Agora Verkehrswende

The transport transformation as value added

Why it makes economic sense to invest now in reducing greenhouse gas emissions from the German transport sector

EXECUTIVE SUMMARY

prognos

Imprint

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DETAILED REPORT

The detailed report by the Prognos AG was published under the title *Szenarienanalyse zur Berechnung der Kosten und Investitionsbedarfe für die Verkehrswende in Deutschland. Studie im Auftrag von Agora Verkehrswende.*

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Foreword

Dear reader,

Whether it's refuelling, parking or buying a car, whether it's the 'Germany ticket' or freight transport – costs and prices play an important role whenever mobility is being written about or discussed. And expenditure on major investment projects – such as a new railway line or the repair of a motorway bridge – always makes the headlines.

However, when it comes to the transport sector as a whole, the financial aspect has so far been difficult to grasp. Concerns are often expressed about rising costs, especially when it comes to the question of how the transport sector can be set on a course towards climate neutrality. A transport transformation that rapidly reduces greenhouse gas emissions from the transport sector in Germany and cuts them to zero by 2045 will cost a lot of money, it is said. Money that is simply not available in an era of tighter public budgets and rising living costs.

Certainly, there is a lot of money involved. In 2019 alone, around 356 billion euros were spent in the German transport sector – in buying cars, lorries and buses as well as in their fuel and maintenance, in roads, railways and trains, in the workforce in both public and freight transport. Given that so much money is already involved, why not focus on climate compatibility and reduce external costs? By 2045, the target year for climate neutrality in Germany, it should be possible to achieve a great deal in this way. So far, however, only limited efforts have been made to minimise social costs through investment; for example, by avoiding weather extremes caused by global warming, by reducing air pollution and the resultant health problems, or by reducing land sealing or accidents.

In this study, in collaboration with the economic research institute Prognos, we investigated how the economic costs and investment requirements in Germany's transport sector might develop over the next twenty years – paying particular attention to the implications of the transformation to climate neutrality. We have summarised the most important findings in this report; the full scientific research and analysis on which it is based can be found in the Prognos expert report.

The overall conclusion is promising: Germany's transport sector can already contribute its fair share to climate protection over the next few years – without any reduction in mobility and without additional costs when compared to a scenario in which no additional climate protection measures are taken. Following increased initial investment expenditure, an ambitious climate protection policy can lead to overall economic savings after just a few years, even if only the direct costs of climate damage are taken into account from among the various externalities. However, in order to realise this added value, policymakers must act quickly and decisively. Political hesitancy has a price. The price can be measured either in money or in greenhouse gases, with all their associated risks. Greater investment in the future is needed initially, but not more money in total. Above all, more political will is required.

In the context of this study, decisive political action primarily means drawing up a plan for the financing of the transport transformation. The federal government must work out how the public sector can invest quickly, reliably and on the required scale in climate protection over the long term. In addition, the federal government has the power to incentivise private climate protection investment by establishing the appropriate framework conditions – for example, by reforming the taxes, levies and subsidies relating to cars based on their CO_2 emissions.

Our aim is to provide a sound research basis for the discussion around the financial consequences of the transport transformation and to enable economically sustainable political decision-making. In this spirit, we hope you enjoy reading this report and look forward to the continuation of the debate.

Dr. Wiebke Zimmer
Deputy Director, Agora Verkehrswende,
Berlin, May 2024

Key takeaways

1. **It pays to act quickly:** With swift and decisive action, Germany can become climate-neutral in the transport sector by 2045 at the latest and, when compared to a continuation of the current policy without new measures (reference scenario), can save cumulatively around 590 million tonnes of CO_2. This can be achieved without additional economic costs and while maintaining overall mobility levels in full (Transformation 2025 target scenario).

2. **Political hesitancy comes at a price:** Delays in the transport transformation will lead either to missing the climate targets or, if climate neutrality is still to be achieved by 2045, to higher costs. Structural disruption and the devaluation of investments will then be almost inevitable. If the change of course in climate policy in the transport sector does not begin until 2030 (Transformation 2030 target scenario), there is a risk of additional costs of around five percent or 500 billion euros by 2045 compared to the Transformation 2025 target scenario as well as to the reference scenario.

3. **Early investment yields long-term benefits:** Compared to the reference scenario, which does not envisage any new measures and does not lead to the achievement of climate neutrality by 2045, the scenario of early transport transformation action (Transformation 2025 target scenario) initially involves higher investments. These go in particular towards expanding public transport capacity, purchasing more climate-friendly vehicles and developing the charging infrastructure. Savings will then be achieved in later years – primarily as a result of more efficient and reduced car traffic. In the long term, the savings even outweigh the initial additional investment.

4. **Securing long-term financing:** Building up the necessary public transport infrastructure and capacity requires sufficient long-term funding for public investment. For private investment – especially in more climate-friendly vehicles and their energy supply – citizens and companies need framework conditions that are geared towards climate protection and that provide planning certainty.

5. **Creating added value through averting damage:** Quite apart from the direct financial expenditures and savings within the transport system, the earlier and more consistent the action taken, the lower will be the costs to society of the damage done to the climate, the environment and public health. In addition, costs running into billions of euros for compensation payments under European climate legislation can be averted in this way.

What will the transport transformation cost? Anyone considering this question should bear in mind what is at stake politically. Investments and expenditures for a climate-neutral transport system are not an end in themselves. The transport transformation is an element of national climate policy. This in turn is embedded in the climate protection programmes of the European Union and the United Nations. In accordance with the German Basic Law, it serves to protect the natural foundations of life – and the civil liberties that go along with them.

Under current legislation in Germany, greenhouse gas emissions must be reduced such that net greenhouse gas neutrality is achieved by 2045. The Federal Climate Protection Act also stipulates that Germany's greenhouse gas emissions must be reduced by at least 65 percent by 2030 and by at least 88 percent by 2040 compared to 1990 levels.

Meeting legal obligations

Up to and including 2023, Germany's greenhouse gas emissions fell by 46 percent compared to 1990. The volume of emissions currently stands at 674 million tonnes of CO_2 equivalent, with the transport sector contributing around 146 million tonnes.[1] Although emissions from the transport sector fell by just over 18 million tonnes between 1990 and 2023, other sectors have reduced their emissions by a significantly greater amount. The transport sector's share of total greenhouse gas emissions has therefore risen noticeably. It now amounts to almost 22 percent. Apart from the energy industry, where emissions are mostly from fossil-fuelled power plants, the transport sector is the most significant emitter of greenhouse gases. These emissions must be reduced to zero or near zero by 2045 at the latest. According to the OECD, Germany is 'not on track'.[2]

The Federal Climate Protection Act in the version dated 18 August 2021 stipulates annual reduction targets for each of the emissions sectors up to 2030. This requires the transport sector to limit its emissions to 85 million tonnes by 2030. In the amended Climate Protection Act adopted by the parliament on 26 April 2024 the annual sectoral climate targets are no longer binding, although they remain in place as 'guidelines'. In future, the decisive factor for the monitoring and enforcement of climate policy will be whether the emissions targets for Germany as a whole are being met across all sectors, whereby the projected emissions rather than, as before, past emissions data will be used. The overall climate targets for 2030, 2040 and 2045 remain unchanged.

Focusing on economic costs

If the law now only sets cross-sectoral targets, the question arises as to which reduction path the individual sectors should take in order to achieve the overarching zero emissions target and the interim targets. This applies in particular to the transport sector, which to date has barely reduced its emissions. Various reduction paths are conceivable, for example continuous, steady emissions reductions over the years. However, a discontinuous reduction path is also conceivable, in which initially only small emissions reductions are planned which would then subsequently have to be made all the more ambitious in order for the goal of climate neutrality to be achieved and the permissible total budget of cumulative greenhouse gas emissions not to be exceeded.

Policymakers are responsible for deciding on the design of climate policy instruments, with or without binding sectoral targets, and thus ultimately also for determining how far emissions are to be reduced and by when. The Federal Constitutional Court has instructed the German government 'to formulate in good time transparent measures for further greenhouse gas reduction that provide orientation for the necessary development and implementation processes and to ensure that they provide the required planning pressure and certainty'.[3]

For parliament and government, multiple aspects will play a role, including the degree of public support for political projects. In view of scarce resources, it will be necessary to prioritise economic considerations when

1 https://www.umweltbundesamt.de/presse/pressemitteilungen/klimaemissionen-sinken-2023-um-101-prozent und https://www.umweltbundesamt.de/daten/klima/treibhausgas-emissionen-in-deutschland#nationale-und-europaische-klimaziele

2 https://read.oecd.org/10.1787/9a336992-de

3 https://www.bverfg.de/e/rs20210324_1bvr265618.html

making the necessary decisions. A better understanding of which greenhouse gas reduction pathway for the transport sector has the most favourable cost-benefit ratio, i. e. is the most economically advantageous, is therefore required.

