Enhancing Transport Decarbonization in the European Union

WORLD BANK GROUP

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Foreword

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Tackling transport emissions is one of the toughest yet most critical battles in our fight against climate change. As the impacts of climate change intensify, the need for urgent and transformative action in every sector becomes more evident. Transport, as a cornerstone of economic activity and social connectivity, must be a key part of this global effort.

The European Union has demonstrated commendable leadership in climate action, with ambitious targets, a robust policy framework and substantial funding initiatives that have significantly advanced decarbonization across many sectors. Yet, transport remains the only major sector where emissions have failed to substantially decline. What's worse, they are still rising in many EU countries and across the world. This trend highlights the critical need for innovative approaches to address the unique challenges of the sector and achieve the targets established in the context of the European Green Deal.

Drawing knowledge from the World Bank Group's regional engagement and global experience, this latest report *Enhancing Transport Decarbonization in the European Union* offers a range of policy options to reduce GHG emissions, enhance efficiency, and use market instruments to promote sustainable transport solutions. It explores areas of opportunity to accelerate the shift toward transport decarbonization across the EU, considering the diverse needs and capacities of its member states. The proposed recommendations are also extended to accession states, where financial and institutional capacity constraints are especially pronounced.

The bottom line is that a cost-effective transport decarbonization strategy requires a more prominent role for the private sector, as well as new funding and financing mechanisms, enabled by targeted programs at EU-, national-, and local-levels. Accordingly, the report offers recommendations on how the EU and its member states can optimize the use of their resources while strategically leveraging private sector expertise and capital to drive efficiencies and amplify impact. At the same time, it acknowledges the broader social, industrial, and economic implications of this transition, emphasizing the importance of a just and inclusive approach.

The urgency of the climate crisis demands leadership. The EU has an opportunity not only to chart its own path toward sustainable transport but also to inspire global action. We hope this report serves as a valuable resource for policymakers, development partners, industry stakeholders, researchers and all those committed to advancing a sustainable future.

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Acronyms

BEV	Battery Electric Vehicle
CF	Cohesion Fund
CO_2	Carbon Dioxide
EGD	European Green Deal
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ETS	Emissions Trading System
ETSAP	Energy Technology Systems Analysis Program
EU	European Union
EUI	European Urban Initiative
EV	Electric Vehicle
FUA	Functional Urban Area
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HDV	Heavy-Duty Vehicle
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
IEA	International Energy Agency
IRA	Inflation Reduction Act
KINESYS-ECA	Knowledge-Based Investigation of Energy System Scenarios for The Europe and Central Asia Region
LEZ	Low-Emission Zone
LVC	Land Value Capture
MaaS	Mobility as a Service
OECD	Organisation for Economic Co-Operation and Development
PPP	Public-Private Partnership
RCBF	Results-Based Climate Financing
RFC	Rail Freight Corridor
SSMS	Sustainable and Smart Mobility Strategy
SUMP	Sustainable Urban Mobility Plan
SUV	Sport Utility Vehicle
SWL	Single Wagonload
TCO	Total Cost of Ownership
TEN-T	Trans-European Transport Network
TOD	Transit-Oriented Development
ZET	Zero-Emission Truck
ZEZ	Zero-Emission Zone

Executive Summary

The European Union (EU) has established itself as a global frontrunner in climate action, targeting a climate-neutral economy by 2050 with a sector-specific ambition to cut transport-related greenhouse gas (GHG) emissions by 90 percent from 1990 levels. Despite stringent regulatory requirements and a strong policy framework, transport emissions in the EU remain off track, highlighting the need for additional efforts to reverse this trend. Transport is the only major economic sector where GHG emissions remain above 1990 levels, with emissions in 2022 being 26 percent higher than in 1990,[i] with road transport accounting for 73 percent of transport emissions. Analysis undertaken for this report suggests that meeting growing passenger and freight transport demand will require a new approach that complements existing efforts.

This report highlights strategic areas of opportunity for the EU and its member states to use existing funds more efficiently while implementing public policies and incentives that can drive substantial progress toward meeting the EU's transport decarbonization goals. The report targets the EU and its 27 member states, focusing on strategic policy actions to advance transport decarbonization at the EU-, national-, and local-level.

Recommended policy actions also target EU accession countries due to their close economic and geographical ties to the EU and their aspiration to become future EU member states. As part of this process, accession countries are mandated to align with the European Green Deal and transpose the EU acquis, making them strategic partners in achieving transport decarbonization goals. However, despite the direct influence of current EU policies and funding, the limitations in implementation are often more pronounced in accession countries because of financial and institutional capacity constraints. The World Bank, due to its firsthand experience and extensive engagement in these countries, is well positioned to provide targeted support to EU accession countries to overcome challenges and maximize opportunities presented by the implementation of transport decarbonization policies.

This report focuses on three specific transport challenges that are critical for the EU's transport decarbonization trajectory: i) Accelerating the transition to zero-emission road transport technologies;[ii] ii) sustainable urban and metropolitan mobility; and iii) increasing the role of rail in helping decarbonize transport. While looking into these areas, a number of transversal actions to accelerate the decarbonization of the transport sector emerge from the modelling and analysis undertaken for this report. This represents a paradigm shift, highlighting the crucial role of innovative financing sources and the need to ensure better results from EU funding. These can be organized around four key themes for action: (i) the need to better leverage the private sector; (ii) de-risking mechanisms to crowd in private capital; (iii) conditioning the use of EU funds to deliver results at scale; and (iv) rethinking the role of climate finance and the EU Emissions Trading System (ETS).

Leveraging the Private Sector

The EU can do more to take advantage of private sector energy, expertise, and capital to support transport decarbonization. The report finds that, relative to global good practice, the EU is overly reliant on well-functioning public sectors to achieve some of its policy objectives. In particular, efficiency and decarbonization objectives could be well served by a stronger private sector role in managing infrastructure and services. The report suggests that the EU could consider (i) introducing financial instruments to bridge participation and viability gaps that limit the private sector's ability to invest decarbonization, ; (ii) implementing reforms that improve governance and enhance the profitability and financial sustainability of public transport enterprises,

enabling them to increase their access to commercial finance; and (iii) making greater use of public-private partnerships for transport infrastructure and services, as PPPs are not just a way to mobilize private capital, but are also critical to crowd-in global expertise and innovation.

To take the example of public transport, local and national governments can scale up e-bus deployment through private participation models that can help finance the larger upfront costs and mitigate the specific risks of electric mobility. Although several EU cities have already successfully implemented concession models for public transport, wider adoption of these approaches could help complement limited public resources and better leverage EU funds. Also, going beyond the traditional public transport concession, cities may consider new models where one or more cities or operators (either public or private) procure charging infrastructure, equipment (e-buses or batteries) from specialized private sector entities, such as leasing companies, utilities, original equipment manufacturers; or outsource the whole e-mobility solution from an asset company that integrates all these components into a single offer (e-mobility as a service). For instance, a city may enter into a lease-like PPP for the provision of e-buses for multiple lines that is isolated from operational risks and independent from operations concessions/service agreements as a way to create scale in procurement, mitigate risks, and reduce financing costs.

To ensure a better competitiveness of sustainable urban mobility solutions, the EU should also mobilize substantial funding and financing from different sources. This includes supporting the expansion and strategic utilization of land value capture mechanisms across member states through comprehensive training and knowledge transfer.

Likewise, to unlock the potential of underutilized rail corridors, including outside of the Trans-European Transport Network, alternative business models with higher participation of the private sector can be considered, such as the introduction of infrastructure concessions along international corridors. This arrangement could help to increase the efficiency of infrastructure management across borders while reducing reliance on public budget support for maintenance purposes.

Developing Derisking Mechanisms to Crowd in Private Capital

A cross-cutting recommendation made in this report is the need to use financing mechanisms that mobilize private finance and leverage the limited public resources available for decarbonizing the transport sector. This includes introducing financial instruments (pricing incentives, credit enhancement, de-risking, and partial upfront grant mechanisms) that bridge participation and viability gaps limiting the private sector's ability to invest in transport decarbonization.

EU technical support and funding should be used to de-risk investments by the private sector, leveraging public resources. This can support three objectives. First, promoting scale by promoting standardization, aggregating procurement, and providing EU funding via participation in aggregation platforms. Second, providing viability gap financing by prioritizing funding for those projects that leverage private finance, addressing cost differences, for example, between electric and internal combustion vehicles for public buses and trucks. Third, stepping up support for guarantees by developing risk-sharing facilities to attract financing for zero-emission buses and trucks and providing financing guarantees to reduce the cost of financing for concessionaires. For instance, a government-backed financial institution could establish a Zero-Emission Trucks (ZETs) de-risking fund with different types of financial solutions, which can include: (i) Partial Credit Guarantee/Risk Sharing Facility to commercial lenders to encourage lending to private ZET/charging point operators that meet eligibility criteria (that is, participation in priority corridors program); (ii) Viability Gap Funding; (iii) credit enhancements; or (iv) liquidity facilities for ZET/charging point operators.

Conditioning and Coordinating the Use of EU Funds to Deliver Results at Scale

The EU can maximize the impact of its support by conditioning the use of EU funds on projects/recipients that also address demand management or that aim to maximize sector revenues/funding while complementing scarce public resources with private finance. This includes: (i) expanding policy-based conditionalities to access EU regional funds; (ii) coordinating EU funds/policies to be more coherent in policy objectives; and (iii) creating incentives to attract private capital and expertise through concessions and other innovative financing mechanisms. Moreover, the introduction of conditionalities for EU financing, with clearly defined targets, could enhance the effectiveness and coherence of urban mobility initiatives across EU cities. A potential strategy is to condition funding for infrastructure investments on the introduction of demand management policies, particularly in connecting peri-urban areas.

On the coordination side, EU transport policy should place rail transportation on a more equal footing—rail freight is currently not on a level playing field with road transport, even though it is a potentially more efficient mode of freight transport for long distances. Legal provisions and the level of financing for railway and road infrastructure and incentives need to be created to ensure that road pricing adequately captures externalities and thus supports a modal shift toward railways.

Rethinking the Role of Climate Finance and the EU ETS

The EU could consider creating preconditions for tapping into climate finance to support the growth and sustainability of the transport sector. This would be beneficial for system sustainability, as new sources of funding can reduce the burden on the public purse—especially for fiscally constrained member states. To date, railways have had limited success in accessing climate-specific financing instruments. Building on the EU ETS, the EU could develop regulations and methodologies to allow rail projects that reduce GHG emissions to benefit from carbon credits. Moreover, initiatives like Connecting Europe Facility could be complemented with Results-Based Climate Financing to incentivize efficient investments in green rail, ports, and intermodal facilities.[iii] EU-funded projects for intermodal facilities or ports could include modal shift to rail, or better GHG savings, as key result indicators on which funds would be allocated, encouraging accountability and efficiency.

The Way Forward

The recommendations in this report recognize that the gap between the funding needed to decarbonize the transport sector in the EU is large, and there is, therefore, a crucial and, to date, underutilized role for non-public funds, both at the EU and member state levels. The private sector can help spur investment by creating new markets and offering innovative solutions but needs the right enabling environment to flourish. This report also focuses on the need for appropriate incentives to encourage a more commercial orientation of transport operators and to ensure that large investments in low-carbon transport infrastructure and systems translate into modal shifts toward lower-emitting modes.

Although the report does not intend to provide in-depth details on implementation, it offers comprehensive policy insights around the themes highlighted above, focusing on three specific transport challenges that are critical for the EU's transport decarbonization trajectory: (i) accelerating the transition to zero-emission road transport technologies; (ii) creating sustainable urban and metropolitan mobility; and (iii) enhancing the role of the rail sector to decarbonize transport (see selected examples of thematic recommendations in table E.1). While some of the recommended actions can be taken at the EU-level, other policy interventions and investments regard national or local jurisdiction, potentially facilitated by EU-level enablers or incentives. A more comprehensive list of the proposed recommendations for each subsector is

presented in the dedicated chapters and in table 5.1 at the end of the report. Other transport subsectors, namely aviation, maritime, and inland waterways, are acknowledged in this report as critical areas where major additional efforts are needed but are not the primary focus of the analysis.

Table E.1. Examples of Thematic Recommendations (Non-Exhaustive List)

	Accelerating the transition to zero-emission road transport technologies
	To increase the supply of smaller and more affordable electric vehicles (EVs) in the passenger car segments—a prerequisite for a large-scale uptake of EVs outside the luxury segment—this report suggests three actions: (i) using tax policies to promote smaller, lower-priced vehicles (new and secondhand) while penalizing larger vehicles with poor energy efficiency; (ii) promoting the electrification of company fleets and highly utilized vehicles, which will increase the availability of secondhand EVs in the medium term; and (iii) using resources from the Social Climate Fund (complemented with revenues from differentiated vehicle taxation schemes) to support national EV programs of lower-income population segments. For Zero-Emission Trucks, a range of financing and de-risking mechanisms need to be considered, including risk-sharing instruments for lenders to unblock commercial financing, viability gap funding, credit enhancements to promote investment in local capital markets instruments (that is, green and sustainability-linked bonds), and liquidity facilities for private e-trucks operators and charging companies.
	Creating sustainable urban and metropolitan mobility
	The report posits that cities in the European Union (EU) need to access substantial funding and financial sources, beyond public funding, to ensure the competitiveness and sustainability of urban mobility solutions. For instance, the report suggests: (i) strengthening and diversifying partnerships with the private sector through concessioning (several EU cities have successfully implemented concession models for public transport, which can be replicated across the EU); and (ii) mobilizing funding through innovative instruments, such as increasing the use of land value capture. Moreover, to encourage effective shifts in mobility behaviors, the report recommends introducing demand management policies as conditionalities to access urban mobility funding from the EU.
	Enhancing the role of the rail sector to decarbonize transport
	The report highlights several areas of opportunity to achieve a modal shift toward railways, especially on freight transport. Some recommendations include: (i) exploring alternative funding mechanisms to reduce reliance on public funds, such as enhancing access to climate finance from Emissions Trading System revenues (based on emission reduction potential); (ii) mapping supply chains of emerging new markets and working closely with industry players to strategize how to serve these markets; and (iii) developing framework conditions to discourage road use (in addition to carbon pricing from the ETS2) and encourage a modal shift, such as strengthening and expanding carbon dioxide-differentiated tolling systems.

Source: World Bank.

Notes

[i] Including international bunkers (international navigation and aviation).

[ii] These are technologies not leading to direct (or tailpipe) emissions of local pollutants and greenhouse gases. They need to be paired with low-emission energy and materials to enable the low life-cycle emissions needed to meet climate change mitigation goals.

[iii] For more information on the Connecting Europe Facility, see https://cinea.ec.europa.eu/programmes/connecting-europe-facility/transport-infrastructure_en.

1. Introduction

The European Union (EU) stands as a global front-runner in the transport decarbonization agenda. The EU aims for a climate-neutral[i] economy by 2050 as part of the European Green Deal (EGD) (European Commission 2019), initiated in December 2019, aligning with the Paris Agreement.[ii] A detailed sectoral approach to address the targets proposed in the EGD has been outlined in the Sustainable and Smart Mobility Strategy (SMSS) (European Commission 2020), launched in December 2020. This strategy presents 82 transport-specific initiatives aimed at achieving the emissions reduction targets.[iii] The SMSS includes a target to reduce transport-related greenhouse gas emissions by 90 percent by 2050, compared to 1990 levels. The European Climate Law, passed in July 2021, makes these targets legally binding and establishes an additional goal of reducing total net emissions by at least 55 percent by 2030, compared to 1990 levels (European Parliament and Council of the European Union 2021). Also in July 2021, the European Commission launched the first tranche of its Fit for 55 package,[iv] with a set of proposals to revise the EU's climate policy framework and put it on track to achieve the established decarbonization targets. The REPowerEU plan, launched in 2022 in response to Russia's invasion of Ukraine, underscores the need for energy diversification, particularly through renewables, to ensure energy security while adhering to climate goals (European Commission 2022). Building on these steps, the Green Deal Industrial Plan (European Commission 2023), announced in 2023, has shifted the EU's policy focus to better align environmental goals with economic and industrial development, aiming to bolster the EU's industrial base and close the competitiveness gap (Schnabel 2024).

Despite the policies and ambitions set by the EU, the transport sector remains a significant contributor to carbon dioxide (CO_2) emissions and is the only sector with emissions still above 1990 levels by a wide margin. In the EU, transport is currently the second-largest source of CO_2 emissions,[v] accounting for 31 percent of total net emissions (European Environment Agency 2024). Unlike other EU economic sectors that, in aggregate, have successfully decreased emissions by 41 percent between 1990 and 2022 (including power generation, industry, and agriculture), transport emissions in 2022 were still 26 percent higher than in 1990.[vi] As transport activity is expected to grow in the EU with rising wealth, decarbonizing transport remains critical to meeting the EU's commitment to become climate-neutral by 2050.

This report provides an overview of the crucial areas where further action is needed to accelerate the transition to a carbon-neutral inland transport sector. The primary focus of this analysis is on land-based transportation, including zero-tailpipe emission road transport technologies, urban mobility, and rail transport. The focus on land transport aims to address the challenges of reducing the significant emissions coming from road vehicles, which accounted for 73 percent of EU transport emissions (including domestic transport and international bunkers) in 2022 (European Environment Agency 2024). The challenges posed by the growing emissions from shipping and aviation—where the current supply of low-carbon fuels remains marginal, and the cost of alternative technologies is expected to remain high in the medium term—are acknowledged as critical sectors, but are not the focus of this report. Also, while acknowledging that a comprehensive strategy on climate action, including in transport, needs to consider the increasing impact of climate change and associated adaptation costs for existing and new infrastructure, the focus of this report is limited to mitigation of transport-related emissions.

This report suggests actions to optimize funding and financing instruments to unlock private sector investment and foster commercially competitive growth in three key areas for transport decarbonization: (i) accelerate the e-mobility transition, with considerations of equity and competitiveness; (ii) advance

sustainable urban mobility in metropolitan areas; and (iii) increase the rail modal share for both passenger and freight transport. The report is organized into four main chapters. Chapter 2 provides an overview of the main trends characterizing EU transport activity, related energy use, and emissions. Chapter 3 presents relevant insights from a transport demand and energy emissions model developed to assess potential decarbonization pathways. Chapter 4 assesses key priorities, opportunities, and challenges to decarbonize the transport sector across three main areas: accelerating the transition to zero-emission road transport technologies; creating sustainable urban and metropolitan mobility; and enhancing the role of the rail sector to decarbonize transport. Finally, chapter 5 summarizes the key findings and makes recommendations for future work and policy actions.

Notes

[i] Climate neutrality by 2050 means achieving net-zero greenhouse gas emissions for European Union countries as a whole, mainly by cutting emissions, investing in green technologies, and protecting the natural environment.

[ii] The Paris Agreement is a legally binding international treaty on climate change that entered into force on November 4, 2016. Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."

[iii] The Sustainable and Smart Mobility Strategy includes 10 flagship areas under three pillars: (i) Sustainable: 1- zero-emissions vehicles, 2- ports and airports, 3- urban mobility, 4- greening freight transport, 5- pricing carbon; (ii) Smart: 6- connected and automated multimodal mobility, 7- innovation and artificial intelligence; and (iii) Resilient: 8- reinforcing the single market, 9- fair and just mobility, 10- improving transport safety and security.

[iv] The Fit for 55 package consists of 13 interlinked proposals to revise existing European Union climate and energy laws, and six proposals for new legislation. For more information see the Fit for 55 website at https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/.

[v] This is without considering the emissions generated from the manufacture of transport vehicles, production of transport fuels, and building of transport-related infrastructures, such as roads, railways, ports, and airports.

[vi] Including international bunkers (international navigation and aviation).

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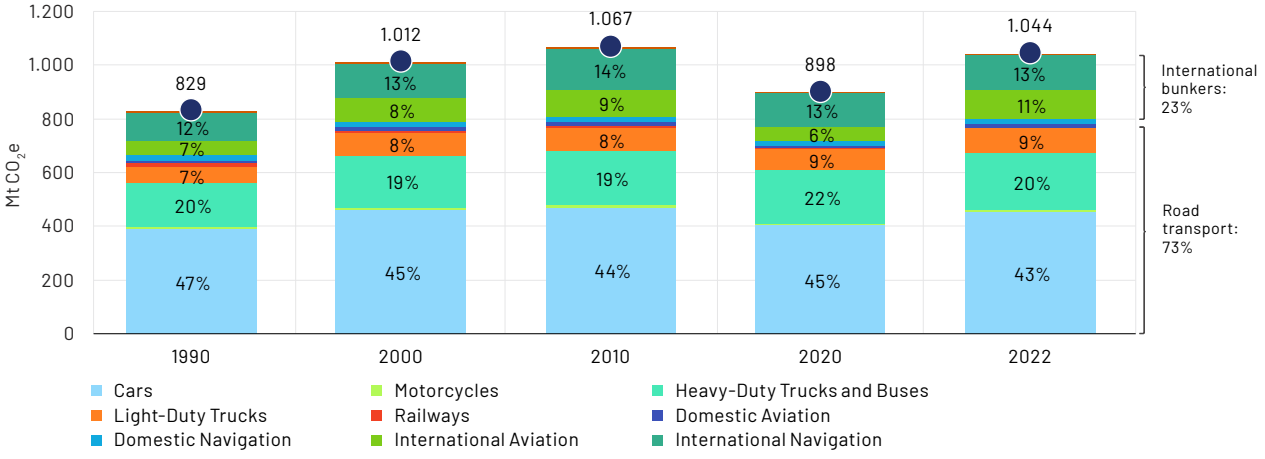
2. EU Transport Trends: Activity, Energy Use, and Emissions Insights

Transport remains the only major economic sector in the European Union (EU) where current greenhouse gas (GHG) emissions are above 1990 levels and increasing. Despite the target to cut emissions by 90 percent compared to 1990 levels, direct carbon dioxide (CO_2) emissions from transport vehicles continued to rise, net of the COVID-19 pandemic's residual impacts (Figure 2.1). In contrast to all other major EU economic sectors, which have collectively reduced emissions by 42 percent, the transport sector's GHG emissions remained 26 percent higher than in 1990 in 2022 (Figure 2.2), limiting the overall EU emissions reduction to 31 percent (European Environment Agency 2024). By 2019 (before the COVID-19 pandemic), the highest relative increases in emissions within the transport sector were observed in international aviation (+143 percent), followed by light-duty trucks (+47 percent), international navigation (+34 percent), domestic aviation (+31 percent), heavy-duty trucks and buses (+30 percent), and passenger cars (+24 percent). International aviation accounted for 12 percent of transport sector emissions in 2019 (compared to 7 percent in 1990),[i] and this steep growth alone accounts for around 27 percent of the total transport emissions increase, second only to the increase from passenger cars (32 percent of the emissions increase). Emissions from rail transport, on the other hand, have declined, now accounting for only 0.3 percent of transport emissions.[ii] This decline is partially driven by a higher reliance on road-based transport but also by significant energy efficiency improvements in rail transport.[iii]

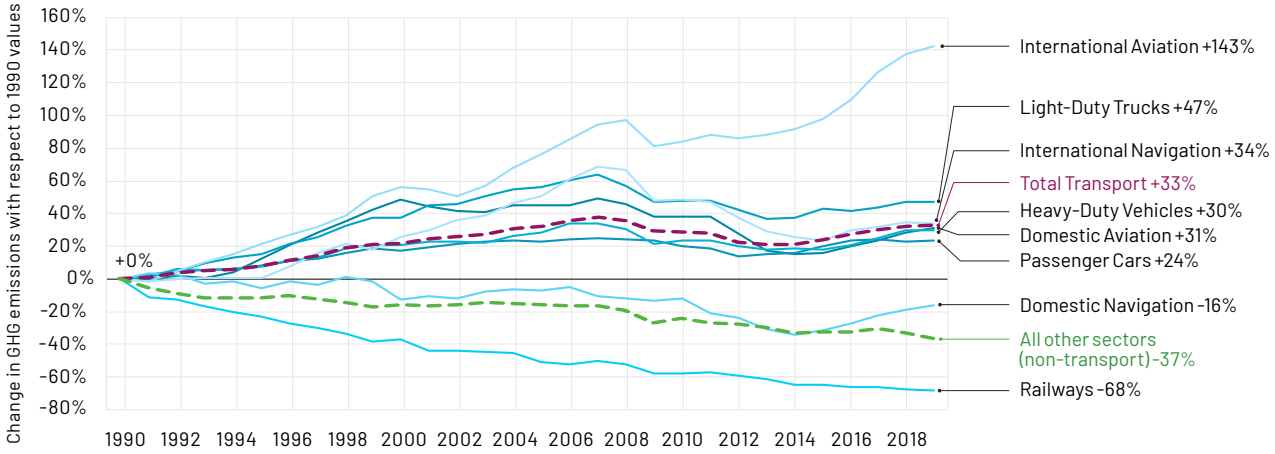
The EU's transport emissions trend reveals significant differences among member states (Figure 2.3). The highest relative increase among the main emitters occurred in Poland, where transport-related emissions more than tripled from 1990 to 2022 (+223 percent), boosted by income and car ownership growth (as further discussed below). This placed Poland among the top six highest transport-related emitters in the EU in 2022, collectively accounting for 70 percent of EU transport emissions. In absolute terms, only Spain contributed more to transport emissions growth in this period, emitting an additional 58 Mt CO_2e/year in 2022 compared to 1990 (+78 percent).

