ITF Transport Outlook 2023

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Please cite this publication as:
ITF (2023), *ITF Transport Outlook 2023*, OECD Publishing, Paris, https://doi.org/10.1787/b6cc9ad5-en.

ISBN 978-92-82-14481-7 (print)
ISBN 978-92-82-16726-7 (pdf)
ISBN 978-92-82-14109-0 (HTML)
ISBN 978-92-82-15523-3 (epub)

ITF Transport Outlook
ISSN 2520-2359 (print)
ISSN 2520-2367 (online)

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Preface

The transport sector has moved through one global crisis and into another since the publication of the previous edition of the *ITF Transport Outlook*. Since the Covid-19 pandemic, the war in Ukraine has brought untold destruction and human suffering. The conflict has also precipitated an energy crisis and widespread supply-chain disruptions.

In this challenging environment, global transport systems have proved remarkably resilient. That said, transport's near-complete dependency on fossil fuels has made it particularly vulnerable to rising energy prices. Overcoming this dependency needs to be at the forefront of policy makers' thinking to further strengthen transport's resilience and curb the sector's harmful carbon dioxide emissions.

The good news is that the transition to clean transport makes economic sense. Investing in sustainable modes and improved efficiency will reduce emissions without hindering travel or the movement of goods. There are wider benefits as well. Done the right way, green, clean and more resilient transport will offer more affordable, safer and accessible services to all citizens.

This report sets out policy actions for creating such a sustainable transport future for all based on projections for future transport activity and its impact, using some of the most sophisticated modelling tools available today. My wish is that the findings of the *ITF Transport Outlook 2023* may help leaders around the world take the right decisions, for the benefit of our planet and its people.

Young Tae Kim

Secretary-General
International Transport Forum

Foreword

Every two years, the International Transport Forum (ITF) publishes the *ITF Transport Outlook*, which provides an overview of current trends and near-term prospects for the global transport sector based on its in-house transport models.

The transport sector plays a significant role in increasing access to opportunities and influencing individuals' economic and social outcomes. It also contributes to sustainable development worldwide and is a crucial global actor in the 2030 Agenda for Sustainable Development.

However, the sector also accounts for 23% of the world's energy-related carbon-dioxide (CO_2) emissions. Transport policy makers and planners therefore face a critical challenge: how to meet increasing transport demand while reducing emissions.

The ITF contributes to meeting this challenge in multiple ways.

Through its Decarbonising Transport initiative, the ITF provides decision makers with tools to select CO_2 mitigation measures that deliver on their climate commitments. These tools include a knowledge base of actionable measures (the ITF Transport Climate Action Directory), in-depth sectoral studies of national decarbonisation pathways and accompanying policy dialogues involving high-level roundtables and technical workshops.

The Secretariat to the United Nations Framework Convention on Climate Change (UNFCCC) has named the ITF as a focal point for transport under its Marrakech Partnership. In this role, the ITF supports the exchange of information between actors in the transport sector, the UNFCCC and the High-Level Action Champions Team, as well as providing inputs to the UNFCCC process. The ITF also tracks governments' Nationally Determined Contributions (NDCs) made under the Paris Agreement through its constantly updated Transport NDC Tracker.

In this context, the *ITF Transport Outlook 2023* performs a crucial role. By projecting future transport demand and the associated CO_2 emissions, and examining different policy scenarios with more or less ambitious decarbonisation pathways, it offers policy makers critical indicators they need to support policy decisions that will have long-lasting consequences.

The *ITF Transport Outlook 2023* was approved for publication by the ITF's Transport Research Committee at its March 2023 meeting in Paris.

Acknowledgements

The *ITF Transport Outlook 2023* was prepared by the Research Centre at the ITF, with support from numerous individuals and partner organisations. The project was managed by Orla McCarthy, with Josephine Macharia as deputy project manager. Luis Martinez led the modelling. Jagoda Egeland and Elisabeth Windisch provided oversight.