Ensuring efficiency and effectiveness

Every transport system incurs costs, both the current system and the future system – which, according to current legislation, must be climate-neutral within 20 years at the latest. However, a climate-friendly transport system is likely to have both a different cost level and a different cost structure. This may be due to the specific challenges of the mobility transformation (the shift to more climate-friendly modes of transport) as well as the drive system transformation (the switch to emissions-free drive technologies).

For example, in order to ensure climate-neutral mobility for people and goods, the public transport system should be expanded. This requires additional investment in suitable infrastructure and vehicles and may require considerable expenditure on transport personnel. At the same time, the switch to emissions-free drive technologies needs to take place. This requires, among other things, the installation of charging infrastructure and the procurement of climate-friendly vehicles. These additional costs would be offset by savings resulting from the transport transformation, for example through lower costs for private vehicles (due to the reduced number) and for energy sources and highways infrastructure.

In order to be able to make economically sound decisions on the transformation of the transport system, policymakers need to know which pathway to climate neutrality looks the most promising from a cost-benefit perspective: one with a faster start or one that provides for even greater emissions reductions after a slower start. With the help of a clear strategy for the pace and timing of climate policy measures and for the prioritisation of the drive system and mobility transformations, policymakers can gain public trust and channel public and private investment effectively and efficiently so that they do not waste scarce resources.

Taking into account harmful climate impacts averted

The benefits from reducing emissions take the form of averted climate damages. If, as is currently the case, carbon pricing does not fully cover the costs occasioned by damage to the climate, then from the point of view of each and every individual, these are largely externalities. Externalities are costs which are not (or not fully) borne by those responsible for them and which are therefore not adequately taken into account in their decision-making. This creates the impression that these costs do not exist. In fact, climate change in Germany has already caused losses totalling at least 145 billion euros in the period from 2000 to 2021.[4]

Due to the long atmospheric lifetimes of greenhouse gas molecules, the greater the total amount of greenhouse gases emitted over a certain period of time, the greater the climate damage costs. Target-oriented policy therefore endeavours to keep the total amount of greenhouse gases emitted over the years (cumulative emissions) as low as possible. This is even more important than hitting precisely an allocated volume of emissions in a specific target year.

Under the old Climate Protection Act, which allocated each sector a certain permissible emissions volume for each year up to 2030, the cumulative emissions volume was also implicitly defined for each sector up to that point, i. e. the climate damages that had to be borne. Although the legally defined sectoral annual emissions volumes no longer apply, policymakers still have a duty to restructure the transport system in such a way that the economic costs, i. e. the total sum of internal and external costs, remain as low as possible. Meeting this challenge is now more urgent than ever.

Recognising that a change of course is required

In accordance with European and German law, the German government regularly publishes a report showing the projected long-term development of greenhouse gas emissions in Germany. These are not forecasts, but

4 https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/kosten-klimawandel-2170246

projections that represent a plausible emissions trend under certain modelling assumptions.

The last complete projection report is from the year 2023 and describes two scenarios. The With Measures Scenario (*Mit-Maßnahmen-Szenario*, MMS) models and analyses the effect of climate protection measures that have already been implemented and adopted.[5] A further scenario, the With Additional Measures Scenario (*Mit-Weiteren Maßnahmen-Szenario*, MWMS) takes into account additional measures planned by the government but not yet implemented.[6] This broader scenario serves as the reference scenario for the present study.[7]

In this reference scenario, greenhouse gas emissions from transport fall to 111 million tonnes of CO_2 equivalent by 2030 and to around 15 million tonnes by 2045. This would mean that both the 2030 sectoral target under the Climate Protection Act – previously binding and now indicative – and the zero emissions target for 2045 would be missed. In addition, the cumulative target shortfall of 180 million tonnes by 2030 alone is significantly greater than the comparatively small gaps for individual years.[8]

However, it is the cumulative total of greenhouse gas emissions over the years that determines the climate impact. It is therefore clear that a change of course in climate policy in the transport sector is unavoidable.

5 https://www.umweltbundesamt.de/publikationen/projektionsbericht-2023-fuer-deutschland

6 https://www.umweltbundesamt.de/publikationen/projektionsbericht-2023-fuer-deutschland

7 The MWMS from the 2023 projection report largely corresponds to the MMS of the 2024 projection report, which has not yet been published, although the key results of the projection have been. The most significant change in the MMS 2024 compared to the MMS 2023 lies in the more extensive toll regulations for HGVs, particularly the introduction of a CO_2 component, something already taken into account in the MWMS 2023.

8 This means that the gap in terms of cumulative emissions in the reference scenario is slightly smaller than in the MWMS 2023, in which it is 187 million tonnes of CO_2 equivalent. In the MMS 2024, the emissions gap also narrows slightly to 180 million tonnes of CO_2 equivalent by 2030. This is due to lower emissions in the last two years, largely as a result of the current economic downturn.

Choosing between 'Transformation 2025' and 'Transformation 2030'

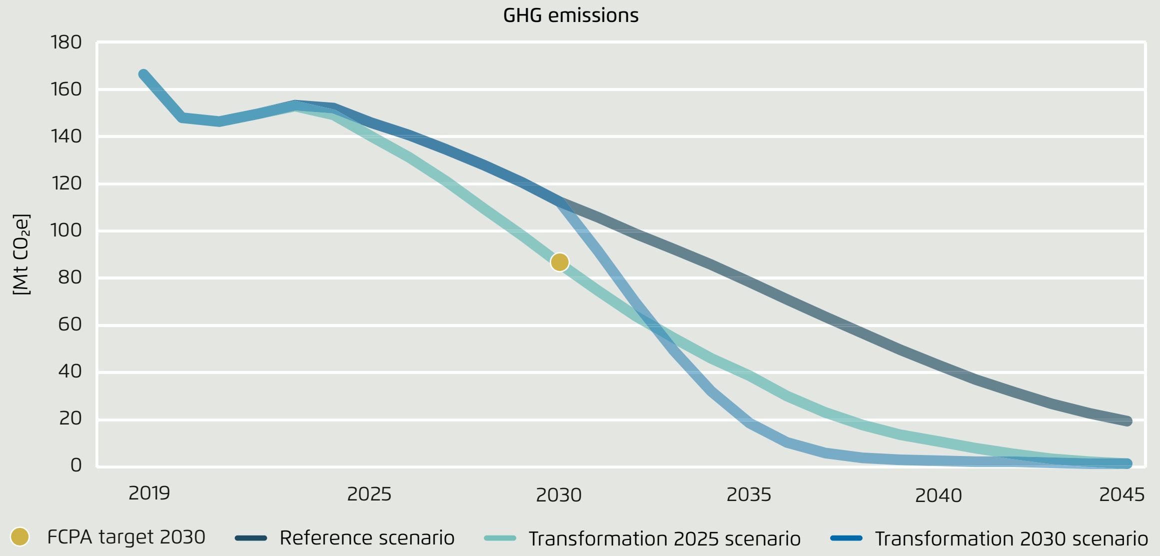
The need for action arises not only from the huge shortfall compared to the sectoral emissions targets for transport by 2030, but also because of the necessary greenhouse gas reduction contribution from the transport sector after 2030. In the years following 2030, other sectors, such as the energy industry, will no longer be able to compensate for shortfalls in the transport sector. This is because the more the other sectors reduce their emissions, the less scope there will be to compensate for shortfalls in the transport transformation through additional reductions. Consequently, and in light of the cross-sectoral emissions reduction targets after 2030, significant and rapid emissions reductions will also be required in the transport sector. The sooner ambitious climate protection measures are taken in the transport sector, the slower the remaining budget for total cumulative emissions will be used up and the less drastic subsequent reduction measures will have to be.