Figure 2.1. Direct GHG Emissions from the Transport Sector in the EU



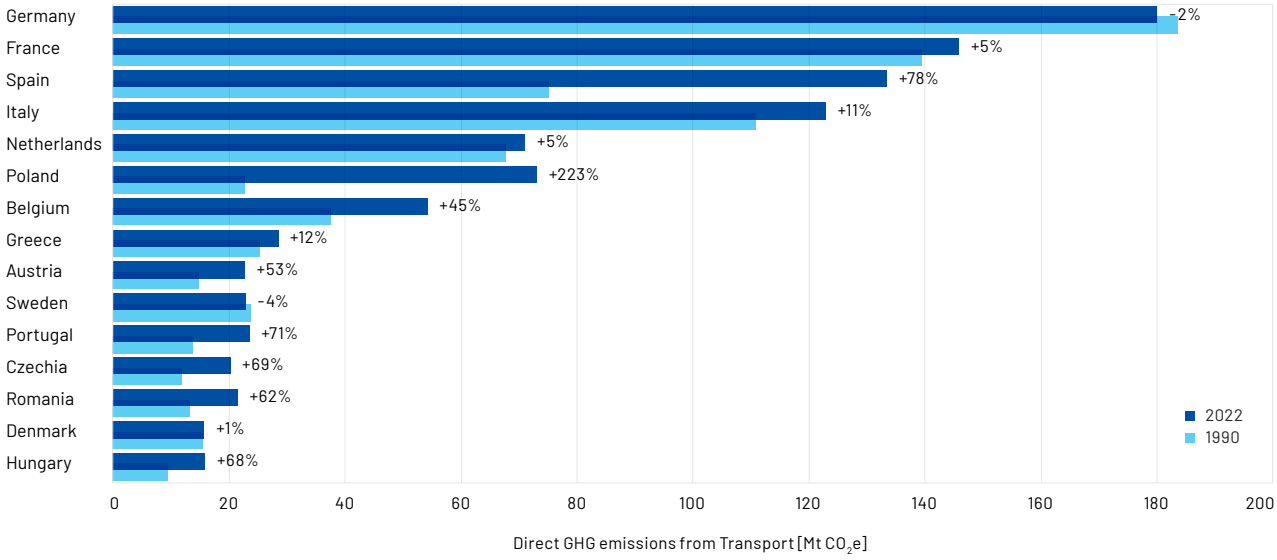
Source: Graph elaborated using data from European Environment Agency 2024.

Figure 2.2. Relative Change of Direct GHG Emissions from the Transport Sector and Subsectors in the EU with Respect to 1990 Levels



Source: Graph elaborated using data from the European Environment Agency 2023.

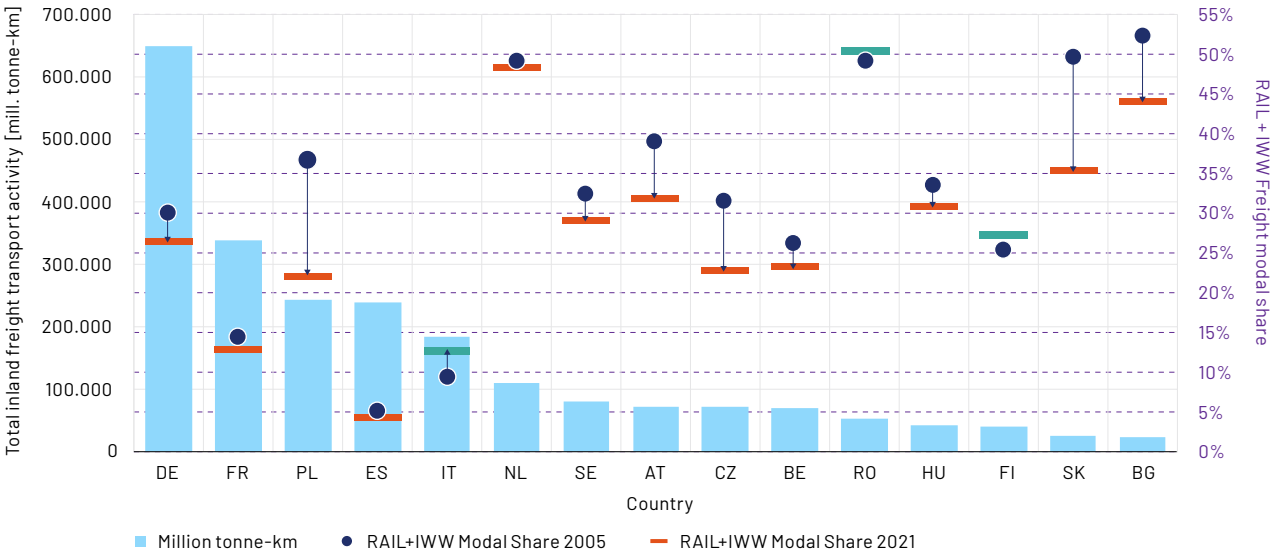
Figure 2.3. Transport Emissions Growth from 1990 to 2019 for the Top 15 Transport-Related Emitters



Source: Graph elaborated using data from the European Environment Agency 2023.

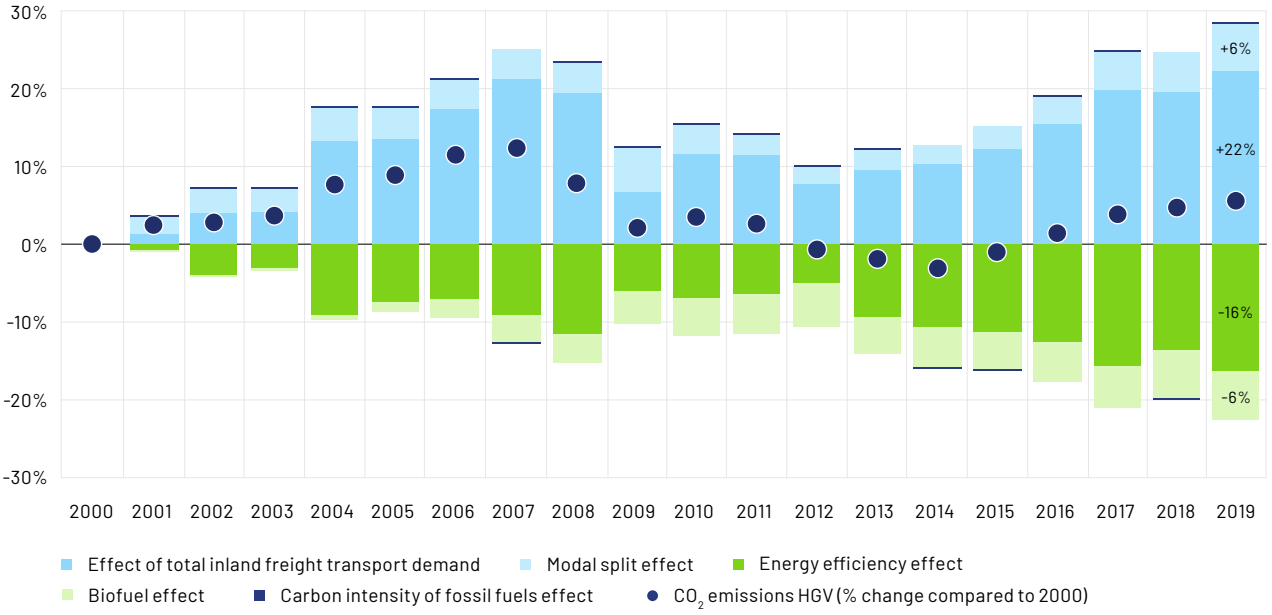
Contrary to the EU's goal of increasing the inland freight modal share of more energy-efficient and less carbon-intensive modes, namely rail and inland waterways, these options have lost market share. Modal shifts in the last few decades have moved in the opposite direction, with the combined share of rail and inland waterways declining from 26 percent in 2005 to 23 percent in 2021 for the EU as a whole, contributing to the increase in energy consumption and CO_2 emissions from transport. As shown in Figure 2.5, 12 out of the 15 countries with the highest levels of inland freight activity have seen a decline of the modal share of rail and inland waterways. Countries that experienced strong increases in road transport motorization also saw major drops in the share of freight rail, as shown by the case of Poland (down from 37 percent to 22 percent from 2005 to 2021). ThThe European Environment Agency estimated that the modal shift toward trucking contributed alone to a 6 percent increase in direct CO_2 emissions from heavy goods vehicle between 2000 and 2019 (figure 2.5). To date, the improvements in energy efficiency have not led to reductions in direct CO_2 emissions from trucking, as increases in freight transport demand have been larger.

Figure 2.4. Inland Freight Transport Volumes in 2021 and Modal Shifts from 2005 to 2021 in Major Markets



Source: Graph elaborated using data from Database, Eurostat, Luxembourg City (accessed X), https://ec.europa.eu/eurostat/data/database#Updates.

Figure 2.5. Decomposition Analysis of direct (tailpipe) CO_2 Emissions from Trucks in the EU (2000–19)

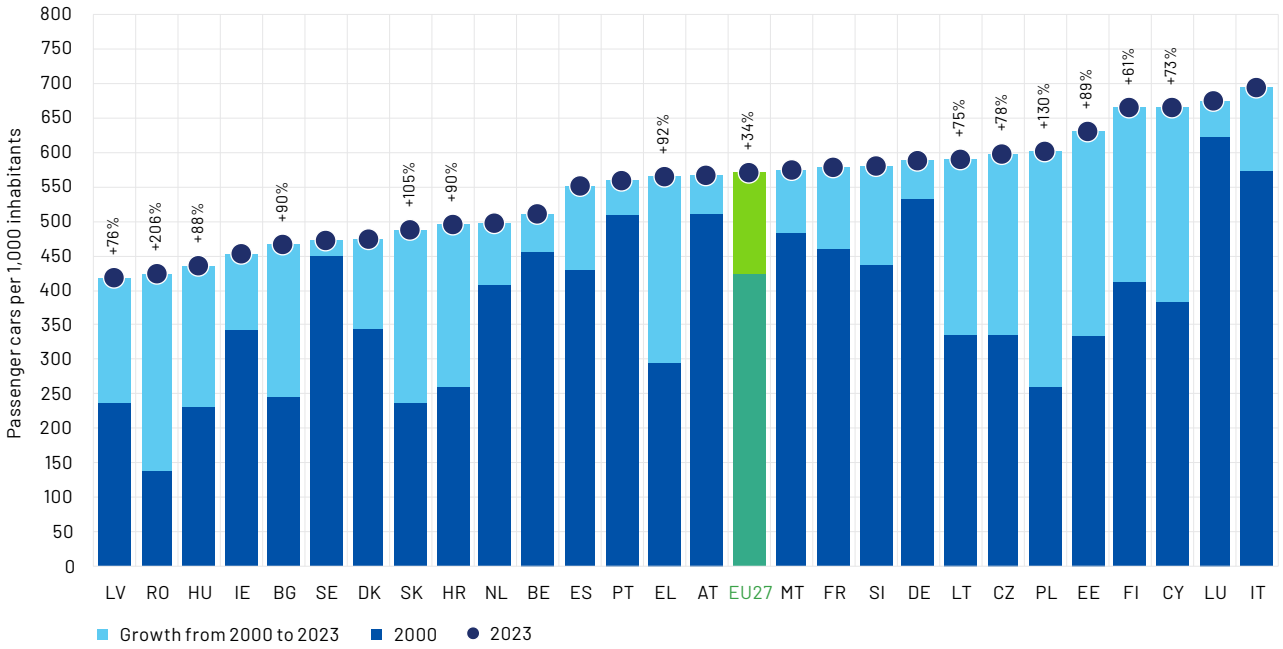


Source: Graph adapted from European Environment Agency 2022.

The surge in passenger car motorization across the EU from 2000 to 2023, with an increase of one-third, outnumbers the impact of energy savings achieved through advancements in vehicle energy efficiency. A notable case is Poland, where the passenger motorization rate more than doubled (+130 percent), from 261 cars per 1,000 inhabitants in 2000 to 601 cars per 1,000 inhabitants in 2023, making it one of the most motorized countries in the EU (Figure 2.6). Romania has seen the highest relative increase in car ownership within the EU, more than tripling it in the same period, which is likely to continue in the medium term as it still holds the lowest rate in the region. Odyssee-Mure (2023) estimates that the impact of increased passenger transport

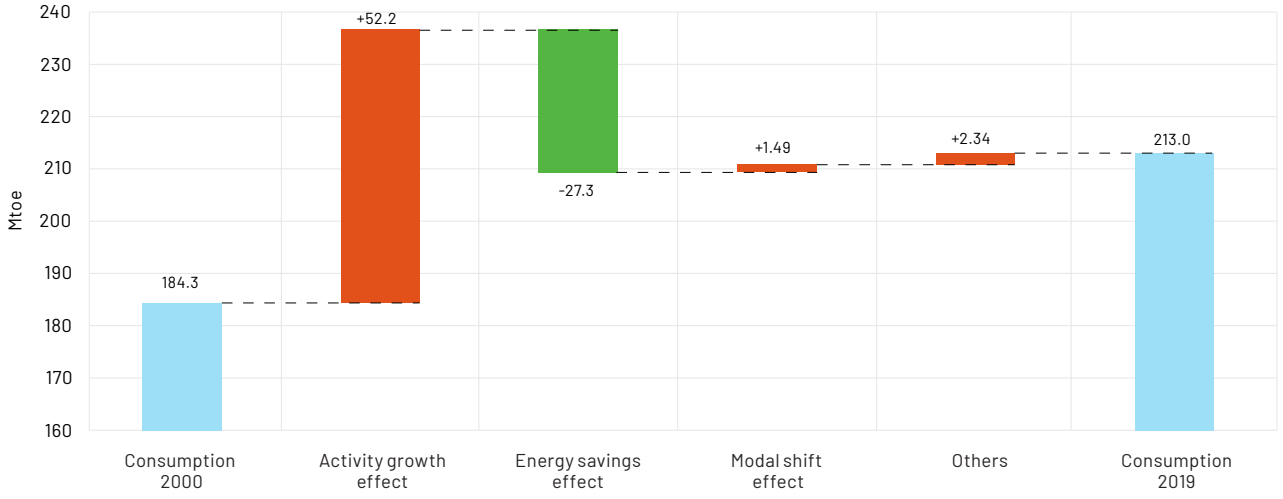
activity and the modal shift to cars on energy demand growth is roughly double the energy savings resulting from energy-efficiency improvements (Figure 2.7). As shown in Figure 2.8, the total transport activity in the EU increased by 33 percent from 1995 to 2019, with two-thirds of this growth coming from passenger car activity, followed by the growth of air transport.

Figure 2.6. Passenger Car Motorization Levels in the EU (2000 and 2023)



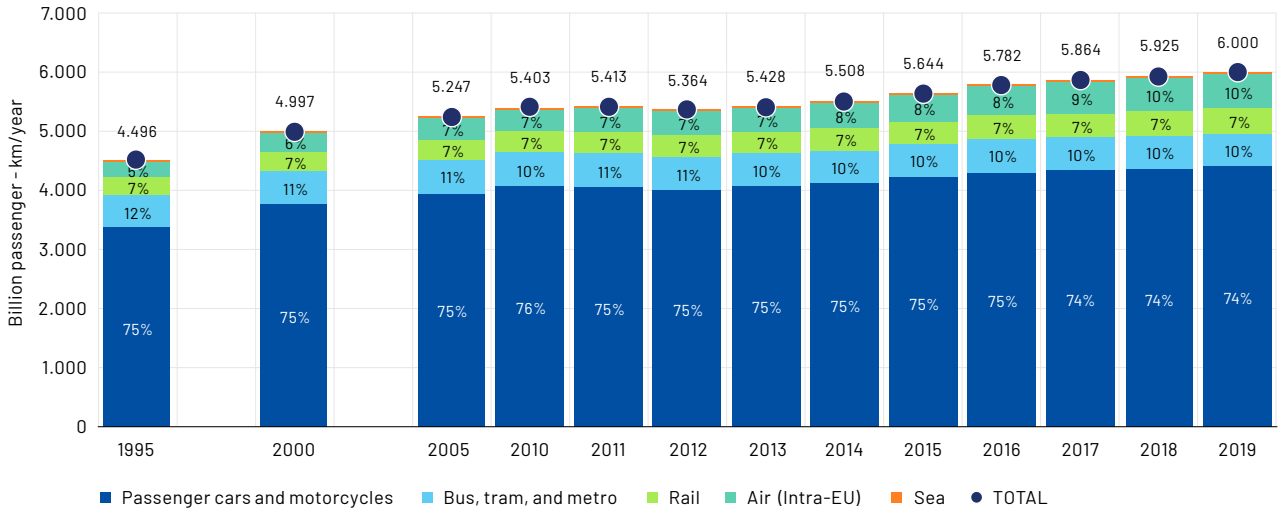
Source: Graph elaborated using data from Database, Eurostat, Luxembourg City (accessed X), https://ec.europa.eu/eurostat/data/database#Updates.

Figure 2.7. Decomposition Analysis of Energy Consumption for Passenger Transport in the EU (2000–19)



Source: Graph adapted from Odyssee-Mure's website at https://www.odyssee-mure.eu/publications/efficiency-by-sector/transport/passenger-energy-consumption.html.

Figure 2.8. Passenger Transport Activity and Modal Share in the EU-27 (2005–19)



Source: European Commission 2021.

The EU transport decarbonization strategy relies strongly on zero-emission vehicles and alternative fuels. The EU has adopted stringent regulatory requirements regarding zero-emission vehicles, recharging infrastructure, and sustainable EV battery sourcing to address its energy and resource scarcity. These measures aim to utilize key characteristics of the EU—including high energy efficiency and low carbon intensity—complemented by a growing shift toward economic circularity—to promote a pathway toward decarbonization that also supports industrial growth and economic expansion. The same strategy aims to improve energy security through energy diversification, thanks to greater reliance on electricity rather than fossil fuel combustion.

While the strong technology focus of this strategy is consistent with the increasing motorization trends, technology alone might not address the emerging multifaceted set of challenges and risks with economic, social, political, and resource-related dimensions. The transition to electric vehicles presents industrial and social challenges, given the equity implications for lower-income households and small businesses, as well as the need for a substantial transformation of the automotive industry. This sector's transformation is further complicated by geopolitical tensions, and the necessity of adapting European manufacturing capacities and workforce skills to new technologies and competitive pressures. These challenges call for a comprehensive set of measures to complement the existing policy framework, with special attention needed to manage the industrial and social impacts of these transformations.

Cities will need to play a significant role in managing motorization growth and delivering on the EU's decarbonization objectives while also enhancing urban accessibility and mobility. Ensuring that urban environments can effectively reduce emissions while improving well-being requires a focus on the containment and reversal of urban sprawl in favor of compact city and transit-oriented development. This approach can support the cost-effective reinforcement of both active mobility and low-carbon-intensive modes of transport, such as public transportation and rail. The same dynamics offer opportunities to reduce reliance on motorized private vehicles while increasing resource efficiency and helping to reduce emissions more broadly (OECD 2021). The EU urban mobility framework and the Trans-European Transport Network (TEN-T) regulation integrate key decisions enabling this development, starting from the adoption of Sustainable Urban Mobility Plans in all TEN-T urban nodes by 2027.

The EU's pursuit of transport decarbonization is challenged by increasing demand for passenger and freight transport, a growing preference for energy-intensive modes like cars and aviation, and continued reliance on oil-based fuels. Despite improvements in enhancing energy efficiency across all transport modes, this has not been enough to offset the growing demand. This prevailing trend is particularly relevant for some lower-income EU member states, such as Poland and Romania, which are more likely than others to face headwinds in adopting more capital-intensive decarbonization technologies. This highlights the need for an approach that addresses specific challenges within the diverse landscape of member states. Cohesive support for the countries experiencing greater declines in the shares of energy-efficient and low-carbon modes of transport (rail and inland waterways) and more exposed to a shift toward capital-intensive technologies (especially those with limited financial capacity) is essential for yielding comprehensive transport emissions reduction effects at the EU level.

Notes

[i] Emissions from international bunkers (aviation and maritime) are based on the countries' submissions to the United Nations Framework Convention on Climate Change and the EU Greenhouse Gas Monitoring Mechanism (European Environment Agency 2024).

[ii] Note that emissions from electrified rail are primarily attributed to the electricity generation rather than transport sector in GHG accounting.

[iii] Odyssee-Mure (2023) estimates that between 2000 and 2021, the European Union's rail sector achieved an average energy efficiency improvement of 2.2 percent per year, significantly higher than the 0.3 percent per year achieved for passenger cars (fleet-wide). Trucks saw a 1.5 percent energy efficiency improvement per year.

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3. Pathways toward EU Transport Decarbonization

This chapter presents the results and main takeaways of an assessment of potential decarbonization pathways for the transport sector in the European Union (EU) until 2050. The analysis was developed through a modelling framework that incorporates a transport demand model and a whole-energy system model (KINESYS-ECA model). The transport demand model covers both passenger and freight activity across all main transport modes and estimates what may be considered a "likely" transport demand trajectory until 2050. The estimates are based on defined assumptions regarding income growth and demographic changes, as well as the potential for modal shifts to more sustainable transport modes. The transport demand model is linked to a techno-economic whole-energy system model, namely the World Bank's Knowledge-based Investigation of Energy System Scenarios for the Europe and Central Asia Region model, which aims to estimate minimum-cost decarbonization trajectories given a range of available technological solutions. More details on the implemented methodology can be found in Annex 3A.

The results presented in this chapter aim to provide an overview of the expected changes in transport demand levels in the coming decades and highlight the transformation of the transport system needed to meet the climate targets. The modelling work presented here does not aim to estimate the effects of individual potential policy interventions but rather to provide insights that identify areas where further action is needed and for which in-depth modelling may be required in a subsequent stage.

Transport Activity Changes and Modal Allocation

Passenger Transport

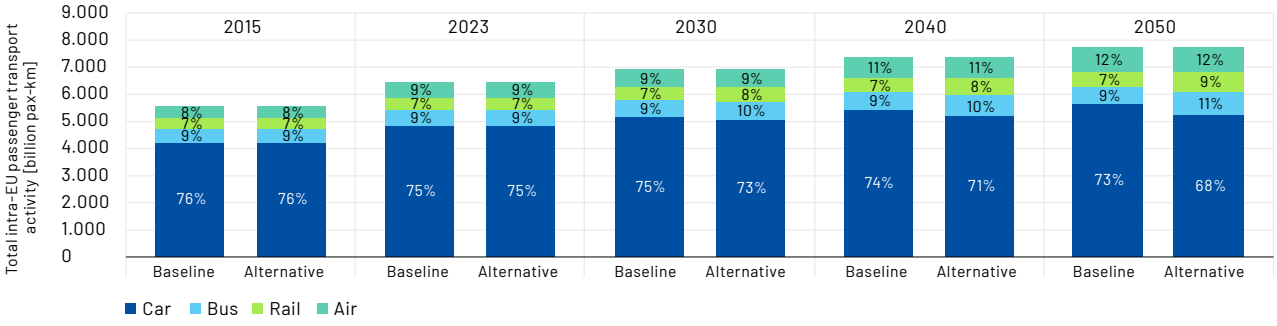
While the total population in the EU is expected to remain stable in the decades to come, our baseline scenario projects a 20 percent increase in passenger transport activity (expressed in passenger-kilometers or pax-km) by 2050 compared to 2023. This increase is mainly driven by income growth. The highest growth levels, in relative terms, are expected in the aviation sector (+57 percent); however, the largest contribution in absolute terms (passenger-kilometer) will still come from passenger car activity. The increase in passenger car demand (16 percent) will be driven primarily by rising motorization levels. Limiting the environmental impact of this expected growth will require a cost-effective combination of travel demand management; a modal shift toward affordable and less resource-, energy-, carbon-, and space-intensive modes; and a technology shift toward low-emission powertrains and forms of energy, challenging the recent trends observed in the EU (see Chapter 2).

A modal shift to more sustainable transport modes is a powerful tool to reduce carbon dioxide (CO_2) emissions from passenger transport—and other transport externalities—but it will require decisive policy action to reverse historical trends. The policy scenarios assessed in the European Commission's Staff Working Document (European Commission 2020) accompanying the Sustainable and Smart Mobility Strategy (SSMS) envision an increase in rail passenger volumes of 80 percent by 2050 compared to 2015 levels, as well as a 70 percent increase in bus passenger volumes over the same period. Our demand estimates suggest that such envisioned changes would require increasing the modal share for passenger rail from the current 7 percent to more than 9 percent by 2050, and the bus modal share from the current 9 percent to more than

11 percent by 2050. While in a "baseline" scenario passenger car modal share is estimated at 73 percent in 2050 (including two-wheelers), achieving the two targets above for rail and bus transport would reduce car modal share down to 68 percent, resulting in a 7 percent reduction in pax-km for passenger cars compared to the baseline scenario (Figure 3.1). Achieving this would require reversing the trends observed in the last two decades, during which the rail transport share has remained constant, and the bus share has declined, while both motorization rates and air transport have grown significantly (see Chapter 2). Defying these trends will require a multi-pronged approach that implements a combination of policy measures for both urban and non-urban transport. Recommended policy options in these areas are presented in the sections "Creating Sustainable Urban and Metropolitan Mobility" and "Enhancing the Role of the Rail Sector to Decarbonize Transport". While our demand projections conservatively exclude the effect of AVOID measures for modelling purposes (promoting access with fewer or shorter trips, achieved for instance through compact mixed-used urban developments and teleactivity measures), or the effect of increased vehicle occupancy rates, these are acknowledged as relevant levers to be pursued to reduce transport demand and contribute to the sector's decarbonization.