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Statistical and analytical support was provided by Diego Botero, Rachele Poggi and Xiaotong Zhang (ITF). Data collection support was provided by Rita Prior Felipe and Eyal Li (ITF) and Shaoni Purkait (Consultant).

Editing and publication support was provided by David Prater, Hilary Gaboriau and Michael Kloth (ITF). The cover design is by Chris Wells (ITF).

The authors would like to thank colleagues at the ITF for their valuable comments and contributions to the report: Malithi Fernando, Véronique Feypell, Matthew Ireland, Andreas Kopf, Olaf Merk, Stephen Perkins and Olivia Wessendorff.

The authors would also like to thank the following non-ITF contributors for authoring boxes in the report: Jane Cheatley, Cédric Doucet and Michele Cecchini of the OECD's Employment, Labour and Social Affairs directorate for Box 5.1 on the connection between transport planning and physical activity; and Jasper Verschuur (University of Oxford) for Box 6.2 on decarbonisation and climate change risks to port infrastructure.

The authors are also grateful for the comments and contributions of their external reviewers: Anne Aguiléra (Université Gustave Eiffel), Paulo Anciaes (University College London), Juan Pablo Bocarejo (Universidad de los Andes), Pierpaolo Cazzola (University of California Davis), Francisco Furtado (Centro de Competências de Planeamento, de Políticas e de Prospetiva da Administração Pública), Fabien Leurent (Université Gustave Eiffel), Alan McKinnon (Kuehne Logistics University, Hamburg), Jayant Mukhopadhaya (International Council for Clean Transportation, ICCT), Daniel Sperling (University of California Davis) and Jose Viegas (Professor emeritus, Lisbon University).

The policy scenarios in this report were influenced by surveys of transport experts in academia, industry, international organisations and government as well as the Transport Research Committee. The ITF thanks the respondents for their contributions. The report has also benefitted from the insightful contributions of panelists during the "ITF in Focus" session at the ITF Summit 2022, who discussed the approaches to consider for this edition: Clarisse Cunha Linke (Institute for Transportation Development and Policy), Mohamed Hegazy (Africa Road Transport, UNFCCC Climate Champions), Neil Pedersen (Transportation Research Board) and Sonal Shah (The Urban Catalysts).

The modelling approach was inspired by Tristan Smith (University College London), Alan McKinnon (Kühne Logistics University), Andreas Schäfer (University College of London) and Lóránt Tavasszy (Delft University of Technology). The ITF also benefited from help provided by the following bodies of the OECD: the Environment Directorate for trade projections, the International Energy Agency for consolidation of strong decarbonisation scenarios, and the Economics Department for gross domestic product projections.

Several partners have been valuable in developing the ITF modelling framework, methodologies and providing data: the ICCT for data on local pollutant emissions; the International Maritime Organization for data on vessel fleet composition and vessel speed data; the Energy and Resources Institute India; the China Academy of Transportation Sciences; the Japan International Cooperation Agency; the United Nations Economic Commission for Latin America and the Development Bank of Latin America for data on Latin American cities and trade; the Road Freight Lab of the World Business Council on Sustainable Development on freight optimisation; and the International Civil Aviation Organisation and the Airport Council International Europe on aviation forecasts and emissions.

Finally, the *ITF Transport Outlook 2023* benefitted from valuable comments by the members of the ITF Transport Research Committee, which also approved the report.

The International Transport Forum is an intergovernmental organisation with 64 member countries. It acts as a think tank for transport policy and organises the Annual Summit of transport ministers. The ITF is the only global body that covers all transport modes. The ITF is politically autonomous and administratively integrated with the OECD.

The ITF works for transport policies that improve peoples' lives. Our mission is to foster a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and to raise the public profile of transport policy.

The ITF organises global dialogue for better transport. We act as a platform for discussion and pre-negotiation of policy issues across all transport modes. We analyse trends, share knowledge and promote exchange among transport decision-makers and civil society. The ITF's Annual Summit is the world's largest gathering of transport ministers and the leading global platform for dialogue on transport policy.