Against this background, this study analyses two target scenarios in addition to the reference scenario with the climate protection measures adopted to date. While maintaining the same levels of mobility, both achieve the zero emissions target by 2045 at the latest; both also lead to almost identical cumulative greenhouse gas emissions over the period 2021 to 2045 (around 1,650 million tonnes of CO_2 equivalent, compared to 2,240 million tonnes in the reference scenario).[9]

In the target scenario which is more ambitious in the short term (Transformation 2025), further-reaching climate protection measures in the transport sector are implemented immediately with effect from 2025, while in the target scenario that is less ambitious in the short term (Transformation 2030), a change of course does not take place until 2030 (Figure 1). From an economic

9 The total emissions budget for the transport sector of 1,650 million tonnes of CO_2 equivalent over the period 2021 to 2045 was calculated as follows. The sectoral targets under the Federal Climate Protection Act were taken as a basis up to 2030; for the remaining years up to 2045, it was assumed that the permissible emissions in transport will continue to fall proportionally in line with the cross-sectoral emissions targets.

GHG emissions in the transport sector under the different scenarios — Figure 1



Agora Verkehrswende (2024) | Note: FCPA stands for Federal Climate Protection Act. Source: Prognos 2024.

perspective, the question now arises as to which of the two target scenarios results in lower costs, i. e. is more favourable in economic terms. The costs of the two target scenarios are also compared with the costs of the reference scenario – even if persisting on a 'business as usual' path would very likely mean a breach of constitutional and international emissions reduction obligations.

Although both target scenarios lead to the same volume of cumulative emissions, they show considerable differences in the course of their respective emissions paths. By acting earlier, the indicative sector target for transport in 2030 of 85 million tonnes of CO_2 equivalent can be achieved in the Transformation 2025 target scenario, although a cumulative target shortfall of 80 million tonnes remains.[10]

In the reference scenario and the Transformation 2030 target scenario, on the other hand, both the annual sectoral target for 2030 and the cumulative emissions target for 2030 are missed – by 26 million tonnes and 180 million tonnes respectively. To ensure that the cumulative emissions up to 2045 in the Transformation 2030 target scenario are not higher than in the Transformation 2025 target scenario, the measures from 2030 onwards must be more rigorous. The initial shortfalls must be compensated for at the end.

Mobility, measured in person-kilometres or tonne-kilometres, is identical in both target scenarios and does not deviate from the values in the reference scenario, where however the climate target is clearly missed. A reduction in mobility is not necessary. Transport performance increases for both passenger and freight transport in the target scenarios compared to 2019; indeed, in freight transport it increases by a good 25 percent.

The differences in the emissions paths are due to divergent drive technologies and transport mode choices. Although all scenarios assume the electrification of road transport, this will occur at different speeds. Only the Transformation 2025 target scenario achieves the German government's goal of 15 million battery-electric cars by 2030; in the other two scenarios, the figure is only 8.5 million. With regard to the mobility transfor-

10 The cumulative emissions volume of the sectoral targets for transport from 2021 to 2030 under the Climate Protection Act is 1,184 million tonnes of CO_2 equivalent.

mation, there are also major differences between the scenarios, especially after 2030. This can be seen in the different trends in the modal split and in the number of cars on the road.

Maintaining, electrifying and shifting mobility

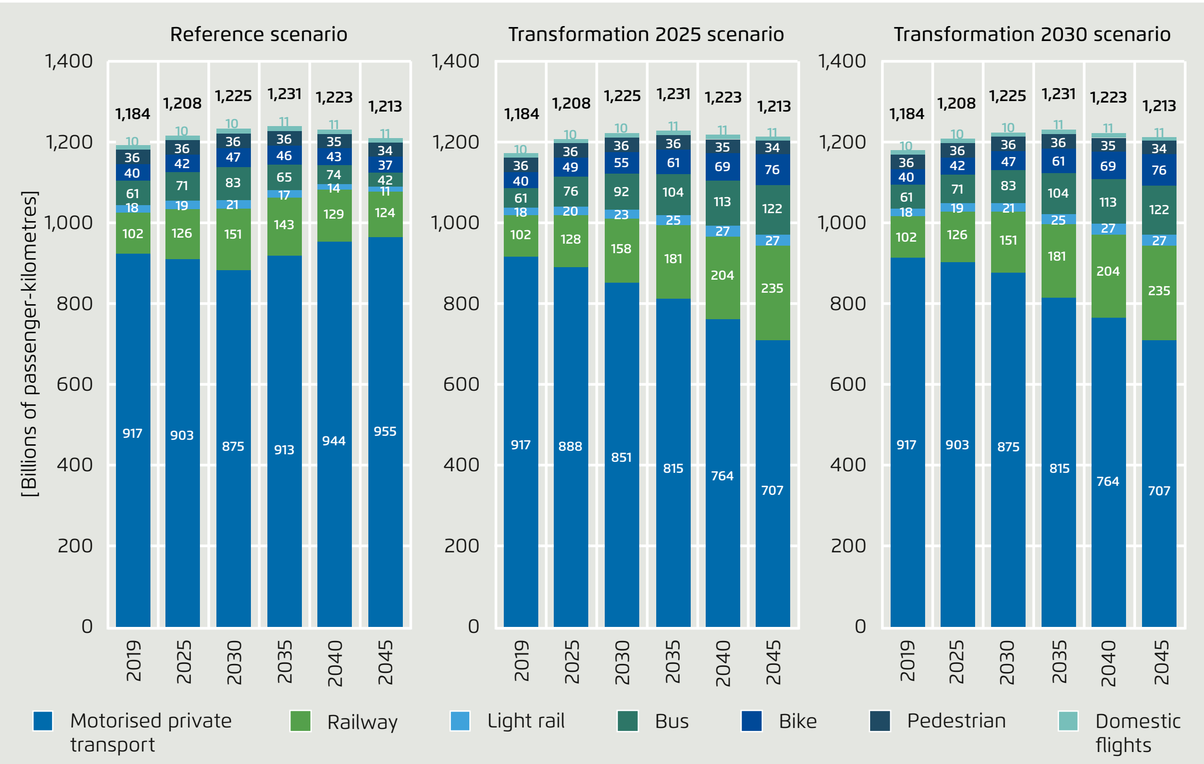
In the Transformation 2025 target scenario, the share of motorised private transport already shrinks slightly between 2025 and 2030 in favour of trains and buses as well as walking and cycling (see Figure 2). Together with the initially faster electrification of passenger cars, this leads to early emissions reductions, which in the Transformation 2030 target scenario must be caught up on, particularly in the first half of the 2030s. This can only be achieved by accelerating the switch from cars to public transport and by decommissioning combustion vehicles early and increasing the use of synthetic fuels.

From 2035, the development of the modal split is parallel in both target scenarios. In the target year 2045, the overall share of motorised private transport is only 58% (2019: 77%), while the share of trains and buses increases to almost one third. The total volume of rail transport will then be almost twice as high as in the reference scenario, while that of the bus network will be three times as high.

The number of passenger cars develops in line with the shrinking share of passenger cars in the modal split: in both climate target scenarios, it falls from 47 million to around 38 million, while in the reference scenario it rises to 54 million (Figure 3). It is notable that in 2045, 45 million of these 54 million vehicles will have a battery-electric drive. In absolute terms, this is significantly more e-vehicles than in the two climate target scenarios. Greenhouse gas emissions are nevertheless higher because there are still many combustion engines on the roads.

Demand for passenger transport by mode

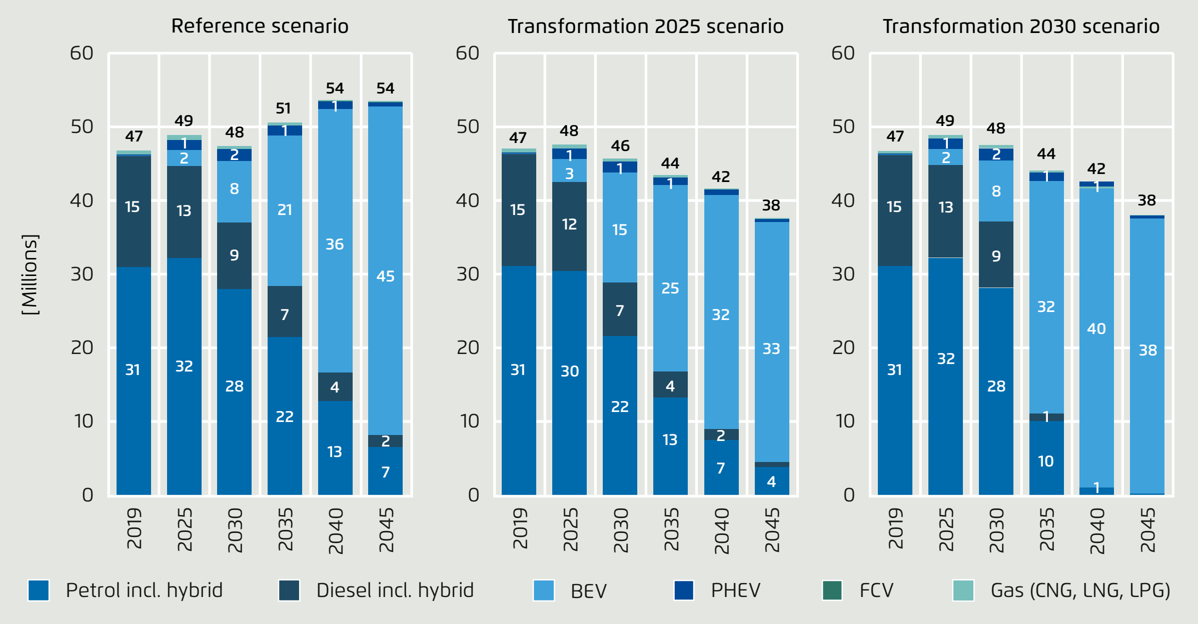
Figure 2



Agora Verkehrswende (2024) | Source: Prognos 2024.

