Towards EU climate neutrality

Progress, policy gaps and opportunities

Chapter 6: Transport

Assessment Report 2024

European Scientific Advisory Board on Climate Change

Contents

6 Transport

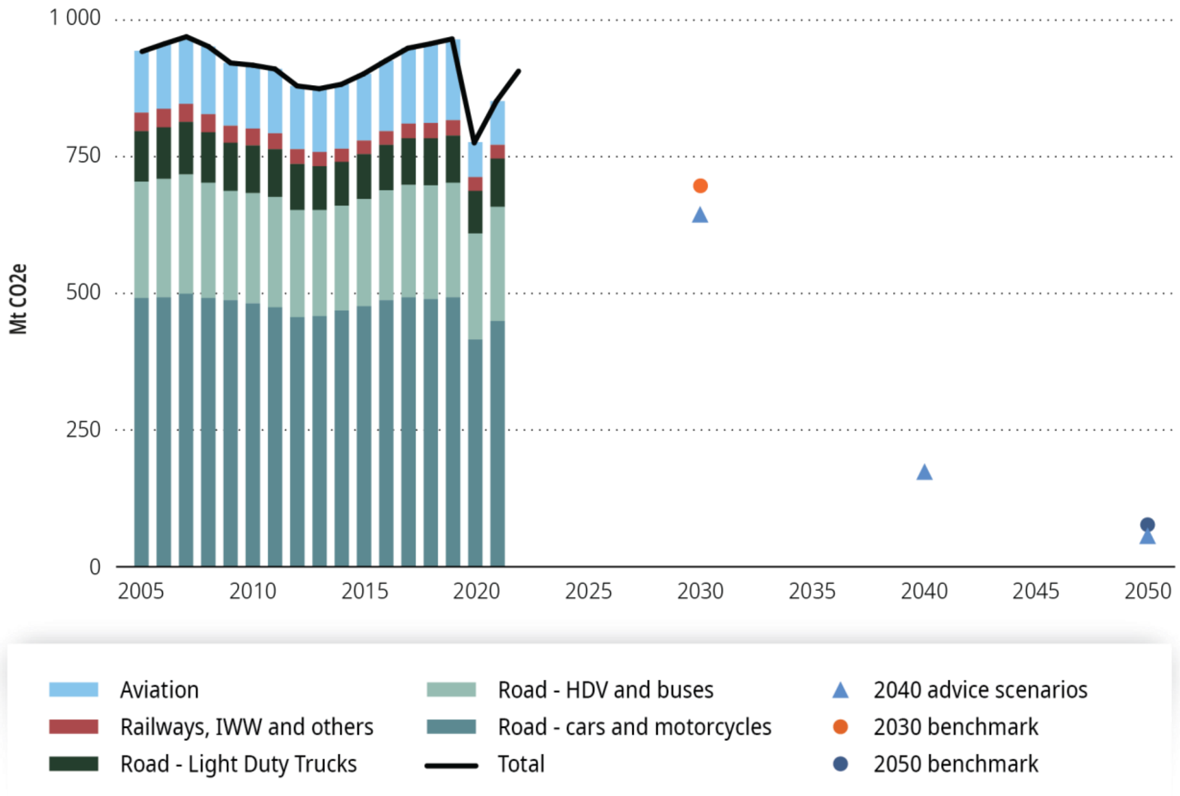
Key messages

The pace of GHG emission reductions in the EU transport sector needs to at least double to align with the EU's climate objectives.

As shown in Figure 32, the EU has not managed to structurally reduce the GHG emissions of its transport sector since 2005. There have been improvements in vehicle efficiency and the GHG intensity of transport fuels, but these have been offset by increased overall transport demand (in particular for aviation) and – in more recent years – the shift towards heavier, less-efficient passenger cars. A substantial decrease occurred in 2020 (– 20 % compared to 2019) in the context of the COVID-19 pandemic, but emissions have largely rebounded since then (– 4 % in 2022 compared to 2019). In recent years, the share of zero-emission vehicles (ZEVs) in new sales has been increasing, in particular in the passenger car segment; which is expected to lower GHG emissions in the coming years.

The average rate of reduction since 2005 (by 2 Mt CO_2e per year) needs to increase more than tenfold to be consistent with the trajectories towards the overall 2030 – 55 % objective (– 26 Mt CO_2e per year in 2023–2030), and even more so after 2030 to be consistent with the 90 % reduction objective for transport GHG emissions by 2050 (– 31 Mt CO_2e per year in 2031–2050). Even steeper reductions (– 52 Mt CO_2e per year) would be required in 2031–2040 to be consistent with the scenarios underpinning the recommended 90–95 % reduction objective for 2040.

Figure 32 Indicator T1 – overall progress in reducing transport GHG emissions



Sources: See Figure 34 for detailed sources and notes.

Moderate growth in overall transport demand and encourage a modal shift.

Needs. The growth in overall transport demand in the EU needs to slow down, and part of the remaining demand should shift towards lower-emission transport modes (e.g. from aviation and road to rail and inland waterways (IWW) to be consistent with the scenarios that underpin the EU's 2030 and 2050 climate objectives. Activating demand-side mitigation levers in parallel with decarbonisation of supply is important to reduce pressure on constrained resources, to accelerate emission reductions and to reduce emissions in subsectors where supply-side decarbonisation technologies are not yet proven at scale (e.g. synthetic fuels). Whereas such demand-side levers primarily rely on (sub)national policies, these can be supported by EU policies, in particular when considering cross-boundary transport flows.

Gaps. Moderation of overall transport demand is not considered as an option in the EU's Sustainable and Smart Mobility Strategy **(policy gap)**. Furthermore, EU policies to support a modal shift (the Combined Transport Directive, the Rail Freight Corridors Regulation, the Trans-European Transport Network (TEN-T) regulation) have so far had little success owing to lack of ambition (e.g. outdated provisions in the Combined Transport directive that prevent digitalised workflows, lack of adequate delivery mechanisms in the Rail Freights Corridors Regulation, lack of an overview of current and future required capacities of intermodal terminals under the TEN-T regulation) **(ambition gap)** and incomplete and heterogeneous implementation at the Member State level **(implementation gap)**. Recent proposals by the European Commission (the 2021 proposal to revise the TEN-T regulation, the recent proposals for a regulation on the use of railway capacities and the revision of the Combined Transport Directive) aim to address these gaps. Given how recent they are, the Advisory Board has not been able to assess the adequacy of these proposals.

Recommendation T1. EU policies should seek to curb growth in overall transport demand, for example by supporting more efficient spatial planning at the (sub)national level where possible (see also Section 7.5).

Recommendation T2. EU policies should also more effectively support a modal shift by tackling non-market barriers that hinder a shift towards lower-emission transport modes, including operational and regulatory barriers, infrastructural bottlenecks, and lack of available and integrated data. To this end, EU legislators should adopt an ambitious revision of the Combined Transport Directive and the regulation on the use of railway infrastructure capacities. In parallel, both overall demand moderation and a modal shift should be further facilitated through a further alignment of pricing policies with climate objectives (see recommendations T5 and T6).

Promote uptake of the most efficient ZEVs.

Needs. The share of ZEVs in new registrations has been increasing in recent years, but the increase needs to accelerate to achieve the EU's objectives, in particular for vans and HDVs. Adequate charging/refuelling infrastructure and the availability of critical raw materials and batteries are the two main prerequisites for accelerated uptake of ZEVs.

Gaps. The EU has put in place several policies to increase the uptake of ZEVs. These include strengthened CO_2 emission performance standards for passenger cars and vans (adopted) and HDVs (proposed, currently under negotiation), the Alternative Fuel Infrastructure Regulation to enhance charging and refuelling infrastructure (adopted) and the revised Clean Vehicles Directive (adopted). In addition, EU State aid guidelines allow Member States to provide financial support for the purchase of ZEVs. Whereas these policies can effectively accelerate the uptake of ZEVs, they currently do not incentivise efficiency (smaller, more efficient vehicles) within the segment of ZEVs **(ambition gap)**, and might even incentivise the uptake of larger, less-efficient ZEVs **(policy inconsistency)**, increasing pressure on the already constrained availability of critical resources.

Recommendation T3. EU policies that incentivise the uptake of ZEVs should prioritise the uptake of energy- and resource-efficient ZEVs.

Prioritise direct electrification where possible, and promote biofuels only from sustainable feedstocks.

Needs. Achieving the required reductions by 2050 will require deep GHG reductions in all transport modes, and an acceleration of the trend in phasing out fossil fuel use. Direct electrification is an energy-efficient option with relatively low sustainability concerns. However, despite recent improvements in battery technology, decarbonising aviation, maritime and (specific segments of) heavy-duty road transport will probably require the use of low-carbon fuels, including synthetic fuels and sustainable biofuels.

Gaps. The RED III, ReFuelEU Aviation and FuelEU Maritime set specific objectives for the uptake of low-carbon fuels in the transport sector, while limiting the potential contribution of biofuels with high negative spillover risks. Nevertheless, concerns remain, as these policies continue to promote some biofuels with potentially high indirect effects, such as fuels made from food and feed crops (up to 7 %), intermediate crops and specific types of animal fats (so-called "category 3 animal fats") **(ambition gap)**. Furthermore, there are well-founded suspicions of fraud in the labelling of biofuels as sustainable **(implementation gap)**. This illustrates that the risk of spillover effects is inherent to biofuels, as impacts can be indirect (e.g. demand for fuel can contribute to land use change far away from a specific supply chain), and their sustainably available supply is constrained.

Recommendation T4. EU policies should prioritise direct electrification in the transport sector where possible. Given their limited availability, the use of sustainable biofuels and hydrogen-based fuels should be promoted for only those transport modes for which direct electrification is not suitable, such as aviation, long-haul shipping and possibly some cases of heavy-duty road transport. These policies should only promote the use of biofuels made from truly sustainable feedstocks, reflecting their overall limited availability.

Further align EU pricing policies in the transport sector with the EU's climate objectives (see also Chapter 10 'Pricing emissions and rewarding removals')**.**

Needs. Consistent EU pricing policies are needed to incentivise emission reduction options across all possible transport choices, including demand moderation, a shift towards lower-emission transport modes, and the uptake of ZEVs and low-carbon transport fuels. Such policies need to be accompanied by measures to address potentially adverse social impacts (see Chapter 11 'Whole-of-society approach').

Gaps. Recent policy developments are expected to improve the alignment of the EU's pricing policies in the transport sector with its climate objectives. The revised EU ETS will gradually phase out free allocation for aviation and extend the system to maritime transport by 2026, while introducing a separate EU ETS 2 for (amongst others) road transport fuels in 2027 or 2028. The revised Eurovignette Directive (adopted) mandates a shift from time-based to distance-based road pricing, which would better internalise externalities. The proposed revision of the ETD would limit current exemptions for commercial transport fuels, and for aviation and maritime transport.

However, gaps remain even when taking these recent developments into account. The price difference between the EU ETS and the EU ETS 2 (which is more likely due to the 'soft' price cap under the latter) would continue to promote fossil fuel use over electrification in the transport sector **(policy inconsistency)**. Furthermore, extra-EU aviation and half of extra-EU maritime transport remains exempt from the EU ETS **(policy gap)**. Finally, progress on the adoption of the ETD proposal has been slow, and current exemptions are still in force **(policy inconsistency)**.

Recommendation T5. In the short term, the proposed revision of the ETD should be adopted to phase out exemptions for commercial, aviation and maritime transport.

Recommendation T6. In the longer term (after 2030), carbon price levels between the EU ETS and the EU ETS 2 should converge to level the playing field between electrified and fuel-based transport (see also Chapter 10 'Pricing emissions and rewarding removals').