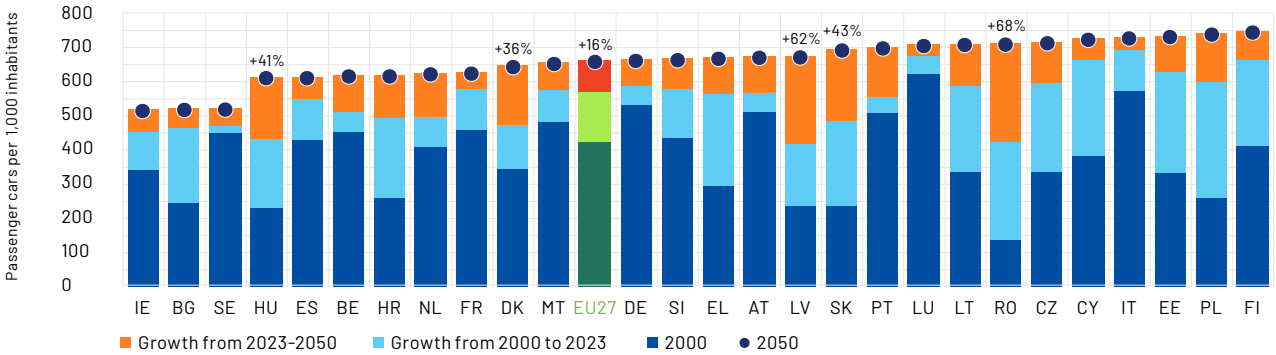
While the growth of the passenger car motorization rate at the EU level is expected to slow down going forward (due to more EU countries moving toward saturation in vehicle ownership), the vehicle stock is still likely to grow significantly in the coming decade, especially in some EU member states. Our baseline scenario estimates a 16 percent increase in the EU-level motorization rate from 2023 to 2050, reaching around 660 passenger cars per 1,000 inhabitants, with an absolute increase of almost 35 million passenger cars in the EU. In this scenario, Romania sees the highest growth rate, in line with the trend observed over the last two decades (Figure 3.2).

Figure 3.1. Intra-EU Passenger Transport Demand Projections



Source: World Bank elaboration.

Figure 3.2. Passenger Car Motorization Level Projections



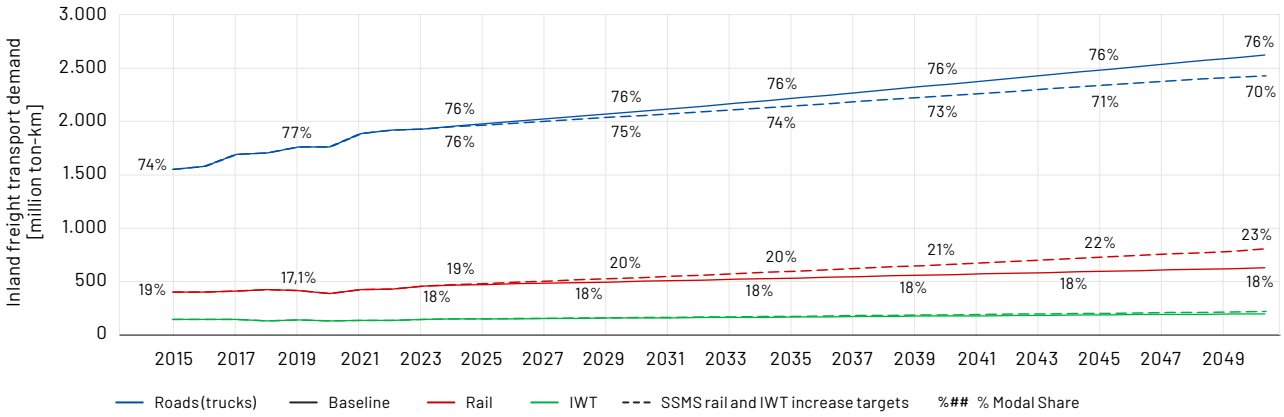
Source: World Bank elaboration.

Freight Transport

Transport demand for freight is likely to grow even faster than for passenger mobility, with our estimates suggesting a 36 percent increase by 2050 compared to 2023. This aligns with historical trends, which have shown a strong correlation between freight demand and economic output. Combined with decarbonization requirements and the contextual need for productivity increases and resource efficiency, this underscores the importance of enhancements in logistics and its optimization, as well as a strengthened role for rail and inland waterways, which will require improvements in competitiveness to be sustainable. Additionally, this highlights the need for a major technological transition in powertrains and the energy used for the movement of goods.

Meeting the SSMS ambition for increasing rail and inland waterway freight traffic (in absolute terms) will require reversing the declining trends observed over the last decades. Based on the expected growth in total freight transport demand by 2050, the rail modal share would need to increase from the current 17 percent to about 23 percent by 2050 in order to achieve the SSMS objective of doubling rail freight volumes (Figure 3.3). Achieving this objective would result in an 8 percent reduction in trucking activity (vehicle-kilometers) compared to a counterfactual scenario where rail retains its current modal share, with notable environmental and economic benefits, given the challenges of decarbonizing the trucking sector (particularly for long-haul transport). Reaching the SSMS objective for inland waterway freight transport would require smaller increases in modal share compared to 2019 (from 6.0 percent in 2019 to 6.4 percent in 2050), but this could still be challenging given the declining trends observed since 2010 (from 7.6 percent in 2010 down to 6.0 percent in 2019). Recommendations to increase the modal share of rail in freight transport are presented in the section on "Enhancing the Role of the Rail Sector to Decarbonize Transport".

Figure 3.3. Inland Freight Transport Demand Projections



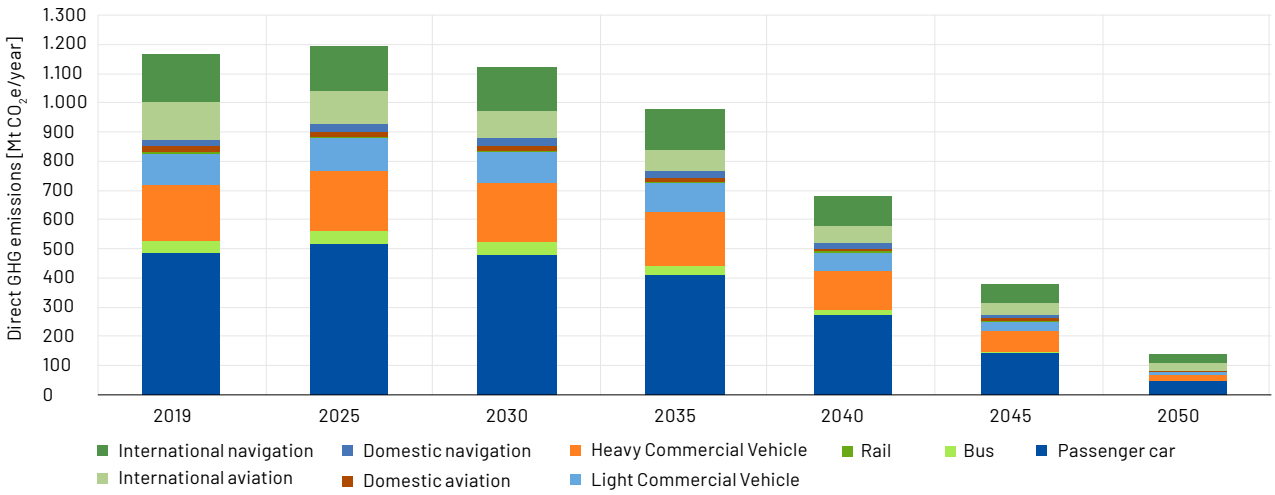
Source: World Bank elaboration.

Key Technological Transitions

The modelling analysis presented considers that domestic transport CO_2 emissions decrease by 88 percent in a scenario aiming for economy-wide carbon neutrality by 2050, compared to 1990 levels, while total transport emissions (including international sources) would see an 83 percent reduction. This result is close to the EU's goal of a 90 percent reduction in transport emissions by 2050 and highlights the significant challenges and costs involved in fully decarbonizing the sector, as other sectors would need to compensate for the residual emissions from transport.

Achieving this will require the road transport sub-sector to nearly eliminate its carbon footprint by 2050, as greenhouse gas emission reductions from fuel switching in maritime and aviation are likely to come at higher costs. Direct CO_2 emissions from road transport would need to decrease from 830 Mt CO_2e in 2019 to less than 80 Mt CO_2e in 2050. By then, international navigation and aviation would account for around 40 percent of the residual direct CO_2 emissions (compared 23 percent in 2022) (Figure 3.4). The sections below will expand on the required technological transformation of road vehicles for passenger and freight transport.

Figure 3.4. Projected Direct Emissions of CO_2 per Mode of Transport (Domestic and International) by 2050



Source: World Bank analysis (KINESYS-ECA model).

Passenger Road Transport

To decarbonize passenger cars, a rapid shift to battery electric vehicles (BEVs) across EU member states is crucial, particularly addressing the strong reliance on secondhand vehicle trade and longer vehicle lifespans in Eastern member states and accession countries. The assessed decarbonization scenario suggests that about 86 percent of the total passenger car fleet should be consisting of electric vehicles (EVs) by 2050, with interim shares of approximately 17 percent by 2035 and 40 percent by 2040 (Figure 3.5). This implies that all new passenger car sales should be BEVs by 2035, aligning with current EU CO_2 regulations for light-duty vehicles. However, this shift may be insufficient if internal combustion engine vehicles from Western Europe continue to be widely used in Eastern member states through the secondhand market over longer periods of time. Despite notable advances, including a surge in BEV car registrations in the EU (with BEVs accounting for 14.6 percent of new vehicle sales in the EU in 2023) (ACEA 2024a), meeting the objectives of the EU Climate Law requires an accelerated technological transition,[i] as only 1.7 percent of the total EU passenger cars on the road were BEVs in 2023 (Eurostat 2024). Policy interventions should thus aim to increase the availability of affordable EV models in both new and secondhand markets, especially in regions heavily dependent on imported secondhand cars (see the section on accelerating the transition to zero-emission road transport technologies).

The decarbonization of the bus fleet is expected to be dominated by BEVs (Figure 3.6) and is already advancing well in the EU, particularly within urban buses. Given the high average mileages traveled by buses and the declining costs of fully electric alternatives, the competitiveness of e-buses in terms of total cost of ownership (TCO) is expected to drive the accelerated e-transition within this segment. In fact, the EU has seen significant progress in the electrification of urban bus fleets in the past couple of years, with 40 percent of new city buses registered in the first half of 2024 being battery-electric (Ananda, Musa, and Basma 2024). The main challenges ahead for this sector concern interurban buses, where less than 1 percent of new

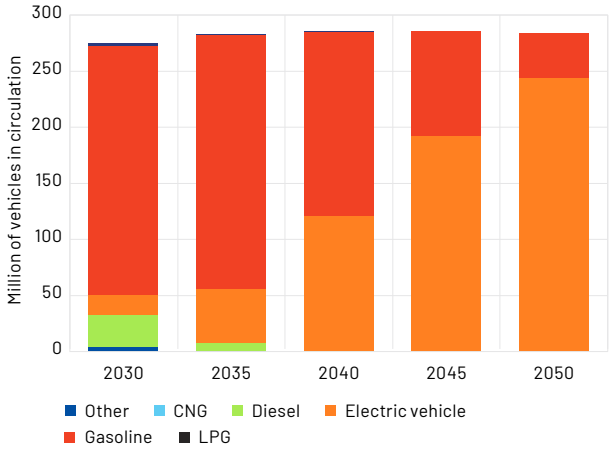
registrations were battery-electric over the same period (Ananda, Musa, and Basma 2024).

Freight Road Transport

The required emissions reduction in road transport, combined with increasing freight transport activity, calls for high levels of penetration of trucks with zero direct emissions of CO_2, or zero-emission trucks (ZETs), challenging the industry and requiring policy action to accelerate and finance the transition. The assessed decarbonization scenario suggests the need for around 80 percent of the truck fleet being ZETs by 2050, and 20 percent diesel or diesel-hybrid trucks (Figure 3.7). Such high levels of ZET penetration, considering the fleet turnover dynamics, implies that after 2030 the ZET uptake should ramp up quickly, and, due to the time needed for fleet replacement, by 2040, almost all new truck sales should be ZETs. This is in line with the ambition set under the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles (Drive to Zero 2024) signed by multiple EU member states, and close to the regulation agreed by the European legislators regarding the CO_2 emission limits for new heavy-duty vehicles (HDVs) coming into the market, requiring a 90 percent decline in new vehicle CO_2 emissions by 2040 compared to 2019 (European Council 2024). Recommended policies to accelerate the transition to ZETs are presented in the section on accelerating the transition to zero-emission road transport technologies.

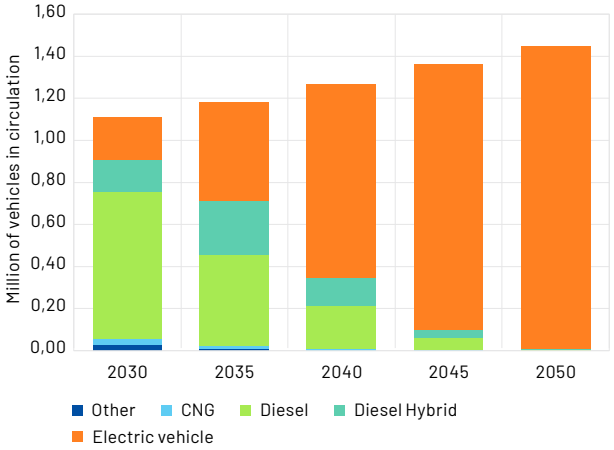
Achieving the needed uptake of ZETs will be particularly challenging for Eastern European member states, requiring policy action beyond CO_2 regulations. The decarbonization scenario explored here highlights differences in ZET adoption across subregions within the EU. This scenario estimates that around 73 percent of the truck fleet in the Eastern member states will need to be ZETs by 2050, which is lower than the 90 percent estimated for Western member states and the 80 percent EU-wide average. Even the "lower" value target for Eastern member states is ambitious, and CO_2 standards are necessary but not sufficient to achieve this. The prominence of the secondhand vehicle import market, along with longer vehicle lifespans (and thus

Figure 3.5. Powertrain Distribution of Passenger Cars—Decarbonization Scenario



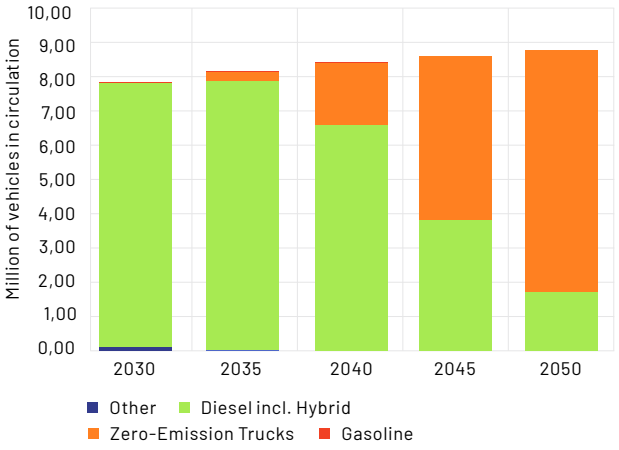
Source: World Bank analysis (KINESYS-ECA model).

Figure 3.6. Powertrain Distribution of Buses—Decarbonization Scenario



Source: World Bank analysis (KINESYS-ECA model).

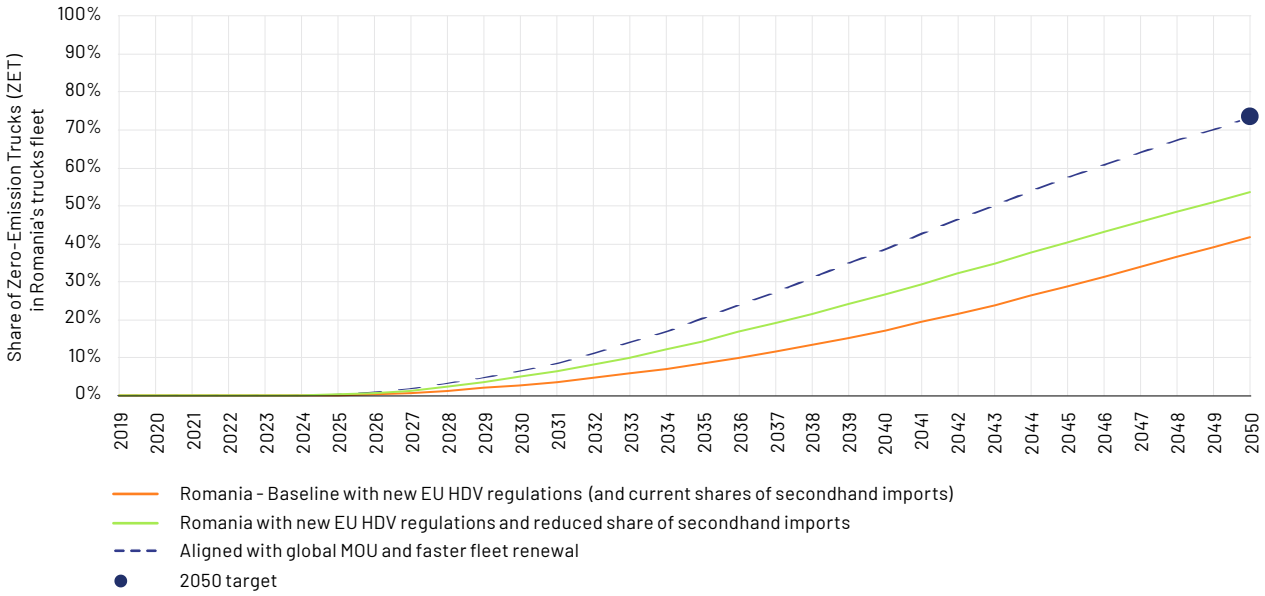
Figure 3.7. Powertrain Distribution of HGVs—Decarbonization Scenario



Source: World Bank analysis (KINESYS-ECA model).

lower fleet renewal rates), will delay the transition in some member states. For example, in Romania, the average age of trucks in the fleet is 30 percent higher than the EU average (18.6 versus 14.2 years) (ACEA 2023), and more than 70 percent of new truck registration are secondhand imports, according to the National Institute for Statistics – Romania.[ii] Figure 3.8 shows different potential trajectories for the share of ZETs in the total truck fleet in Romania through 2050. The analysis suggests that achieving a 73 percent fleet-wide share of ZETs will not only require Romania to meet the ambition of the global memorandum of understanding for new trucks (which Romania has not yet signed), which is even more ambitious than the recently agreed EU HDV CO_2 emission regulations (European Parliament and Council of the European Union 2024), but also to implement significant changes in the truck market dynamics, such as reducing the share of secondhand vehicle imports and accelerating the fleet renewal rate or enabling EV retrofits for ICEV trucks. Recommended policies to address these challenges are presented in the section on accelerating the transition to zero-emission road transport technologies. Failing to accelerate the uptake of ZETs would increase reliance on alternative fuels (such as biofuels or e-fuels), which are expected to be subject to limitations in large-scale availability, due to competing demand for biomass and land-use in the context of deep decarbonization scenarios, and risk to be more expensive, at scale, on a TCO basis, with negative implications for competitiveness.

Figure 3.8. Share of Zero-Emission Trucks in the Fleet in a Decarbonization Scenario for Romania



Source: World Bank analysis.

International Aviation and Maritime Transport

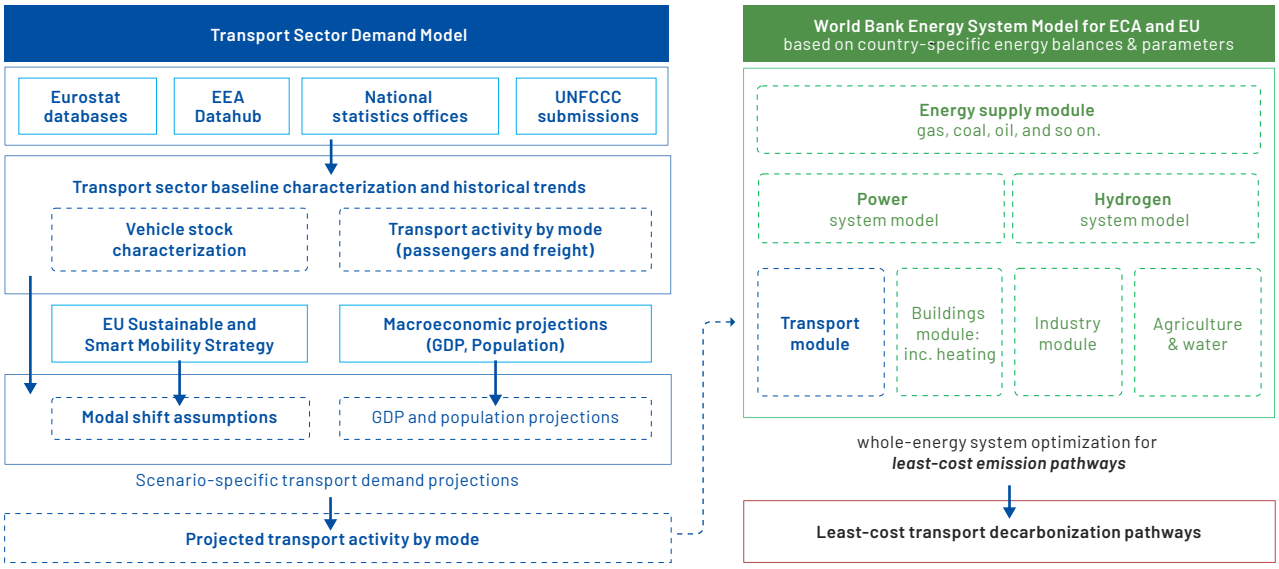
While not the focus of this report, the modelling results highlight the challenges associated with decarbonizing the aviation and maritime sectors. While aviation and maritime transport accounted for 24 percent of transport emissions in 2019,[iii] these sectors may contribute to more than 40 percent of residual emissions by 2050. This increase is linked to both the higher costs associated with the alternative fuels and technologies, as well as the lower maturity levels of such alternatives. The EU has taken decisive action to accelerate the decarbonization of both the international aviation and maritime sectors. Yet, reducing emissions from these sectors requires coordinated action through international organizations, such as the International Civil Aviation Organization and the International Maritime Organization. The international (global) nature of these segments lies outside the scope of this report and is therefore excluded from the assessment of policy options and recommendations presented in the following chapters.

Annex

Annex 3A. Transport and Energy Model Methodology

The assessment of potential transport decarbonization pathways for the European Union (EU), summarized in chapter 3, relied on the implementation of a modelling framework incorporating a transport demand model and a whole-energy system model (Figure 3A.1).

Figure 3A.1. Modelling Framework Scheme



Source: World Bank.

Transport Demand Projection

Based on previously observed data on transport activity (by segments and modes), vehicle stock development, greenhouse gas (GHG) emissions, and their relationship with economic parameters [population and gross domestic product (GDP)], projections for the period 2023–50 were estimated. Baseline input data was collected from Eurostat and European Environment Agency databases to ensure data consistency and comparability across countries, complemented by national datasets where necessary. The projections account not only for past observed trends and the expected evolution of macroeconomic indicators (mainly population and GDP) but also for the potential saturation of motorization rates and activity levels that may limit or slow future demand growth.

A contribution from modal shift in both passenger and freight transport was incorporated into the decarbonization trajectory projections. Since calculating the actual potential for modal shift to more sustainable transport modes is beyond the scope of this current report, inputs on potential modal shift relied on the estimates and targets reported in the European Commission's Staff Working Document accompanying the Sustainable and Smart Mobility Strategy. Consequently, the modal shift is reflected here as an exogenous input to the decarbonization scenario. Our demand projections conservatively exclude the effect of AVOID measures (reducing the need to travel without reducing access, achieved for instance through compact mixed-used urban developments, telecommuting, or digital access to services), or the effect of potential increases in vehicle occupancy rates.

Energy System Model

The World Bank Knowledge-based Investigation of Energy System Scenarios for the Europe and Central Asia Region (KINESYS-ECA) model is a global energy system model based on a bottom-up model generator applied to the Europe and Central Asia region. KINESYS-ECA is a multiregional and inter-temporal partial equilibrium model of the global energy system, based on the TIMES paradigm developed by the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency (IEA), which is widely used for energy modeling. The model covers energy flows for each energy supply and demand sector (transport, electricity generation, residential, commercial, agriculture, industry), as well as a wide range of subsectors/services. KINESYS-ECA includes detailed, explicit descriptions of more than 1,000 technologies and over 100 commodities in each model region.

