from a net-zero transition.



Accelerate to zero:
From 2041 to 2050

The decarbonisation adjustments in industry are almost made, the cost of new low-emission technologies is decreasing, and net economic gains are shared more widely. These efforts would also ensure that global warming remains on a path as close to 1.5°C – and well below 2°C.

Germany reaches carbon neutrality before its European neighbours and is reaping the benefits of this transition. Its industries can now fully capitalise on the opportunities of net-zero as well as benefitting from the avoided costs of climate change damage.

As Germany accelerates its decarbonisation to net-zero, the economic benefits of doing so also accelerate.

This period sees many industries surging in terms of output, such as clean energy industries, water and utilities and private and public services. However, this is also a period of recovery as some industries break free of the burdens of transition costs and start to see positive gains. Construction had previously been slowed by significant transition costs, but output sees significant positive gains during this period. In fact, it began to pick up pace during the 2030s, peaking in output compared to a climate damaged world in the mid-2040s.

This late surge in output is largely a result of construction especially vulnerable to some of the 'locked-in' climate damages to labour productivity and infrastructure through rising temperatures, and thus negatively affected earlier on.. This is combined with the future need to decarbonise buildings and infrastructure. As building standards change to incorporate net-zero policy, there is an economic opportunity in retrofitting existing building stock to be net-zero compliant.[27] These building standards will be easier to meet as the clean electrification of the wider economy is expanded, and energy efficiency improves over time via technological advancements and building design. As such, construction is expected to accelerate due to the transition to net-zero, with a significant burst in demand during this decade, before a slight slowdown post-2050 as more of the existing building stock is retrofitted over time.

Whilst Germany had previously seen several industries with declining employment, this period now sees many industries benefit from the opportunities of decarbonisation, as employment starts to gain with the rest of the economy. Services had previously been burdened by significant transition costs, but employment begins to see positive gains in this phase, with the largest employment gains by 2070. This indicates that despite the 'lockedin' damages, with a coordinated and efficient transition, Germany can revitalise and strengthen sectors that are vulnerable to the effects of climate change.

A low-emission future: Beyond 2050

The economies of Europe are at net-zero emissions and the economic systems of production now keep global average warming to around 1.5°C by the end of the century. Economic structures have been radically transformed, underpinned by a series of interconnected, low-emission systems spanning energy, mobility, manufacturing, and food and land use.

The energy mix is dominated by low- or zero-emission sources across every market, with green hydrogen and negative emissions solutions, both natural and technological, playing prominent roles. With fossil fuels replaced and automotive now dependent on renewables, Germany is rapidly gaining economic dividends from global decarbonisation. Germany remains a leader in the automotive manufacturing industry, and a low-emissions future offers both Germany and the world new sources of economic growth.

Compared to other European countries, Germany does not experience as severe a transition as others, but it has had much to gain in make this transition. **Now, Germany sees higher growth under a net-zero transition, with GDP 2.5% higher in 2070 than in a world without climate action.**

Beyond 2070 is where some of Germany's final industries will see positive gains as a result of decarbonisation. Heavy manufacturing and transportation, for example, are two of Germany's largest emitting industries, but even they see positive gains by 2070, benefiting from the transition to net-zero.

As such, Germany's exporting strengths in automobile manufacture and transportation industries, supported by Germany's general high use of cars, begin to be regained in this period. This recovery is accelerated by the hydrogen sector, which is expected to have grown significantly to 2070. This fuel source provides a powerful alternative to fossil fuels, and by investing in this fuel source, Germany has the opportunity to capitalise on this technology to revitalise its automobile industry. In fact, the use of hydrogen to revolutionise Germany's energy sector is part of the Climate Action Plan 2050.[28]

Hydrogen is key to decarbonising the heavy emitting automobile manufacturing and transport sectors. As such, the government has already put over €7 billion of funding into hydrogen technology research to support this industry into a net-zero future.[29]

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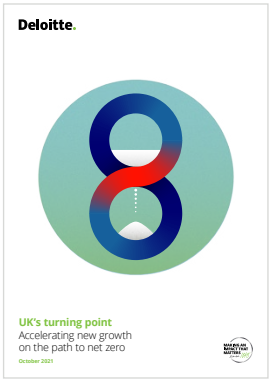

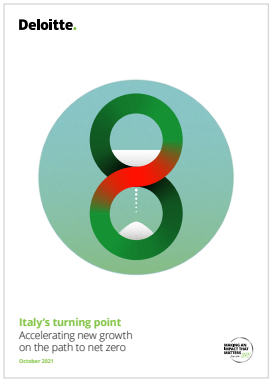

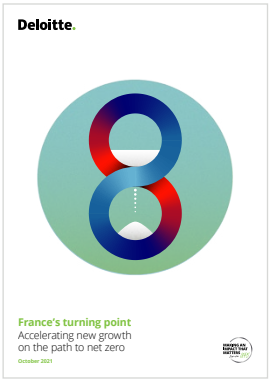

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