6.1 Scope and sectoral assessment framework

Scope

This chapter covers all activities that result in transport GHG emissions as reported under the United Nations Framework Convention on Climate Change (UNFCCC), including:

— emissions from road, rail, domestic navigation and domestic aviation, and other transport (CRF category I.3 – energy use in transport);
— emissions from international aviation and international maritime transport (on the basis of bunker fuels sold in the EU, which would cover all outgoing voyages and 'at berth' fuel consumption; reported as memo items in the GHG inventory).

Transport by active modes (walking, cycling, etc.) is not covered in the data shown in this chapter.

Throughout the chapter, it is further specified whether data shown includes international bunker fuels or not.

Greenhouse gas emission reductions required in the transport sector to reach climate neutrality

The European Green Deal (EC, 2019c) states that the transport sector will have to reduce its emissions by 90 % ([1]) by 2050 (compared to 1990, which implies a reduction of 92 % compared to 2005) as a contribution to the overall climate neutrality objective. The European Commission's LTS A Clean Planet for all (EC, 2018e) presents a similar reduction level, with transport emissions reduced by 89–90 % by 2050 under the 1.5TECH and 1.5LIFE scenarios (compared to 1990). Scenarios underpinning the Advisory Board's recent report on a greenhouse target for 2040 suggest that CO_2 emissions in transport could be reduced by up to 79 % by 2040 and 93 % by 2050 (compared to 1990) ([2]).

By 2030, the European Commission's scenarios that underpin the overall 55 % reduction objective require transport emissions excluding international aviation and maritime to reduce by 29 % compared

([1]) This includes international aviation, but not international maritime. Emissions from international maritime should reduce by 80 % by 2050 compared to 1990 (see footnote 8 of SWD(2020) 331 final).

([2]) Based on reductions in domestic transport emissions from the 90–95 % reduction scenarios assessed by the ESABCC, combined with an illustrative reduction for aviation based on the Sustainable and Smart Mobility Strategy.

to 2005. Emissions from international aviation and maritime transport would peak in 2025, and return to 2005 levels by 2030.

Assessment framework for the transport sector

The selection of outcomes, mitigation levers and enabling conditions is primarily based on the transport chapter (chapter 10 of the contribution of Working Group III) (IPCC, 2022j). Whereas the IPCC covers the challenges and opportunities to decarbonise the transport sector at a global level, its findings also apply to the EU context.

Outcomes. IPCC AR6 highlights a growing awareness that achieving the necessary GHG emission reductions in the transport sector will require a combination of demand management with new technologies. In line with this, two main outcomes are considered for the assessment:

- **curbing demand for emission-intensive transport**, which covers the need both to moderate overall demand (e.g. through digitalisation) and to switch part of it from emission-intensive to lower-emission transport modes,
- **decarbonising the transport fleet** through scaling up ZEV and fuel technologies, and improving the energy and resource efficiency of vehicles (in order to reduce emissions and resource use along the whole supply chain).

Mitigation levers. To achieve these outcomes, five main mitigation levers were identified, based on the different mitigation pathways described in IPCC AR6.

- An overall **moderation of transport demand** would lower GHG emissions, and can be pursued through a range of measures, including changes in infrastructure and spatial planning (referred to as 'urban form' in IPCC AR6), promoting changes in travel habits, shorter supply chains and digitalisation trends.
- A **modal shift** from emission-intensive (e.g. cars, lorries, planes) to lower-emission (e.g. rail, maritime and waterways, active transport) transport modes – including through multimodality – can contribute to GHG emission reductions, if the shift leads to an overall reduction in the activity of the most GHG-intensive transport modes (road and air).
- The uptake of **ZEVs** is a key lever to decarbonise the transport sector, and notably road transport. Electromobility has the potential to rapidly reduce GHG emissions, especially when combined with low-carbon electricity supply (see Chapter 4 'Energy supply'), but might need to be complemented by other types of ZEVs such as hydrogen-powered fuel cell electric vehicles or low-carbon fuels (see the final lever below) in specific circumstances.
- More **energy-efficient vehicles** can reduce GHG emissions both directly (lower tailpipe emissions) and indirectly (lower emissions from electricity production in the case of BEVs), fuel refining in case of internal combustion engine vehicles (ICEVs)). Similarly, more **resource-efficient vehicles** can indirectly reduce emissions from car manufacturing, including battery manufacturing (in the case of BEVs).
- For those subsectors that cannot be (fully) electrified, **a switch towards non-fossil, low-carbon fuels** can be used to achieve deep GHG emission reductions. This is particularly the case for the aviation and maritime sectors, and for some parts of heavy-duty road transport in particular circumstances. For these sectors, advanced bio- and hydrogen-based fuels (e.g. synthetic jet fuels for aviation, methanol and ammonia for maritime transport) are emerging as viable options, with the first pilot projects already in or close to operation today (IPCC, 2022g). The contributions of such fuels to atmospheric GHG concentrations depend strongly on their the types of inputs used (e.g. the type of biomass feedstock, hydrogen and CO_2 used) and their production processes.

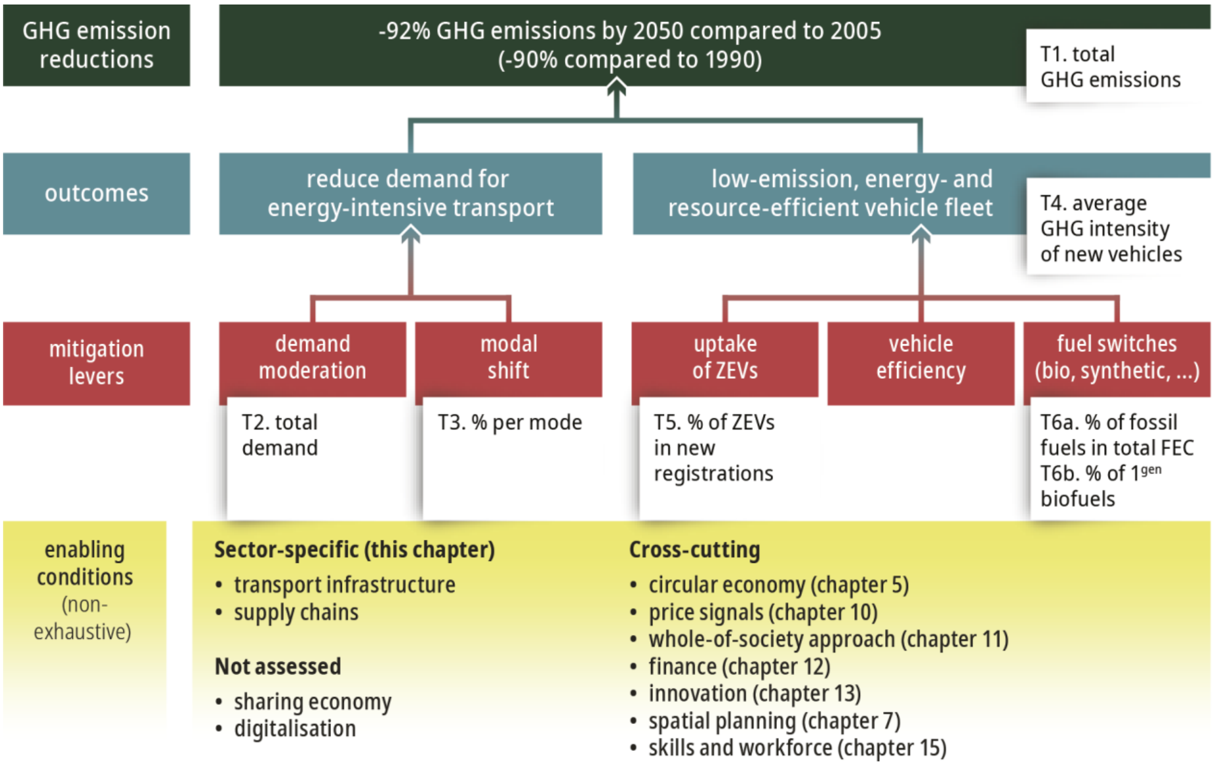
Enabling conditions. In addition, the Advisory Board identified seven enabling conditions (based on IPCC AR6) that can facilitate one or several of the levers described above.

— **Transport infrastructure** such as road, rail and waterway networks, cycling infrastructure and airport capacities is an important driver of overall transport demand and modal choices (IPCC, 2022j). Charging and refuelling infrastructure is a crucial enabler to facilitate the rapid uptake of ZEVs and non-fossil transport fuels in the transport system, in particular to increase user-friendliness and overcome range anxiety (IPCC, 2022j).
— **Price signals** determine the cost of use for different transport modes, vehicle technologies and fuel types, and can therefore enable both overall demand moderation and shifts to lower-emission transport modes, technologies and fuels. They include, for example, carbon prices, road charging, fuel taxes, congestion charges and parking fees. In general, transport GHG emissions are highly inelastic, at least in the short term (IPCC, 2022j). However, there are also indications that price elasticity increases over time and is three to four times larger if the price change is driven by persistent policies rather than market fluctuations. This is because policy-induced changes are expected to cause a more structural, long-term price increase than short-term fuel market price fluctuations, and are therefore more likely to trigger behavioural change and steer investment decisions (Andersson, 2019; Rivers and Schaufele, 2015).
— **Spatial planning** refers to the physical characteristics of human settlements, including their shape, size, density and configuration. It determines the need, time, space and cost of travel, which in turn can drive transport demand and modal choices (IPCC, 2022j) (see also Section 7.5).
— The **sharing economy** refers both to traditional mobility concepts such as carpooling and to more recent developments such as vehicle sharing and mobility as a service. There is still much uncertainty about the net effect of shared mobility on net emissions, although there is growing evidence that structural, large-scale behavioural change through shared mobility can indeed facilitate emission reductions (IPCC, 2022j).
— The **circular economy** could support emission reductions in the transport sector by reducing the amount of materials that need to be transported (through lower material use) and by reducing the distance across which these need to be transported (through more local value chains) ([3]). However, the net impact is still uncertain, as some evidence suggests that reductions in material use from more efficient product design are offset by increased consumer demand. Furthermore, the collection of waste streams for recycling purposes might also increase transport demand (IPCC, 2022j).
— **Digitalisation** can enable transport emission reductions in several ways (IPCC, 2022j). It enables teleworking and teleconferencing, which reduce travel demand. It also enables online shopping, although the net impact of this on transport emissions can be either positive or negative. Finally, it can support smart mobility, which could reduce transport demand and increase efficiency.

Some other cross-cutting enabling conditions, which are discussed in other chapters of this report (whole-of-society approach, finance, innovation and a skilled workforce), are also relevant to the transport sector, as shown in Figure 33. This figure also shows the indicators (shown in the white boxes) that were selected to track progress in the transport sector.

([3]) A similar impact could be achieved by other measures to shorten supply chains.

Figure 33 Assessment framework for the transport sector



Source: Advisory Board (2024).

6.2 Emission reduction progress

The EU has not managed to structurally reduce the emissions of its transport sector since 2005. A breakdown is shown in Figure 34. There were some reductions in 2008–2013, triggered at least partially by the economic crisis of 2008–2010. However, emissions have increased again since 2014, and by 2019 emissions were 2.4 % above 2005 levels. This increase was mainly caused by a strong growth in aviation emissions (+ 31 % by 2019 compared to 2005) combined with very limited reductions in other transport modes (– 1.5 % in 2019 compared to 2005) ([4]). The underlying drivers of the limited decrease in non-aviation emissions are an overall increase in transport activity and the lack of a modal shift to low-emitting transport modes, which have largely offset any improvements from efficiency improvements and fuel switches. The observed increase in car GHG emissions in the years preceding 2020 was mostly due to an increasing share of larger and heavier cars, such as sport utility vehicles (EEA, 2022d).