The model generated by the TIMES paradigm represents two complementary sets of system elements: economic aspects and technical aspects. It computes a dynamic, inter-temporal partial equilibrium in energy and emission markets based on the maximization of total surplus, defined as the sum of the surpluses of both suppliers and consumers. In other words, the system is assumed to evolve while maintaining intra-temporal and inter-temporal partial economic equilibrium, always occupying the technical possibility frontier. As an economic model, its optimization does not factor in subsidies or taxes, meaning that all deployed technologies are selected based purely on cost-effectiveness (without subsidies). The model comprises several thousand technologies across all sectors of the energy system and includes emission coefficients for the three main GHGs, namely carbon dioxide, methane, and nitrous oxide.

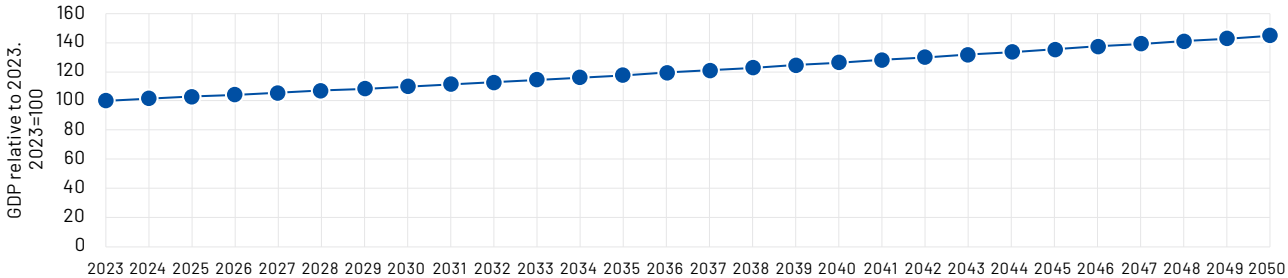
The model is calibrated to the values of the IEA's 2019 energy balance, broken down at the level of service and technology (IEA 2019). The static input of the model is a snapshot of the energy system in the base year, consisting of the stock of all "processes" that produce, transform, and use energy flows, along with their technical and economic characteristics. The team chose 2019 as the base year because the years 2020 and 2021 were not reflective of long-term structural trends due to the COVID-19 pandemic. The impact of 2022–23 geopolitical events on gas, oil, and electricity markets, simulating the energy crisis, was also represented.

The dynamic inputs of the model relate to future events, such as the availability of new technologies, their characteristics, the discovery of new resources, and learning rates for capital expenditure cost curves across all technologies, as well as population and GDP growth.

GDP and Population Growth Assumptions

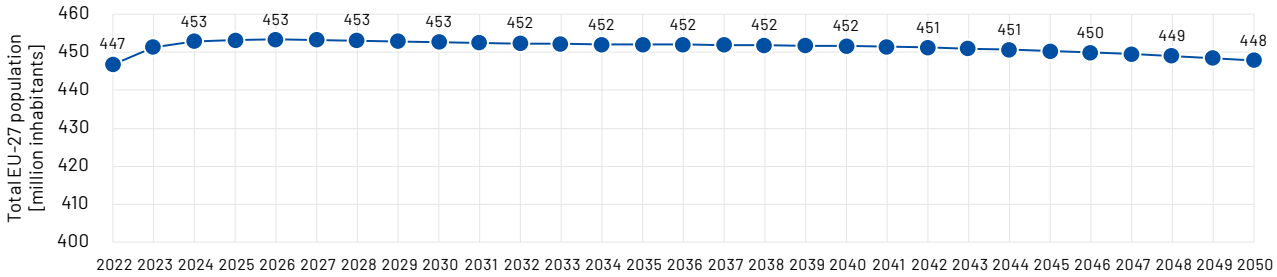
The GDP growth assumed for EU member states in this analysis follows the Shared Socioeconomic Pathways 2 trajectory, presented in aggregate in Figure 3A.2. Country-level population projections are based on the latest Eurostat baseline projections, presented in Figure 3A.3 for the EU level. The analysis includes the 27 member states comprising the European Union as of 2024.

Figure 3A.2. EU-27 GDP Trajectory Used in this Analysis



Source: Based on the Shared Socioeconomic Pathways 2 scenario.

Figure 3A.3. EU-27 Population Projection used in this analysis



Source: Data Browser (database), Eurostat, Luxembourg City (accessed July 28, 2024), https://ec.europa.eu/eurostat/databrowser/view/proj_23np/default/table?lang=en&category=proj.proj_23n.

Notes

[i] Should a quick transition toward electric vehicles be delayed (for example, due to challenges related to the development of sustainable battery value chains), alternative technological pathways would require significantly greater amounts of primary low-carbon energy, given the lower energy efficiency of powertrains other than electric motors. This would be coupled with challenges regarding the sustainable and affordable availability of biomass, and/or the need for an even faster scale-up of low-carbon electricity supply, which is also not without cost, critical raw material supply issues, and land-use availability challenges. Greater reliance on carbon dioxide removals, considering the scale of emissions reduction required, would demand a major increase in low-carbon energy and primary resource supplies, or, in case of nature-based solutions, a significant scale-up that faces both governance and climate-relate challenges.

[ii] See National Institute for Statistics – Romania's website at http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table.

[iii] Emissions from international bunkers (aviation and maritime) are based on the countries' submissions to the United Nations Framework Convention on Climate Change and the EU Greenhouse Gas Monitoring Mechanism (European Environment Agency 2024).

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4. Key Priorities, Opportunities, and Challenges for EU Transport Decarbonization

As presented in the previous chapter, the projected increase in passenger and freight transport within the European Union (EU) underscores the significant need to expand the adoption of low-carbon transport modes. A central element of the EU's strategy to decarbonize the transport sector heavily relies on the large-scale adoption of zero-emission technologies for road transport, notably the shift toward battery electric vehicles (BEVs). In parallel, enhancing the competitiveness of railways is crucial, as it offers a sustainable alternative to road and air travel with significantly lower carbon emissions. Additionally, in urban areas, effective demand management and a shift away from the use of private cars are essential. The challenges and risks associated with these transitions vary along geographic and economic lines, with lower-income member states facing particularly steep hurdles. The EU should address such disparities and ensure a cohesive transition across all member states. It is therefore imperative to delve deeper into challenges that will critically influence achieving the EU's decarbonization strategy. This chapter provides an overview of major challenges and identifies areas of opportunity for further action in three pivotal areas: (i) accelerating the transition to zero-emission road transport technologies; (ii) creating sustainable urban and metropolitan mobility; and (iii) enhancing the role of the rail sector to decarbonize transport. Moreover, one overarching recommendation from this report is presented below regarding maximizing the impact of EU resources by leveraging private capital and fostering commercially oriented operations.

Maximizing the Impact of EU Resources: Leveraging Private Capital and Fostering Commercially Oriented Operations

The EU can optimize the use of funding and financing instruments to unlock private sector investment to support transport decarbonization. Decarbonizing transport will require a significant, but cost-effective, shift toward less energy- and carbon-intensive transport modes (that is, rail, public transport, and active mobility) and technologies (for example, BEVs). These alternatives not only offer environmental benefits but also provide life-cycle cost advantages that make them economically competitive. However, their implementation requires substantial upfront capital investments, which presents a financial challenge, particularly for lower-income member states and capital-constrained businesses and population segments. The EU has already established considerable funding and financing mechanisms to support this transition. Nonetheless, there is an urgent need to refine these approaches to increase the leverage of EU resources and maximize their impact by using them to mobilize private capital.

A cross-cutting recommendation made in this report is the need to use financing mechanisms that mobilize private finance and leverage the limited public resources available for decarbonizing the transport sector. This includes: (i) introducing financial instruments (pricing incentives, credit enhancement, de-risking, and partial upfront grant mechanisms) to bridge participation and viability gaps that limit the private sector's ability to invest in transport decarbonization; (ii) implementing reforms that improve governance and enhance the profitability and financial sustainability of public transport enterprises, enabling them to

increase their access to commercial finance; and (iii) making greater use of public-private partnerships (PPPs) for transport infrastructure and services, as PPPs are not just a way to mobilize private capital but are also critical to crowd-in global expertise and innovation. The adoption of such approaches is a transversal recommendation that applies to all three pillars analyzed in this report:

- **While the EU plays a crucial role in addressing affordability and ensuring a cohesive transition for passenger electric vehicles (EVs), improving the financial viability of heavy-duty EVs is needed to facilitate private investments in these segments (trucks and buses).** The EU can help mobilize private capital by: (i) supporting financing and de-risking instruments, especially for heavy-duty trucks and high-powered charging infrastructure along selected high-demand priority corridors; and (ii) advancing PPPs for e-bus scale-up, including new business models that can benefit from de-risking and financing instruments mentioned above, such as unbundled bus provision and operation (that is, fleet PPPs), e-mobility as a service, and procurement aggregation to increase scale and reduce costs. This could also be integrating provisions (e.g. on the carbon content of products and the sustainable sourcing of materials) that favor the competitive transformation of the European industry and the development of cost-efficient and geographically diverse supply chains for low-carbon technologies.

- **Transforming urban transport systems requires leveraging diverse sources of funding, as any form of financing will still need to be repaid from sector revenues.** The transition will not be free, and a larger amount of transport sector revenues, or funding, will be needed to finance the upfront capital investments. This highlights the importance of tapping into different funding sources, such as: (i) promoting greater usage of land value capture (LVC) mechanisms in urban areas; (ii) scaling up the application of pricing mechanisms for demand management policies, such as parking fees and congestion charge; and (iii) exploring other revenue sources from sectors/stakeholders that stand to benefit from the transition.

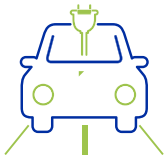
- **The EU can also maximize the impact of its support by conditioning the use of urban mobility finance on projects/recipients that seek to maximize sector revenues/funding and complement scarce public resources with private finance.** This includes: (i) expanding policy-based conditionalities to access EU regional funds; and (ii) creating incentives to attract private capital and expertise through concessions and other innovative financing mechanisms.

- **Unlocking the competitiveness of the rail sector, where there is potential for growth, requires a more commercially oriented mindset among railway undertakings.** While the EU is making significant efforts to support rail infrastructure development and renewal, capturing demand away from road transport—such as the long-distance container rail segment across EU-wide rail corridors—requires a transformation toward railways that can nimbly respond to market needs in a reliable and cost-effective way. Developing the conditions to further attract private sector participation (for example, allowing rail and intermodal projects to tap into carbon markets if they manage to reduce emissions) and including conditionalities on financing related to consumer orientation of rail operations can incentivize efficiency and maximize the impact of EU funds.

These points illustrate ways in which EU financial support can be used more strategically and efficiently, giving the private sector a larger role than has been the case to date. Further details are presented throughout the report and within the relevant sections below.

Accelerating the Transition to Zero-Emission Road Transport Technologies

Summary of Key Recommendations



Box 4.1. Summary of Key Recommendations: Zero-Emission Road Transport Technologies

Leveraging the Private Sector

- Expand the use of modern concession models with performance-based remuneration to increase the uptake of e-buses at scale, potentially including separation of asset ownership and operations, and aggregating procurement initiatives.
- Developing De-Risking Mechanisms to Crowd in Private Capital.
- Establish and implement de-risking and financing schemes for the transition to Zero-Emission Trucks and deployment of high-power charging infrastructure (for example, partial credit guarantees/risk-sharing facilities; viability gap funding; credit enhancements; or liquidity facilities).

Conditioning and Coordinating the Use of EU Funds to Deliver Results at Scale

- Prioritize the electrification of company fleets and other highly utilized vehicles, combining taxation and regulatory instruments.
- Revise existing vehicle regulations and member state taxation policies and electric vehicle (EV) incentives to favor smaller, more affordable, and more energy-efficient vehicles.
- Use resources from the Social Climate Fund (complemented with revenues from differentiated vehicle taxation schemes) to support lower-income groups and small businesses.
- Offer conditional European Union (EU) incentives for e-bus procurement schemes that maximize scale and leverage private capital, such as fleet PPPs.
- Use EU funds to provide derisking mechanisms to enable the mobilization of private finance for (i) electrification of public transport, and (ii) deployment of ZETs and high-power charging infrastructure along high-demand freight corridors.

Managing the Implications of the Industrial Transformation for the EU Car Industry

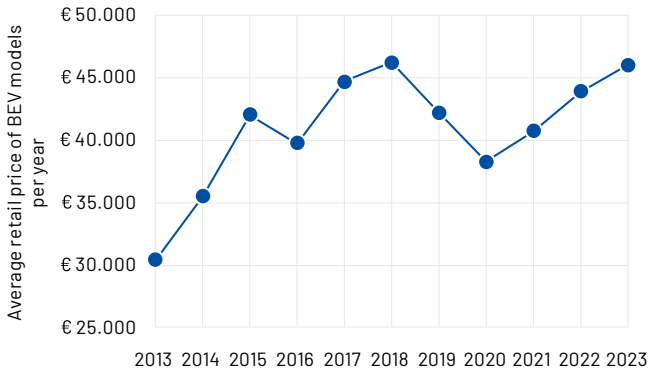
- Introduce procurement and regulatory requirements based on nondiscriminatory and non-price criteria (for example, on greenhouse gas intensity, reparability, and recycled content).
- Implement policies favoring access to raw materials.
- Integrate accession countries into the EU's EV and battery supply chains.
- Support workforce upskilling and reskilling.

Current Context and Rationale for Further Action

The EU's policy framework has spurred the growth of EV penetration in its initial phase. In 2023, Europe accounted for 25 percent of global EV sales and saw a 20 percent increase in new registrations from 2022, reflecting robust growth (IEA 2024a).[i] However, the extent of the EV penetration and the development of associated infrastructure remain uneven across geographies and income groups. This uneven penetration is exacerbated by the dual challenges of higher upfront costs for EVs and increased borrowing expenses, which disproportionately affect EU member states, businesses, and households with limited financial resources. Addressing affordability challenges is not merely an option but a necessity for the EU to ensure equitable access to e-mobility solutions and to sustain its growing EV adoption trend.

The offering of electric cars in the EU has focused on larger, premium, high-end market segments, leading to distortions in EV adoption across society and exposing the EU industry to risks of losing market share to global new entrants. European automakers have predominantly targeted larger and more expensive market segments [such as sport utility vehicles (SUVs)] for the early deployment of EVs, partly driven by greater profitability margins (Cazzola, Paoli, and Teter 2023). This approach has kept the average retail price of battery electric vehicles (BEVs) in the EU above €40,000 since 2015, increasing to €46,000 in 2023[ii] (Figure 4.1), with 2020 as an exception due to tighter carbon dioxide (CO_2) emission regulations pressing manufacturers to boost EV sales. This preference for premium and larger vehicles complicates the mass transition, as EVs' higher initial costs compared to internal combustion engine vehicles (ICEVs) present a significant hurdle. The upward trend in new passenger car prices exacerbates affordability issues for consumers and businesses, particularly those with limited access to affordable financing. This is further compounded by data showing longer vehicle lifetimes for the existing stock (slower fleet renewal) (ACEA 2024a). Such trends not only risk widening social inequalities but also negatively impact energy efficiency, energy diversification, local pollution, and CO_2 emission goals. While a decline in average EV prices is expected in 2025 as automakers will face tightened CO_2 targets for the coming year (Transport & Environment 2024), additional policy measures are needed to further steer the market toward smaller and more affordable EVs.

Figure 4.1. Available Battery Electric Vehicle Models in Europe per Year



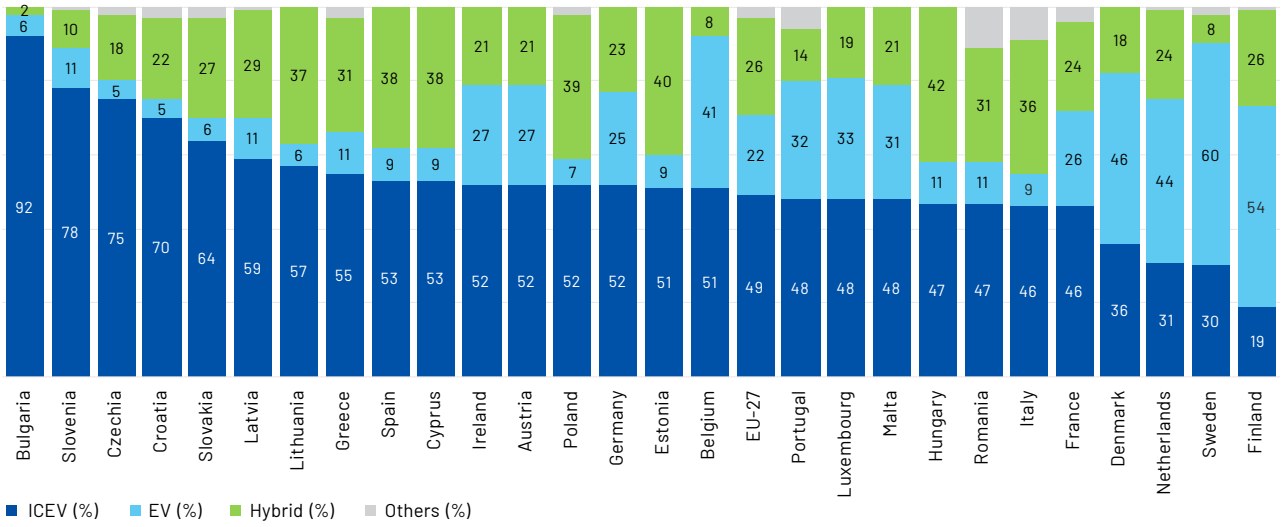
Source: "Electric vehicle model statistics," European Alternative Fuels Observatory, European Commission, https://alternative-fuels-observatory.ec.europa.eu/policymakers-and-public-authorities/electric-vehicle-model-statistics.

The transition to EVs highlights the need to explore new tax and road charging schemes to limit the growing average size of new vehicles and to replace the missed revenues from fuel taxation. The average vehicle size in Europe has been close to the global average and well below that of the United States. This may partly be explained by spatial constraints in European cities, but also by the EU's higher fuel retail prices, which encourage greater fuel efficiency and smaller vehicles. With significantly lower operational costs of EVs compared to ICEVs, there is a risk of a more rapid increase in the average size of new vehicles as the fuel tax incentive diminishes. In fact, Europe has seen a higher share of SUVs within the EV market compared to the ICEV market (Cazzola, Paoli, and Teter 2023). Larger vehicles would not only be less energy- and resource-efficient but would also exacerbate the disproportionate use of public space by private cars in urban areas and negatively impact road safety for pedestrians and cyclists. Moreover, given the importance of fuel tax revenues to the public budgets of EU member states, the transition to EVs underscores the need for alternative revenue streams to replace these taxes.

Disparities in EV adoption also exist across member states, reflecting a divide largely along geographic and economic lines. EV uptake has been mostly concentrated in Northern and Western EU countries, with the share of new electric passenger cars ranging from 60 percent in Sweden to 5 percent in Croatia and Czechia (Figure 4.2), and mainly concentrated within the high-income segments of the population (note that Figure 4.2 does not account for secondhand vehicle registrations). Another disparity in the EU is the deployment of charging infrastructure. The highest density of publicly accessible charging stations is concentrated in the Netherlands, France, and Germany (ECA 2021; ACEA 2023a), when evaluating the ratio

of charging points per 100 square kilometers. Similar contrasts are also observed analyzing EV chargers to EV ratios. EU countries more successful in stimulating EV deployment—such as Norway, Germany, and Sweden—have lower rates of available kilowatts in charging stations per EV, indicating a more intensive use of publicly accessible chargers compared to EU countries with relatively low EV stock shares, such as Italy, Greece, and Poland (IEA 2023).[iii]

Figure 4.2. Powertrain Distribution of New Vehicles Registered in EU Member States in 2023



Source: ACEA 2024b.

Note: "EV" includes both Battery-Electric Vehicles and Plug-in Hybrid Vehicles. "Others" includes fuel-cell EVs, natural gas vehicles, LPG, E85/ethanol, and other fuels.

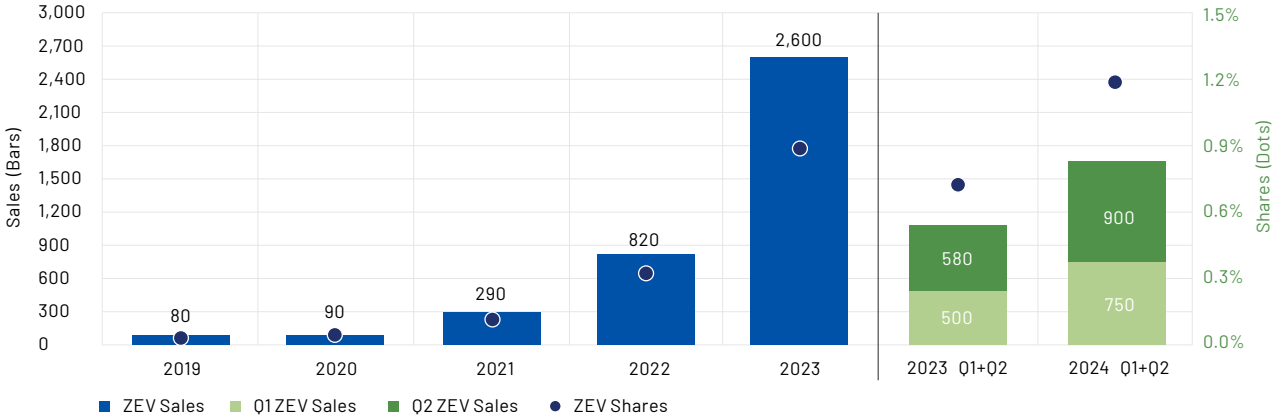
Slower EV adoption in lower-income countries and those reliant on secondhand vehicle imports, compounded by rising motorization rates, hinders the fleet-wide e-mobility transition. The disparity in EV adoption is exacerbated by the dominant market share of secondhand vehicle imports in Eastern EU member states and candidate countries for EU accession, where motorization rates are also rising (ITF 2023; UNEP 2021). In Europe, there are significant flows of secondhand vehicles between countries due to the relative ease of transport between markets and open borders (ITF 2023). Typically, vehicles move from wealthier Western European countries to lower-income Eastern European countries as they age. In higher-income Western European countries, used vehicle imports tend to be relatively new and account for a smaller share of total new annual registrations. In contrast, used vehicles imported into lower-income Eastern European countries are considerably older (median age approximately seven to eight years) and account for a greater share of the vehicles entering the stock (ITF 2023). Coupled with the market growing preference for premium, high-end vehicles, traditional access to motorization via secondhand imports from wealthier European countries is becoming more expensive.[iv]

Having achieved economic viability with a lower total cost of ownership (TCO) in many applications, e-buses in the EU are now positioned to enable mass adoption through leveraging private sector investment. The sales of zero-emission buses in the EU in the first half of 2024 increased by 35 percent compared with the first half of 2023, with electric buses reaching a market share of 40 percent for new city buses, but less than 1 percent for new interurban coaches (Ananda, Musa, and Basma 2024). Despite these advances, e-bus adoption still predominantly relies on public funding, primarily sourced from initiatives like the NextGenerationEU plan and member states' national budgets.[v] While upfront costs remain high—both for fleets and charging

infrastructure—compared to diesel counterparts, these are often offset by lower operational costs over the vehicle's lifetime, eventually resulting in an overall lower TCO. This reinforces the rationale for cities to pay for services rather than assets, which can be facilitated through modern concessions that leverage private sector participation and share the financial burdens and risks across acquisition, operation, and management between public and private entities. This strategic shift will not only reduce reliance on public funds but also ensure widespread deployment of e-buses across the EU.

The transition of trucks toward the EU target of a 90 percent reduction in tailpipe emissions for new trucks by 2040 (implying the need for high electrification rates) is only just beginning. The EU is gaining momentum in heavy, long-haul electric truck sales, with a 53 percent increase in ZET sales during the first half of 2024 compared to the same period in 2023 (and in 2023 ZET sales were more than three times the sales in 2022). However, these trucks still account for only 1.2 percent of total heavy truck sales (Ananda, Musa, and Basma 2024) (Figure 4.3). In Europe, battery electric trucks are expected to become the most cost-effective decarbonization option for most truck categories by 2030 from a TCO perspective, as their lower operating costs are expected to offset their higher initial purchase prices (Basma and Rodríguez 2023), presenting relevant industry opportunities to improve competitiveness. Nevertheless, high initial costs and insufficient high-power charging capacity remain significant barriers to adoption, particularly for smaller businesses, which often have limited access to financing or lower credit.

Figure 4.3. Sales of Zero-Emission Trucks in the EU



Source: Adapted from Ananda, Musa, and Basma 2024.