Numbers of cars on the roads by drive system

Figure 3



Agora Verkehrswende (2024) | Note: PHEV = Plug-in Hybrid Electric Vehicle; BEV = Battery Electric Vehicle; FCV = Fuel Cell Vehicle; Source: Prognos 2024.

It is also notable that in the Transformation 2030 target scenario, almost all cars will be battery-electric in 2045, which can only be achieved through the early decommissioning of combustion engines. This 'full electrification' is necessary in order to compensate for the increased emissions from previous years. In the Transformation 2025 target scenario, this is not necessary, so even in 2045 some combustion engine cars can still remain on the roads, albeit running on emissions-free fuels.

Electrifying and shifting the increasing volume of freight transport as well

When it comes to freight transport, the differences between the scenarios are less pronounced than in passenger transport. In the climate target scenarios, with very similar trends, the share of road freight transport (Heavy Goods Vehicles) falls to 67 percent by 2045 (575 of 853 billion tonne-kilometres), while in the reference scenario it remains at 72 percent (612 of 853 billion tonne-kilometres) (Figure 4). Nevertheless, in all scenarios there will be more lorries on the roads than today. However, the total volume of rail transport grows even more strongly.

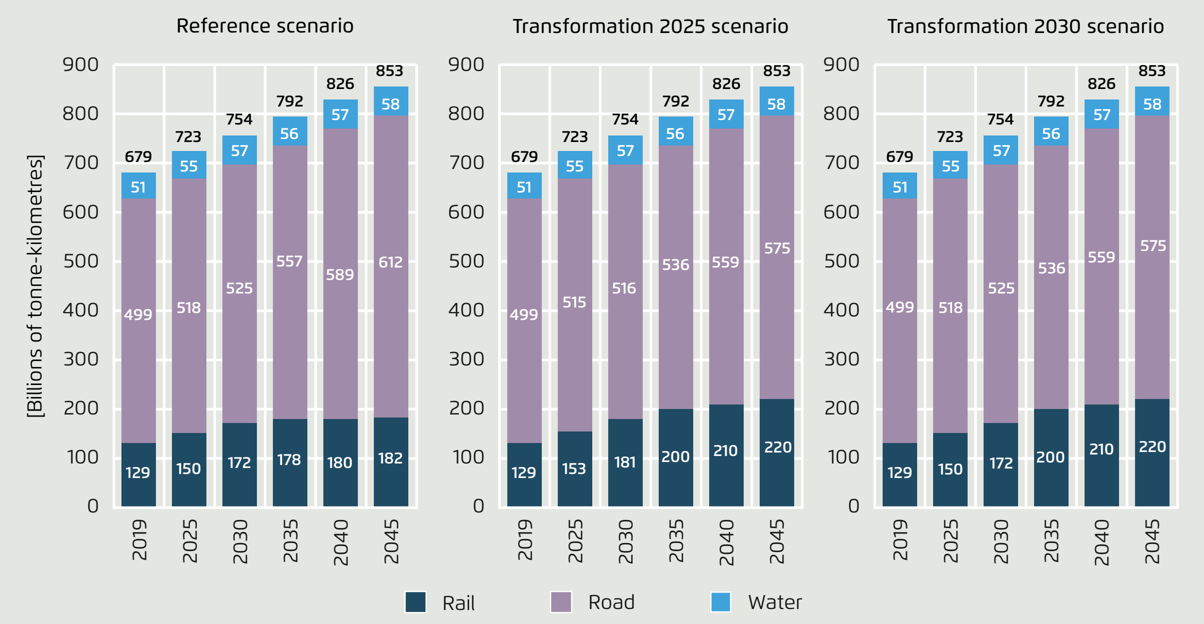
In fact, in the two target scenarios, more than half of the growth in total freight transport is attributable to rail – and is therefore powered by electricity, as already today in freight transport 'almost 90 percent of all train kilometres are powered by electricity',[11] i.e. with zero local emissions.

In contrast, the electrification of the commercial road vehicle fleet is still to come. However, even in the reference scenario, just under a quarter of all light commercial vehicles, which are expected to grow rapidly in number, will be battery-electric by 2030, as will also be the case in the Transformation 2030 target scenario. In the Transformation 2025 scenario, it is more than a third, which means that almost half of the total distance travelled by light commercial vehicles will be on electric power. By

11 https://www.deutschebahn.com/de/presse/suche_Medienpakete/Nachhaltigkeit/Alternative-Antriebe-und-Kraftstoffe

Freight transport demand by mode

Figure 4



Agora Verkehrswende (2024) | Source: Prognos 2024.

2045, around 90 percent of all light commercial vehicles will be battery-powered in all scenarios, with the share of electric mileage exceeding 90 percent in each case.

Battery-electric drive systems are also gaining ground in the heavy commercial vehicles sector, albeit less quickly than in light commercial vehicles. In the Transformation 2025 target scenario, battery-electric driving accounts for around one third of the total in 2030, rising to 70 percent by 2035 and to more than 90 percent by 2045. For new registrations of heavy commercial vehicles, the share of battery-electric vehicles is already over 70 percent in 2030 and reaches around 95 percent five years later (Figure 5). In the reference scenario, electrification is delayed through the entire period: battery-electric heavy commercial vehicles only predominate in terms of new registrations from the first half of the 2030s and in terms of mileage covered only in the second half. In the Transformation 2030 target scenario, the same number of battery-electric lorry registrations is achieved from 2030 as in the Transformation 2025 scenario, so that battery-electric mileage covered is also largely equalised by the early 2040s. Hydrogen-powered lorries only occupy a marginal niche in all scenarios.

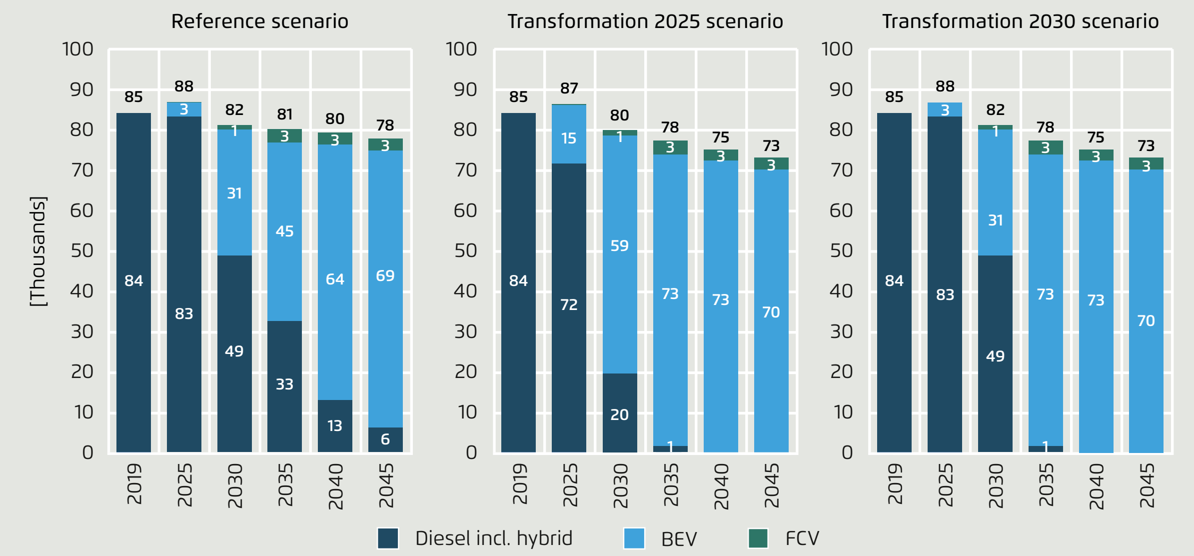
Capturing the costs systematically

Cost comparison calculations are generally used to determine the most cost-effective option when making investment decisions. As far as possible, all costs that can be allocated to a specific investment are included in the comparison, including the operating costs arising. Investments serve to generate future benefits, which are not necessarily of a directly financial nature. An investment decision can therefore only be well founded if the benefits are considered alongside the costs. A focus on the cost side is appropriate if the investment alternatives lead to comparable benefits (outputs) in terms of quantity and quality.