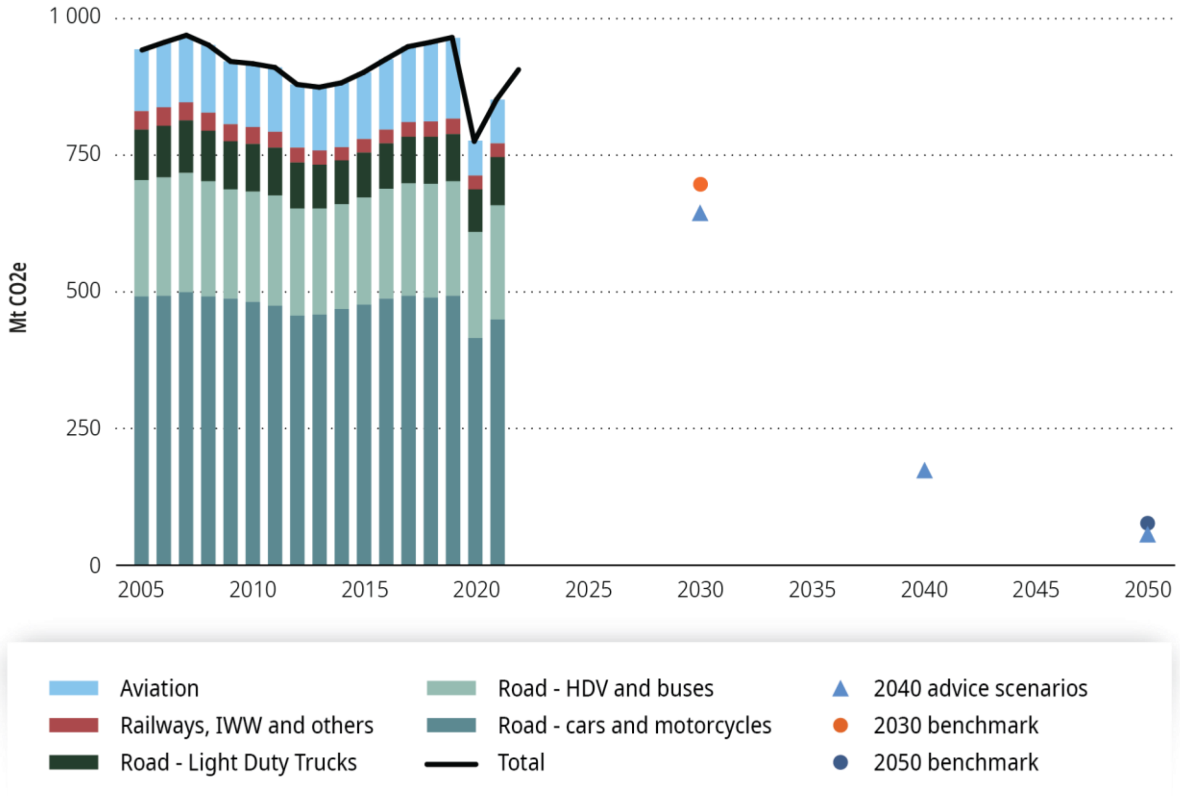
The COVID-19 pandemic caused a significant reduction in transport emissions in 2020, notably in emissions from aviation and cars. Although there was a partial rebound in 2021–2022, they were still 6 % below 2019 levels in 2022 (based on proxy data). Eurostat quarterly GHG emission data shows that this rebound continued in Q1 2023 (Eurostat, 2023q).

The average rate of emission reduction since 2005 (– 2 Mt CO_2e per year) needs to accelerate more than tenfold to be consistent the trajectories towards the overall 2030 – 55 % objective (– 26 Mt CO_2e per

([4]) Emissions including international aviation but excluding international maritime, in line with the 90 % reduction objective put forward by the European Green Deal.

year in 2023–2030), and even further after 2030 to be consistent with the 90 % reduction objective for transport GHG emissions by 2050 (– 31 Mt CO_2e in 2031–2050) as set out in the European Green Deal. In pathways consistent with the 90–95 % objective recommended by the Advisory Board, the reduction rate for 2031–2040 would need to be even higher (– 52 Mt CO_2e per year).

Figure 34 Indicator T1 – overall progress in reducing transport GHG emissions (including international aviation, excluding international maritime)



Notes: Historic emissions up to 2021 from the EU GHG inventory, with 2022 data based on proxy data reported to the EEA. 2030 benchmark based on the Fit for 55 MIX scenario. 2050 benchmark is calculated as a 90% reduction compared to 1990 as put forward by the European Green Deal and Sustainable and Smart Mobility Strategy thereunder. The 2040 advice range represents average domestic transport emission levels in the scenarios which underpin the Advisory Board's 2040 advice, combined with an illustrative path for aviation based on the Sustainable and Smart Mobility Strategy. All data includes international aviation but excludes international maritime transport, in line with the 90% reduction objective by 2050.

Sources: EU GHG inventory (EEA, 2023f), Fit for 55 MIX scenario (EC, 2021v), Sustainable and Smart Mobility Strategy (EC, 2020k), Advisory Board 2040 advice scenarios (ESABCC, 2023b).

6.3 Outcome 1: reduce demand for emission-intensive transport

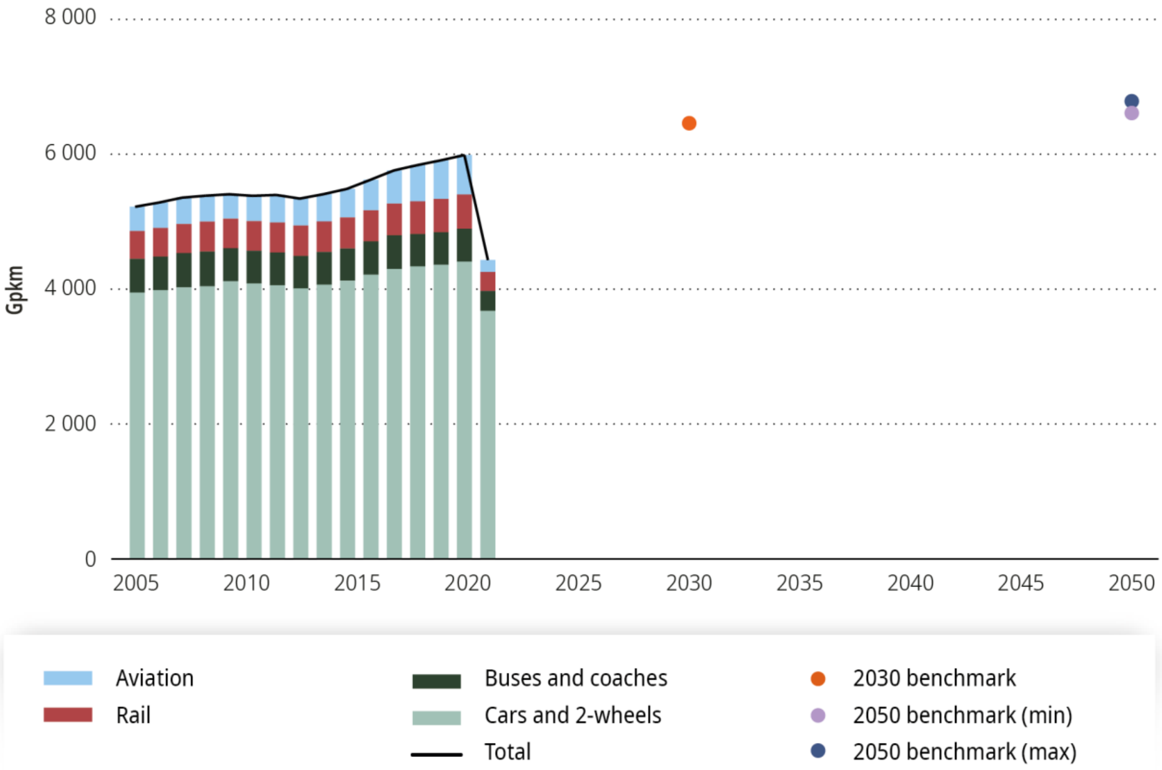
Lever: demand moderation

Both transport and freight demand have been increasing at a rate that is not in line with the European Commission's scenarios that underpin the EU's climate objectives.

Total passenger transport (including domestic and intra-EU aviation, but excluding water-based transport and extra-EU aviation because consistent data is lacking) increased from 2005, with an acceleration after 2013, before a sudden drop in 2020 linked to the COVID-19 crisis (see Figure 35).

About three quarters of the observed increase in 2005–2019 is due to higher demand per capita, with the remaining growth linked to the EU's increasing population. In relative terms, growth has been strongest for aviation (+ 62 % in 2005–2019), followed by rail (+ 23 %) and private road transport (+ 11 %). Total transport by bus and coach declined slightly (– 2 %). Under the European Commission's scenarios underpinning the EU's climate objectives, transport demand would continue to increase, but the average rate of increase would decrease by more than half compared to 2015–2019 until 2030, and then slow further in 2031–2050.

Figure 35 Indicator T2a – passenger transport demand

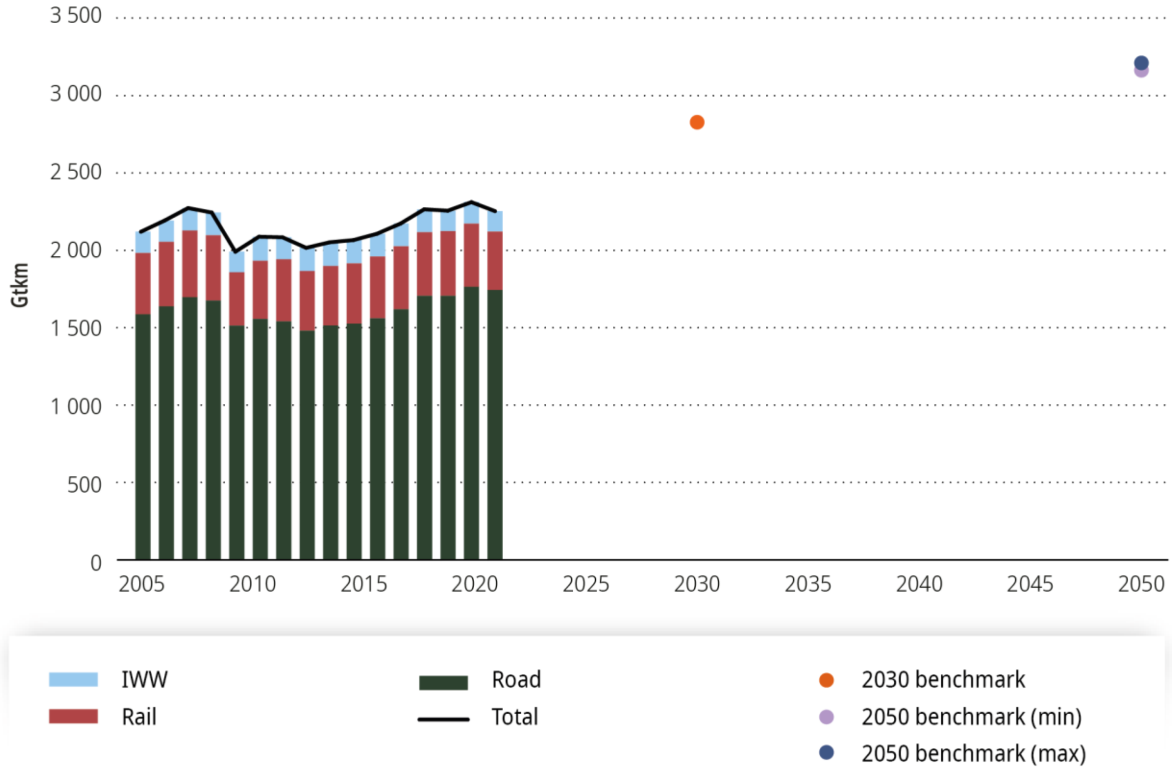


Notes: The 2030 benchmark is based on the Fit for 55 MIX scenario. The 2050 benchmarks are based on the 1.5TECH and 1.5LIFE scenarios of the in-depth analysis accompanying a Clean Planet for All (see figure 45, recalibrated for EU27 based on 2015 data). All data includes domestic and intra-EU aviation, but excludes extra-EU aviation, IWW and intra-EU maritime transport. All data expressed in billion passenger-kilometers (Gpkm).