The EU has set rigorous targets for the transition toward zero tailpipe emission vehicles, but its industry is struggling to secure competitiveness in the EV market. While the EU automotive industry has generally supported the European Green Deal (EGD), it has expressed concerns about the rapid pace needed for the technology transition required in the Fit for 55 policy packages (ACEA 2019; Huitema 2020; ACEA 2023b; and ACEA 2024c). Nevertheless, various EU industry stakeholders have adopted differing positions, particularly regarding the technology pathway to follow. Stakeholders who have invested in BEVs and the related value chains—including leading EU automakers, top-tier suppliers, novel and existing battery makers, and charging point suppliers and operators—have shown greater enthusiasm for continued ambition to secure a competitive advantage as early movers in the market, especially with new entrants capturing an increasing market share (AVERE 2022; ChargeUp Europe 2021). Conversely, those with a stronger stake in ICEV sales—such as numerous tier 2 and tier 3 suppliers in the automotive value chain, still focused on the ICEV components—have preferred more technology opening (CLEPA 2021; AECC 2021), despite the risk of losing competitiveness

to manufacturers from other parts of the world, notably China (Adeola et al. 2023). As the transition remains incomplete and stakes are high for the sector, it is crucial to achieve greater alignment and strengthen public-private cooperation on this topic.

The technology transition required for net-zero compliance carries significant social and economic impacts, particularly concerning job security. The European automotive sector, still predominantly reliant on ICEVs, is a cornerstone of the region's economy, contributing approximately 7 percent to its gross domestic product and employing around 14 million people.[vi] This transition is further complicated by the emergence of new automotive market entrants, notably from China, amid a challenging macroeconomic environment in Europe, such as rising energy costs, inflation, and geopolitical tensions. According to the European Commission, the share of Chinese EVs sold in Europe has risen to 8 percent and is projected to reach 15 percent in 2025, with prices typically 20 percent below those of EU-made models (Blenkinsop 2023). These factors have affected the European auto industry and make navigating the sector's transformation challenging. This significant contribution of this sector underscores the importance of carefully managing the transition to safeguard social and economic stability, highlighting the necessity of targeted measures to mitigate potential adverse effects on jobs and production processes driven by the shift toward green and digital technologies.

Securing EV and battery supply and value chains in the global market is an emerging challenge, crucial for attracting production investments to the EU. Given the substantial capital requirements to rapidly scale up EV and battery production, the delays accumulated relative to competing global players, and the significant impact of battery costs on the total value of vehicles, the EU must accelerate the mobilization of investments to build a competitive battery value chain (ECA 2023a). Key milestones in this context include the activities of the European Battery Alliance, which began as early as 2017, along with increased efforts to diversify sourcing of critical resources and develop EU-based manufacturing capacities. These are reflected in initiatives such as the Critical Raw Materials Act[vii] and the Net-Zero Industry Act,[viii] as well as other tools, including policies like the Battery Regulation (European Parliament and Council of the European Union 2023a). Such policy responses aim to secure regional manufacturing capacities and reduce overreliance on single-country sources. Their development is intended to address the challenges the EU has faced in keeping pace with global competitors, particularly China and the United States (ECA 2023a).

The evolving global landscape for EV and battery manufacturing could challenge the EU's long-term ambitions to meet rising EV demand. The United States (Box 4.2) has gained significant traction in the EV and battery supply chain through the Inflation Reduction Act (IRA), offering attractive funding packages,[ix] including direct payments of uncapped amounts, to attract global manufacturers (Transport & Environment 2023). The EU has committed substantial funds for similar purposes, such as REPowerEU Recovery and Resilience Facility funds, InvestEU, and the Innovation Fund (European Commission 2023a). However, relatively complex and slower funding procedures could affect the EU's investment attractiveness, compounded by structural challenges such as higher energy prices and labor costs. The IRA's introduction has also significantly altered the industrial landscape, potentially redirecting some investments originally planned for Europe to the United States (Scheinert 2023). A key indicator of this shift is the substantial increase in announced U.S. battery gigafactory capacity, more than double Europe's growth since the act passed.[x] The IRA has also been transformative for the U.S. battery supply chain, attracting over $110 billion in clean energy investments, with more than $70 billion directed toward enhancing the U.S. battery supply chain, including gigafactory projects essential for EV production (Mehdi and Moerenhout 2023).

Box 4.2. Case Study: Mobilizing Private Investment: The U.S. Inflation Reduction Act and Its Impact on EV Manufacturing Capacity

The global landscape around securing electric vehicle (EV) and battery manufacturing capacities is rapidly evolving, driven by growing demand for EVs and the urgent need for sustainable transport solutions. This shift is critical for global EV leaders to enhance their competitive edge. A major development is the U.S. Inflation Reduction Act (IRA), signed in August 2022, which has profoundly impacted the EV and battery sectors by attracting over $13 billion, including from European carmakers, and accelerating technological advancements (Transport & Environment 2023).

The IRA's success stems from several strategic mechanisms. the IRA modified and extended a tax credit for clean vehicle purchasers, providing $3,750 for vehicles meeting the critical minerals requirement and an additional $3,750 for vehicles meeting the battery component criteria for North American manufacturing.[a] Furthermore, the IRA offers production tax credits for domestic manufacturing of renewable energy components, including batteries and critical minerals (White House 2022). The act builds on the Bipartisan Infrastructure Law, allocating over $7.5 billion for a national network of 500,000 EV chargers, more than $7 billion for domestic EV battery production, and $10 billion for clean transit and school buses (White House 2022). The act aims to catalyze investments in domestic manufacturing capacity.

The tax credits are simple, bankable, and can be stacked by one company. Another critical aspect is the guarantee of longer-term financing. Unlike many annual funding programs that lack the long-term certainty needed for technological transitions, the IRA guarantees financing until 2032. Many of the bill's tax incentives are direct pay (McKinsey & Company 2022),[b] ensuring companies benefit fully, even if their tax liability is less than the credit.

Strategic financial mechanisms are crucial to boost the EV sector's growth and competitiveness without creating distortions or discriminatory measures. It is essential to design financing processes and funding packages that are attractive and accessible to manufacturers, ensuring long-term industry investment and development.

[a] These credits are income-based and, from 2024, will exclude vehicles with foreign-manufactured battery components.
[b] This means that an entity can claim the full amount.

Without renewed strategic support for the EU's EV battery value chain, achieving decarbonization goals may result in higher costs and increased environmental strains. Scaling a broader set of technologies, including biofuels and e-fuels, requires greater land use for biofuels and higher energy demands for renewable hydrogen or e-fuels compared to direct electricity use. Due to inefficiencies in energy supply chains, these technologies are likely to incur structurally higher costs, potentially hindering economic growth (Huntington and Liddle 2022; André et al. 2023). This scenario underscores the need for targeted policy and industrial efforts to economize the EV transition, in road transport.

Strategic Actions

Increasing Electric Car Adoption at Scale

To progress beyond the "early adopter" phase and achieve "early majority" adoption of EVs for passenger cars and light commercial vehicles, affordability across all income levels through its member states needs to be achieved. Recommended policy actions in this area are presented below.

To bridge the affordability gap, EU member states can revise national and local vehicle taxation policies and EV incentive structures to promote smaller, lower-priced vehicles (both new and secondhand) while penalizing larger, premium segments with higher CO_2 emissions and poor energy efficiency. In EU member states, vehicle registration and/or circulation taxes already differ based on parameters such as price, engine power, capacity, CO_2 emissions/kilometer, powertrain type, and vehicle weight. EVs are often exempted from or subject to taxation advantages. This is also applicable to secondhand imports in some cases (PwC 2022). A more unified approach to fiscal policies, including vehicle registration/circulation and energy taxation across the EU, can incentivize industrial development by de-risking investment decisions for manufacturers regarding the type of products to commercialize, ultimately helping to ensure that the potential of the EU to leverage its single market's power is better exploited, in line with recent recommendations (Letta 2024). New Zealand's bonus/malus system, which adjusted taxes based on a vehicle's CO_2 emissions per kilometer for all newly registered vehicles between 2022 and 2023, including secondhand imports,[xi] or the differentiated taxation system in place in Greece, applying levies that depends on the value of the cars, its CO_2 emissions and its local pollutant emission standard, and it is also applicable to secondhand cars (Government of Greece, 2022), offer a compelling models that could inspire similar implementations in other parts of the EU and in EU accession countries, considering also vehicle size and energy efficiency.

Through regulatory requirements and vehicle taxation reforms, member states and local authorities can prioritize the early electrification of company fleets and other highly utilized vehicles (for example, taxis, ride-sourcing and other public transport services, and urban freight deliveries). This can be achieved via targeted regulations (which would be best developed at the EU level, or with EU-wide coordination tools, but could also be effectively enacted by local authorities, for some applications[xii]), CO_2-differentiated vehicle taxation for company fleets (as in Belgium), corporate social responsibility reporting and/or greenhouse gas (GHG) emission mitigation obligations, and/or with specific regulatory requirements for the electrification of fleets. This is important as it can leverage the greater capacity of corporations to withstand a higher tax burden compared to households (Carpenter and Antich 2022). Additionally, it can also help increase, cost-effectively, the medium-term availability of affordable EVs in the secondhand market. As it increases the number of EVs deployed, and as this increase tends to be paired with higher EV charging infrastructure utilization, this acceleration of EV deployment can also help reduce the cost of accessing electricity by improving the economics of the deployment of recharging infrastructure. According to Transport & Environment (2024a), 60 percent of new car registrations in the EU in 2023 were company cars (up from 50 percent back in 2015), and these would be responsible for 74 percent of total new car GHG emissions.

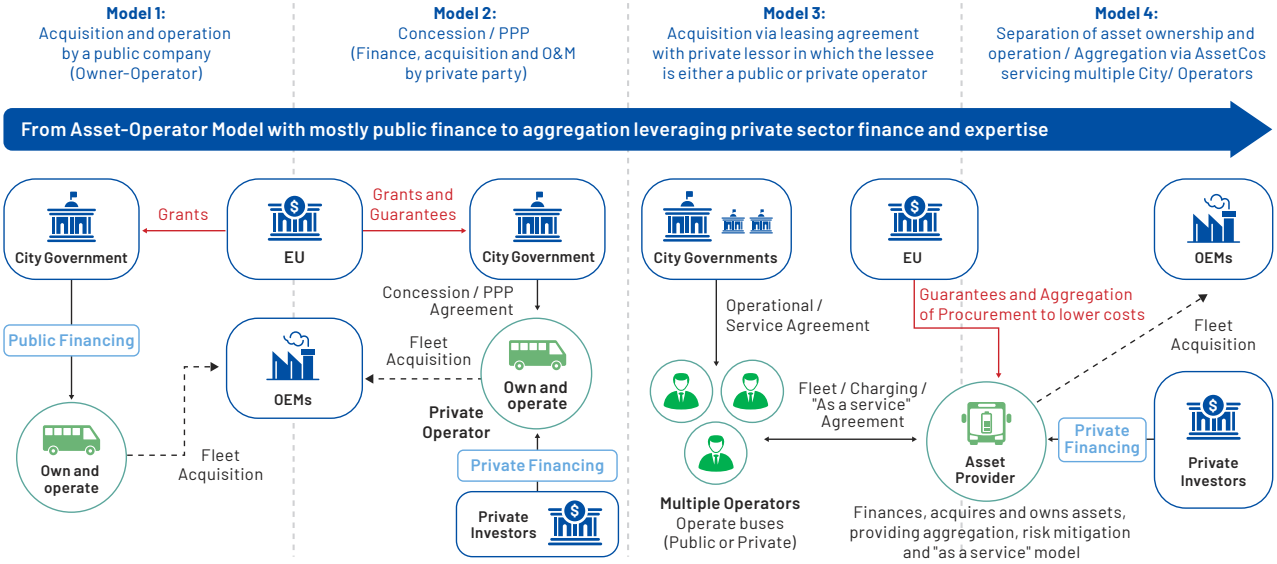
EU member states may leverage revenues from the Social Climate Fund to support targeted programs like "social leasing," but these need to be carefully designed to avoid discouraging public transport use. Social leasing can improve access to EVs for lower-income groups and small businesses, while also incentivizing manufacturers to offer affordable EV models in response to growing demand. A prominent example of this type of approach was adopted in France, offering incentives based on income, minimum travel thresholds, and the necessity for an EV to reach the workplace (Ministère de la Transition Ecologique et de la Cohesion des Territories 2024). The success of this program quickly depleted its budget in 2024, highlighting the critical need for robust funding for similar approaches. A secured funding source is particularly critical for lower-income member states, which face more constraints in rolling out such programs due to their reliance on public budgets. Key options include differentiated vehicle taxation, with higher charges for vehicles with high emissions, and carbon pricing mechanisms. For EU member states, this can also leverage the revenues that will become available from the Social Climate Fund.[xiii] For EU accession countries, this will require the development of specific funding mechanisms, which could be based on the same principle and would benefit from financial assistance from the EU. To limit potential negative effects on encouraging a

shift from public transport to private cars, eligibility criteria may be introduced for these programs, such as minimum commuting distances or the need for vehicle use for professional activities (similar conditions applied in the pilot program in France).

Leveraging the Private Sector's Potential to Transition to e-Buses

Local and national governments can scale up e-bus adoption by leveraging private capital through concession models, effectively utilizing public resources and EU funds. E-buses require different types of investments, including in infrastructure, power supply, and have higher upfront costs, which creates a significant initial capital burden and comes with new risks. Although several EU cities have already successfully implemented concession models for public transport, wider adoption of these approaches could help complement limited public resources and better leverage EU funds. Going beyond the traditional public transport concession, cities may consider new models where one or more cities or operators (either public or private) procure charging infrastructure, equipment (e-buses or batteries) from specialized private sector entities, such as leasing companies, utilities, original equipment manufacturers; or outsource the whole e-mobility solution from an asset company that integrates all these components into a single offer (e-mobility as a service). For instance, a city may enter into a lease-like PPP for the provision of e-buses for multiple lines that is isolated from operational risks and independent from operations concessions/service agreements as a way to create scale in procurement, mitigate risks, and reduce financing costs. Promoting e-bus procurement aggregation, supported by technical standardization and aggregation platforms, can help streamline the process and lower vehicle acquisition costs and offer opportunities to support the industrial transition. Furthermore, public authorities can incentivize e-bus adoption by integrating performance-based remuneration, ensuring to include environmental impacts and service quality rather than covering upfront capital costs. The EU can enhance funding strategies by offering conditional incentives for e-buses in aggregated procurement initiatives or private sector partnerships, and by providing financial tools, such as guarantees to lower financing costs for concessionaires. Figure 4.4 summarizes different models for bus-based public transport fleet and service provision, with growing levels of private sector participation.

Figure 4.4. Different models for bus-based public transport fleet and service provision with growing levels of private sector participation.



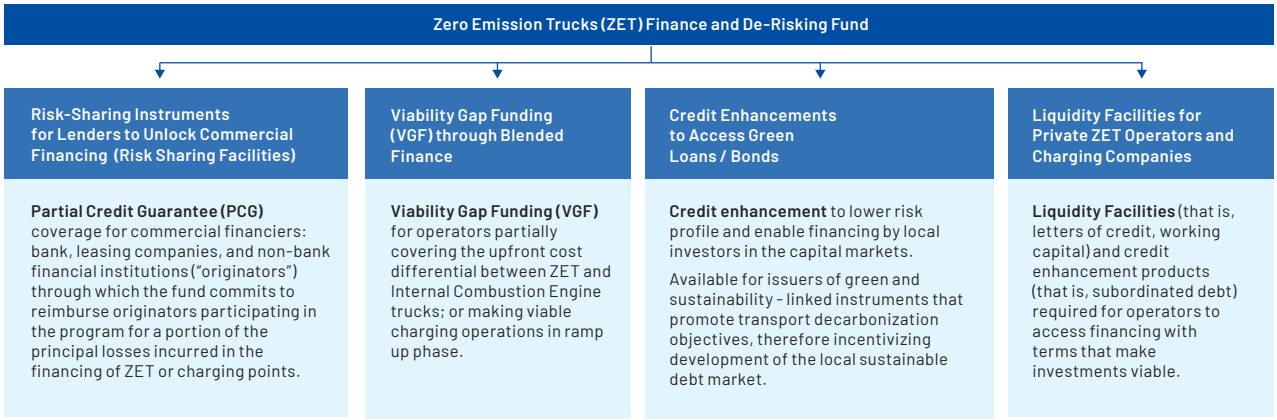
Source: World Bank elaboration

Advancing Electrification of Heavy-Duty Trucks through Innovative Financing Mechanisms

Overcoming financial barriers is essential, particularly for capital-constrained businesses. The EU has adopted ambitious regulations on CO_2 emissions/kilometer for heavy-duty vehicles (HDVs) to boost the supply and adoption of zero- and low-emission HDVs (European Parliament and Council of the European Union 2019). With its Alternative Fuels Infrastructure Regulations, the EU has also established minimum requirements for charging infrastructure, first across the Trans-European Transport Network and then (via national plans) also beyond it, within member states. Moreover, battery-electric trucks are expected to have a lower TCO than diesel counterparts for most truck categories by 2030, as their lower operating costs are expected to offset their higher initial purchase prices (Basma and Rodríguez 2023). Nevertheless, higher upfront costs will remain a barrier in the transition, especially for small and medium enterprises with limited access to capital. To overcome these financing barriers, the EU and member states could support specific financing programs that offer low interest rates to small businesses and those most impacted by the transition. To boost the uptake of ZETs, the expansion of business models such as electric truck leasing and truck-as-a-service programs (including charging and battery) will also be important, as well as prioritizing zero-emission vehicles in public procurement.

National governments can support financial institutions in providing financing and de-risking mechanisms that facilitate private sector investment and address equity concerns in the ZET transition. For example, a government-backed financial institution could establish a ZET De-Risking Fund offering various financial solutions, which may include: (i) Partial Credit Guarantee/Risk Sharing Facility to commercial lenders, to encourage lending to private ZET/charging point operators that meet eligibility criteria (that is, participation in the priority corridors program); (ii) Viability Gap Funding; (iii) credit enhancements to entice investors to invest in capital market instruments (that is, green and sustainability-linked bonds) in the local markets; or (iv) liquidity facilities for ZET/charging point operators. These are briefly presented in Figure 4.5.

Figure 4.5. Potential Financial Solutions under a Zero-Emission Trucks Finance and De-Risking Fund



Source: World Bank.

Developing Charging Infrastructure to Support the e-Transition and Meet Future Demand

The EU and its member states must prioritize the swift transposition of EU-level directives into national legislation to enhance charging infrastructure provision and green the grid. The EU has introduced several critical directives aimed at enhancing the provision of charging infrastructure and the greening of the grid. The Energy Performance of Buildings Directive, proposed in 2021 and now close to finalization (European Commission 2021a; European Commission 2023b; European Council 2023), mandates pre-cabling for all new constructions and major renovations and facilitates the installation of charging points in residential buildings, thus securing

a "right to plug." This implementation is impactful because it allows households and businesses to access private chargers, where most charging events occur due to their lower cost compared to publicly accessible chargers. Furthermore, the Renewable Energy Directive is crucial for aligning member states' energy grids with EV charging infrastructure needs (European Parliament and Council of the European Union 2023b). It supports the diversification of energy sources and aids in greening the energy grid, thereby accommodating different grid capacities across EU member states. A key implementation of this directive is evident in Germany's TGH quota system, which credits renewable electricity used in EVs. This system not only fosters a sustainable energy model but also creates revenue streams for EV owners and operators. Such mechanisms exemplify how targeted regulatory frameworks can boost the economic viability of EVs in other EU markets, including Eastern Europe.

Supporting the deployment of charging infrastructure in disadvantaged and lower income areas will be needed to mitigate accessibility disparities. Leveraging private sector participation, member states can employ strategies that enable charging point providers to use cross-subsidization (for example, properly designing public competitive concession tenders to include multiple locations), using revenue from high-usage chargers to fund deployments in underserved areas. They can also support charger deployment by public funding. This approach is most effective when it bridges remaining gaps in charger deployment for communities that face challenges in accessing private charging, such as those without access to private parking (Ministère de la Transition Ecologique et de la Cohesion des Territories 2019). Public service contracts targeting these disadvantaged communities can also be designed progressively, leveraging revenues from carbon pricing or general taxation. The Cohesion Fund (CF) targets investments in specific member states to support emission reduction and energy poverty initiatives,[xiv] aligning with national energy and climate strategies (European Parliament and Council of the European Union 2021). It is critical for the European Commission to allocate adequate CF resources to low-income member states to bridge the existing gap and support the minimum deployment of chargers across the EU.

For road freight, the EU can begin by enabling private investments in EV charging infrastructure tailored to HDVs' higher power needs along major freight routes where high demand can be aggregated. This could be done, for instance, through de-risking mechanisms, and complementing it with public funding in parts of the road network requiring geographical coverage but not being as attractive for the private sector. Grid enhancements or stationary storage capacity are also likely to be important for heavy vehicle charging to accommodate their significant energy and power demands (Shoman et al. 2023). Enhancing the grid to support these high-capacity systems will be critical. Developing assessments of current and projected power supply needs can facilitate simplified permitting processes. This planning is also vital for electricity network operators preparing for grid enhancements to support these demands (Punte 2023). A relevant example is the National Zero-Emission Freight Corridor Strategy in the United States, which aims to increase charger installations in high freight traffic areas (U.S. Department of Energy 2024). Potential corridors for similar upgrades in Europe include, for instance, routes connecting Poland, Germany, and the Netherlands—regions that are not only highly industrialized but also represent major road freight markets. Poland's strategic position as a conduit between Eastern, Central, and Western Europe further enhances the potential for scaling up this infrastructure. This approach emphasizes targeted investments that could kickstart and rapidly expand the electrification of key freight corridors, potentially surpassing the foundational requirements of the EU's Alternative Fuels Infrastructure Regulation for broader infrastructure development.

Fostering Resilience and Diversification in EV and Battery Supply Chains

Procurement and regulatory requirements based on nondiscriminatory and non-price criteria (for example, GHG intensity, reparability, recycled content) and policies favoring access to raw materials are important for mobilizing investments in more diverse EV and battery value chains. They can also

help avoid exacerbating harmful forms of competition focused on industry subsidies, which pose a risk to financial stability. Nondiscriminatory and non-price criteria for these technologies can help shape regulatory requirements and public procurement to stimulate investments that increase diversification, leveraging the competitive advantage of the European economy in terms of energy efficiency and lower carbon intensity.

Integrating accession countries into the EU's EV and battery supply chain offers a strategic opportunity to enhance regional manufacturing capacities while supporting these countries' electrification efforts, in line with EU enlargement goals. This approach can be particularly advantageous considering the global shift toward localizing EV and battery production. Accession countries bring competitive advantages, including lower labor, production, and operational costs, which could help mitigate some of the EU's production challenges. Their geographical proximity to the EU, existing logistics infrastructure, and free trade agreements enhance the attractiveness of near-shoring for the EU market. Accession countries hold further potential to complement parts of the supply and value chains, from mining and battery refining to processing and recycling, leveraging their critical minerals reserves and anticipating the flow of used EVs from the EU (Directorate-General for Neighbourhood and Enlargement Negotiations 2024). This also supports the EU-Ukraine strategic partnership on raw materials (European Commission 2021b). It aligns with the recently announced EU growth strategy for the Western Balkans, which integrates strategic partnerships on sustainable raw materials value chains among its priority actions for integration of countries in the Western Balkans in the EU single market (European Commission 2023c).

Mitigating Socioeconomic Impacts of the Industrial Transition

Comprehensive strategies for workforce upskilling and reskilling are needed, particularly in EV and charging technologies. The growing reliance on batteries, electric motors, and shifts in material requirements associated with EVs can create new opportunities for workers involved in the battery and EV value chains. This shift will also boost jobs in electricity generation and the manufacturing and installation of charging stations, further supported by the integration of digital technologies in the energy transition. Additional opportunities may also arise from the development of technical standards regarding EV retrofits, along the line of the international activities starting in the context of the World forum for the Harmonisation of vehicle regulations, at the UN (UNECE, 2024). However, this transformation also poses challenges for workers in sectors likely to be adversely affected, such as fossil fuel production and refining (ITF 2021a). The workforce, long established in traditional energy resources, faces significant transitional impacts, including the need for new skill sets. To finance these transition plans effectively, governments must allocate adequate budgets, potentially supported by mechanisms like carbon pricing and corporate taxes on multinationals (ITF 2021a). Anticipating changes, increasing labor market flexibility, and providing incentives for employer-driven training and reskilling are critical to support workers displaced by obsolete technologies. Complementary actions are also needed to ensure that the skills of individuals entering the workforce match those required for the transition. At the EU level, instruments like the CF, the Just Transition Mechanism, the European Regional Development Fund (ERDF), and the European Social Fund Plus (ESF+) can support workforce upskilling and reskilling.[xv]

The CF and Just Transition Fund play crucial roles in supporting regions most impacted by economic transitions, especially in lower-income areas and those dependent on the automotive industry. These funds aim to reduce income disparities and improve access to capital, addressing social risks that are unevenly spread across the EU. This approach ensures that local challenges are integrated into broader EU strategies, promoting cohesion. With the Green Deal prompting significant changes, it is essential for the EU to strike a balance by enhancing support mechanisms to address disparities among member states while seizing the opportunity to build a competitive industrial sector. This strategy not only manages the impact of these transitions but also strengthens EU integration by turning challenges into opportunities for growth and cohesion.

Creating Sustainable Urban and Metropolitan Mobility

Summary of Key Recommendations

Box 4.3. Summary of Key Recommendations: Urban and Metropolitan Mobility

Leveraging the Private Sector

- Mobilize substantial funding and financing from different sources to support urban mobility investments, including supporting the expansion and strategic utilization of land value capture mechanisms across member states through comprehensive training and knowledge transfer.
- Expand the participation of the private sector through concessions and public-private partnerships for transport infrastructure and services (for example, public transport, parking, mobility as a service, and so on).