This study compares scenarios in which the same passenger and freight transport performance – and thus a comparable mobility level – are achieved. The focus of the economic analyses carried out is therefore on the economic costs of providing this transport service output.

Direct expenditure in the transport sector, the focus of the next section, consists of the capital expenditure (CapEx) and operating expenditure (OpEx) required to provide this level of mobility. The latter consists primarily of expendi-

New vehicle registrations in freight transport (heavy goods vehicles) Figure 5



Agora Verkehrswende (2024) | Note: Heavy goods vehicles include articulated lorries and trucks over 3.5 t excluding other tractors and other motor vehicles. Source: Prognos 2024.

ture on energy, personnel and maintenance. Vehicles (trains, buses, cars and trucks) and infrastructure (charging stations and hydrogen refuelling stations as well as roads and railways) represent investment in capital assets; they are used over a longer period of time.

While the annual expenditure on ongoing operations, i.e. OpEx, also corresponds to the annual costs, this is not the case for investments due to their utilisation over several years. Expenditure on capital goods, i.e. CapEx, is incurred directly at the time of acquisition, but the accounting treatment of their costs should be spread over their useful life. To this end, the initial expenditure is annualised i.e. distributed evenly over the years of useful life of the capital assets.

The annual costs for infrastructure and vehicles shown in this study therefore correspond to the real value of this annualised expenditure.[12] A nominal interest rate of three percent is assumed in order to calculate the annual figure (annuity) for the cost analysis; this roughly corresponds to the yield on 15-year German government bonds. The real costs of the investment are determined by discounting the annualised expenditure, for which an annual discount rate of two percent is applied to all payments in the study.

In order to determine the expenditures and costs, calculations were first made of the physical requirements in terms of fixed assets, energy, services and personnel costs for the respective scenarios. Net prices (excluding taxes) were then applied in order to create an economic projection (see box on page 21).

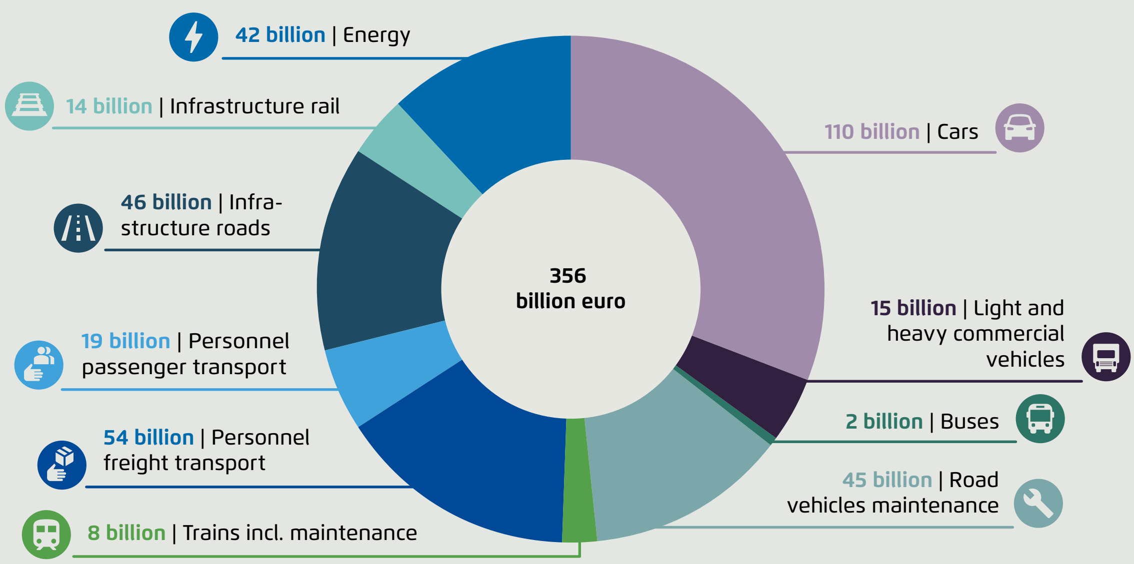
Understanding the mechanics of the cost structure

In 2019, expenditure in the transport sector totalled around 356 billion euros (Figure 6).[13] Over a third of annual expenditures (in 2019, 127 billion euros) is invested in road vehicles (cars, light and heavy com-

12 The service life assumed here is 10 years for charging points, 16 years for cars, an average of 10 years for commercial vehicles and 19 years for buses. For road and rail infrastructure, it is 35 years in each case, and 30 years for rolling stock.

13 Unless otherwise stated, the expenditures and costs detailed in this report are inflation-adjusted figures based on 2022 prices [EUR 2022].

Expenditure in the transport sector in 2019 in euros — Figure 6



Agora Verkehrswende (2024) | Source: Prognos 2024.

mercial vehicles, buses), the majority of this in cars (110 billion euros); an additional 45 billion euros is spent on their maintenance. This is followed by personnel expenditure totalling 73 billion, of which 54 billion is attributable to freight transport, with road freight transport dominating in absolute terms at 53 billion; the remainder is divided between road passenger transport (12 billion) and rail transport including light rail (7 billion). Other significant blocks of expenditure are investments in road infrastructure (46 billion), rail infrastructure (14 billion) and trains including maintenance (8 billion), as well as 42 billion for energy. Expenditure on charging stations and hydrogen refuelling stations was still negligible in 2019. Climate losses are not included in this list, as the emission of greenhouse gases does not result in any immediate, direct financial outlays; nevertheless, they are highly relevant, including financially. The costs of climate damage from emissions in 2019 can be estimated at around 30 billion euros.

This expenditure makes the transport sector one of the most capital-intensive economic sectors in Germany. Significantly more than half of all direct expenditure recorded here is on fixed assets (CapEx). Up to 2045, road vehicles will continue to account for by far the highest capital investment expenditure (Figure 7.1); they also form the largest single cost block in every year and every scenario (Figure 7.2). By contrast, the highest (absolute) growth up to 2045, especially in the target scenarios, is in personnel costs.

In the reference scenario, investments in cars and lorries remain at a similar level to today through to 2045, while in the Transformation 2025 target scenario they initially increase slightly due to the purchase of slightly more expensive zero-emissions vehicles, but then fall significantly below the level of the reference scenario. The reason for this is the decline in the number of cars and the shift to other modes of transport.

In the Transformation 2030 target scenario, expenditure on road vehicles in the 2030s has an upward outlier. During this period, the electrification of the vehicle fleet – being too slow up to that point – must be redressed in order to meet the emissions budget. This requires the decommissioning of combustion cars before they reach the end of their normal service life. The replacement of a significant proportion of the car fleet and the increased number of battery-electric car registrations required for this will massively increase expenditure; the capital losses occasioned by the premature decommissioning are reflected in the economic costs.