The Members of the Forum are: Albania, Armenia, Argentina, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Cambodia, Canada, Chile, China (People's Republic of), Colombia, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Kazakhstan, Korea, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Republic of Moldova, Mongolia, Montenegro, Morocco, the Netherlands, New Zealand, North Macedonia, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Tunisia, Türkiye, Ukraine, the United Arab Emirates, the United Kingdom, the United States and Uzbekistan.

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Chapter 2 **Decarbonising transport: Scenarios for the future**	An overview of the assumptions underpinning the two policy scenarios explored in Chapters 3-6 (the Current Ambition and High Ambition scenarios) and the key results for demand and emissions projections.
Chapter 3 **Managing transport demand: Offering attractive choices**	A detailed look at the demand management and mode-shift policy measures included in the two policy scenarios.
Chapter 4 **Cleaner fleets: The key to decarbonising transport**	A detailed look at the evolution of maritime, aviation and road vehicles and fuels and the policies required to increase low- and zero-emission transport.
Chapter 5 **Liveable cities: The broader benefits of transport decarbonisation**	Examines indicators for co-benefits of decarbonisation policies, including equity considerations. The indicators include: • emissions of other air pollutants • road safety • accessibility and affordability • congestion and space consumption.
Chapter 6 **Investing in the future: The financial implications of decarbonising transport**	A consideration of some financial aspects of the Current Ambition and High Ambition scenarios. The chapter looks at the investment needs of infrastructure required to cater to demand under the two scenarios, the investment needs for the charging networks potentially needed to support the uptake of electric vehicles, and the future of diminishing fuel-tax revenues.

Glossary

The following table defines key terms used in the *ITF Transport Outlook 2023* including transport modes, transport policy measures and exogenous factors considered in each of the policy scenarios, scenario definitions and more.

Term	Definition
Active mobility and micromobility	In the context of this edition of the *ITF Transport Outlook,* walking, cycling, scooters and all forms of e-micromobility that are privately owned or shared.
Active transport modes	Travel undertaken by foot, bicycle or other human-powered modes.
Air connectivity	Refers to the density, extensiveness, and directness of destinations in a transport network.
Autonomous vehicle	A vehicle operated by a driving system that either assists or replaces humans in the driving task. Automation can be of different degrees according to the portion of the operations the driving system can conduct without human intervention.
Biofuel	Fuels that are directly or indirectly produced from organic material (i.e. biomass) such as plant materials or animal waste. In this publication, biofuel refers to liquid biofuels, such as ethanol or biodiesel.
Car	A road motor vehicle, other than a moped or a motorcycle, primarily designed to carry one or more persons. This includes SUVs and is equivalent in the text to passenger light-duty vehicles (PLDVs).
City	Used as a generic term to designate all urban agglomerations. The boundaries of a city in the Transport Outlook tend to go beyond administrative boundaries (see *Functional urban area*).
Congestion	The relative travel time-loss at the peak traffic hour on the road network due to slower travel speeds.
"Decide and provide"	An approach to transport planning that involves making investments that are strategically aligned to a vision of the future transport system, in contrast to the "predict and provide" approach, which involves providing infrastructure in response to existing or projected demand (Lyons et al., 2015[1]).
E-commerce	The sale or purchase of goods or services, conducted over computer networks by methods specifically designed to receive or place orders.
Freight transport demand/activity	A measure of the volume of freight travel, measured in tonne-kilometres.
Functional urban area (FUA) or macro FUA	Macro FUAs are aggregations of FUAs defined by the joint EC-OECD Cities in the World project and identified in the UN DESA World Urbanization Prospect 2018 project (UN DESA, 2019[2]; OECD/European Commission, 2020[3]).
Income classifications	The classifications in this report are based on the World Bank's *World Development Index* (2022[4]). A reporting region is denoted as "Low-income", "Lower-middle-income", "Upper-middle-income" or "High-income" based on the World Bank category into which the majority of the economies in the region fit.
Intercity travel	Transport activity happening between cities/urban areas.
Local pollutants	Elements of ambient air pollution, including emissions of mono-nitrogen oxides (NOx), sulphate (SO4) and fine particulate matter (PM2.5).
Mobility as a Service (MaaS)	Digital platforms that enable demand-responsive route optimisation across modes, including dockless micromobility modes.
Mode	Refers to the method of transport service. For example, road, rail, waterway, air or private car, powered two-wheeler, bus, metro, or urban rail.
Mode split/mode share	Percentage of total passenger-kilometres or trips accounted for by a single mode of transport. Values should specify whether mode split/share is calculated based on trips of passenger-kilometres.
Motorcycle	Powered two-wheeled vehicles, motorcycles and scooters, equivalent in this text to two-wheelers.
Net Zero	According to the United Nations, "net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance" (UN, n.d.[5]).
Informal public transport (PT)	Public transport-like services operating under unclear regulatory frameworks. Paratransit is more common in developing countries where such services play a significant role in the transport system, operating in parallel to formal services. The term is also used in the United States and Canada to mean on-demand transport services, typically used by the elderly or those with mobility restrictions who find it difficult to use fixed-route systems. However, these services are not included in the *ITF Transport Outlook* definition of paratransit.