Sources: Statistical pocketbook on transport 2022 (EC, 2022al), Fit for 55 MIX scenario (EC, 2021v), in-depth analysis accompanying A Clean Planet for All (EC, 2018e)

Figure 36 displays total freight transport demand, excluding aviation and maritime freight. Demand dropped following the economic crisis in 2008–2010 but rose steadily from 2013 until a limited drop in 2020 linked to the COVID-19 crisis. The relative increase was considerably higher for road transport (+ 11 % in 2005–2019) than for rail transport (+ 3 % in 2005–2019), whereas the volume of freight transported by IWW remained stable. Similarly to passenger transport, the European Commission's scenarios underpinning the EU's climate objectives assume a continued growth in freight transport demand but at a slower pace, in particular after 2030.

Figure 36 Indicator T2b – total freight transport demand



Notes: The 2030 benchmark is based on the Fit for 55 MIX scenario. The 2050 benchmarks are based on the 1.5TECH and 1.5LIFE scenarios of the in-depth analysis accompanying a Clean Planet for All (see figure 45, recalibrated for EU27 based on 2015 data). All data includes domestic and intra-EU aviation, but excludes extra-EU aviation, IWW and intra-EU maritime transport. Domestic maritime transport in 2030 was filtered out of the MIX scenario data based on the 2015 ratio between IWW and domestic maritime transport. All data expressed in billion tonne-kilometers (Gtkm).

Sources: Statistical pocketbook on transport 2022 (EC, 2022al), Fit for 55 MIX scenario (EC, 2021v), in-depth analysis accompanying A Clean Planet for All (EC, 2018e)

The EU's overall strategy to reduce transport GHG emissions does not aim to moderate demand.

The EU's overall strategy to reduce GHG emissions in the transport sector has been to focus exclusively on modal shifts and technological, supply-side improvements, without considering the option of curbing growth in demand. The 2011 White Paper on transport (EC, 2011) – which formed the overarching strategy for EU transport policies between 2012 and 2022 – had the objective of allowing continued transport growth while reducing GHG emissions by 60 % by 2050 thanks to a combination of modal shifts, increased efficiency and technological changes. It explicitly excluded the option of curbing mobility to achieve emission reductions. This overall strategy was maintained in the European Commission's Sustainable and Smart Mobility Strategy (EC, 2020k), which is the EU's overarching mobility strategy under the European Green Deal. It states that the greening of the mobility system, through modal shifts and technological changes, must be a new licence for the transport sector to grow, thereby confirming that the strategy will not aim to moderate or curb transport growth. So far, this strategy has proven ineffective in reducing GHG emissions, as incremental efficiency improvements and fuel switches have been outpaced by increased transport demand (see Section 6.2).

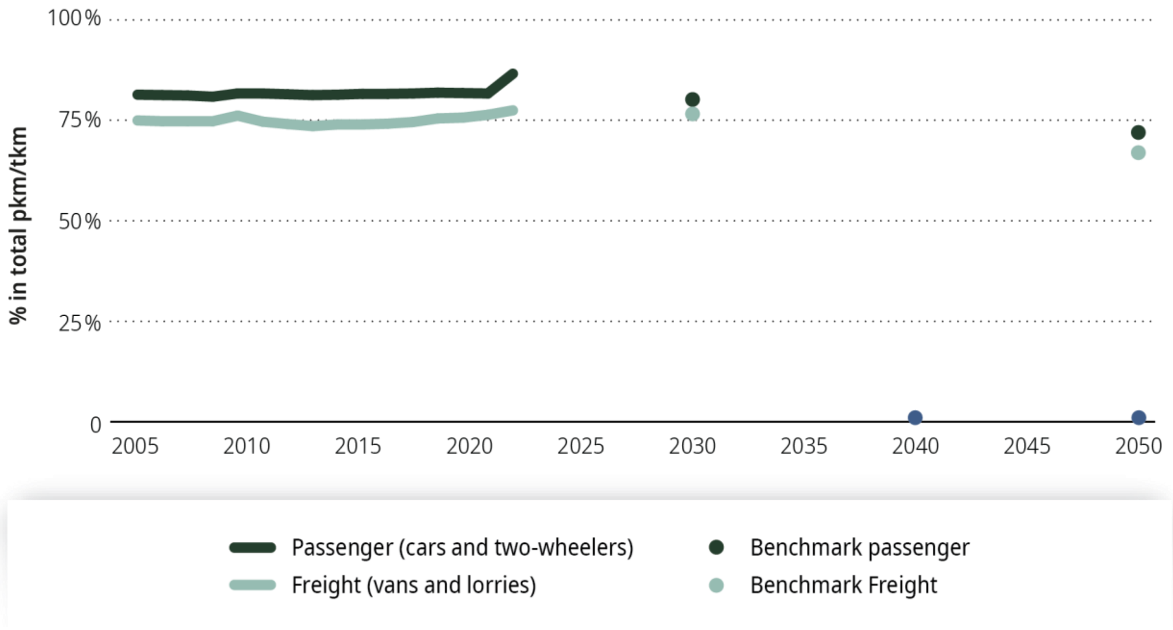
As transport demand has historically been strongly correlated with household income and overall economic activity (IPCC, 2022j), there is a risk that efforts to reduce overall transport demand could lead to reduced economic activity and corresponding income losses. Nevertheless, there are several enabling conditions that policymakers could activate to decouple this correlation (IPCC, 2022j). For instance, spatial planning policies that encourage more compact urban forms and reduce the distances people need to travel to work, education or services can also have positive economic and social co-benefits. A large body of literature (see Puga (2010) and Rosenthal and Strange (2004) for overviews) has found that density and spatial clustering of economic activity is linked to higher productivity, incomes and innovation – referred to as 'agglomeration economies'. The exact causes of agglomeration economies can vary, although research has generally pointed to how densification leads to the development of deeper labour markets, supply chain efficiencies, greater opportunities for knowledge spillover between workers and companies, and closer access to goods and services. While these benefits can come with trade-offs that must also be managed through spatial planning policies, such as congestion, pollution and higher land/housing prices (Duranton and Puga, 2020), there are synergies with other policy areas that can help to mitigate these trade-offs (e.g. reduced congestion from modal shifts, and lower pollution from uptake of ZEVs and renewable energy technologies).

Lever: modal shift

The EU has so far not managed to achieve a shift towards lower-emission transport modes.

Over the past decade, the increase in overall transport demand (both passenger and freight) has not been accompanied by notable shifts towards low-emission transport modes. As seen in Figure 37, road transport remained dominant in demand in inland transport, both for passenger and freight transport. Its share has even slightly increased in recent years. This trend is not in line with the European Commission's scenarios underpinning the EU climate objectives, which would require a decrease in the overall share of road in both passenger and freight transport by 2030 and 2050.

Figure 37 Indicator T3a – share of road transport in total motorised inland transport (excluding aviation and maritime, excluding active transport modes)



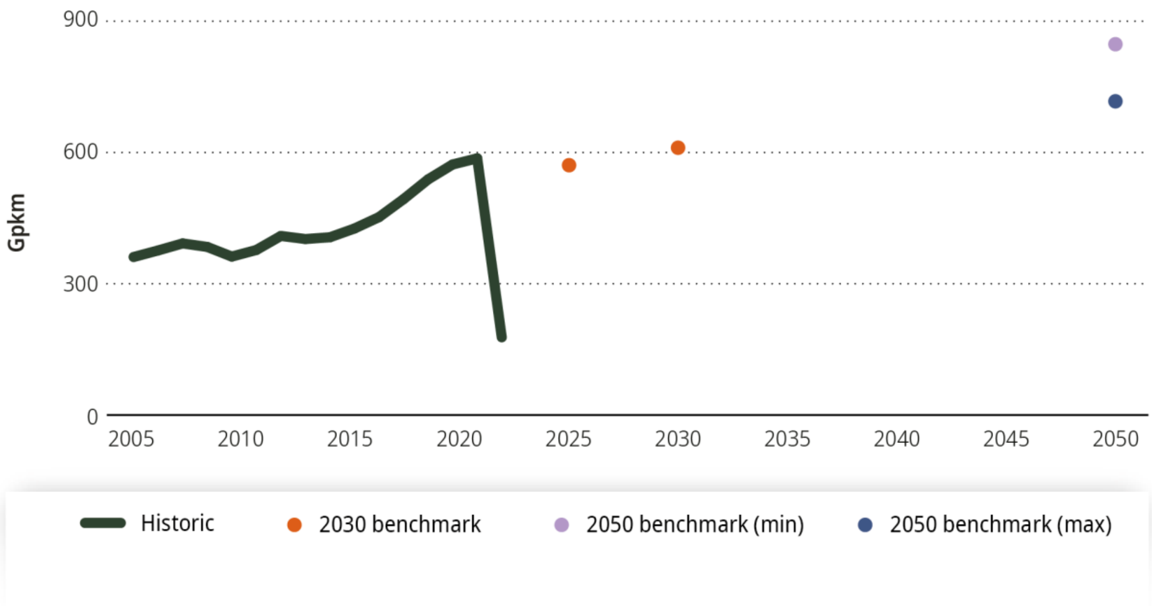
Notes: 2030 benchmark based on the Fit for 55 MIX scenario. 2050 benchmarks based on the 1.5TECH and 1.5LIFE scenarios of the in-depth analysis accompanying a Clean Planet for All (see figures 45 and 46, recalibrated for EU27 based on 2015 data).

All shares expressed as percentage of passenger-kilometers or percentage of tonne-kilometers in total motorised transport by road, rail or IWW. Aviation and international maritime are excluded, to filter out the effect of substantial growth in international (extra-EU) transport. Active transport modes (walking, cycling) are also excluded for lack of data. The 1.5TECH and 1.5LIFE scenarios do not provide a split between private and public road transport, so the share of buses and coaches has been assumed to remain at 9% under these scenarios.

Sources: Statistical pocketbook on transport 2022 (EC, 2022al), Fit for 55 MIX scenario (EC, 2021v), in-depth analysis accompanying A Clean Planet for All (EC, 2018e)

As mentioned in Section 6.2, there has been a particular increase in passenger aviation transport (see Figure 38). Between 2015 and 2019, intra-EU aviation grew by on average 33 Gpkm per year. This rate of increase is not in line with the European Commission's scenarios underpinning the EU's climate objectives, which anticipate growth of only 2 Gpkm per year until 2030 and 5–12 Gpkm per year thereafter.

Figure 38 Indicator T3b – intra-EU passenger transport by air



Notes: The 2030 benchmark is based on the Fit for 55 MIX scenario. The 2050 benchmarks are based on the 1.5TECH and 1.5LIFE scenarios of the in-depth analysis accompanying a Clean Planet for All (see figure 45, recalibrated for EU27 based on 2015 data).