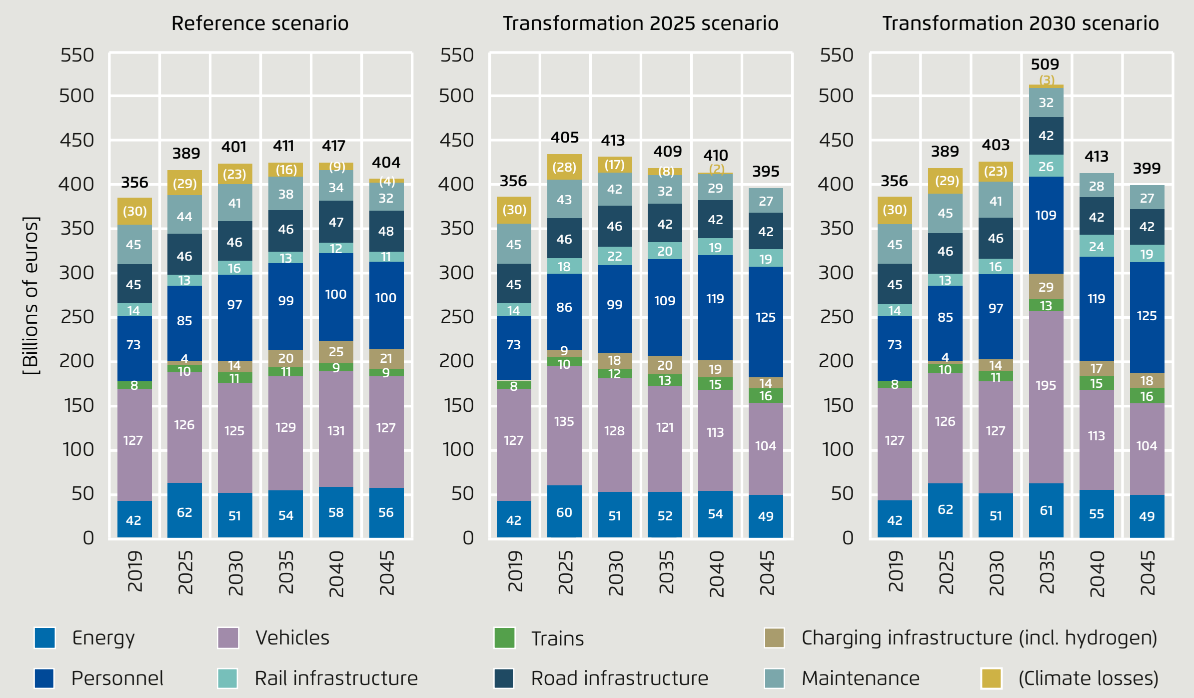
A massive expansion of the EV charging infrastructure will be necessary in all scenarios, as will a certain number of hydrogen refuelling stations. The associated expenditure and costs reflect the different speeds of electrification. While the Transformation 2025 target scenario already requires high investments in the energy supply infrastructure until the early 2030s, in the other scenarios, these investments – in line with the number of electric vehicles – are primarily made from the mid-2030s onwards. In the Transformation 2030 scenario in particular, very high expenditure is then incurred for the charging infrastructure in line with the rapid growth in the number of e-cars.

Expenditure on road infrastructure differs relatively little between the scenarios – unlike expenditure on rail infrastructure. In order for rail transport to increase, the network must be expanded considerably. Over the period from 2023 to 2045, the additional expenditure in the two target scenarios totals around 150 billion euros, which includes investments of around 60 billion euros for light rail infrastructure (Tables 1 and 2). With regard to road infrastructure, the only distinction made between the scenarios is that in the climate target scenarios there is no further expansion of the national main roads network after 2030. This could lead to an overestimation of the relative costs of the climate target scenarios in this category, as the reduced road traffic could also result in lower costs for the expansion and maintenance of the minor roads network.

Buses and trains are significantly more energy-efficient than cars and lorries. This is why energy costs fall the more transport services are provided by them rather

Annual expenditure in the transport sector by scenario

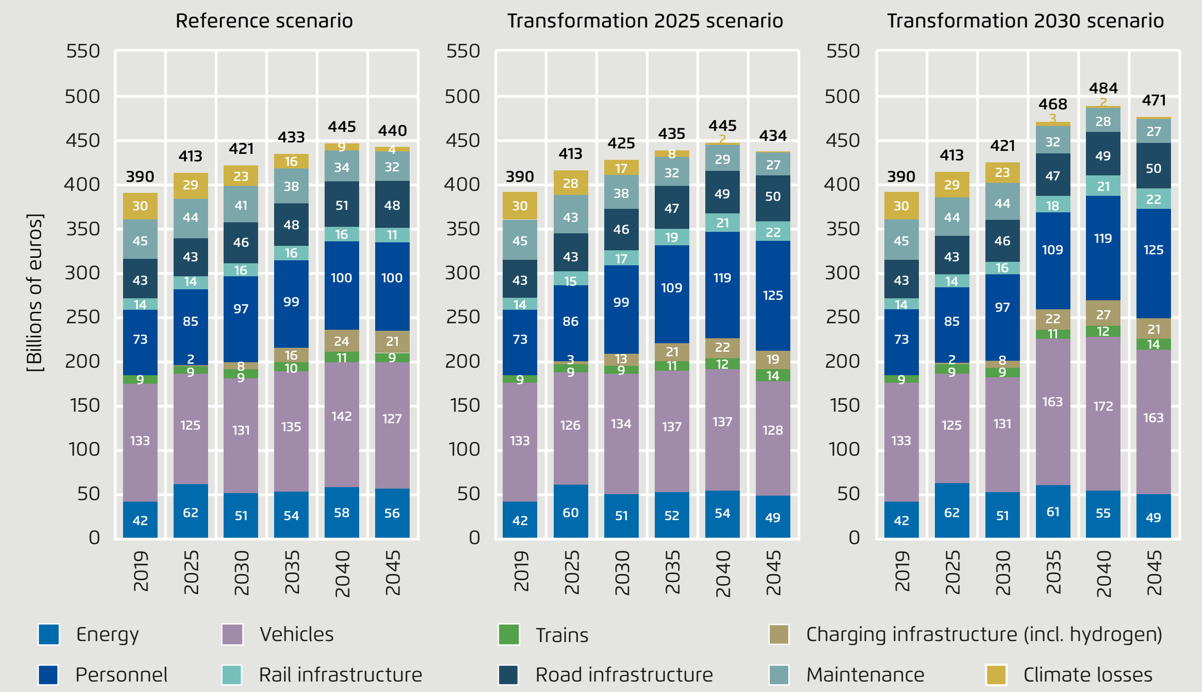
Figure 7.1



Agora Verkehrswende (2024) | Note: Climate losses are shown in the graph due to their high relevance, but are not included in the total expenditure shown. Although the costs are triggered in the year of emission, most of the expenditure resulting from climate damage occurs in later years; however, it is not possible to apportion the expenditure over time in this study. Source: Prognos 2024.

Annual costs in the transport sector by scenario

Figure 7.2



Agora Verkehrswende (2024) | Source: Prognos 2024.

than by cars and lorries. Electrically powered vehicles are also more energy efficient than those with combustion engines. On balance, this saves 61 billion euros in energy costs in the Transformation 2025 target scenario compared to the reference scenario.

Unlike cars, which are driven free of charge by private individuals, buses and trains require drivers and therefore more funds for personnel costs. The additional personnel costs in passenger transport – cumulatively up to 2045 – amount to 245 billion euros in the Transformation 2025 target scenario, of which 169 billion euros are for the operation of buses alone. The reverse is true for freight transport: in the Transformation 2025 scenario, the shift to rail will result in cumulative labour cost savings of 6 billion euros by 2045 compared to the reference scenario. Road transport by lorry is more labour-intensive per tonne-kilometre than rail transport, due to the significantly lower transport weight and volume per vehicle driver.

Minimising expenditure and costs

If we look at the provisional balance of additional and reduced expenditure directly incurred for the provision of mobility for people and goods over the entire period up to 2045, both transformation scenarios are still above the reference scenario in terms of expenditure: the Transformation 2025 target scenario only slightly, the Transformation 2030 target scenario substantially (Figure 8). However, this picture is not complete.

If the costs saved due to averted climate damages are also taken into account, the Transformation 2025 target scenario proves to be economically more advantageous than the reference scenario. The point in time from which the annual reduction in expenditure is greater than the additional expenditure compared to the reference scenario is already reached in 2031. Looking at the cumulative expenditure, the break-even point after which total expenditure is below the reference scenario when climate damage costs are added in occurs around 2040.