Passenger transport demand/activity	A measure of the volume of passenger travel, measured in passenger-kilometres.
Passenger-kilometre	Unit of measurement for passenger transport activity representing the transport of one passenger over a distance of one kilometre.
“Predict and provide”	An approach to transport planning that involves making infrastructure investment decisions in response to existing or projected demand.
Private motorised vehicles	Private vehicles including motorcycles and cars.
Proxy indicator for crash risk	An indicator developed by the ITF to estimate the risk of potential conflicts between pairs of travel modes (e.g. pedestrians and passenger cars) using the same street. These indicators account for total vehicle volumes, the difference in average travel speed between the modes, and the degree of longitudinal separation between the modes. However, they do not include potential conflict with urban freight vehicles.
Public transport	Public transport services served by bus, metro, tram, and rail.
Regional travel	Transport activity happening outside urban areas (i.e. in rural, peri-urban areas).
Shared mobility	In the context of the *ITF Transport Outlook,* this includes taxis, taxi-buses, and ridesharing. The modelled shared mobility results do not include shared micromobility (see 'active and micromobility').
Shared transport	If discussing both together, shared mobility and shared vehicles are sometimes referred to as shared transport.
Shared vehicles	Shared ownership schemes for cars and motorcycles.
Slow steaming	Slow steaming is reducing the speed to decrease fuel consumption, saving costs and cutting emissions. Mostly discussed in the context of maritime transport, but it can be generalised to other non-urban freight transport modes.
Sustainable aviation fuel (SAF)	Liquid drop-in fuels that are compatible with existing aircraft.
Tank-to-wheel emissions	Emissions generated from the use of transport vehicles. Also known as tailpipe emissions. It does not include well-to-tank emissions, which make up part of the total emission pathway (well-to-wheel).
Teleworking	Carrying out work at a location that is remote from the employer’s office while staying connected to the office via network technologies.
Three-wheeler	Powered three-wheeled vehicle, such as auto-rickshaws in India.
Tonne-kilometre	Unit of measurement of goods transport which represents the transport of one tonne of goods over a distance of one kilometre.
Trade regionalisation	Current developments might indicate a more regionalised trade system in the future with increased trade exchanges within regions or trade blocks and a relative decrease of longer distance intra-regional trade. Emerging economies have gained a larger share in global trade and increasingly trade with each other. One of the major trends in trade policy is the continuous increase in preferential trade agreements at a regional level. Especially in Asia, intra-regional trade has increased in relative and absolute terms. For example, the share of Chinese exports directed to emerging and developing Asian countries has grown considerably in the last decade, accelerating in the most recent years.
Transit-oriented development	A dense development with access to public transport within walking distance and characterised by a mix of residential, employment, commercial and other uses.
Two-wheeler	Powered two-wheeled vehicle, motorcycle or scooter; equivalent in this text to motorcycles.
Vehicle-kilometre	A unit of measurement for freight and passenger transport demand that represents the movement of a single vehicle over a distance of one kilometre.
Well-to-tank emissions	Emissions generated from the production and transport of fuel (or another energy source such as electricity) for transport vehicle use.
Well-to-wheel emissions	The total emissions associated with transport vehicle use. Including well-to-tank (indirect) and tank-to-wheel (direct) emissions.