Sources: Statistical pocketbook on transport 2022 (EC, 2022al), Fit for 55 MIX scenario (EC, 2021v), in-depth analysis accompanying A Clean Planet for All (EC, 2018e)

The Sustainable and Smart Mobility Strategy has put forward specific objectives to substantially increase passenger transport by high-speed rail (+ 100 % by 2030 and + 200 % by 2050 compared to 2015), and freight transport by rail (+ 50 % by 2030 and + 100 % by 2050 compared to 2015) and IWW (+ 25 % by 2030 and + 50 % by 2050 compared to 2015). As reflected in Figure 39, achieving these objectives would need a substantial acceleration of the observed annual rate of change in 2015–2019 for high-speed rail (+ 33 %) and rail freight transport (+ 600 %), and a reversal of the declining trend observed for IWW.

Figure 39 Indicator T3c – passenger transport by high-speed rail, and freight transport by rail and IWW

Sources: Statistical pocketbook on transport 2022 (EC, 2022al), Sustainable and Smart Mobility Strategy (EC, 2020k)

EU policies to trigger a modal shift have been ineffective.

In the past, the EU has put several policies in place to shift transport from road to rail and IWW. The 2011 White Paper on transport (EC, 2011) already included an objective to achieve a 50 % shift of medium-distance intercity passenger and freight journeys from road to rail and waterborne transport by 2050. However, as evidenced above, so far these objectives have not been achieved. Several causes have been identified for this lack of progress, including persistent operational and regulatory barriers (e.g. lack of interoperability, insufficient coordination and information sharing, lack of accessible data), infrastructural bottlenecks (hindered by high investment needs and low investment capacities), lack of available and integrated data and digital platforms, and higher costs of lower-emission transport modes (either perceived or effective) (ECA, 2023b; Finger et al., 2021; Pastori et al., 2018; Serafimova et al., 2022).

Several EU policies are already in place that address these issues, but so far they have been ineffective and insufficiently aligned with the EU climate ambitions. The Combined Transport Directive (EU, 1992), which governs intermodal freight transport in the EU, has not yet been revised since its inception in 1992, and both the European Commission and the ECA have assessed it as outdated and ineffective at promoting intermodal transport in the EU (EC, 2021s; ECA, 2023b). Key issues identified are legal requirements for paper documentation (preventing digitalised workflows) and a minimum threshold of 100 km for the non-road leg (which limits the scope of the directive). Furthermore, the implementation of the directive by Member States has been heterogeneous, which creates uncertainty for logistics operators. The Rail Freight Corridors Regulation (EU, 2010b) aims to boost the competitiveness of rail freight by creating transnational rail freight corridors but has been found to be insufficiently effective. Reasons include shortcomings within the regulation itself (e.g. the lack of adequate tools to deliver on its objectives, and the absence of an entity in the governance framework that transcends national interests) as well as how it was implemented at the national level (e.g. heterogeneous implementation due to lack of sufficiently clear rules, stakeholders approaching it as a tick-box exercise rather than implementing it in a way conducive to achieving its objectives) (EC, 2021f; Finger et al., 2021).

Finally, until recently EU pricing policies did not effectively support the modal shift. The Eurovignette Directive (EU, 1999) has not – except in a few specific cases – promoted a shift of freight towards lower-emission transport modes. Among the reasons cited are road charges applied under the directive being too low or insufficiently differentiated to trigger a substantial shift, and the lack of sufficient, reliable and efficient alternative transport modes (Gomez and Vassallo, 2020). The EU ETS has put the highest real carbon price (after accounting for free allocation) on electrified transport – such as the majority of rail transport, in which electricity accounts for 75 % of final energy use (Eurostat, 2023b) – whereas aviation has received most of its allowances for free, and road transport fuels have been excluded altogether. The ETD puts relatively high minimum energy tax rates on road transport fuels, but this is undermined by an exemption that allows lower rates for commercial passenger and freight transport. It also completely exempts aviation and maritime transport from energy taxation (see Chapter 10 'Pricing emissions and rewarding removals' for more details on the EU ETS and the ETD).

Several steps have been taken in recent years to address these issues. The Eurovignette Directive was revised in 2022 to expand its scope and to ensure better internalisation of transport externalities (EU, 2022d). The European Commission also announced a range of both legislative and non-legislative initiatives under the Sustainable and Smart Mobility Strategy and the Fit for 55 package, including an action plan to boost long-distance and cross-border passenger rail (EC, 2021k), a revision/replacement of the Rail Freight Corridors Regulation (EC, 2023av), a revision of the Combined Transport Directive (EC, 2023ap), a revision of the TEN-T regulation (see Section 6.5 below), the creation of a new EU ETS 2 for (amongst others) road transport, and a revision of the ETD (Chapter 10 'Pricing emissions and rewarding removals') ([5]). It is a positive development that the European Commission has acknowledged the need for additional efforts to achieve a modal shift and has taken steps in that direction, but it is too soon to assess whether these will be sufficiently effective, notably because these initiatives have not yet been adopted by the co-legislators (the TEN-T Regulation, a regulation on the use of railway infrastructure capacity that would replace the Rail Freight Corridors Regulation, the revision of the Combined Transport Directive) or will start to operate in the future (the EU ETS 2). Other reasons for concern are the lack of progress in the revision of the ETD (which, under the European Commission's proposal, would aim to tax the most environmentally harmful fuels the most and remove certain tax exemptions for fossil fuels, including transport fuels), and the 'soft' price cap under the EU ETS 2 (see Chapter 10 'Pricing emissions and rewarding removals').

When striving for a modal shift to reduce GHG emissions, it is important to consider the total aggregate impact, as measures to promote a modal shift (e.g. the construction of a new railway line) may lead to overall increases in transport demand (Kemp, 2016). Overall, the GHG reduction potential of a modal shift is largest where population density is large, whereas it is limited in more remote areas (Pastori et al., 2018). Furthermore, according to the ECA, urban mobility accounts for only 23 % of total transport emissions (ECA, 2020c). Consequently, although a modal shift in European cities could make significant contributions towards other environmental and societal objectives such as improved air quality, reduced noise nuisance, more efficient and safe mobility, it would yield only limited GHG emission reductions compared with modal shifts in intercity travel.

([5]) For a full overview, see the action plan annex to the Sustainable and Smart Mobility Strategy (EC, 2020k).

6.4 Outcome 2: low-emission and efficient transport fleet

Levers: uptake of zero-emission and efficient vehicles

The average CO_2 intensity of new vehicles is decreasing thanks to the uptake of ZEVs, but the rate of that uptake needs to accelerate to remain on track towards the 2035 objectives.

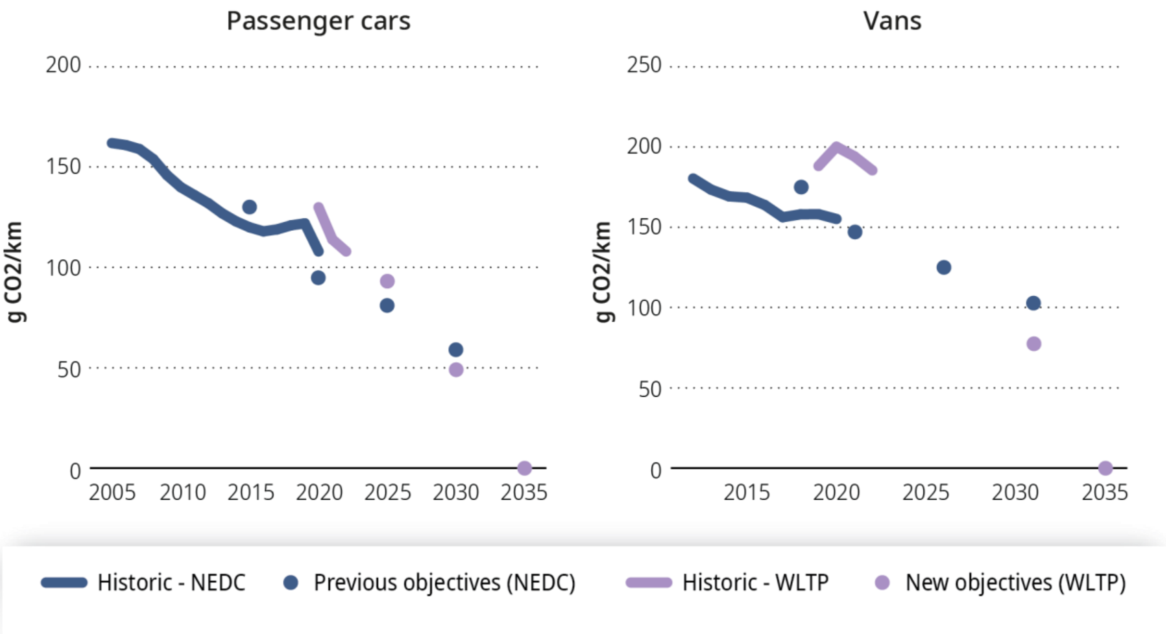
As shown in Figure 40, the average GHG intensity of new passenger vehicles declined in 2005–2015, but rebounded in 2016–2019 owing to a shift from diesel to petrol and the increased market share of sport utility vehicles and other larger and heavier cars (EEA, 2020). As of 2020, the GHG intensity started to decline again thanks to the increasing market share of plug-in hybrid electric vehicles (PHEVs) and BEVs, a trend that continued in 2021 and 2022. Progress in reducing the CO_2 intensity of new vans has been slower than for passenger cars. It declined steadily in 2005–2016, but then stagnated as a result of an increase in the average mass, engine capacity and size of vans. The downward trends resumed as of 2021 thanks to the uptake of zero-emission electric vans (EEA, 2023c).

HDV manufacturers have been required to monitor and report the CO_2 emission intensity of new vehicles since 2019 (EU, 2018d). Reported data so far shows that the average CO_2 intensity for new HDVs sold in 2019 to mid-2020 was 52.75 g CO_2 per tkm (EEA, 2022d). Current legislation requires this intensity to decrease by 15 % by 2025 and 30 % by 2030 (EU, 2019f). In 2023, the European Commission has proposed to increase the objective for 2030 to – 45 %, and to achieve a 65 % reduction by 2035 and a 90 % reduction by 2040 (EC, 2023ar). At the time of writing this report, the European Commission proposal had not yet been adopted by the Council and the European Parliament, and no data beyond 2020 on the average GHG intensity was yet available. Once more up-to-date data is available, it will be possible to assess the progress made and the required acceleration to remain on track towards the objectives set out in EU legislation.

Recent years have witnessed a breakthrough of BEVs on the European **passenger car** market, as illustrated in Figure 41. Their share in new registrations increased from less than 1 % in 2017 to more than 13 % in 2022. In the same period, the share of PHEVs increased from less than 1 % to almost 10 %, meaning that in 2022 more than 23 % of new passenger cars registered in the EU had a plug. Nevertheless, the uptake needs to accelerate even further (from on average + 3 pp in 2018–2022 to on average + 7 pp in 2023–2035) for the EU to achieve the binding objective of 100 % ZEVs by 2035 as set out under the revised CO_2 emission performance standards for cars and vans (EU, 2023k). Preliminary data from the European Automobile Manufacturers Association shows that the share of ZEVs in new car sales continued to increase in 2023 in line with earlier trends (12 % in January–April 2023 compared with 9 % in January–April 2022) (ACEA, 2023).

The uptake of battery electric **vans** seems to be following a similar trajectory, although with a few years' delay compared with passenger cars. The share of ZEVs (predominantly BEVs) among newly registered vans increased from less than 1 % in 2017 to 5 % by 2022, increasing by on average 1 pp per year in 2018–2022. This rate should increase to on average 8 pp per year in 2023–2035 to achieve 100 % ZEVs by 2035.