Expenditure (cumulative 2023–45) — Table 1

Billions of euros (real, 2022)			Reference scenario	Divergence between target scenarios and reference scenario: Transformation 2025 scenario	Divergence between target scenarios and reference scenario: Transformation 2030 scenario
Investments in vehicles / trains			3,177	-85	+397
	Road	Passenger transport	2,378	-171	+333
		Freight transport	568	+21	+3
	Rail	Passenger transport	185	+60	+57
		Freight transport	46	+5	+4
Maintenance			889	-101	-79
	Road	Passenger transport	669	-88	-74
		Freight transport	220	-13	-5
Personnel			2,197	+239	+222
	Road	Passenger transport	286	+169	+156
		Freight transport	1,665	-9	-8
	Rail	Passenger transport	218	+76	+72
		Freight transport	28	+3	+3
Energy			1,298	-61	+9
	Road	Passenger transport	781	-70	-45
		Freight transport	441	-11	+35
	Rail	Passenger transport	53	+18	+17
		Freight transport	23	+3	+2
Infrastructure, routes			1,391	+83	+83
	Road	Passenger transport	527	-34	-34
		Freight transport	541	-35	-35
	Rail	Passenger transport	273	+147	+146
		Freight transport	49	+6	+6
Charging infrastructure (incl. hydrogen)			378	-4	+14
	Road	Passenger transport	269	-28	+6
		Freight transport	109	+25	+7
Total expenditure			9,329	+71	+645
Climate losses			401	-131	-128
	Road	Passenger transport	248	-77	-81
		Freight transport	150	-53	-47
	Rail	Passenger transport	2	0	0
		Freight transport	1	0	0
Total expenditure plus climate losses			9,731	-60	+518

Agora Verkehrswende (2024) | All figures are rounded. The totals may therefore not always correspond to the sum of all the itemised figures. Source: Prognos 2024.

Costs (cumulative 2023–45) — Table 2

Billions of euros (real, 2022)			Reference scenario	Divergence between target scenarios and reference scenario: Transformation 2025 scenario	Divergence between target scenarios and reference scenario: Transformation 2030 scenario
Investments in vehicles / trains			3,325	-10	+395
	Road	Passenger transport	2,575	-52	+375
		Freight transport	521	+22	+3
	Rail	Personenverkehr	184	+18	+16
		Freight transport	44	+2	+1
Maintenance			889	-101	-79
	Road	Passenger transport	669	-88	-74
		Freight transport	220	-13	-5
Personnel			2,197	+239	+222
	Road	Passenger transport	286	+169	+156
		Freight transport	1,665	-9	-8
	Rail	Passenger transport	218	+76	+72
		Freight transport	28	+3	+3
Energy			1,298	-61	+9
	Road	Passenger transport	781	-70	-45
		Freight transport	441	-11	+35
	Rail	Passenger transport	53	+18	+17
		Freight transport	23	+3	+2
Infrastructure, routes			1,455	+46	+32
	Road	Passenger transport	541	-11	-11
		Freight transport	555	-11	-11
	Rail	Passenger transport	308	+67	+52
		Freight transport	51	+3	+3
Charging infrastructure (incl. hydrogen)			328	+24	+35
	Road	Passenger transport	236	-4	+27
		Freight transport	92	+28	+8
Interim total			9,492	+138	+615
Climate losses			401	-131	-128
	Road	Passenger transport	248	-77	-81
		Freight transport	150	-53	-47
	Rail	Passenger transport	2	0	0
		Freight transport	1	0	0
Grand total			9,894	+8	+487

Agora Verkehrswende (2024) | Note: All figures are rounded. The totals may therefore not always correspond to the sum of all the itemised figures. Source: Prognos 2024.

In comparison, the Transformation 2030 target scenario still looks worse, due in particular to the very high costs of scrapping cars, even taking into account the credit for averted climate damage costs. After a few years of – in some cases very significant – additional expenditure, the annual burdens also fall here compared to the reference scenario: the turning point in terms of annual expenditure is reached in the Transformation 2030 target scenario around 2038, after the end of the car scrappage programme. Cumulatively, however, this financial burden cannot be recouped over the long term.

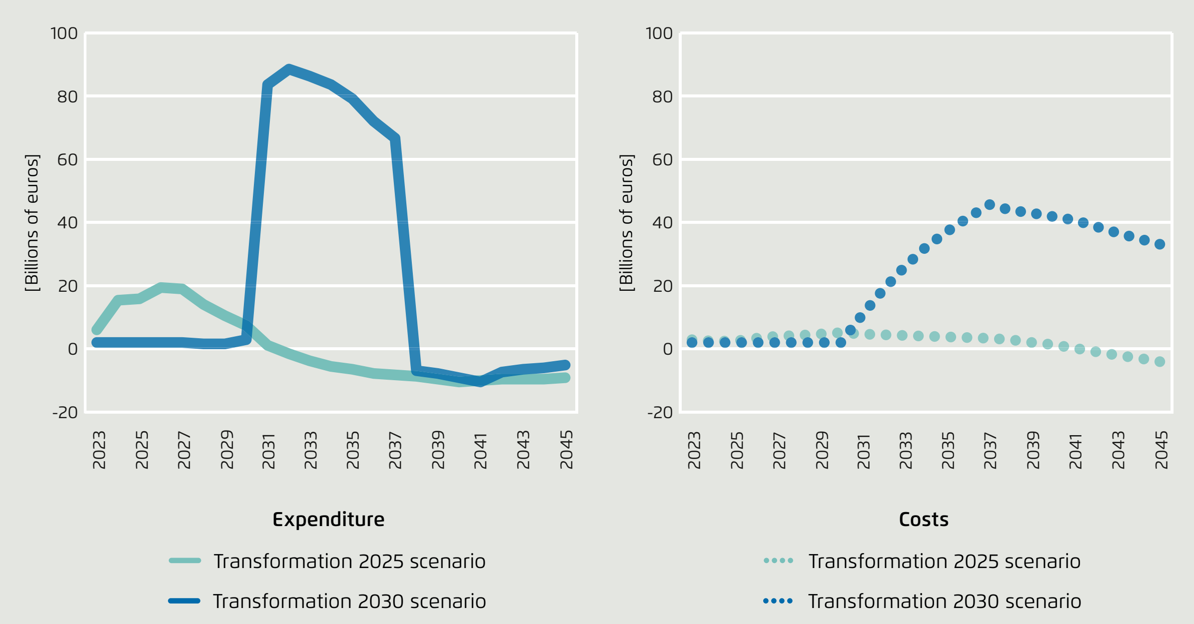
If we switch from the expenditure perspective to that of economic costs, the mathematical break-even point for the Transformation 2025 scenario in terms of cumulative costs (including climate losses) occurs a few years later. This is due to the fact that the higher expenditure in the reference scenario in the 2030s and 2040s – particularly for private cars – is spread over their entire useful life through annualisation. However, even in this cost perspective, the Transformation 2025 target scenario 'overtakes' the reference scenario even by 2050 at the latest.

This means that the costs incurred up to the middle of the century are lower in the case of a rapid transport transformation than in the case of 'business as usual'. For the Transformation 2030 target scenario, from a cost perspective, the cost burden of the car scrappage programme is too great to catch up with the other scenarios.

Therefore, if the transport transformation is taken forward at pace and rigorously, although it will cause additional expenditure in the years up to 2030, it promises growing benefits from 2031 onwards in the form of annual reductions in expenditure compared to the reference scenario. Cumulatively, these savings (including climate losses) will exceed the additional early expenditure from around 2040. Not opting for the Transformation 2025 target scenario will either lead to climate targets not being met, as in the reference scenario, or to structural disruptions and the devaluation of investments, as in the Transformation 2030 target scenario.[14]

14 There is also the threat of compensation payments under the European Effort Sharing Regulation.

Annual divergence in expenditure and costs between the climate target scenarios and the reference scenario — Figure 8



Agora Verkehrswende (2024) | Note: The graph showing the differences in expenditure also takes into account the diverging climate losses. Source: Prognos 2024.

In terms of new or developing initiatives, this means that the drive system transformation is coming anyway, but it must be accelerated. This will only succeed with the help of significantly more political support and appropriate framework conditions. The most striking difference in the Transformation 2025 scenario is the rapid implementation of the mobility transformation, i. e. the shift to rail, local public transport, cycling and walking. This would not only bring savings in vehicle investment costs and expenditure on energy and maintenance, but would also reduce the costs arising from climate damage and bring further social benefits.

Taking into account other effects and additional benefits

Other economic benefits of the target scenarios in addition to the avoidance of climate damage, such as avoiding or reducing the costs of air and noise pollution or land consumption, were not taken into account in this study. Similarly, other economic cost-benefit factors such as time costs and comfort were not taken into account. Taking all these factors into account in euros and cents would be very complex and ultimately not possible to do in full. Nevertheless, they are relevant for the evaluation of different transport systems. In a more comprehensive economic balance sheet, the target scenarios would probably emerge looking even better.