Reporting regions

The following table defines the regions referred to in the modelling for the *ITF Transport Outlook 2023.*

Name/acronym	Reporting region
Europe	European Economic Area and surrounding countries, including accession states to the European Union
ENEA	East and Northeast Asia
LAC	Latin America and the Caribbean
MENA	Middle East and North Africas
SEA	Southeast Asia
SSA	Sub-Saharan Africa
SSWA	South and Southwest Asia
TAP	Transition economies and other Asia Pacific
UCAN	United States, Canada, Australia and New Zealand

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Executive summary

Background

This edition of the *ITF Transport Outlook* examines the impacts of different policy measures on global transport demand and carbon dioxide (CO_2) emissions to 2050. The analysis covers passenger and freight activity across all transport modes. It places a particular focus on transport policies that make cities more liveable. A second focus is on infrastructure investment decisions and what different policy scenarios mean for them. As a third focus, the report explores regional differences in policy impacts.

The report analyses two policy scenarios for the future of transport, using the ITF's in-house transport models. The Current Ambition scenario assumes policies to decarbonise transport continue along their current pathway and considers the implications for transport demand, CO_2 emissions and further aspects over the next three decades. The High Ambition scenario assumes policies focused on accelerating the decarbonisation of the transport sector and their impact.

Findings

Time is running out to meet the Paris Agreement goal to limit global warming to "well below" 2 degrees Celsius above pre-industrial levels. Despite efforts by some regions to decarbonise, transport emissions will not fall fast enough, as transport demand will grow in the years to come. By 2050, passenger demand will increase by 79% under the Current Ambition scenario and freight demand will roughly double. Under the High Ambition scenario, the equivalent increases are 65% and 59%.

Policy makers play a crucial role in breaking the link between transport demand and emissions. They must use the tools at their disposal to ensure zero- and low-carbon technologies and fuels scale up to become cost-competitive. For road and rail transport, low- and no-carbon technologies require large-scale rollout. For the maritime and aviation sectors, developing sustainable and affordable fuels, in sufficient quantities, will be crucial to decarbonising in the long term.

Public transport and mass transit offer great opportunities to advance zero-emission travel. But an integrated mixture of transport modes – including ridesharing, shared vehicles and infrastructure for walking and cycling – will be essential. With bolder policies, mode share for private motorised vehicles in urban areas falls from 49% in 2019 to 36% in 2050, as most passenger travel switches to sustainable modes. Outside urban areas, mode-shift policies will succeed in specific contexts. Rail, in particular, achieves a higher mode share under both the Current and High Ambition scenarios. However, roughly 50% of regional trips will still happen by passenger car in 2050, even with ambitious policies.

International and intercity travel rely on carbon-intensive transport modes. Aviation alone accounts for nearly half (47%) of international and intercity passenger-kilometres. Long-distance trips are particularly hard to decarbonise for both passenger and freight. Making these trips more sustainable without reducing travel will require reducing the carbon intensity of the travel.

Freight mode choice is mostly unresponsive to pricing measures. The exceptions are road and port access modes in multimodal trips. Coherent pricing policies can ensure that the most sustainable of the viable modes are chosen. Carbon pricing can encourage a move away from the most carbon-intensive fleets and make low-carbon fuels more cost-competitive.

Regardless of the pathway chosen, the transport system will require significant investment in the coming decades. Core infrastructure investment needs to meet projected demand are estimated at 1.7% of global GDP annually through to 2050 under the Current Ambition scenario, and marginally less (1.6%) under the High Ambition scenario. However, the rollout of electric vehicle charging networks, which is essential for electric vehicle uptake, will require significant additional investment.