Conditioning and Coordinating the Use of EU Funds to Deliver Results at Scale

Incentivize local authorities, through conditionalities to access national or European Union urban mobility funds, by requiring certain policies aiming to:

- Integrating land use and transport planning, developing compact and mixed-use neighborhoods, and promoting transit-oriented development.
- Reclaiming road space for sustainable mobility alternatives.
- Implementing demand management measures, such as road usage restrictions and dynamic pricing schemes.
- Enhancing multimodal integration and information sharing among different public transport operators.

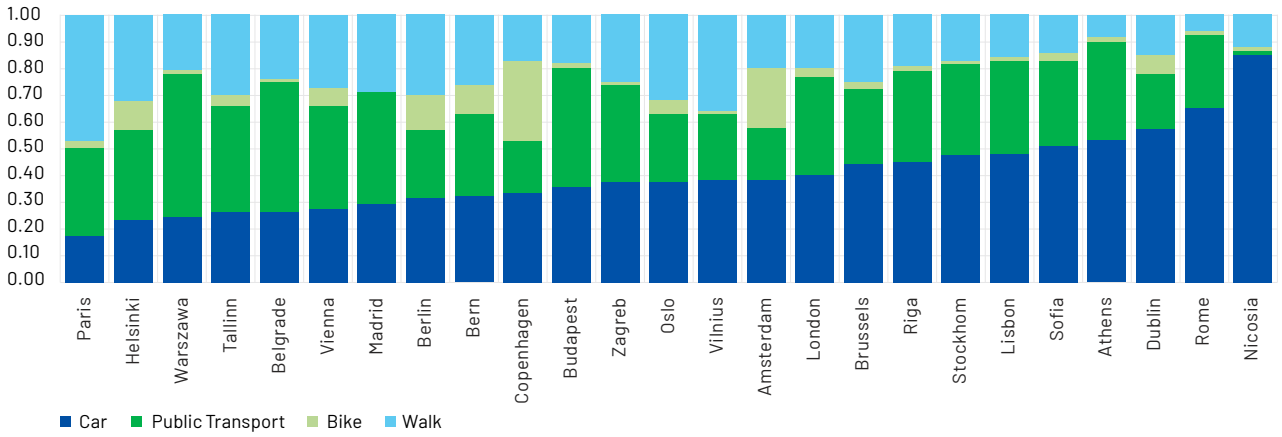
Additional Recommendations

- Establish stronger metropolitan transport governance to enhance intermunicipal cooperation.
- Develop tailored strategies for transport management and planning in secondary cities.
- Develop funding and execution plans for Sustainable Urban Mobility Plans, highlighting possible financing avenues not only from local government budgets but also through collaborations between the public and private sectors.

Current Context and Rationale for Further Action

Although there is a general trend toward multimodal transport systems in EU cities rather than a car-centric approach, considerable diversity can be observed across Europe (Figure 4.6). This variety includes cities with a high reliance on active mobility such as Copenhagen; cities predominantly using public transport, such as Paris, where car use is below 20 percent; and cities with a strong reliance on personal vehicles, like Rome (ECA 2020; Prieto-Curiel and Ospina 2024) (Figure 4.6). The economic and social costs of urban congestion, estimated at €270 billion annually in the EU (ECA 2020), add to energy-, resource-, and environment-related challenges, especially in urban areas that are highly reliant on personal vehicles and lack policies that bring people close to their destinations.[xvi]

Figure 4.6. Modal Share in Selected European Capitals (2018)



Source: Adapted from Noussan 2019.

EU policies aim to enhance urban mobility by making passenger and freight movements more sustainable, smart, and affordable with high-quality transport. This is in line with the Sustainable and Smart Mobility Strategy (European Commission 2020a), the European Pillar of Social Rights, and the subsequent Action Plan (European Commission 2021c). The EU Urban Mobility Framework, the TEN-T Regulation, and the Alternative Fuels Infrastructure Regulation are three important policy initiatives influencing EU urban mobility. Their joint action targets the provision of multimodal mobility infrastructure through Sustainable Urban Mobility Projects (SUMPs) for passenger and freight transport and promotes a proactive role for cities in the transition toward urban transport vehicles with zero CO_2 and pollutant tailpipe emissions.[xvii] These measures supplement research funding aimed at facilitating the same goals and also include a "mission" to create 100 climate-neutral and smart cities by 2030 under Horizon Europe (European Commission 2021d).

The EU's Urban Mobility Framework is struggling with challenges, including outdated plans that are not aligned with the EU's carbon neutrality goals, limited financial resources, low collective ownership of policies, and capacity gaps within administrations (ECA 2020; European Commission 2021e). These challenges are partly related to the principle of subsidiarity, which implies that urban mobility policies should be addressed locally, leaving the EU with a role that has historically focused on guidance and funding. To address these challenges, recent developments for TEN-T nodes now incorporate more stringent regulatory requirements. The EU has issued guidelines for SUMPs and recommended that member states incorporate national legislation and develop national support programs for their municipalities (European Commission 2023d).[xviii] Additionally, member states can utilize EU technical support Instruments to establish national platforms, further supported by the European Urban Initiative (EUI), which focuses on enhancing CF utilization through innovation and capacity building (European Urban Initiative 2022). Despite these efforts, the implementation of urban mobility policies remains uneven across the EU.

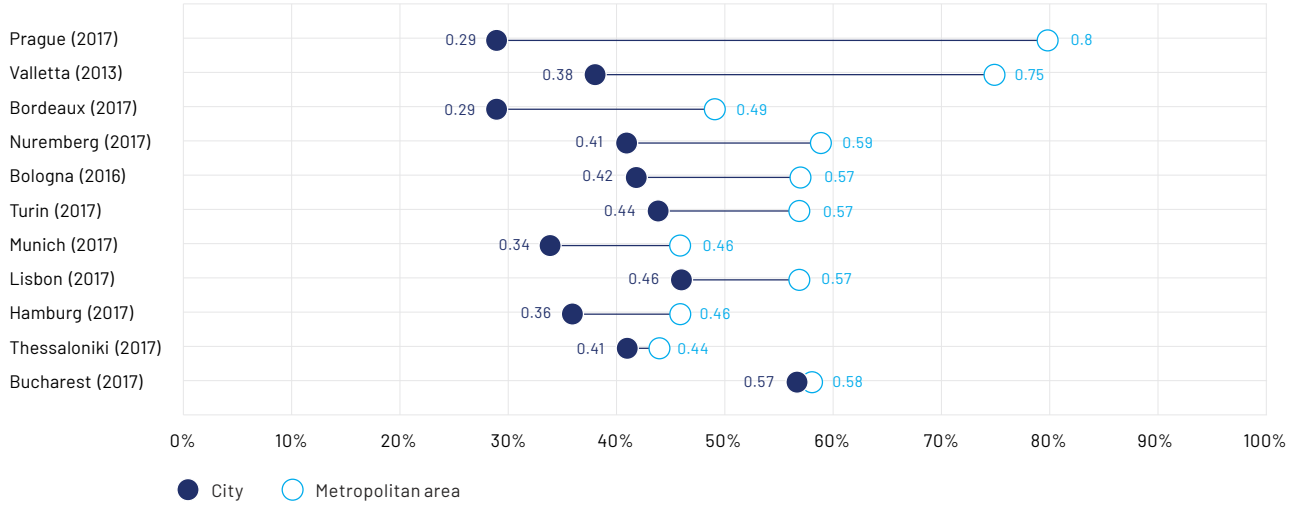
Investing in public transport is essential for EU urban sustainability, but it alone is insufficient to significantly change mobility patterns. The EU's strategy for decarbonizing urban mobility has predominantly focused on enhancing public transport infrastructure, while the potential of soft measures to reduce vehicle dependency is often underutilized in many cities and metropolitan areas. International evidence suggests that combining transport policies with compact urban planning can substantially reduce per capita transport-related energy consumption and GHG emissions, with positive welfare implications (OECD 2020). Successful examples from EU cities like Paris (L'Hostis and Darchen 2015), Copenhagen (Knowles 2012), Stockholm (Paulsson 2020), and Amsterdam (Pojani and Stead 2015) are exceptions rather than the norm. The EU faces a critical challenge

in expanding these models across the bloc, hindered by inconsistent political will and public acceptance, highlighting a disconnect in the EU's strategy toward achieving sustainable urban mobility.

While the financial cost of some demand management strategies may be low, their political implications can be significant, demanding robust leadership. Efforts to alter transportation habits, including pricing external environmental costs, face hurdles in political acceptance and are particularly sensitive at the local level. Many EU cities have experienced protests and resistance movements in the context of transport reforms, such as the "Yellow Vest" uprising in Paris (2018) and the protests against the development of new bike lanes in Milan (2020), indicating strong public pushback against perceived restrictive measures. The social resistance following the introduction of sustainable mobility policies can potentially undermine the implementation of the proposed reforms.

Suburban areas in Europe are growing more rapidly than core cities; yet, their public transport systems are not effectively attracting passengers, thereby increasing dependence on private vehicles for daily travel. While core urban centers serve as job hubs with mass transit solutions, EU cities have witnessed shifting trends and growing suburban populations. This growth is primarily driven by rising housing prices and improved road access, leading to longer commuting distances and lower population densities in these outskirts. These communities are often left behind in sustainable mobility agendas, with significantly lower public transport modal shares in the periphery compared to the core and between cities themselves. The disparity in car usage between the city center and its surrounding regions is notable, with an 18.3 percent higher rate of commuting by car in the suburbs (71.1 percent versus 52.8 percent) (Eurostat 2016). People who live in the suburbs tend not only to own more cars but also to drive them more often and farther than those who live in the core area (Figure 4.7).

Figure 4.7. Modal Share of Private Vehicles in Selected EU Cities and Their Respective Metropolitan Areas



Source: Adapted from ECA 2020.

A barrier to the effective development of multimodal public transport systems, especially in suburban areas, lies the insufficient integration between municipal public transport, commuter rail, and suburban buses (European Commission 2020b). While some EU cities offer integrated multimodal services spanning city centers and surrounding areas, many suburban regions still face challenges in achieving this (European Commission 2021f). The risks of poor integration are higher for subsystems organized separately, financed from different sources, and operated under different legal frameworks. This is often the case with urban and suburban transport services, which may involve a combination of private and public operators or multiple municipal governments, each with its distinct fare system across different modes and operators (European Commission 2020b).

Although the EGD recognizes Mobility as a Service (MaaS) as a key strategy for promoting sustainable transport, there are integration and competition challenges associated with the implementation of such systems in the region. Promoting multimodal mobility—and thus the concept of MaaS—is crucial to achieving more sustainable and efficient urban transport systems. While some cities are struggling with insufficient development of digitally enabled integration platforms,[xix] others are facing competition issues and exclusionary practices where dominant firms deny access to essential transport products and mobility data. For instance, in Spain, Germany, and Italy, there have been instances where leading transportation entities, particularly national train operators, have exhibited behaviors that could potentially stifle competition (Braeken and Versteeg 2024). As a result, specific MaaS legislation has been enacted or revised in recent years, including the establishment of the European mobility data space to provide an interoperability framework and reduce fragmentation of mobility data within the EU.[xx] The effectiveness of these measures, as well as the consequent impact of MaaS on sustainability, will depend on vigilant oversight of authorities to ensure fair competition as well as fair and equitable access to mobility data.

LVC instruments,[xxi] despite their potential to fund public transport infrastructure and address local inequalities (IEA 2019; OECD and Lincoln Institute of Land Policy 2022), are subject to heterogenous uses across member states (OECD and Lincoln Institute of Land Policy 2022). This inconsistency stems from the nature of national (or regional) legal frameworks and the way LVC is integrated into strategic plans. The challenges are multifaceted: misalignments between LVC policies and actual market conditions on land value, differences in land value between large and small cities, inadequate administrative capacity of local governments, and varying degrees of political will and public acceptance. Efforts by organizations like the Organisation for Economic Co-operation and Development (OECD) to synthesize effective LVC practices through the Global Compendium of Land Value Capture face the hurdle of context-specific barriers, indicating that the assessment of best practices is likely to be case-specific.[xxii] Greater EU support for identification and replication of these best practices could help to streamline LVC mechanisms across the region, taking into consideration the needs and characteristics of each city. In particular, capacity building and knowledge transfer efforts would be crucial to creating an enabling environment for the effective implementation of such measures.

Transport authorities in some of EU cities, particularly in the East, face a lack of possibilities and capacity to access funding. This challenge is not solely due to unharmonized national funding frameworks—a consequence of subsidiarity—but is also intensified by the uncertainties associated with today's rapidly changing transport landscape. This sector is struggling with the twin challenges of decarbonization and the shift toward more capital-intensive technologies such as electrification and smart transport systems. These financial hurdles are particularly pronounced in Eastern European cities, where the transport infrastructure is under strain and access to capital is constrained, partly due to higher cost of capital. Cities like Bucharest and Sofia exemplify areas where public transport remains insufficient to meet the needs and expectations of the population. This is also the case for many secondary cities experiencing rapid growth that outpaces their planning capacities. Due to insufficient public transport services, people who can afford them prefer to use private cars (including secondhand imports), while public transport is mainly used by those who have no other alternatives for their mobility and well-being, such as low-income groups, students, or elderly people (Redman et al. 2013; Prato, Halldórsdóttir, and Nielsen 2016; Göransson and Andersson 2023). Therefore, it is crucial to strengthen transport management and planning capacities in these cities to ensure that local transport services are competitive, not only to attract more choice riders but also to provide better service and dignity for the captive riders.

Strategic Actions

Shifting Away from Cars: Implementing Complementary Measures to Encourage Behavioral Shifts

Integrating transport planning with land use policies can catalyze the development of compact, mixed-use, and transit-oriented neighborhoods, diminishing reliance on private vehicles and fostering active mobility (OECD 2020). This includes policies that focus on developing mixed-use neighborhoods, promoting transit-oriented development (TOD), and reclaiming road space for sustainable mobility alternatives (public transportation, walking, cycling). For instance, good examples of TOD can be found in many European cities, such as Paris (L'Hostis and Darchen 2015), Copenhagen (Knowles 2012), Stockholm (Paulsson 2020), and Amsterdam (Pojani and Stead 2015), based on a successful combination of efficient public transport networks with a dense and compact urban form. In Poland, Bulgaria, and other Eastern European countries, several cities are converting industrial brownfield sites into mixed-use neighborhoods as part of their efforts to limit territorial expansion and manage motorization (Stanek 2011; Ciesiółka and Burov 2021).

The implementation of road usage restrictions and dynamic pricing schemes, reflective of the true societal costs of car dependency, can serve as a powerful economic disincentive against excessive private vehicle use. Adopting congestion charges, parking fees, and other taxes that affect both the ownership and usage of private vehicles should be consistently applied as demand management measures tailored to the reality of each city. Moreover, establishing low-emission zones (LEZs) or zero-emission zones (ZEZs) in all major EU metropolitan areas, combined with the provision of quality public transport and cycling/walking infrastructure, could be a valuable measure to encourage sustainable mobility behaviors and make driving less attractive. There are successful examples of ZEZs/LEZs in the region, such as the cases of Madrid and Paris,[xxiii] that demonstrate the direct and swift impact of these measures on the modal shift toward more environmentally friendly modes of transport. This change in mobility patterns not only reduces emissions but also brings positive externalities in social cohesion, economic development, and public health.

The EU comprises a diverse range of urban settings, and it is crucial that policies and investments are tailored to accommodate the unique needs and dynamics of different city tiers. While major metropolitan areas like Paris, Madrid, and Berlin each boast populations exceeding 5 million, approximately 20 percent of the EU's population resides in towns with fewer than 50,000 inhabitants. Given this diversity, it is important for the EU to adopt a flexible approach to supporting a diverse array of urban mobility measures that can be customized to the specific needs of each city, thus facilitating the creation of effective and responsive solutions. For instance, small cities may benefit from support for transport planning and investments in public transport, while larger cities might require more robust policy solutions to reduce motorization growth and sophisticated investments to manage their complex urban environments effectively.

Refocusing Urban Mobility Policies to Account for the Most Relevant Geographical Boundaries

Establishing stronger metropolitan transport governance can enable intermunicipal cooperation and effectively manage the complexities of growing urban and suburban transit demands. This involves enhancing intermunicipal cooperation through improved coordination across different municipalities and geographic areas. The Organisation for Economic Co-operation and Development developed a methodology to define functional urban areas (FUAs),[xxiv] which has been applied to all EU countries in partnership with the European Commission (Dijkstra, Poelman, and Veneri 2019). Building on the existing work can foster a strategic approach for the development of integrated transport policies and services,[xxv] especially since FUAs are already foreseen in the TEN-T Regulation as the basis for the development of SUMPs. In that context, assigning responsibilities for inter-city and suburban/secondary city public transport to larger administrative units, such as metropolitan transport authorities, could facilitate more effective public transport planning

and operations at scale. This should be combined with support to multimodal integration and information sharing among different public transport operators to achieve a seamless mobility ecosystem across urban and suburban areas. There are several successful examples in the region, such as in Barcelona, Paris, and London, that could be streamlined and replicated in other cities while respecting their specific local contexts and administrative structures. For instance, the Paris case presents a compelling model where a local payroll tax (versement mobilité) is applied to fund the metropolitan transport authority and its efforts to improve transport infrastructure and services within the city or region.[xxvi] In 2021, this tax generated about €4.9 billion for the Paris region, which represents about half the total of all operating revenues. This instrument was first piloted in Paris in 1971 and has since been successfully expanded to several urban areas across France.

A tailored strategy for transport management and planning is imperative for secondary cities. Many secondary cities in the EU are important economic centers, offering a range of employment and education opportunities. However, these areas often have less advanced sustainable mobility approaches and require tailored solutions based on their specific characteristics (typically lower population density, reduced public transport offer, higher car dependency, and infrastructure constraints). The introduction and subsequent expansion of Demand-Responsive Transport systems could bring interesting results. This strategy moves away from traditional fixed-route schedules toward a flexible, demand-driven model, employing digital technologies (for example, app-based platforms) for real-time routing based on user requests (ITF 2021b). Additionally, hybrid models that combine fixed routes with shared mobility services offer a cost-effective solution in areas where conventional public transport is impractical (Ray 2014; Ray and Khedira 2023). Secondary cities also have higher demand for intercity transport due to their strong socioeconomic links with core urban hubs, which creates a natural market for the deployment of e-buses as an affordable and sustainable option for longer-distance commutes. Such initiatives promise not only to improve the accessibility and appeal of public transport but also to ensure a sustainable transformation of urban mobility in secondary cities and their connectivity with major urban centers.

Mobilizing Finance for Investments in Urban Mobility

The EU needs to mobilize substantial financing from different sources to ensure the competitiveness of sustainable urban mobility solutions. The main source of EU funding for sustainable urban mobility comprises two of the five European Structural and Investment Funds, namely the European Regional Development Fund and the CF (European Parliament and Council of the European Union 2021).[xxvii] The amount devoted to urban mobility within these EU structural funds has been increased from €11.2 billion in the 2007–13 period to €16.3 billion for the 2014–20 period, which represents 6 percent of the two combined budgets (ECA 2020). While funding for the 2021–27 period has also been increased (European Urban Initiative 2022), it is estimated that cities will require an additional €86 billion by 2030 and €150 billion by 2050 in investments to sustain urban mobility beyond current levels (EIT Urban Mobility 2021). To address this need, the EU should consider not only unlocking additional grant funds for urban mobility directly targeting local and regional authorities, but also establishing cofinancing and guarantees schemes to leverage the participation of the private sector, particularly in the deployment of zero- and low-emission technologies.

For SUMPs to effect change once adopted, it is crucial to address the specifics of funding, timelines, and responsibilities. The EU's acknowledgment of the needs of smaller cities, including suburban and secondary cities, within the SUMP framework highlights the necessity for urban mobility planning that differs from approaches used in larger metropolitan areas. Developing a funding and execution plan is instrumental for smaller cities, highlighting possible financing avenues such as allocations not only from local government budgets but through collaborations between the public and private sectors (Brand, Böhler, and Rupprecht

2021). The source of financing can also include EU funds. For example, the EU's financial planning for local mobility and urban transport between 2021 and 2027 rests upon the Multiannual Financial Framework and the Next Generation EU recovery instrument.[xxviii] This support encompasses grants, financial tools, and initiatives by the European Investment Bank that promote sustainable and tech-forward transportation projects, with provisions for focusing on the unique needs of peri-urban and secondary urban areas.[xxix]

The EU could enhance the impact and coherence of urban mobility projects by introducing conditionalities for the financing of these projects.[xxx] The introduction of conditions with clearly defined targets aims to enable the replicability and diffusion of best practices, as well as the facilitation of a capacity build-up in local administrations (in line with a coherent set of skills). In practical terms, conditional access to funding could require complementing infrastructure investments with demand management policies to increase the potential for modal shift and maximize the social returns from supported projects. Alternative conditionalities could aim at ensuring that projects have a positive effect on sustainable transport connections to peri-urban areas, where demand is growing and supply for public transport and active mobility is limited. Such measures should also aim to improve the attractiveness of public transport to increase modal share, including through park and ride options, as well as measures aimed at making vehicle use less attractive (such as parking policies, including supply and price).

To maximize public benefits in urban mobility and public transport infrastructure development, the EU can stimulate progress on the use of LVC mechanisms. Considering the complexity and heterogeneity of approaches to LVC in EU member states, the assessment of existing practices and the identification of those that work best are key prerequisites for the preparation of targeted reforms. This process could lead to specific policy reforms, potentially including EU-wide recommendations to address existing barriers to LVC implementation and establish core principles to ease its adoption for member states. An expanded mandate for the EUI, with explicit provisions for LVC, is also well-suited to enhance the effectiveness of this approach. Concrete steps toward fully embracing LVC in the EU could unlock opportunities on a much wider scale than what has been achieved to date.

Funds coming from carbon pricing mechanisms and land use transactions should be earmarked, either fully or partially, to be reinvested in transport decarbonization efforts. This encompasses revenue streams from congestion charges, parking fees, and contributions from the Emissions Trading System. Directing these funds toward initiatives that promote cleaner and more sustainable urban mobility, such as investing in public transport and expanding cycling and pedestrian infrastructure, can enable cities to significantly reduce GHG emissions. The EU plays a crucial role in supporting the wider adoption of these alternative funding mechanisms by strengthening regional policies and building capacity in cities across the region.

In conclusion, addressing the urban mobility challenges in EU cities necessitates efforts on several fronts. Firstly, enhancing regional and metropolitan governance with better coordination across municipalities and geographical areas is essential. This approach would improve service coverage in diverse urban contexts, including suburbs, and capitalize on the benefits of scaling systemic changes and technological shifts. Secondly, there is a need to bolster the financial and institutional strength of public transport systems; utilizing mechanisms such as LVC could significantly enhance financing avenues for these systems. Lastly, a comprehensive policy framework is required to discourage private vehicle use and promote nonmotorized transportation. This includes tighter integration of land use and transport policies and creating an environment that encourages private sector investment in collective urban mobility solutions. Together, these strategies aim not just to lower transport-related carbon emissions but also to improve the overall livability and sustainability of urban environments.

Enhancing the Role of the Rail Sector to Decarbonize Transport

Summary of Key Recommendations

Box 4.4. Summary of Key Recommendations: Railways

Leveraging the Private Sector

- Explore alternative governance and business models for rail infrastructure development and maintenance (for example, infrastructure concessions along selected international corridors).

Conditioning and Coordinating the Use of EU Funds to Deliver Results at Scale

- Apply conditionalities to European Union (EU) funds, requiring the adoption of practices that enhance efficiency and profitability, such as optimizing service pricing, deploying market-responsive services, mobilizing private investment, and exploring new revenue streams.

Rethinking the Role of Climate Finance and the EU Emissions Trading System

- Develop a regulation and methodology to allow rail projects to qualify greenhouse gas reductions from modal shift for carbon credits to fund capital investments, building on the EU Emissions Trading System.
- Introduce Results-based Climate Financing, complementing initiatives like the Connecting Europe Facility to incentivize efficient investments in rail and intermodal facilities to increase rail modal shares.

Additional Recommendations

- Enhance an EU-wide approach to long-distance rail transport by: (i) introducing a control authority at the EU level for train capacity allocation; (ii) improving EU-level coordination on the national European Railway Traffic Management System deployment plans; and (iii) scaling up digitalization to increase sector efficiency and competitiveness.
- Capture demand from new market segments by: (i) improving the flexibility to transport small shipments by enhancing Single Wagonload logistic and its financial viability; and (ii) mapping the supply chain of growing markets to assess proactively the need for new infrastructure, intermodal hubs, and consolidation facilities.
- Strengthen (or introduce where nonexistent) the environmental component of carbon dioxide-differentiated road user chargers for heavy-duty freight transport.
- Define more specific targets on rail freight growth (rather than an EU-wide target), differentiated by countries (or corridors) and eventually commodity groups, to facilitate monitoring and accountability.