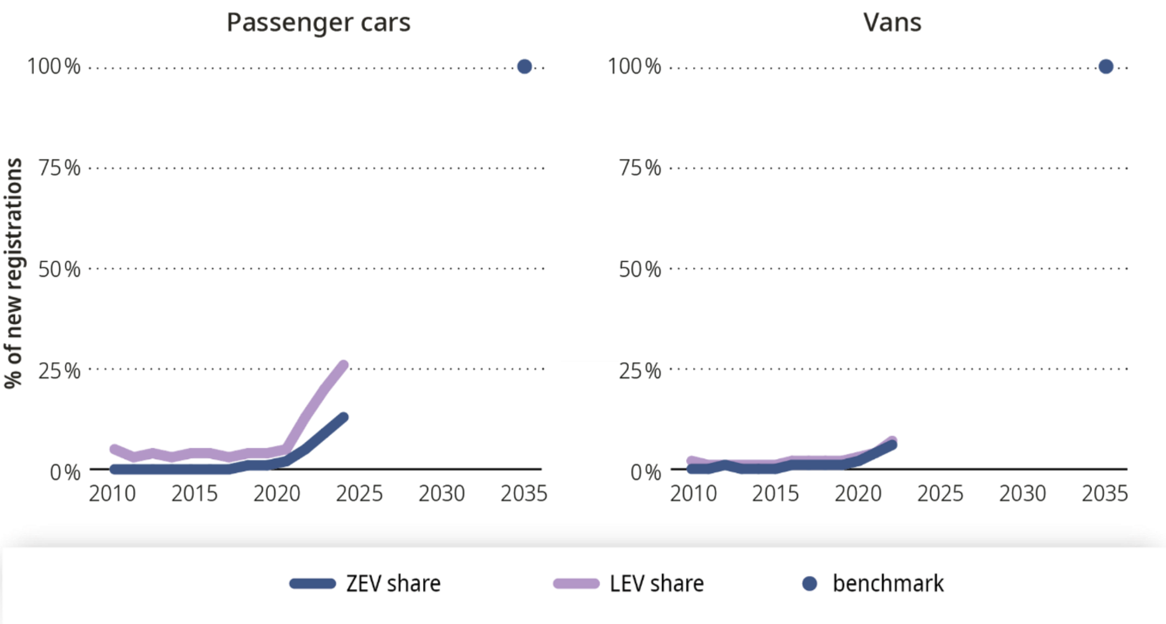
Figure 40 Indicator T4 – average GHG intensity of new passenger cars and vans (g CO_2/km)



Notes: Historic data is based on EEA data on emission intensity according to the New European Driving Cycle (data available up to 2020) and the Worldwide Harmonised Light Vehicle Test Procedure (data available as of 2020). The objectives are based on the CO_2 emission performance standards for passenger cars and vans.

Sources: EEA (2023c, 2023d) , CO_2 emission performance standards for passenger cars and vans (EU, 2019d, 2023k).

Figure 41 Indicator T5a – share of ZEVs in new registrations of passenger cars and vans

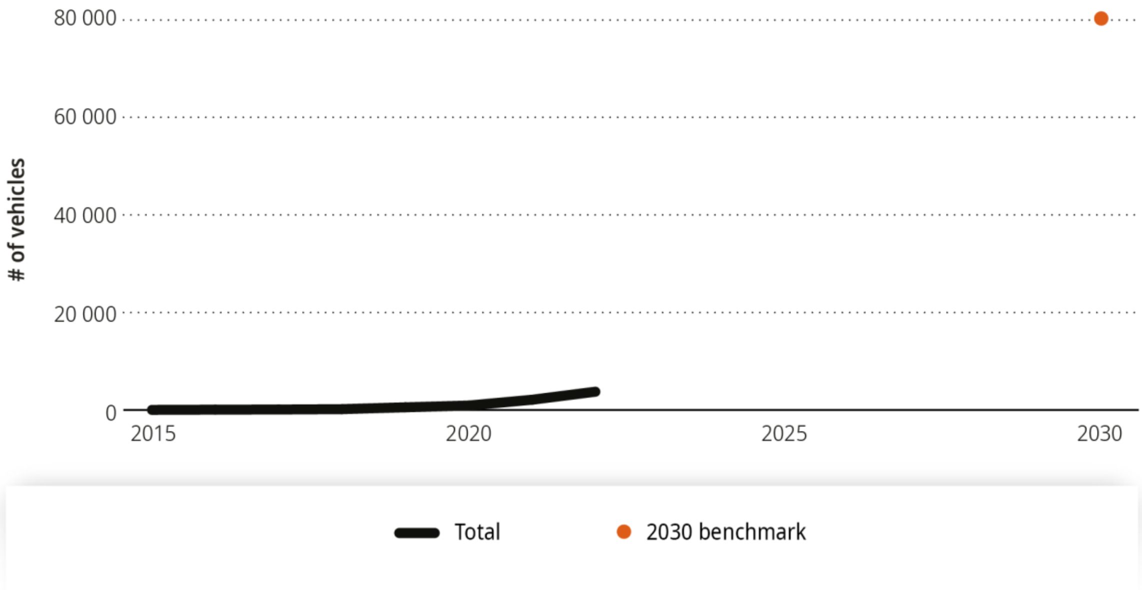


Notes: LEV refers to the share of low-emission vehicles, which primarily constitutes PHEVs, with a smaller contribution of CNG/LNG vehicles

Sources: European Alternative Fuels Observatory (EC, 2023ab), CO_2 emission performance standards for passenger cars and vans (EU, 2023k).

For **HDVs** (shown in Figure 42), the uptake of ZEVs has been slower, reflecting a lower maturity level ([6]) of zero-emission technologies for this segment. According to Eurostat, the share of ZEVs in new vehicle registrations was still very low in 2021 at 0.29 % for tractor trailers and 0.15 % for lorries (Eurostat, 2023b). The average annual rate of uptake would have to increase more than tenfold to have 80 000 zero-emission lorries in the EU fleet by 2030 as envisaged by the Sustainable and Smart Mobility Strategy.

Figure 42 Indicator T5b – total number of zero-emission lorries in the total EU fleet



Sources: European Alternative Fuels Observatory (EC, 2023ab), Sustainable and Smart Mobility Strategy (EC, 2020k).

Overall, ZEV technology is relatively new, and its uptake could be expected to follow a non-linear, S-shaped trajectory (see also Section 2.2). Therefore, although recent historical rates of change are not sufficient compared with the linear trajectories towards the objectives for 2030/2035, developments have been positive, and future years will need to clarify whether the deployment will accelerate as the technology matures. However, so far, the acceleration has not yet started, with the annual increase of ZEV shares in passenger cars relatively stable at 3 pp per year.

EU standards are an effective tool to drive the uptake of ZEVs, but currently fail to incentivise efficiency within the ZEV segment.

Emission performance standards for new vehicles have been the main tool in the EU policy toolbox to drive the uptake of ZEVs and increase vehicle efficiency. The most recent revision of the CO_2 emission performance standards for passenger cars and vans targets a 55 % reduction in CO_2 intensity for cars (50 % for vans) by 2030 (compared to the 2021 objective), and a de facto ban on the sale of non-ZEVs as of 2035 (EU, 2023k). Assuming an average 15-year lifetime for ICEVs, this should result in a completely zero-emission car and van fleet by 2050. The decrease in average CO_2 intensity suggests the policy instrument has been effective. The observed uptake of ZEVs in recent years is particularly promising with a view to achieving rapid emission reductions in the sector.

([6]) In particular, the relatively low energy density of batteries requires a trade-off between the range and the weight (and price) of battery electric HDVs.

However, while current emission performance standards incentivise energy efficiency within the segment of ICEVs and a switch from ICEVs to ZEVs, they do not provide an incentive (in addition to the electricity price) to increase efficiency within the segment of ZEVs (e.g. by prioritising the development and sale of compact, energy- and resource-efficient models). On the contrary, recent analysis (Gómez Vilchez et al., 2023; Thies et al., 2022) has cautioned that the current legislation incentivises car manufacturers to prioritise the development and sale of larger ZEVs over more compact ZEVs in two ways. Firstly, the calculation method to measure compliance with the CO_2 performance standards considers the mass of a vehicle, which means that replacing a large ICEV with a large ZEV will contribute more towards reaching the overall average CO_2 standard than replacing a compact ICEV by a compact ZEV. Secondly, ZEVs are still more costly to produce and have lower profit margins than ICEVs. Car manufacturers will therefore be more inclined to develop ZEVs for their larger car segment, as overall profit margins in that segment are higher (because there is less price elasticity in that market segment). Similarly, current State aid guidelines do not require Member States to differentiate financial support for clean vehicles as a function of their energy efficiency and resource efficiency (e.g. battery pack size), and most Member States are not doing this at the moment (IEA, 2023f). Currently, larger models including sport utility vehicles account for the majority (60 %) of all BEV models on the EU market (IEA, 2023e).

From a narrow perspective, faster electrification of the segment of larger vehicles is beneficial for the climate, as it yields the highest direct emission reductions. However, from a broader perspective the trend towards large electric vehicles is worrisome, as larger vehicles are more resource- and energy-intensive. On average, large BEVs weigh 50 % more, are 20 % less energy efficient and require 70 % more critical raw materials than smaller BEVs (IEA, 2023e). This increases their life cycle environmental footprint both directly (from higher electricity use) and indirectly (from higher resource use). Furthermore, the focus on larger, less efficient BEVs also undermines the overall availability and affordability of BEVs, as they add pressure on the constrained availability of critical raw materials, which is a key driver of their production cost. Reducing the average vehicle size is – together with the development of new battery types – a key pathway to moderate demand for (and therefore enhance the security of supply of) critical raw materials, which is a prerequisite to enable worldwide electrification of the transport fleet (IEA, 2023e).

For HDVs, emission standards were first introduced in 2019 (EU, 2019f), and currently revised under the Fit for 55 package (EC, 2023ar). The European Commission's proposal aims to reduce the average CO_2 intensity of new HDVs by 45 % by 2030 and 90 % by 2040 (compared to 2020 levels) and expands the scope to cover additional vehicle types such as buses and coaches (which would need to become zero-emission by 2030). A first independent assessment (not peer-reviewed) by the International Council on Clean Transport has found that, despite its overall high level of ambition, the regulation would lead to only 64 % GHG emission reductions by 2050 (compared to 1990), which falls short of the 90 % reduction envisaged by the European Green Deal (Mulholland and Rodriguez, 2023).

In addition to CO_2 emission performance standards, the EU also promotes the uptake of clean and energy-efficient road transport vehicles through public procurement, by means of mandatory minimum targets for each Member State set out in the Clean Vehicles Directive (EU, 2019c). Furthermore, in its Sustainable and Smart Mobility Strategy (EC, 2020k), the European Commission announced further proposals to boost the uptake of ZEVs in corporate and urban fleets. To date, to the Advisory Board's knowledge, no further actions in this domain have been taken.

Further action is needed to ensure security of supply and reduce the environmental impact of critical raw materials and batteries.

Battery technology and production costs have improved substantially over the last decade, and the overall expectation is that costs will continue to decrease with technological advances and economies of scale, even when taking into account raw material price increases (Mauler et al., 2021). As a result, the total cost of ownership of passenger car BEVs has decreased and is approaching parity with ICEVs in at least some market segments (IEA, 2022a). These developments have also increased the technological feasibility and economic competitiveness of battery electric HDVs (Bhardwaj and Mostofi, 2022; Nykvist and Olsson, 2021), and several lorry manufacturers are currently offering commercial BEV models or are planning to do so in the coming years (Mollière, 2023).

However, key bottlenecks in their large-scale deployment persist, such as the lack of available charging infrastructure (see Section 6.5) and the availability of critical raw materials and batteries (ECA, 2023d; Hao et al., 2019; IEA, 2021b). The EU is in a particularly vulnerable position, due to its limited domestic capacity to extract and process critical raw materials and produce batteries. Furthermore, global value chains are concentrated in just a few countries, primarily China, which produces 75 % of all lithium ion batteries and is home to 70 % of the production capacity for cathodes and 85 % of the production capacity for anodes (ECA, 2023d; IEA, 2022b). Finally, there is strong competition between different regions in the world to attract private investment in clean technology value chains – including battery production – as illustrated by the US Inflation Reduction Act. The combination of the EU's limited own extraction, processing and production capacities and its high dependence on imports from a limited number of trading partners with strong incentives in other regions of the world to attract investments in battery supply chains, and projected strong increases in demand globally, makes it very vulnerable to supply chain disruptions.