One challenge for the mobility transformation is the human resources required for the expanded operation of buses and trains. This applies not only to the associated costs, but even more so to the availability of drivers. However, digital technologies and self-driving vehicles offer the prospect of further expanding public transport services notwithstanding this – be it underground and suburban trains, regular bus services or autonomous shuttles. The latter in particular can also play an important role in strengthening public transport (particularly in rural areas) and serving as a feeder for rail transport.

If this automation potential can be utilised, the economic benefits of a thoroughgoing transport transformation policy would be even greater – in terms of improved mobility, lower external costs and possibly also lower public transport costs. This prospect should encourage those responsible, from the federal government down to local transport companies, to push ahead with digitalised services. However, in view of political and technological uncertainties, a somewhat conservative assumption was made for the purposes of this study. According to this, the real personnel costs per passenger kilometre in public transport will continue to rise moderately until 2030 and remain constant thereafter.

There is another obvious additional benefit of a more thoroughgoing transport transformation policy: an enhanced quality of life in urban areas. The car would remain the number one means of transport, but while the volume of motorised private transport would actually increase slightly in the reference scenario, it could be reduced in the target scenarios by more than 20 percent by 2045 without a reduction in mobility. Not only would there be fewer cars on the road, they would also take up less public space for parking, space that could be used for other purposes: open space for the development of tomorrow's cities.

Transport transformation now – a good investment that creates added value for the whole of society

The transport sector is the ‘problem child’ of climate policy. There is still no sign of a political change of course. In no other sector are the deficits – measured against the German government's own targets – as large as in transport. But it doesn't have to stay that way. Transport, too, can be set on a course towards climate neutrality and can contribute its fair share to Germany's greenhouse gas reduction commitments. Although it is now virtually impossible for the emissions targets for the transport sector up to 2030 as set out in the 2021 Federal Climate Change Act to be achieved – especially in a cumulative perspective – those missed targets can be recouped in the years that follow.

The prerequisite for this is that politicians commit to an ambitious transport transformation. And this change of course should take place without further delay, from an economic perspective not least. Persevering with business as usual over the next few years would result in structural disruptions and the devaluation of existing investments. Although it would then still be possible, by means of a drastic change of course, to achieve similar cumulative emissions reductions and ultimately climate neutrality, the costs would be substantially higher.

This study shows that the climate targets leading to climate neutrality by 2045 at the latest can be achieved in the transport sector too – while maintaining mobility in full and at comparable costs to the reference scenario. Although the total costs up to 2045 in the reference scenario and the Transformation 2025 target scenario are very similar, the two scenarios differ significantly in their cost structure.

In the Transformation 2025 target scenario, higher expenditure will be incurred in the next few years for investments in expanding public transport capacity and in electric vehicles and their charging infrastructure. In the short term, a rapid transport transformation scenario therefore requires higher investments.

However, these investments will already pay for themselves from the beginning of the 2030s, resulting in lower annual expenditures than in the reference scenario. The Transformation 2025 target scenario catches up with every additional year. If the climate losses averted by the transport transformation are taken into account, the break-even point for cumulative expenditure – i. e. the point at which the Transformation 2025 scenario has lower total expenditure than the reference scenario – is reached in the early 2040s. And even if climate losses are completely ignored, this point will be reached only a little later, towards the middle of the century. Policymakers therefore need not only an action plan for the transport transformation, but also a strategy for financing it, especially for the higher expenditure in the initial phase.

The inclusion of further external costs and benefits not quantified in this study – such as additional environmental and health costs or improvements to the quality of life in cities – could serve to bring the economic break-even point even further forward and thereby further improve the bottom line of the transport transformation. This study does not take into account the risks to the German federal budget arising out of the European Effort Sharing Regulation, which run into billions of euros. Without ambitious climate protection measures in the transport sector, there is a risk that emission rights will have to be purchased from other countries at great expense or that penalties will be imposed as a result of treaty infringement proceedings. Funds would then flow out of the national economy that could be used instead to finance its sustainable modernisation.

A rapid and ambitious transport transformation will not only enable Germany to fulfil its constitutional and international climate protection obligations, but will also create economic added value for society. In terms of financial costs, it is cheaper in the long term, averts multiple costs resulting from damage – caused by extreme weather events, land consumption, noise, air and environmental pollution, including the associated health impacts – and can also prevent mobility poverty through providing efficient and easily accessible public transport and a people-centred design of public spaces in both urban and rural areas, thus ensuring greater social participation.

Sources and assumptions underlying expenditure calculations

The detailed calculation of specific expenditures in the study is based on interviews and workshops with experts, the databases of Prognos AG, and data and calculations drawn from the following sources:

- **Passenger cars:** Prognos (2024). Interne Fahrzeugdatenbank (basierend u.a. auf ADAC (2024). Autokatalog; BloombergNEF (2023). Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh).
- **Buses:** Bundesministerium für Wirtschaft und Klimaschutz (n.v.). Begleitforschung.
- **Road freight transport vehicles:** Prognos (2024). Kaufentscheidungsmodell (basierend u.a. auf ICCT (2023). A total cost of ownership comparison of truck decarbonization pathways in Europe; BloombergNEF (2023). Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh).
- **Rail freight transport vehicles:** Verband Deutscher Verkehrsunternehmen, Roland Berger (2021). Gutachten zum Schienengüterverkehr in Deutschland bis 2030.
- **Passenger rail and light rail vehicles:** Ramboll (2023). Ermittlung des Finanzbedarfs für den ÖPNV bis 2031 – Kurzbericht.
- **Rail passenger transport vehicles:** Deutsche Bahn (2023). Integrierter Bericht 2022.
- **Charging infrastructure:** Agora Verkehrswende (2022). Schnellladen fördern, Wettbewerb stärken.
- **Federal highways infrastructure:** Bundesministerium für Verkehr und digitale Infrastruktur (2016). Bundesverkehrswegeplan 2030; Bundesministerium für Digitales und Verkehr (2021). Berechnung der Wegekosten für das Bundesfernstraßennetz sowie der externen Kosten nach Maßgabe der Richtlinie 1999/62/EG für die Jahre 2023 bis 2027.
- **Federal state and district roads infrastructure:** Böttger (2021). Abschätzung der Kosten der Verkehrsträger im Vergleich – Explorative Studie im Auftrag von Netzwerk Europäischer Eisenbahnen (NEE).
- **Local roads infrastructure:** Deutsches Institut für Urbanistik (2023). Investitionsbedarfe für ein nachhaltiges Verkehrssystem – Schwerpunkt kommunale Netze.
- **Rail infrastructure:** Bundesministerium für Finanzen (2024). Bundeshaushaltsplan 2023–2024; Deutsche Bahn (2023). Integrierter Bericht 2022; Verband Deutscher Verkehrsunternehmen, Roland Berger (2021). Gutachten zum Schienengüterverkehr in Deutschland bis 2030.
- **Light rail infrastructure:** Deutsches Institut für Urbanistik (2023). Investitionsbedarfe für ein nachhaltiges Verkehrssystem – Schwerpunkt kommunale Netze.
- **Rail passenger transport personnel:** Jährliche Preisfortschreibungssätze basierend auf Ramboll (2023). Ermittlung des Finanzbedarfs für den ÖPNV bis 2031 – Kurzbericht; Deutsche Bahn (2023). Integrierter Bericht 2022; eigene Berechnungen von Prognos.
- **Road passenger transport personnel:** Jährliche Preisfortschreibungssätze basierend auf Ramboll (2023). Ermittlung des Finanzbedarfs für den ÖPNV bis 2031 – Kurzbericht.
- **Rail freight transport personnel:** Deutsche Bahn (2023). Integrierter Bericht 2022.
- **Road freight transport personnel:** Bünger et al. (2023). Was verdienen Berufskraftfahrer/innen im Güterverkehr? Eine Analyse auf Basis der WSI-Lohnspiegel-Datenbank. Lohnspiegel.de-Arbeitspapier Nr. 61, Düsseldorf.
- **Energy:** Prognos (2020). Energiewirtschaftliche Projektionen 2030/2050.
- **Climate losses:** Umweltbundesamt (2020). Methodenkonvention 3.1 zur Ermittlung von Umweltkosten. (Note: the lower rate with a higher time preference rate was used.)

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Agora Verkehrswende is a Berlin-based think tank that seeks to promote climate-friendly mobility. Non-partisan and non-profit, it works together with key stakeholders in the fields of politics, business, academia and civil society to decarbonise the transport system. To this end, the think-tank team develops evidence-based policy strategies and recommendations.

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