Current Context and Rationale for Further Action

Rail transport is several times less carbon-intensive than road and air transport per unit transported (tonne-km, pax-km), yet its contribution to transport decarbonization is being limited by declining modal shares. Rail's advantages on environmental performance are particularly amplified in Europe, where a large portion of the network is already electrified (60 percent), a substantial share of rail traffic takes place on these electrified lines (80 percent), and electricity generation is increasingly becoming greener.[xxxi] Acknowledging

this, along with the overall lower social costs of rail compared to road or air transport (including road fatalities, local pollution, congestion, and land use), the European Commission (2020c) aims to: (i) double high-speed passenger rail traffic by 2030 and triple it by 2050,[xxxii] and (ii) increase rail freight traffic by 50 percent by 2030 and double it by 2050. This has different implications for freight and passenger transport:

- **For freight rail,** based on our estimates on total transport demand growth, meeting this target would effectively imply an increase in rail inland modal share from the current 17 percent (in 2022) up to around 23 percent by 2050 (see Chapter 2). Achieving this target would shift 8 percent of the freight demand that would otherwise be transported by trucks in a baseline scenario, where the rail modal share would remain around 18 percent in 2050.[xxxiii] However, this clashes with the reality of a rail sector that has seen a decline in average modal share, from 19 percent in 2011 to 17 percent in 2022, with declines observed in almost all EU member states.
- **For passenger rail,** the policy scenarios assessed in the European Commission's Staff Working Document accompanying the SSMS envision an increase in rail passenger volumes of 80 percent by 2050 compared to 2015 levels (European Commission 2020c). Based on out total demand projections, this would require increasing passenger rail modal share from around 7 percent to more than 9 percent by 2050 (see Chapter 3).[xxxiv] Unlike rail freight, the passenger segment has not experienced a decline in modal share over the past two decades, but it has also not increased, remaining stable at around 7 percent.[xxxv]

Since 2001, the EU has adopted a series of four reform packages aimed at creating a single European railway market and opening the sector to competition. These reforms address rules for charging and capacity allocation, market liberalization, simplification of applications and authorization, common procedures for licensing and certification, safety requirements, interoperability, passenger rights, among others. The EU has also assisted candidate countries for EU membership (Albania, Bosnia and Herzegovina, Moldova, Montenegro, North Macedonia, Serbia, Türkiye, and Ukraine) with the adoption of the legislation and modernization of infrastructure required to join this single European railway market. Despite these efforts, EU rail modal shares have declined (for freight) or stalled (for passengers), calling for urgent policy action to get the sector on track to unlock its potential, contribute to the EGD's ambitions, and enhance logistics performance and regional integration.

Infrastructure Funding

The EU expenditure on rail infrastructure relies heavily on national budgets with minimum private sector participation, and this can be a barrier for financially constrained member states (and, importantly, accession countries) to develop a sustainable rail system. The EU spends an average of €94 per inhabitant per year on rail infrastructure, but this Figure varies widely across member states, ranging from more than €450 in Luxembourg and more than €300 in Austria, to less than €50 in Hungary, Bulgaria, and Portugal, and even less in Greece. On average, 69 percent of the infrastructure funding comes from national budgets, 8 percent from EU co-financing, and only 23 percent from railways' own funds (including charges, loans, and equity financing) (European Commission 2023e). Increasing private sector participation in developing and maintaining rail infrastructure, as well as expanding access to climate financing, may be necessary to build a more financially sustainable system across EU member states.

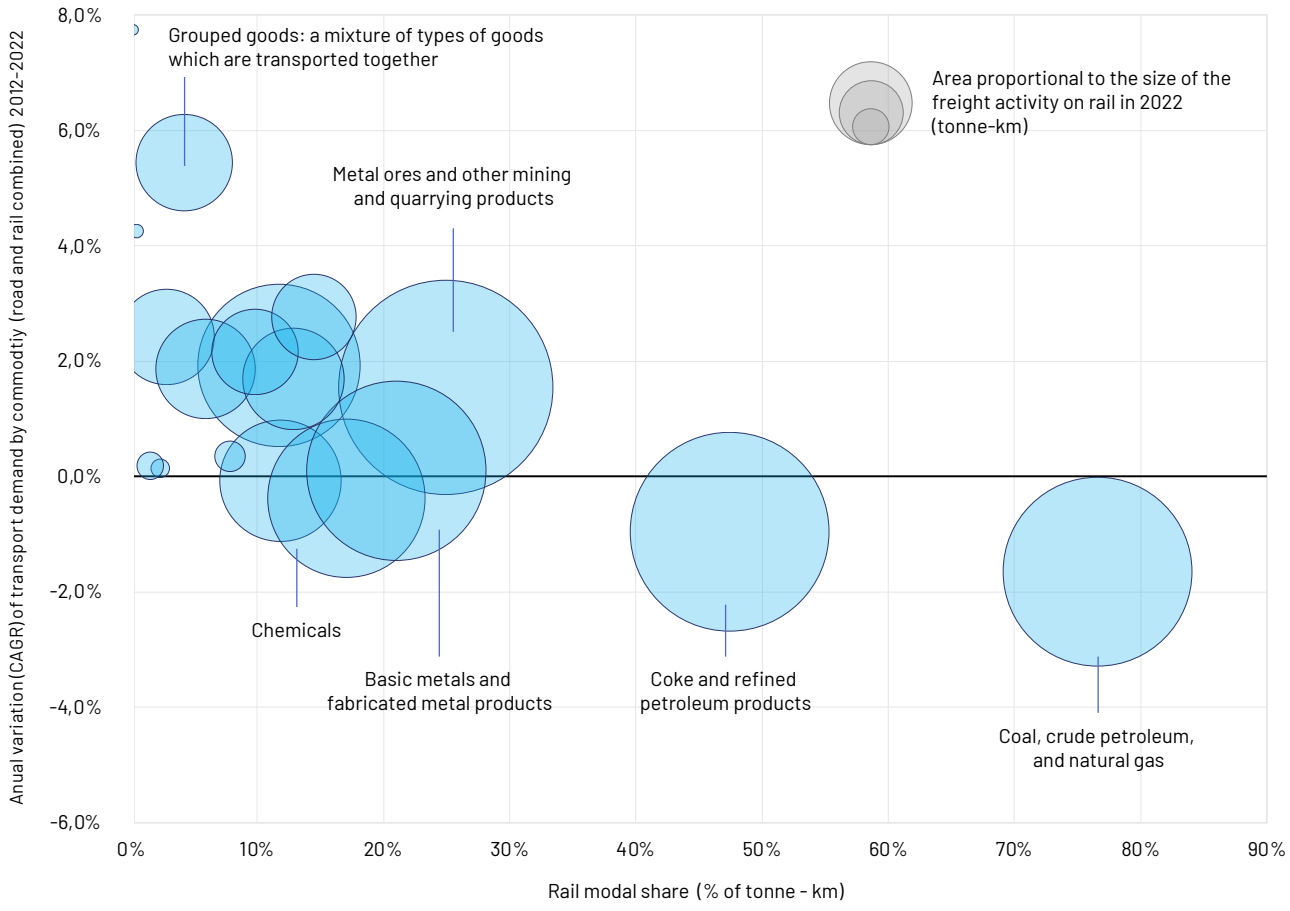
Rail Freight Transport

Rail freight faces significant challenges in achieving its 2050 targets, primarily due to the prevailing dominance of road freight. Despite maintaining a relatively constant volume of transport since 2005, rail's modal share has been declining as road transport activity has increased in absolute terms—capturing almost all the growth in total inland freight transport. Road transport consistently dominates total inland

freight, accounting for around 77 percent of the market share. Since 2005, rail freight's modal share has decreased in 18 out of the 25 EU member states with rail systems.[xxxvi] While the EU may not be able to achieve the notably higher rail shares seen in other contexts, such as in the United States—due to differences in contexts, geographies, industries, and logistics systems— it is critical to grow the sector as much as it makes economic sense (based on its economic competitiveness potential – accounting also for externalities), both to contribute to the EGD's objectives and to improve the EU's logistics systems and competitiveness.

The total transport demand for goods with a typically higher affinity for rail transport (that is, higher rail modal share) and those that currently account for most of the rail traffic (high absolute volumes) has declined or stalled over the past 10 years (Figure 4.8). In contrast, the types of goods with higher reliance on road transport are growing in absolute terms. This is clearly exemplified by coal, oil, and petroleum products—goods with the highest modal shares for rail but also the greatest declines in total demand over the last decade. These trends are expected to continue in the medium and long term, particularly among commodities affected by the energy transition away from fossil fuels and the related industrial transformations. This underscores the need not only to retain customers from industries with higher rail affinity (by improving service reliability) but also to diversify toward industries where rail sector participation could potentially be increased through a strengthened focus on multimodality, logistics efficiency, and service delivery flexibility.

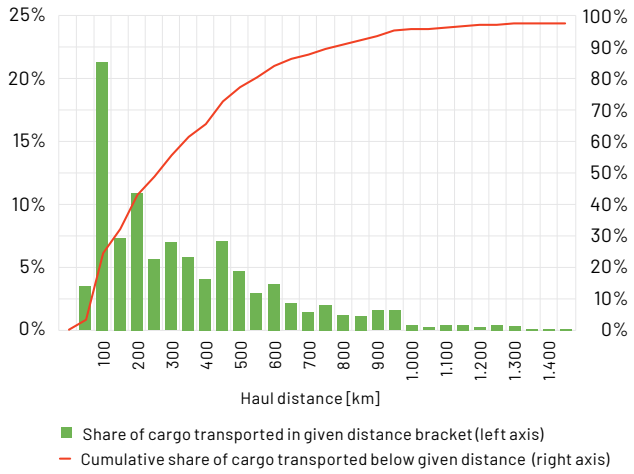
Figure 4.8. Rail Modal Share and Average Annual Variation (CAGR) of Transport Demand by Commodity Group



Source: World Bank elaboration using input data from Eurostat.

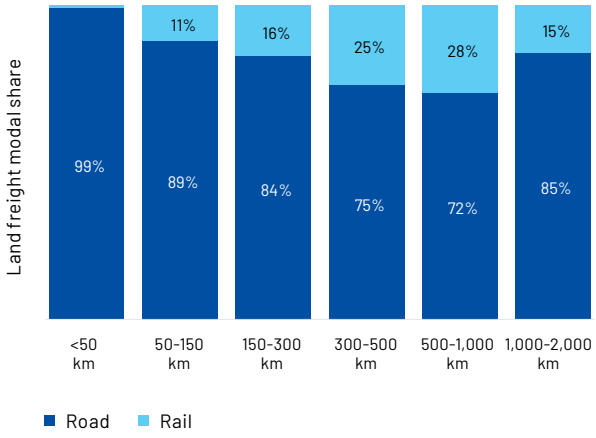
The EU is not fully exploiting the potential competitiveness of railways for long-distance transport. The presence of important maritime gateways for international cargo around the European continent's borders reduces the necessary haul length for land-based freight transport. In fact, the EU's rail system has an average haul length of only 275 kilometers and more than 80 percent of transport occurring over distances under 500 kilometers (Figure 4.9)—a stark contrast to an average haul length of approximately 1,500 kilometers in the United States and over 700 kilometers in China (Shao 2022).[xxxvii] Yet, long-distance transport does take place, but it is not being sufficiently captured by the rail sector. As shown in Figure 4.10, our estimates suggest that the modal share for rail in the EU increases over medium distances, reaching a peak for distances between 500 and 1,000 kilometers, but still remains below 30 percent. It then declines to around 15 percent for distances between 1,000 and 2,000 kilometers. This suggests significant impediments for rail over longer distances in the EU, which offset the natural benefits that this mode would otherwise offer over road transport due to lower variable costs. Some of these impediments are explained by the fact that European railway companies have traditionally operated within national boundaries, creating a fragmented rail system. The complexity of freight interchange, capacity allocation, and the lack of technical interoperability (particularly in areas like train control, electric power, and signaling) pose significant challenges. While the EU's rail network is cross-border in nature, each member state has differing priorities, management approaches, and organizational structures for passenger and freight rail corridors.

Figure 4.9. Distribution of Rail Freight Transport by Distance in the EU-27



Source: World Bank elaboration and estimation, using input data from Eurostat.

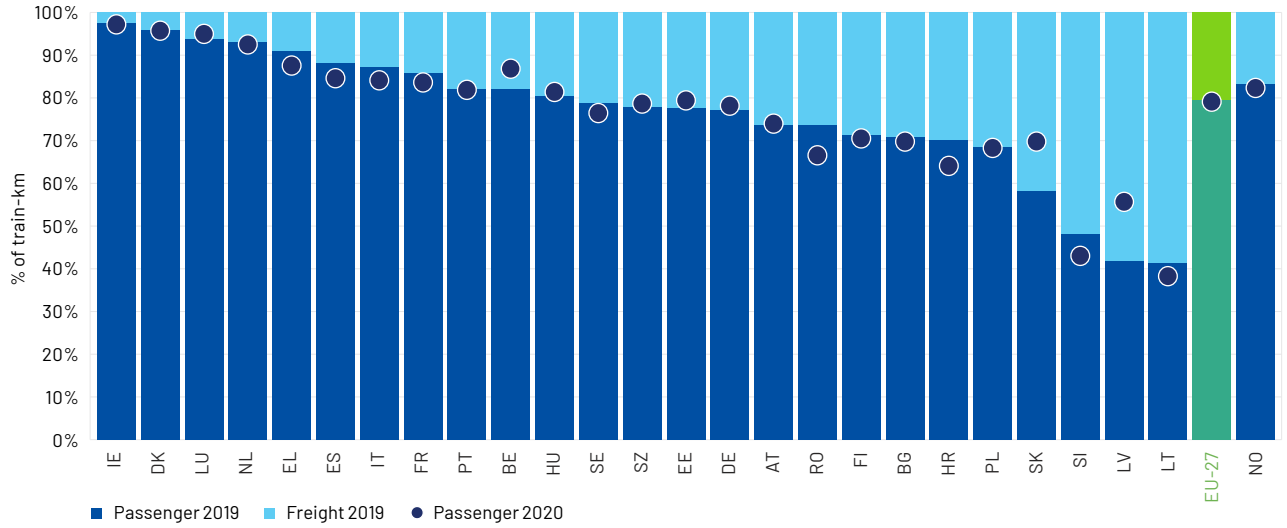
Figure 4.10. Estimated Land Freight Modal Share by Distance Groups in the EU-27



Source: World Bank elaboration and estimation, using input data from Eurostat.

Rail capacity allocation in the EU prioritizes passenger over freight transport, limiting the availability of daytime track access for freight. Despite initiatives like the Rail Freight Corridors (RFCs) aimed at addressing this imbalance, capacity constraints persist.[xxxviii] On average, around 80 percent of train-kilometer in the EU are performed by passenger trains, with 20 member states having this Figure exceed 70 percent (European Commission 2023e) (Figure 4.11). Consultations with RFC managers indicate that, in several corridors, passenger traffic significantly constrains the allocation of freight trains, especially during daytime hours, hindering the competitiveness of the freight segment and limiting potential demand growth. The inability to guarantee increases in path allocations for freight in the coming years also diminishes market interest in shifting to rail transport.

Figure 4.11. Relative Share of Passenger and Freight Train-Km on Total Train-Km per Country (%, 2019 and 2020)



Source: Adapted from European Commission 2023e.

There are conflicting priorities and incentives among member states, as well as among accession countries, that hinder the efficiency of cross-border rail corridors. The differing geographic positions and characteristics of industries and transport systems across European countries influence their interest in investing in rail infrastructure. While some countries seek to access large markets or maritime gateways via rail (countries upstream in the corridors), infrastructure in transit countries may be underdeveloped if those countries lack the economic incentives or capacity to invest public resources in infrastructure used mainly by others. Allowing for different business models, with potentially greater private sector participation and less reliance on public funding, may be explored to overcome this challenge.

Despite multiple efforts, including the introduction of RFCs,[xxxix] cross-border rail transport still suffers from delays at border crossings due to inefficient capacity allocation and lack of technical interoperability. Incompatibility between locomotives can cause delays due to staff and locomotive shortages. Delays are further exacerbated by coordination challenges, such as partner railway undertakings independently requesting paths from infrastructure managers for national stretches, lack of communication, and the absence of a unified approach. While the implementation of RFCs has improved coordination among infrastructure managers and other stakeholders, it has not led to significant improvements in the competitiveness and efficiency of cross-border rail freight (Pastori et al. 2021). In combination with the misaligned priorities and incentives discussed above, these structural challenges may require new institutional arrangements and business models to materialize efficient long-distance freight transport.

Passenger Rail Transport

The EU's commitment to tripling high-speed rail traffic by 2050 presents an opportunity to reshape nonurban passenger transportation. However, the aspiration to scale up high-speed rail services remains as a major challenge due to the high upfront capital costs required. It is estimated that tripling the existing high-speed rail network would require infrastructure investments averaging €550 billion (EY 2023). Deutsche Bahn (2023) estimates that Europe would need to build and upgrade 21,000 kilometers of track, nearly tripling high-speed rail routes from 11,300 kilometers today to about 32,000 kilometers between 2030 and 2050.

Figure 4.12. Speed of Rail Connections between Major Urban Centers in the EU in 2019

Source: Brons, Dijkstra, and Poelman 2023.

Passenger rail transport faces obstacles in achieving the efficiency needed in the long-distance network, which is critical to attracting passenger demand from road-based modes, and to a certain extent also from air transport. On almost one-third of railway routes in the EU connecting medium to large urban centers within a distance of less than 500 kilometers, the straight-line speed of the fastest available service is below 60 kilometers per hour (Figure 4.12), and high-speed rail services are not provided in nearly half of EU member states (Brons, Dijkstra, and Poelman 2023). Cross-border passenger railway services within the EU are even more challenging, with slower speeds than domestic routes. Maximum train speeds are below 60 kilometers per hour on 40 percent of cross-border journeys, compared to just 16 percent for domestic routes. Achieving competitive travel times with enhanced transport services is critical to shift passengers from roads to rail. A shift from aviation to rail can also be achieved, but with a limited emission reduction scope. Dobruszkes, Mattioli, and Mathieu (2022) estimate that, while 27.9 percent of flights in Europe[xl] take place over distances under 500 km (a distance where rail can be competitive), these represent only 5.9 percent of aviation fuel burnt. Transport & Environment (2020) estimates that connecting all major cities with high-speed rail could capture a share of short-haul flights and result in a CO_2 emissions reduction of up to 11 percent from intra-EU aviation and up to 4 percent of total EU aviation (intra- and extra-EU). On one hand, this highlights the need to invest in infrastructure and technology upgrades, as well as on better service provision, to increase rail's competitiveness against air transport for passenger travel over medium distances. On the other hand, this also indicates that most of the emissions from the aviation sector are produced by trips over distances where rail transport is not a competitive or viable option, underlying the need for fuels and technology shifts in the aviation sector to complement demand management.

Strategic Actions

An Enhanced EU-Wide Approach to Unlocking the Potential of Long-Distance Rail Transport

The EU should explore introducing a control authority at the EU level for train capacity allocation. Similar to the scope of Eurocontrol for civil aviation, a control authority at the EU level to allocate paths to passenger and freight trains across borders could significantly enhance long-distance travel, as suggested by the European Union Agency for Railways (ERA 2020). This would likely require developing a regulatory and governance framework with representation from EU member states, infrastructure managers, and EU representatives. While setting up this framework would be a challenging and complex process, it could well be a game changer for international transport. This could potentially be implemented first along the main RFCs, with further gradual expansion in a second phase. The control authority could help introduce freight-priority capacity allocation along a subset of strategic corridors while optimizing the allocation between passenger and freight trains on the rest of the network, where passenger trains currently have priority. This measure could maximize the benefits of the extended deployment of the European Rail Traffic Management System (ERTMS) and ongoing efforts toward interoperability in the EU. A recent study for the European Commission

also highlights the benefits of developing a centralized EU entity with operational and decision-making tasks, while underscoring the importance of a gradual process that pursues this objective in the longer term (European Commission 2023f).

Ensuring coordination at the European level on national ERTMS deployment plans to accelerate interoperability is crucial. The EU has established binding timelines for the deployment of the ERTMS—2030 for the Core TEN-T network and 2050 for the Comprehensive Network. However, progress has been slower than expected and varies across member states and corridors. Table 4 1 shows the progress of European Train Control System (ETCS) (a component of the ERTMS) deployment by the TEN-T corridor in comparison with the 2030 targets. Given the importance of interoperability in facilitating cross-border transport, and the positive business case for the ERTMS along Core Network corridors,[xli] continued EU financial support to accelerate its deployment should be considered (European Commission 2021h). The European Commission has a role in the coordination of ERTMS implementation on the entire TEN-T network, and this role could be further strengthened, potentially by establishing centralized EU-level governance to support National Implementation Plans (CER 2021).

Table 4.1. ETCS Status by Corridor—Long Term (2030)

KPI	Length to be equipped by 2030 (km)	Current ETCS in operation (Km)	Current ETCS in operation (%)	ETCS in operation & ETCS under construction (%)	ETCS in operation & Contracts signed (including Framework Contracts) (%)
Atlantic	11.103,97	1.221,20	11	26	26
Baltic – Adriatic	4.912,91	1.404,94	29	40	50
Mediterranean	11.325,00	2.170,63	19	42	42
North Sea – Baltic	7.870,64	972,56	12	29	31
North Sea – Mediterranean	5.025,54	886,28	18	27	34
Orient/East – Med	6.478,64	966,22	15	50	50
Rhine – Alpine	3.461,79	1.066,65	31	70	76
Rhine – Danube	5.908,22	605,03	10	47	50
Scandinavian - Mediterranean	11.913,85	1.273,73	11	27	54

Source: Based on European Commission's website at https://transport.ec.europa.eu/transport-modes/rail/ertms/state-play_en.

Financing digitalization at scale can maximize the capacity of the existing infrastructure, increase flexibility for rail freight operators, and reduce delays for both passenger and freight traffic. Programs like the Timetable Redesign for Smart Capacity Management,[xlii] led by RailNetEurope and Forum Train Europe, aim to achieve this goal. By harnessing the latest digital technologies and establishing a common information technology systems architecture at the EU level, freight operators could request train paths on shorter notice anywhere in the European network, significantly reducing the flexibility gap that currently favors road transport. These technologies can also improve responses to network disruptions in international transport. The extent of their success will depend on how widely these applications are implemented across Europe, and financial support from the EU for deployment can be critical in obtaining network-level benefits. Failing to harness digitalization in the rail sector would only further diminish this transport mode's competitiveness against road transport, a sector that is constantly innovating to increase operational efficiencies.

Alternative Governance and Business Models on Selected Freight Corridors

To unlock the potential of some corridors that are underdeveloped due to misaligned interests among countries, alternative governance and business models with greater private sector participation may be explored.

These alternatives could take multiple forms and would need to be assessed on a case-by-case basis, requiring flexibility in the EU rail acquis to efficiently address the challenges presented in different contexts. One option might be the introduction of infrastructure concessions along international corridors. A corridor-level concession could provide the right incentives to develop an efficient corridor across borders, align priorities, and ultimately benefit countries upstream, in transit, and downstream along these corridors. This should be complemented by mobilizing alternative funding sources to improve the business case that can attract private sector participation and sustain its long-term interest (see section below on tapping into climate finance to support the growth and sustainability of the sector). Mobilizing such additional funding is critical to reduce reliance on public budget support for infrastructure maintenance through multi-annual infrastructure contracts, especially for countries with highly constrained public finances. Such an option would need to be carefully studied and designed, and especially should aim to respond to the specific needs of the corridors and economies in question. The forms and extent to which the private sector could increase its participation are an area for further research and development.

Tapping into Climate Finance to Support the Growth and Sustainability of the Sector

The EU could develop a regulation and methodology to allow rail projects to qualify GHG reductions from modal shift for carbon credits to fund capital investments, building on the EU ETS. In principle, rail projects could tap into the carbon finance market if they reduce emissions either by transitioning to non-fossil fuels or by diverting traffic from more carbon-intensive modes (such as heavy goods vehicles). To unlock this potential, it will be critical to develop a regulation and framework that addresses the following (Plavec, Lawrence, and Bisbey 2024): (i) a methodology for quantifying emissions of land transport operators for both passenger and freight; (ii) clear rules for quantifying emissions reduction and verifying them using standardized methodologies; and (iii) a methodology and taxonomy of how modal shifts to railway can be counted as carbon credits.

Results-Based Climate Financing (RBCF) for EU-level support, complementing initiatives like the Connecting Europe Facility,[xliii] can incentivize efficient investments in rail, intermodal facilities, and gateway ports to increase the rail modal share. EU-funded projects for intermodality or ports could include modal shifts to rail or GHG savings as key result indicators, based on which funds would be allocated. RBCF encourages accountability and would provide the right incentives to implement a truly effective strategy to maximize the environmental benefits of EU-funded activities at terminals (Plavec, Lawrence, and Bisbey 2024). This contrasts with the current practice, where application for EU grants for intermodal transport infrastructures do not require an assessment of the potential modal shift that could be achieved by the project (ECA 2023b). Any RBCF implemented should learn from similar past experiences in the EU, such as the Marco Polo program,[xliv] and aim to correct the weaknesses that hindered the effectiveness of financial support in truly achieving environmental benefits (ECA 2013).