The European Commission is aware of this challenge and has taken several initiatives to tackle the issue. In 2017, it launched a European Battery Alliance, which is a platform for cooperation with key industrial stakeholders, interested Member States, the European Investment Bank (EIB) and the scientific community to build up battery technology and production capacity in the EU (EC, 2017). In 2018, it followed up with a Strategic Action Plan on Batteries, which listed a range of actions to further build up a competitive EU battery value chain (EC, 2018a). In 2023, as part of its Green Deal Industrial Plan in response to the US Inflation Reduction Act, it proposed a Critical Raw Materials Act (EC, 2023ac) and Net-Zero Industry Act (EC, 2023ao), which contain objectives aimed at boosting the EU's domestic supply chains for critical raw materials and manufacturing of strategic net zero technologies (respectively), including for batteries.

A recent report by the ECA (ECA, 2023d) has found that the European Commission's promotion of an EU industrial policy on batteries has been largely effective, despite some shortcomings regarding monitoring, and regarding coordination and targeting of support. Furthermore, it concluded that projected battery production capacity (based on companies' announcements) would be largely sufficient to meet projected EU battery demand for 2025 and 2030. However, it also warned that the actual deployment of this production capacity is subject to several risks, including time lags, and battery manufacturers reversing on their investment plans because of increasing costs in the EU or more attractive financial conditions offered in regions outside the EU. Furthermore, it warned that access to raw materials remains a major strategic challenge for the EU's battery value chain, which faces a looming global shortage of some key raw materials as of 2030. As a result, the EU might not be able to supply sufficient batteries to achieve its objective of 100 % of new cars and vans sold being ZEVs as of 2035. It would therefore have to rely on considerable imports from other regions of the world, which would undermine its security of supply and would outsource investments and jobs in clean technologies.

IPCC AR6 also highlights the need to address adverse impacts of battery production such as GHG emissions, non-climate environmental impacts and labour rights (IPCC, 2022g). There are several possible approaches to pursue this, which can also increase the EU's resilience against supply chain disruptions, such as such as prioritising smaller, more resource-efficient vehicles, increased recycling or repurposing of batteries (Ioakimidis et al., 2019; Iturrondobeitia et al., 2022; Unterreiner et al., 2016) and switching to alternative battery types (Feng et al., 2022).

Lever: fuel switches

Progress in phasing out fossil transport fuels has been too slow, and relied heavily on first-generation biofuels with high indirect land use change (ILUC) risks.

The share of fossil fuels in the transport energy mix (shown in Figure 43) decreased only slightly from 98 % in 2005 to 93 % by 2021. This reduction was almost exclusively achieved by a shift from fossil fuels to biofuels, whereas the share of electricity remained very small (from 1.4 % in 2005 to 1.5 % in 2021).

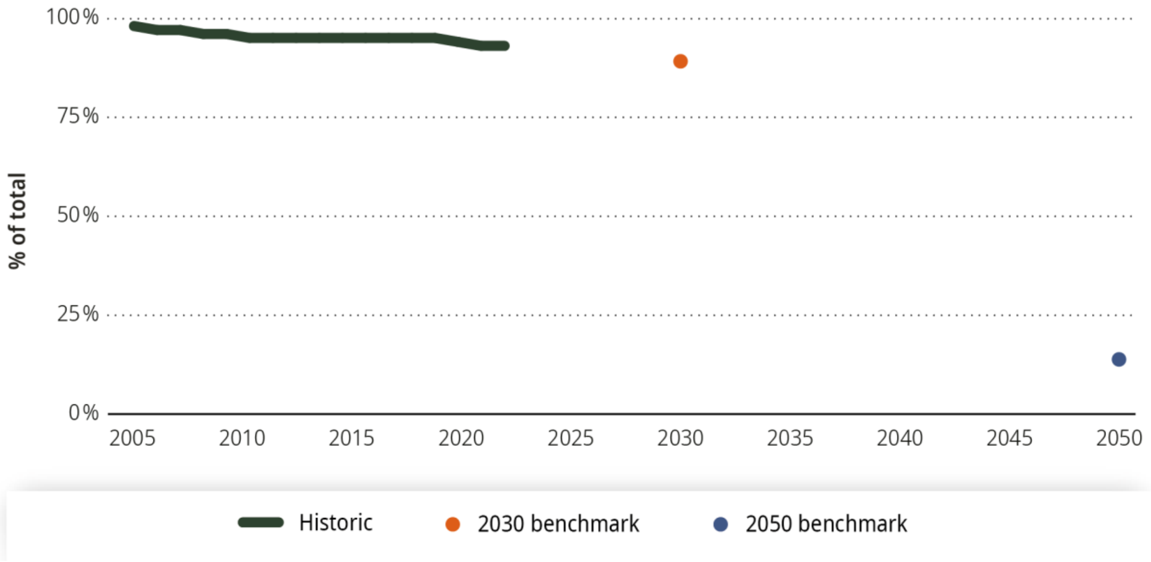
The European Commission's scenarios that underpin the EU climate objectives would require an acceleration of this trend, notably after 2030. This would require a combination of direct electrification and the use of low-carbon fuels (hydrogen and related derivates, and sustainable biofuels). Under the MIX scenario underpinning the Climate Target Plan (EC, 2020s), about 80 % of passenger cars and 70 % of vans would be electric ([7]) by 2050. For HDVs, the feasible share would be lower, with 18 % BEVs and 26 % PHEVs by 2050. Regarding the total energy mix for transport (including aviation and maritime), the share of fossil fuels would decline to 14 % by 2050, to be replaced by electricity (21 % by 2050), hydrogen and related derivates (41 % by 2050) and biofuels (24 % by 2050). However, since the publication of the Climate Target Plan, significant advances have been made regarding electrification technologies, which would make even greater electrification of road freight transport more feasible than it was considered a few years ago, including for HDVs. Nevertheless, low-carbon fuels would still be required to decarbonise international maritime and aviation transport (ESABCC, 2023b).

Biofuels made from food and feed crops (hereafter referred to as first-generation biofuels) accounted for the majority of the biofuels used in the transport sector (EEA, 2022j). Figure 44 displays their absolute volumes, showing that their use increased by almost 60 % in 2011–2019, after which it reduced slightly in parallel with overall lower energy use in the context of the COVID-19 pandemic ([8]). Under the European Commission's scenarios that underpin the EU climate objectives, their use could only increase slightly until 2030, and then phase out completely by 2050.

([7]) The majority (70 % of passenger cars, 63 % of vans) would be fully electric (BEV), with a small minority of PHEVs.

([8]) These figures are based on the SHARES summary results, and only take into account biofuels which meet the minimum GHG savings and sustainability criteria set out in the Renewable Energy Directive.

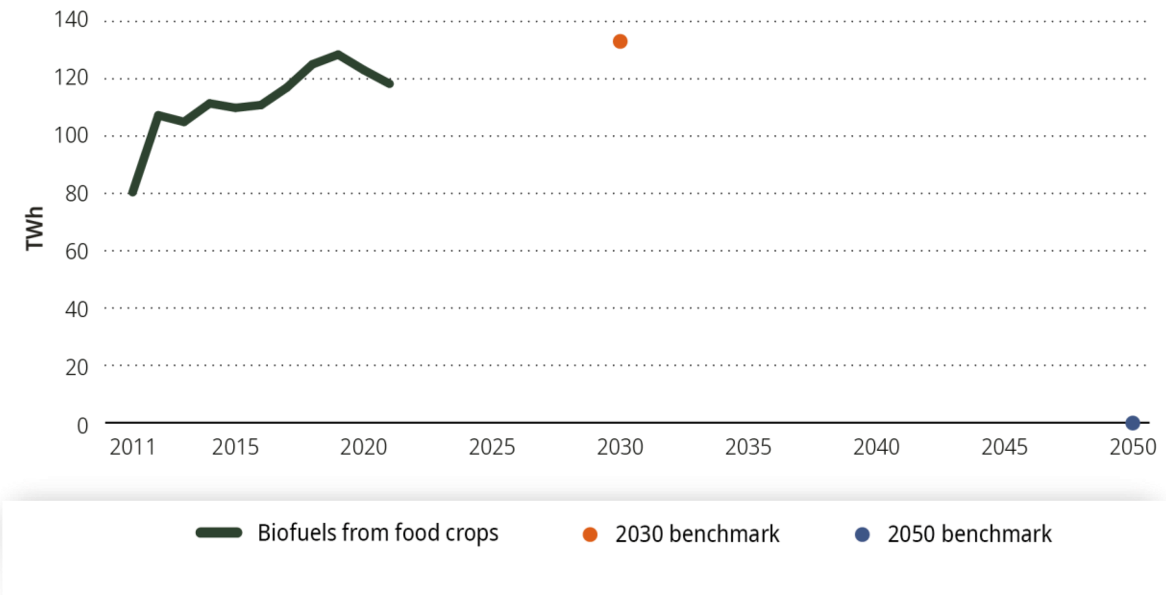
Figure 43 Indicator T6a – share of fossil fuels in transport energy use (including international bunker fuels)



Notes: 2030 and 2050 benchmarks based on the MIX scenario from the Climate Target Plan impact assessment.

Sources: Eurostat energy balances (2023b), Climate Target Plan impact assessment (EC, 2020s).

Figure 44 Indicator T6b – use of first-generation biofuels in the transport sector



Notes: Historic data based on the EU SHARES tool database. The 2030 and 2050 benchmarks are based on the MIX scenario from the Climate Target Plan impact assessment (see figures 77 and 79). Values converted from Mtoe to TWh

Sources: EU SHARES database (Eurostat, 2023r), Climate Target Plan impact assessment (EC, 2020s).

EU policies continue to promote transport biofuels, which have inherent spillover risks.

Since 2003, EU policies have actively incentivised the use of biofuels in the transport sector (EU, 2003). However, awareness has since increased about the high risk of harmful ILUC effects from EU biofuel policies, which could have a net effect of increasing atmospheric GHG concentrations (see e.g. Valin et al., 2015). This led to more stringent rules under the RED II of 2018 (RED II), which increased the total renewable target for transport to 14 % by 2030 but set a cap on the potential contribution of food- and feed-based biofuels at a maximum of 7 % after 2020 ([9]), and required a phase-out by 2030 of the promotion of biofuels made from feedstocks with a high ILUC risk (EU, 2018b).

The Renewable Energy Directive was recently revised (RED III) as part of the Fit for 55 package (EU, 2023). One major change in the agreed outcome is the option for the EU Member States to pursue either a renewable energy target (29 % by 2030) or a GHG intensity reduction target (– 14.5 % by 2030 under the RED III) in the transport sector. The latter option could result in considerably higher overall GHG savings at a considerably lower cost than the renewable energy objective (Christensen, 2021; Baldino and Searle, 2021). Furthermore, the 7 % cap on food- and feed-based biofuels was maintained, as was the required phase-out of fuels made from high-ILUC feedstocks. However, there are concerns that this cap does not sufficiently tackle the problem. The directive continues to promote first-generation biofuels (up to 7 %) and does not stipulate a full phase-out of these fuels (even if they are assumed to be fully phased out by 2050 under the European Commission's scenarios underpinning the 2050 climate neutrality objective). Furthermore, the International Council on Clean Transport has warned that intermediate crops ([10]) are not covered by the 7 % cap, and certain types of them could cause ILUC emissions of the same order of magnitude as regular food and feed crop biofuels. Even more, because they are relatively low-cost to produce, they warn of a potential paradox that the increased renewable energy objective would lead to a high uptake of biofuels from intermediate food and feed crops, thereby reducing overall GHG emissions savings (Baldino and Searle, 2021; Christensen, 2021; Searle, 2021). Furthermore, despite previous warnings by the ECA (ECA, 2016) and reports commissioned by non-governmental organisations (van Grinsven et al., 2020), the issue of fraud in the labelling of biofuels persists (Moskowitz et al., 2023).