Policy recommendations

Develop comprehensive strategies for future mobility and infrastructure

To ensure increased transport activity is as sustainable as possible, governments should change their approach to planning. Instead of providing infrastructure as a reaction to predicted demand, the "decide and provide" approach invests in infrastructure in a vision-led way, with a view to achieving certain public policy objectives. This approach is not necessarily costlier: core infrastructure investment needs could be lower if ambitious decarbonisation policies are implemented now.

Accelerate the transition to clean vehicle fleets

New vehicle technologies and alternative fuels are crucial for decarbonising transport. Accelerating the transition towards cleaner vehicles and fuels requires targeted policy support with clear, ambitious objectives and support measures. Incentives to accelerate zero-emission passenger vehicle use should not disadvantage citizens on lower incomes. Alternative fuels and vehicle technologies rely on enabling infrastructure (e.g. electric charging networks and refuelling sites), which will require additional investment.

Implement mode shift and demand-management policies where they are most effective

Measures that reduce trips and travel distances, and encourage the use of more sustainable modes, work well in cities but are not always feasible elsewhere. Some countries can expect to shift regional and short-distance intercity and international travel, to rail, and should pursue this where feasible. Mode-shift policies will make little impact on longer-distance travel, as long-haul air trips are difficult to replace, for instance. Here, transitioning to lower-emitting vehicles and fuels should be the priority.

Consider the additional benefits for urban areas when evaluating policies

Many policies to decarbonise urban mobility have additional positive impacts. Measures that reduce car dependency in cities and improve sustainable transport options, for instance, can make mobility more affordable and improve access. They can also reduce congestion, free up urban space and improve health outcomes by reducing crash risks for cyclists and pedestrians and limiting air pollutants from road traffic.

Reform vehicle taxation to capture external costs of new vehicle fleets

Government revenues from fuel-excise duties will continue to fall as vehicle efficiency improves and the transition to zero-emission vehicles accelerates. This will make them less effective as a policy lever to encourage sustainable behaviours. Efficient road pricing would mitigate the impact of diminishing revenues from fuel duties. Congestion charging can also help capture the external costs of road use more fairly over time and encourage more sustainable transport choices.

1 The outlook for transport: Speedy recovery, new uncertainties

This chapter summarises the main impacts of the Covid-19 pandemic on the transport sector and describes the major uncertainties currently affecting recovery from the pandemic. The chapter also covers the main drivers of transport demand and the externalities that complicate efforts to decarbonise transport. Next, it outlines the scale of the decarbonisation challenge for the transport sector and provides an update on international co-operation to achieve decarbonisation goals. Finally, it outlines the priorities national transport ministries need to consider when meeting their commitments to the aims of the Paris Agreement.

In Brief

Global disruptions have hindered the transport sector's post-pandemic recovery

The Covid-19 pandemic led governments worldwide to introduce lockdowns and restrictions on travel and movement in 2020-22. These actions profoundly affected the global transport sector, which has nevertheless bounced back quicker than expected. Policy responses have also moved on. Some measures, such as travel restrictions, have ended. Others, such as investment in active travel, have become more mainstream in several regions.

However, in 2022, just as the post-Covid recovery gained momentum, the war in Ukraine brought untold destruction and human suffering. The war has been accompanied by an energy crisis and widespread supply-chain disruptions. These disruptive events create new uncertainties for users and providers of transport worldwide, and their effects continue to unfold as this report went to press.

Global gross domestic product (GDP) trends, changing trade patterns, and the volatility of energy prices provide clues as to the potential impact of current events on transport demand. GDP influences both freight and passenger transport. International trade determines freight transport patterns and demand. Fluctuations in energy prices affect travel behaviour.

Uncomfortable truths accompany evidence of the sector's recovery. Yes, passenger travel is booming now that restrictions on movement have ended. Yes, new trade routes have replaced those closed by the war and sanctions. But the transport sector remains overwhelmingly reliant on fossil fuels. And this continues to make it particularly vulnerable to energy price variability.