Capture Demand from New Market Segments

With the decline of traditionally rail-oriented goods, the rail freight sector must diversify by tapping into growing demand segments through intermodal solutions and enhancing the flexibility to transport small shipments by improving Single Wagonload (SWL) logistics. The flexibility offered by road transport to move small shipments door-to-door is a key factor in its dominance in the freight segment. The economics of SWL are challenged by the higher costs incurred in a more complex logistics chain compared to block train transport, driven by lower economies of scale for first/last-mile and marshalling operations (Guglielminetti et al. 2017). Supporting the SWL segment may require a revision of business models, as the liberalization of freight operations has not had a positive effect on SWL traffic given the low profitability of these operations. For instance, member states may consider implementing public service obligations for SWL operations where commercial conditions do not attract operators, or introducing financial support for track access charges for SWL operations (PwC and La Sapienza 2015).

Building on the ongoing revision of the TEN-T regulation (European Parliament 2024), RFC managers can collaborate closely with industry players to map the supply chain of growing markets and proactively assess the need for targeted investments to meet evolving market demands. The rail sector could capture goods with increasing transport demand, such as batteries for EVs (Chapuis et al. 2022), but this would require strategic investments that account for the specific needs of each market and its supply chain. Moreover, as rail is more competitive over longer distances and with larger consignment sizes, consolidating cargo in intermodal hubs is critical to achieving cost competitiveness against purely road-based transport, including in higher-value segments (via containers). The revision of the TEN-T regulation requires RFC managers to periodically update transport market studies for the relevant corridors (European Parliament 2024). This is an opportunity to involve key industry players in this process to help: (i) map the opportunities to capture new markets; (ii) identify targeted investments to serve their needs; and (iii) mobilize private capital for infrastructure development (e.g. last mile connectivity or intermodal hubs). This would not only increase rail traffic revenues but also benefit the industry by providing an economical and efficient alternative for moving goods while reducing scope 3 emissions.

Building on the 2022 revision of the Eurovignette Directive, which introduces variations on road infrastructure and user charges for HDVs based on CO_2 emissions, member states could incentivize a shift to rail and boost intermodality (European Parliament and Council of the European Union 2022). In addition to the upcoming ETS2, which will apply carbon taxes to road transport fuels and become fully operational in 2027 (European Commission), member states are required to introduce carbon-differentiated rates for distance-based highway tolling for heavy trucks starting in 2024.[xlv] This reform has already been introduced in Austria, Belgium, Czechia, Estonia, Germany, and Hungary, and is in preparation in other member states (Transport & Environment 2024b). If designed as revenue-generating, as in Germany, additional revenues could be used to invest in strategic actions that facilitate a shift to rail for goods and origin-destination pairs where rail may become a competitive substitute. Such investments could aim at reducing bottlenecks by increasing capacity, and could help unlock private sector investments for the development of strategic intermodal facilities and consolidation centers. In this way, strengthening the CO_2-related component of tolling would effectively incentivize not only a shift to cleaner vehicles but also, to a certain extent, a shift from road to rail transport.

Defining more specific targets for rail freight growth, differentiated by countries (or corridors) and eventually commodity groups, would facilitate monitoring and accountability. The current aggregate target of doubling rail freight by 2050 lacks the specificity needed to be actionable. Given the significant changes in the composition of commodities to be transported and the heterogeneity of the economic and transport systems across EU member states, the EU's targets for rail would benefit from greater disaggregation. This could involve defining targets for specific corridors, countries, or commodity groups based on their actual potential to capture additional modal share, making the goals more actionable and easier to monitor.

Complement Financial Support with Requirements for a More Efficient and Commercially Oriented Sector

The EU may consider introducing conditionalities to the financial support provided to accession countries for rail infrastructure, with the aim of fostering stronger customer orientation and promoting innovation in state-owned enterprises. While railway companies have followed the EU reform path in terms of segment separation (unbundling) and have invested in infrastructure with a focus on integration, they have not prioritized optimizing operations to become commercially and financially viable. EU funding, subject to conditionalities and monitored through verifiable key performance indicators, could require a genuine costumer orientation that: (i) identifies markets and develops new services to meet demand; (ii) prioritizes profitable operations; (iii) optimizes pricing; (iv) mobilizes private investment and expertise; and (v) taps into new sources of revenue. Country-specific assessments would be necessary to identify the most relevant reforms required to enhance commercial orientation and define appropriate conditionalities.

Notes

[i] European electric vehicle (EV) sales increased by over 15 percent in 2022, meaning that more than one in every five cars sold was electric. In the EU-27, approximately 56,500 electric vans were sold in 2022, constituting 21.6 percent of new car registrations. Among these, battery electric vehicles accounted for 12.2 percent of total new car registrations, while plug-in hybrid electric vehicles made up 9.4 percent (European Environment Agency 2023).

[ii] For EV model statistics see the European Commission's website at https://alternative-fuels-observatory.ec.europa.eu/policymakers-and-public-authorities/electric-vehicle-model-statistics.

[iii] The Netherlands is again an exception, due to its strong focus on publicly accessible chargers with a low power rating, many of which were deployed on demand for households without access to private parking. As a result, these chargers have comparatively low usage rates compared to other types of publicly accessible chargers.

[iv] In the future, this could lead to an increased reliance on vehicle imports from other geographies, including for EVs (for example from China, as the Chinese market has been more focused on small and more affordable EVs than the European one), in the absence of a change in strategy by European auto manufacturers (ITF 2023).

[v] For more information on NextGenerationEU see the European Commission's website at https://commission.europa.eu/strategy-and-policy/eu-budget/eu-borrower-investor-relations/nextgenerationeu_en.

[vi] For more information on the European automotive industry see the European Commission's website at https://single-market-economy.ec.europa.eu/sectors/automotive-industry_en.

[vii] The Critical Raw Materials Act advances the European Union's (EU's) strategy for secure, sustainable access to critical raw materials, aiming to reduce reliance on single suppliers and enhance circularity. By 2030, it sets benchmarks for domestic capacity: 10 percent extraction, 40 percent processing, 15 percent recycling of the EU's annual consumption, and caps single third-country imports at 65 percent. For more on the Critical Raw Materials Act see the European Commission's website at https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en.

[viii] The Net-Zero Industry Act mandates that the EU's manufacturing capacity for strategic net-zero technologies must meet at least 40 percent of the EU's annual deployment needs by 2030, aiming to bolster competitiveness and energy resilience in support of the EU's green transition goals. For more on the Net-Zero Industry Act see the European Commission's website at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan/net-zero-industry-act_en.

[ix] The Inflation Reduction Act (IRA) tax credits and incentives applied in this analysis of light-duty EVs include Personal Tax Credits for Clean Passenger Vehicles (30D) worth up to $7,500 and Advanced Manufacturing Production Tax Credits (45X) for batteries worth up to $45 per kilowatt-hour. Data taken from Slowik et al. (2023).

[x] Since the IRA was passed, there has been a 35 percent increase in announced capacity in the United States compared to a year ago, versus a 17 percent increase in Europe (Murray 2022).

[xi] For more on New Zealand's Clean Car Standard initiative see New Zealand Transport Agency's website at https://www.nzta.govt.nz/vehicles/clean-car-programme/clean-car-standard/.

[xii] A successful example exists in London, United Kingdon, which announced in 2016 the requirement for all newly registered taxis to be zero-emission capable as of 2018, prompting a voluntary commitment from Uber to aim for every car on the app in the English capital to be fully electric in 2025 (ITF, 2020).

[xiii] Total revenues amount to up to €65 billion (European Council 2022). For transport, the Social Climate Fund should focus on zero-emission and low-emission vehicles, bicycles, and infrastructure for recharging and refueling. It should also support the development of a secondhand zero-emission vehicles market through financial support or fiscal incentives. Additionally, the fund can incentivize the use of affordable, accessible public transport, on-demand shared mobility services, and active mobility options (European Council 2023b).

[xiv] Including Bulgaria, Czechia, Estonia, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia (European Parliament and Council of the European Union 2021).

[xv] For more information on Just Transition funding sources, see the European Commission's website at https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism/just-transition-funding-sources_en.

[xvi] As proximity is a factor that also improves accessibility and helps overcome the negative implications of congestion, accessibility depends not only on how fast one can travel but also how far one needs to travel to reach the destination (ITF 2019).

[xvii] Sustainable Urban Mobility Projects (SUMPs), in particular, are required in the more than 400 TEN-T urban nodes. These nodes are also subject to specific obligations regarding the rollout of recharging and refueling infrastructure for transport modes with zero tailpipe CO_2 emissions, in the context of the Alternative Fuels Infrastructure Regulation. Smart mobility, sustainability, accessibility, and fairness considerations are key aspects that underpin recent guidelines regarding rules for taxis and private

hire vehicles. Digital technologies and smart mobility are also prominently featured in the context of SUMP development guidance documents, where Mobility as a Service (MaaS) is discussed as an enabler of an improved and comprehensive mobility management strategy (Signor et al. 2019).

[xviii] For more on the EU's guidelines for SUMPS see the European Commission's website at https://urban-mobility-observatory.transport.ec.europa.eu/sustainable-urban-mobility-plans/sump-guidelines-and-decision-makers-summary_en.

[xix] The Madrid Urban Region provides a case study of integration challenges, where the commuter rail network, despite its potential for fostering sustainable urban mobility, operates without full integration with the Madrid Regional Transport Consortium. This lack of integration is further compounded by the absence of a regional mobility plan or mobility laws in the Community of Madrid, leading to new urban growth areas that lack coordinated planning with existing public transport infrastructure (Solis et al. 2023). This separation complicates route planning and transfers between modes, discouraging a shift from private to public transport. As a result, public transport becomes less appealing to car owners and operators, and it becomes costly and impractical for public transport operators to provide a frequent service that would be attractive to car owners.

[xx] For more information about the European mobility data space see deployEMDS' website at https://deployemds.eu/.

[xxi] These include infrastructure levies, developer obligations (fees or contributions developers pay in exchange for development approval), charges for development rights (for example, for building at higher density in specific zones), land readjustment (pooling fragmented land parcels for joint development, with owners transferring a portion of their land for public use), and strategic land management (the practice of governments actively participating in buying, developing, selling, and leasing land to advance public needs). For more information see OECD's website at https://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-regional-development-studies_fa744789-en.

[xxii] For more information on the Organisation for Economic Co-operation and Development's (OECD's) Global Compendium of Land Value Capture visit OECD's website at https://www.oecd.org/en/about/programmes/international-programme-for-land-based-finance.html.

[xxiii] See more information on Madrid's low-emission zones at https://www.madrid.es/portales/munimadrid/es/Inicio/Movilidad-y-transportes/Zonas-de-Bajas-Emisiones/Madrid-Zona-de-Bajas-Emisiones/Madrid-Zona-de-Bajas-Emisiones-ZBE-/?vgnextfmt=default&vgnextoid=93e63877029eb710VgnVCM1000001d4a900aRCRD&vgnextchannel=d2d2edf0f70ab710VgnVCM2000001f4a900aRCRD. See more information on low-emission zones in Paris at https://www.zonefaiblesemissionsmetropolitaine.fr/en/.

[xxiv] Functional urban areas (FUAs) encompass the economic and functional extent of cities based on people's daily movements. This work includes not only the identification of FUAs, but also the municipalities included in them. For more information see OECD Definition of Cities and Functional Urban Areas (dataset), OECD, Paris (accessed August 8, 2024), https://www.oecd.org/en/data/datasets/oecd-definition-of-cities-and-functional-urban-areas.html.

[xxv] An example of an intermunicipal transport initiative is the SIT FLEXI project implemented by the Intermunicipal Community of Coimbra Region in Portugal. Designed to address the challenge of providing public transport in low-density areas, this project offered a demand-responsive transport solution involving 18 municipalities. While this initiative served low-density areas, it demonstrates the applicability of adaptive, cooperative strategies in urban and suburban transport development. For more on the SIT FLEXI project see Interreg Europe (2021).

[xxvi] To be paid by all firms with more than 11 employees within the area of the "Périmètre des Transports Urbains"—that is, the urban transport area.

The European Regional Development Fund contributes to reducing disparities between the levels of development of various regions within the EU. The Cohesion Fund provides funding for environmental and trans-European network (TEN-T) projects in the member states, through investments in railway transport, inland waterway transport, road transport, maritime transport, and multimodal transport (European Parliament and Council of the European Union 2021).

[xxviii] For more information on EU funding opportunities for local transport see UITP's website at https://www.uitp.org/eu-funding-opportunities-for-public-transport/.

[xxix] For more information on EU funding opportunities for local transport see UITP's website at https://www.uitp.org/eu-funding-opportunities-for-public-transport/.

[xxx] Conditionalities are a useful tool for ensuring a direct link between financed investments and EU-level policies or priority areas. They contribute to the transposition and implementation of relevant regional legislation, help tackle barriers to investment, and trigger policy reforms.

[xxxi] For more information on the EU's rail sector see the European Commission's website at https://alternative-fuels-observatory.ec.europa.eu/transport-mode/rail.

[xxxii] Compared to 2015.

[xxxiii] The World Bank's EU transport demand model.

[xxxiv] The policy scenarios assessed in the European Commission's Staff Working Document accompanying the SSMS envision an increase in rail passenger volumes of 80 percent by 2050 compared to 2015 levels (European Commission 2020c).

[xxxv] Including air and sea passenger transport (European Commission 2021g).

[xxxvi] Data Browser (database), Eurostat, Luxembourg City (accessed August 08, 2024), https://ec.europa.eu/eurostat/databrowser/view/proj_23np/default/table?lang=en&category=proj.proj_23n.

[xxxvii] Railroads led longer-distance shipping in the United States and handled most of the long-distance coal shipping, with the average shipping distance reaching 1,500 kilometers in 2018. In China, the average shipping distance by railroad increased from 485 kilometers in 1978 to only about 716 kilometers in 2018 (Shao 2022).

[xxxviii] For more on the European rail network for competitive freight see the European Commission's website at https://transport.ec.europa.eu/transport-modes/rail/infrastructure/european-rail-network-competitive-freight_en.

[xxxix] Rail Freight Corridors (RFCs) were established through the Regulation (EU) No 913/2010 of the European Parliament and of the Council of 22 September 2010 Concerning a European Rail Network for Competitive

[xl] Dobruszkes, Mattioli, and Mathieu (2022) considered 31 European countries in the analysis, including all EU27 member states, as well as the United Kingdom, Norway, Iceland, and Switzerland.

[xli] A report published by the European Commission suggests that there is a business case for European Rail Traffic Management System deployment on all core corridors provided that that both trackside and onboard are deployed in a coordinated manner (European Commission 2019).

[xlii] For more information on the Timetable Redesign for Smart Capacity Management see RailNetEurope's website at https://rne.eu/capacity-management/ttr/.

[xliii] For more information on the Connecting Europe Facility see the European Commission's website at https://cinea.ec.europa.eu/programmes/connecting-europe-facility/transport-infrastructure_en.

[xliv] For more on the Marco Polo program see the European Union's website at https://eur-lex.europa.eu/EN/legal-content/summary/the-marco-polo-ii-programme.html.

[xlv] "Member states with distance-based tolls must vary truck tolls by CO2 not later than 25 March 2024. Existing concession contracts can however be exempted. Countries with concessions must only apply CO2 variation when the toll contract is newly signed, renewed or substantially amended" (Transport & Environment 2024b).

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5. Conclusion

The European Union (EU) stands at a critical juncture in its journey toward achieving the transport decarbonization targets established in the context of the European Green Deal (EGD). Although the robust regulatory and policy framework currently in place provides a solid foundation for this transition, the effective realization of the EU's climate goals necessitates a concerted effort that extends beyond existing policy measures.

This report highlights the crucial role of innovative financing sources and the need to ensure better results from EU funding. While looking at sub-sectoral challenges, a series of transversal recommendations emerged in the analysis, which can be organized around four key themes for action: (i) the need to better leverage the private sector; (ii) de-risking mechanisms to crowd in private capital; (iii) conditioning the use of EU funds to deliver results at scale; and (iv) rethinking the role of climate finance and the EU Emissions Trading System (ETS).

To accelerate the transition to zero-emission road vehicles, the report emphasizes the need for policy actions that, inter alia, promote the supply of smaller and more affordable passenger cars (e.g., through vehicle taxation reforms) and accelerate the uptake of EVs among corporate fleets and highly utilized vehicles. To increase the electrification rate of bus fleets in cities, we recommend to better leverage the private sector capital and expertise through modern concession models, enabled by guarantees and incentives from EU- and national- funds, reducing the reliance on public resources. For zero-emission trucks, a series of innovative financing and de-risking mechanisms would be needed to overcome the barriers posed by higher upfront costs and to manage equity implications.

In urban settings, the diverse mobility patterns across EU cities require a better integration of transport and land use policies. Emphasis must be placed on fostering integrated transport planning across metropolitan and intermunicipal boundaries, as well as on diversifying sources of funding, and developing robust financial and institutional mechanisms to support the provision of sustainable transport infrastructure. Additionally, these actions need to be complemented by a comprehensive policy framework that discourages private vehicle use, ensures the competitiveness of public transport systems, and promotes nonmotorized transportation.

Increasing the role of railways in decarbonizing the transport sector requires to enhance the competitive advantage of this mode in the markets that it serves today, but also to proactively develop the flexibility required to capture, to the extent possible, new and growing markets. This will require a focus on intermodality (leveraging synergies with the road, maritime and inland water sectors), digitalization, and partnering with the private sector to better serve growing supply chains. Moreover, this report recommends to further explore options to increase private sector participation in infrastructure development and management, as well as options to enable the rail sector to benefit more from climate financing to reduce the reliance on national public budgets.

Table 5.1 summarizes the strategic areas of opportunity for policy action that are being proposed. While this report has provided valuable insights on how to effectively advance transport decarbonization in the EU, some of the proposed areas of opportunity warrant detailed assessments (analytical "deep dives") to further understand the implications, costs, and benefits of their introduction, as well as to design their implementation mechanisms. Future research should consider a robust analysis of finance and de-risking mechanisms for zero-emission trucks to deepen our understanding of how to scale up the uptake of capital-intensive technologies. It should also inform the development of a comprehensive framework of financial and institutional mechanisms

to support the deployment of sustainable urban mobility solutions, drawing on existing best practices that can be streamlined and adapted across the region. Exploring opportunities to increase the role of private sector in rail operations would be beneficial to address the current capacity constraints faced by the railway system. Future research should also consider assessing the impacts of climate change including the strategies and costs required to improve the resilience and adaptability of existing and new transport infrastructure. These research directions will strengthen the robustness of current findings while contributing significantly to the EGD's objective of achieving a climate-neutral economy by 2050.

Table 5.1. Strategic Actions and Policy Recommendations

Key Area 1. Accelerating the Transition to Zero-Emission Road Transport Technologies		
Short-term and medium-term actions designed ***to accelerate the transition toward low- and zero-emission vehicles***		
Associated benefits	**Proposed Policy Actions**	**Level of Action**
Policy Area: Increasing electric car adoption at scale		
Improved affordability and higher availability of EVs, including in the secondhand market in the medium term	Prioritize the electrification of company fleets and other highly utilized vehicles, combining taxation and regulatory instruments.	EU/Member state
	● Strengthen emission- and size-based differentiated taxation schemes both for new and secondhand vehicles.	Member state
	● Leverage resources from carbon-pricing for enhancing and scaling up targeted social EV leasing programs.	EU/Member state
Policy Area: Advancing electrification of heavy vehicles through innovative financing mechanisms		
Private sector investment boost and reduction of barriers posed by high upfront costs	● ● Expand the use of modern concession models with performance-based remuneration to increase the uptake of e-buses at scale, potentially including separation of asset ownership and operations, and aggregating procurement initiatives.	Member state/cities
	● Support financing and de-risking instruments (e.g., Partial Credit Guarantees) to accelerate the adoption of zero-emission trucks, including targeted programs for small and capital-constrained businesses.	EU/Member state
Policy Area: Developing charging infrastructure to support the e-transition and meet future demand		
Increase equitable charger access. Strategic resource allocation and private sector investment boost	● Use EU funds to provide financial guarantees to enable private investments on ZETs and high-power charging infrastructure along major freight routes where high demand can be aggregated.	EU/Member state
	● Ensure timely transposition of the EU directives into national laws to ensure "right to plug", easier EV charger installation, and renewable energy integration.	Member state
	Simplify grid connection and expansion processes for EV charging, including pricing transparency.	Member state
	● Enable cross-subsidization of EV chargers by properly designing public competitive concession tenders to include multiple locations (using revenue from high-usage chargers to fund deployments in underserved areas).	Member state
Policy Area: Mitigating socioeconomic impacts		
Socially equitable, economically stable transition. Skilled workforce, job transition support	Utilize the Just Transition Mechanism and Cohesion Fund to mitigate socioeconomic impacts in regions dependent on traditional automotive sectors and to address disparities among member states.	EU
	Support workforce upskilling and reskilling programs in EV and charging technologies for workers from sectors adversely affected by the transition.	Member state

● Leveraging the Private Sector ● Developing Derisking Mechanisms to Crowd in Private Capital
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Policy Area: Fostering resilience and diversification in EV and battery supply chains		
Diversified EV and battery supply chains	Enhance EV and battery supply chain resilience and diversification by strengthening partnerships with accession countries.	EU
	Introduce nondiscriminatory and non-price criteria in procurement and regulatory requirements (for example, on greenhouse gas intensity, reparability, and recycled content).	EU
Key Area 2. Creating Sustainable Urban and Metropolitan Mobility		
*Short- and long-term actions to **build sustainable urban transportation solutions for all***		
Associated benefits	**Proposed Policy Actions**	**Level of Action**
Policy Area: Shifting away from cars: measures to encourage behavioral shifts		
Improved transport planning framework, reduced car dependency	● Implement integrated transport and land use policies supporting the development of compact, mixed-use, and transit-oriented urban areas.	Member states/cities
	● Apply conditionalities to make access to urban mobility funding contingent on implementing demand management strategies and land use policies.	EU
	● Implementing demand management measures, such as road usage restrictions and dynamic pricing schemes.	Cities
Policy Area: Refocusing policies accounting for the most relevant geographical boundaries		
Improved transport governance and management systems, regional cohesion	● Establishing stronger metropolitan transport governance to enable intermunicipal cooperation.	Member states/cities
	● Support multimodal integration and information sharing among different public transport operators and across geographical boundaries.	Member states/cities
	Develop tailored strategies for secondary cities, including the deployment of demand-responsive transport systems with dynamic routing and scheduling to meet real-time transportation demands.	Member states/cities
Policy Area: Mobilizing finance for investments in urban mobility		
Increased capital mobilization for the deployment urban transport solutions	● ● Increase EU financial support for urban mobility beyond grants by establishing cofinancing and guarantees schemes to leverage the participation of the private sector, particularly in the deployment of zero- and low-emission technologies.	EU
	Address the specifics of funding, timelines, and responsibilities for Sustainable Urban Mobility Plans implementation (combining diverse funding sources from government budgets, the private sector, and the EU's financial framework).	Member states/cities
	● Stimulate progress on the expansion and effective use of land value capture mechanisms across EU member states to diversify funding for urban mobility.	EU
	● ● Strengthen and diversify partnerships with the private sector to encourage investments in collective urban mobility solutions (for example, concessions).	Member states/cities

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Key Area 3. Enhancing the Role of the Rail Sector to Decarbonize Transport		
Short- and medium-term actions to ***increase the modal share of rail transport***		
Associated benefits	**Proposed Policy Actions**	**Level of Action**
Policy Area: An enhanced EU-wide approach to long-distance rail transport		
Improved network efficiency, connectivity and interoperability	● Explore introducing a control authority at the EU level for train capacity allocation	EU
	● Strengthen coordination at the European level on the national ERTMS deployment plans to accelerate interoperability.	EU
	Advance digitalization in rail systems to increase flexibility for rail operators and enhance competitiveness against road transport.	EU/member states
Policy Area: Alternative governance and business models		
Increased private sector capital mobilization, improved efficiency	● Explore alternative governance and business models for rail infrastructure to enhance private sector involvement.	EU
Policy Area: Capture demand from new market segments		
Expanded freight rail market reach, enhanced competitiveness.	● Collaborate with industry players to proactively map supply chains of growing industries and invest to meet specific needs of such industries.	Member states and Rail Freight Corridor managers
	● Set specific, actionable targets for rail freight growth by corridor, country, or commodity group to facilitate monitoring and accountability.	EU and Rail Freight Corridor managers
	Enhance the financial viability of Single Wagonload operations (e.g., through Public Service Obligations or reduced track access charges)	Member states
Policy Area: Climate finance for rail sector growth		
Increased private sector capital mobilization and lower reliance on national budgets.	● Use Results-Based Climate Financing (RBCF) to support investments on rail and inter-modal facilities, increasing rail modal share and reducing greenhouse gas (GHG) emissions.	EU
	● Develop a regulation and methodology to allow rail projects to qualify greenhouse gas reductions from modal shift for carbon credits to fund capital investments, building on the EU Emissions Trading System.	EU
Policy Area: Funding with requirements for commercially oriented rail		
Improved profitability, market-responsive operations	● Condition EU funding for rail on adopting profitability-enhancing practices like optimizing service pricing, deploying market-responsive services, mobilizing private investment, and exploring new revenue streams.	EU

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WORLD BANK GROUP