In addition to the RED III, the Fit for 55 package also introduced two separate pieces of legislation to decarbonise the fuel mix in the aviation (ReFuelEU Aviation) (EU, 2023q) and maritime sectors (FuelEU Maritime) (EU, 2023p). The first one sets a mandatory requirement for aircraft operators to use a minimum share of 2 % sustainable aviation fuels by 2025, increasing to 6 % by 2030 and 70 % by 2050 (with specific subtargets for synthetic aviation fuels). For maritime fuels, another approach was chosen, which requires their average GHG intensity to decrease by 2 % by 2025, 6 % by 2030 and 80 % by 2050 (compared with a reference value of 91.16 g CO_2e/MJ). Given the lack of progress in these sectors, it is encouraging that separate legislation has been put in place to drive GHG emission reductions in aviation and maritime transport. However, the first assessments have warned they risk reintroducing issues with the sustainability of the biofuels they promote. Whereas ReFuelEU Aviation is more stringent than the RED III on some types of biofuels (e.g. by excluding fuels made from intermediate crops), it does not apply a cap on waste oils and animal fats (which are restricted under the RED III). A report commissioned by a non-governmental organisation has warned that this could increase demand for fuels made from category 3 animal fats, which could drive indirect emission increases by triggering a shift to fossil feedstocks in other sectors such as the chemicals sector (Malins, 2023). The FuelEUMaritime regulation is more stringent than the RED III with regard to fuels made from food and feed crops (which cannot

([9]) Or 1 pp higher than the 2020 value in a specific Member State, whichever value is lower.

([10]) Defined as crops that are not grown as the main crop as per Article 2 (40) of RED II.

count towards the targets under the regulation) but does not put restrictions on biofuels from other feedstocks with high ILUC risks.

The remaining concerns described above highlight the challenge of designing and implementing policies that can effectively promote the use of sustainable biofuels while avoiding potential negative spillover effects. This is because those spillover effects are in large part inherent to biofuels, as impacts can be indirect (e.g. demand for fuel can increase overall demand for agricultural commodities, thereby contributing to land use change far away from a specific supply chain), and their sustainably available supply is constrained.

There are strong arguments for prioritising direct electrification over the use of hydrogen- and bio-based fuels.

There are in total three alternatives to fossil fuels in the transport sector: direct electrification, hydrogen and its derivatives, and sustainable biofuels. A report by Trinomics for the European Parliament (Trinomics, 2023b) found that direct electrification is the most energy efficient and has the lowest sustainability concerns of these three alternatives, even if it also faces potential constraints on raw materials for batteries. Hydrogen-based fuels and biofuels can also deliver substantial GHG emission reductions, but their scalability is constrained by limited availability of the required inputs (sustainable feedstocks for biofuels, zero-emission electricity for hydrogen, and biogenic or atmospheric CO_2 for synthetic fuels), their cost-competitiveness and their technological readiness.

As all transport modes need to be significantly decarbonised to achieve the 90 % reduction objective, there is thus a strong argument for prioritising direct electrification and reserving the use of hydrogen-based fuels and sustainable biofuels for transport modes that are technologically difficult to electrify directly. These include aviation, long-haul shipping and, in some circumstances, heavy-duty road transport (IPCC, 2022j; Trinomics, 2023b).

The study by Trinomics (2023) also compares sustainable biofuels with hydrogen and its derivatives. Whereas sustainable biofuels are more affordable (currently, but probably also in the longer term), they have the disadvantage of facing more stringent availability limitations than hydrogen-based fuels. These constraints are expected to continue in the longer term, as there will be competing demand for biogenic carbon from other sectors. This increases the importance of limiting policy incentives to sustainably sourced biofuels. On the other hand, hydrogen-based fuels are less subject to sustainability constraints, but are more expensive, at a lower technological readiness level and energy-inefficient to produce, which limits their scalability at least in the short to medium term. However, the prospects of future cost reductions through technological improvements, economies of scale and increased availability of zero-emission electricity could improve their scalability in the medium to longer term.

6.5 Enabling condition: transport infrastructure

The EU provides considerable support for transport infrastructure through a range of funds, including the Cohesion Fund, the European Regional Development Fund, the Connecting Europe Facility and the RRF. The Advisory Board has not assessed whether the investments in transport infrastructure under these funds have been consistent with the EU’s climate objectives and in particular its ambitions to achieve a shift towards lower-emission transport modes.

The TEN-T regulation is a specific EU policy instrument to develop a consistent, efficient, multimodal, and high-quality transport infrastructure across the EU (EU, 2013b). However, a recent report by the ECA (ECA, 2023b) has criticised the fact that the current regulation does not require an analysis of the adequacy of existing intermodal terminals and the need for future terminals to meet current and potential future traffic flows. It also does not require the collection of information on the digitalisation of terminal infrastructure, which would allow logistics operators to share information efficiently. Furthermore, Member States have made insufficient progress in ensuring the compliance of their infrastructure with the technical requirements set out in the TEN-E Regulation. In 2021, the European Commission published a proposal for a revision of the TEN-T regulation, with the aim of aligning it with the European Green Deal and the ambition to achieve a 90 % GHG emission reduction in transport by 2050 (EC, 2021ah). Specific measures in the proposal include obligations for Member States to allow faster speeds (at least 160 km/h) on all passenger lines on main TEN-T rail stretches, make it possible for lorries to be transported by train, connect large airports to rail, and increase the number of multimodal transport hubs for freight and multimodal stations for passengers. It would also address the shortcomings described above, by requiring better information on terminal location and digitalisation, and including more means for the European Commission to ensure proper implementation at the Member State level (ECA, 2023b). At the time of publication of this report, the European Parliament and the Council had reached a provisional agreement on the proposal.

The lack of available charging infrastructure has been identified as a key bottleneck to achieving rapid and large-scale electrification of the transport fleet (Nykvist and Olsson, 2021; Osieczko et al., 2021; Shoman et al., 2023). To address this, in 2023 the EU adopted the Alternative Fuels Infrastructure Regulation, which sets binding minimum national targets for charging infrastructure (EU, 2023o). Although it is generally recognised as an effective tool to ensure adequate charging infrastructure, an independent assessment (not peer-reviewed) by the International Council on Clean Transport has warned that the targets for HDV charging stations are insufficiently ambitious, as they are based on conservative estimates of the deployment of heavy-duty BEVs (Basma and Rodriguez, 2021).

6.6 Summary tables

Table 8 Progress summary - transport

Indicator	Reference period	Historical progress	Required up to 2030	Required in 2031–2050
T1: GHG emissions	2005–2022	– 2 Mt CO_2e/yr	– 26 Mt CO_2e/yr	– 31 Mt CO_2e/yr
T2: transport demand				
T2a: passenger	2015–2019	+ 92 Gpkm/yr	+ 41 Gpkm/yr	+ 10 to + 17 Gpkm/yr
T2b: freight	2015–2019	+ 51 Gtkm /yr	+ 46 Gtkm/yr	+ 18 to + 19 Gtkm/yr
T3: modal shares				
T3a: % of cars in passenger transport ([a])	2015–2019	Stable	– 0.2 pp/yr	–0.2 pp/yr
T3b: % of lorries in freight transport ([a])	2015–2019	+ 0.6 pp/yr	– 0.4 pp/yr	–0.2 pp/yr
T3c: aviation passenger transport	2015–2019	+ 33 Gpkm/yr	+ 2 Gpkm/yr	+ 5 to + 12 Gpkm/yr
T3d: high-speed rail passenger transport	2015–2019	+ 5 Gpkm/yr	+ 8 Gpkm/yr	+ 5 Gpkm/yr
T3e: rail freight transport	2015–2019	+ 2 Gpkm/yr	+ 17 Gpkm/yr	+ 10 Gpkm/yr
T3f: inland waterway freight transport	2015–2019	– 2 Gpkm/yr	+ 4 Gpkm/yr	+ 2 Gpkm/yr
T4: road vehicle CO_2 intensities				
T4a: passenger cars (new sales)	2018–2022	– 9 g CO_2/km/yr	– 7 g CO_2/km/yr	– 10 g CO_2/km/yr ([b])
T4b: vans (new sales)	2018–2022	– 1 g CO_2/km/yr	– 8 g CO_2/km/yr	– 16 g CO_2/km/yr ([b])
T5: uptake of ZEVs				
T5a: passenger cars (% in new sales)	2018–2022	+ 3 pp/yr	+ 7 pp/yr (to reach 100 % by 2035)	
T5b: vans (% in new sales)	2018–2022	+ 1 pp/yr	+ 8 pp/yr (to reach 100 % by 2035)	
T5c: lorries (number of ZEVs in total fleet)	2018–2022	+ 729/yr	+ 9 526/yr	No benchmark
T6: fuel mix				
T6a: % of fossil fuels	2017–2021	– 0.4 pp/yr	– 0.5 pp/yr	– 4 pp/yr
T6b: % of first-generation biofuels	2017–2021	+ 0.4 pp/yr	+ 0.04 pp/yr	– 0.6 pp/yr

Legend

On track	The required change ([c]) is ≤ 1.
Almost on track	The required change ([c]) is between 1 and 1.5.
Somewhat off track	The required change ([c]) is between 1.5 and 2.
Considerably off track	The required change ([c]) is ≥ 2.
Wrong direction	The required change ([c]) is < 0.

([a]) Inland transport, excluding aviation and maritime transport volumes.

([b]) To achieve the legally binding objectives for 2035 (cars and vans) or 2040 (lorries).

([c]) See Section 2.2 for more details on how the required change is calculated.

Table 9 Policy consistency summary - transport

Policy inconsistencies	– Current CO_2 emission performance standards incentivise car manufacturers to prioritise larger, less efficient vehicles within the segment of ZEVs. – The price cap mechanism under the EU ETS 2 increases the likelihood of a lower price than under the EU ETS, which undermines electrification in the transport sector. – The ETD continues to provide exemptions for commercial transport fuels, and for aviation and maritime. The proposed revision to tackle this has not yet been adopted. – The RED III, ReFuelEU Aviation and FuelEUMaritime continue to promote some biofuels with potentially high indirect effects, such as fuels made from food and feed crops, intermediate crops and category 3 animal fats.
Policy gaps	– There are no dedicated policies or strategies to curb overall transport demand; moderation of overall transport demand is not considered as an option in the EU's Sustainable and Smart Mobility Strategy. – Extra-EU aviation and half of extra-EU maritime transport remains exempt from the EU ETS.
Ambition gaps	– EU policies to promote a modal shift (the Combined Transport Directive, the Rail Freight Corridors Regulation, the TEN-T regulation) are not yet aligned with the European Green Deal. The European Commission has launched several initiatives to address this gap, including a revision of the TEN-T regulation (provisional agreement reached), a regulation on the use of railway infrastructure capacities (proposed but not yet adopted) and a revision of the Combined Transport Directive (proposed but not yet adopted).
Implementation gaps	– Implementation of the Rail Freight Corridor Regulation and the Combined Transport Directive has been incomplete and heterogeneous across the EU. – There are well-founded suspicions of fraud in the labelling of transport biofuels as sustainable under RED III.

European Scientific Advisory Board on Climate Change