The transport sector's future sustainability depends, to a large extent, on its response to the structural crisis created by global warming. Populations and economies are due to grow in the coming years, meaning freight and passenger demand will also increase. The projections for this report demonstrate that current commitments to reduce carbon emissions are insufficient.

The scale of the decarbonisation challenge is vast. International co-operation to achieve decarbonisation goals is making progress but needs to accelerate. The question of equity in meeting climate goals becomes even more urgent in this context. For many governments, balancing national priorities against the need to meet their commitments under the Paris Agreement remains a serious challenge.

Key takeaways

- The transport sector's recovery following the pandemic has been faster than expected but significant challenges remain.
- Turmoil in energy markets and cost-of-living crises complicate efforts to decarbonise transport.
- Despite some progress, transport emissions will not fall fast enough in the coming years to meet international climate objectives.
- Mechanisms exist to advance decarbonisation goals but they need to become more ambitious.
- Governments face the challenge of balancing multiple priorities while meeting climate commitments.

The global transport sector's recovery from the Covid-19 pandemic has exceeded expectations but there remain significant differences between and within countries, with new uncertainties exacerbating these gaps.

Population and economic growth will continue to drive demand for transport, necessitating international co-operation to meet decarbonisation goals. In this context, transport ministries worldwide will face competing priorities, and will need solutions that can address multiple challenges.

This chapter discusses the transport sector's recovery in the aftermath of the Covid-19 pandemic. It looks closely at how the determinants of transport demand are expected to shape demand in the current economic climate, and in the face of new uncertainties.

Post-pandemic recovery: New uncertainties take hold

All projections of future transport trends are subject to uncertainty. This edition of the *ITF Transport Outlook* is no exception: it reflects both expected and unexpected impacts of the Covid-19 pandemic and the subsequent transport disruptions. In 2022, just as the global economy was recovering from the pandemic, the war in Ukraine caused further turmoil. Despite the current volatility in global trade and supply chains, transport demand will grow significantly in the long term due to expected economic growth. Population growth, density, and urbanisation trends will move upwards and play an essential role in changing transport activity. Other factors, such as energy prices, land-use policies and behavioural shifts, will also affect transport demand and peoples' or businesses' travel/transport choices.

The transport sector plays a significant role in increasing accessibility and influencing individuals' economic and social outcomes. It also contributes to sustainable development worldwide and is a crucial global actor in the 2030 Agenda for Sustainable Development (UN, 2015[1]). The United Nations defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 2022[2]). As demand for transport increases, it will be critical to meet the need for travel and, at the same time, tackle increased carbon dioxide (CO_2) emissions, poor air quality and congestion, and improve access to opportunities, goods and services for all.

However, the challenge is stark. In 2018, the transport sector produced 23% of global energy-related CO_2 emissions (IEA, n.d.[3]). and had the highest reliance on fossil fuels of all sectors (IEA, 2022[4]). In nearly half of all countries, transport is the highest-emitting sector of the economy (UN, 2021[5]). Yet transport is relatively difficult to decarbonise, due to its high dependence on oil and the complexity that arises from individuals' own transport choices. At the same time, people and goods will continue to move. With increasing transport demand, even in uncertain times, policy makers must address and mitigate emissions from the transport sector in line with the goals of the Paris Agreement. Transport demand will have to be met in a socially and environmentally just manner, reducing emissions while enabling the movement of people and goods.

Changes in the economy, population and energy markets primarily impact the demand for transport. A rise in economic activity and disposable household incomes increases passenger and freight transport demand. Similarly, a rising population leads to a rise in demand for transport. Accompanying demographic changes, such as increasing urbanisation and changes in national age profiles, also impact the demand for transport and how policy makers tackle it. Furthermore, price fluctuations in energy markets influence travel patterns and investments in alternative fuels. In addition, technological advances and long-term behavioural changes impact the demand for transport. All of these factors, taken together, affect travel demand. This demand, in turn, shapes transport planning and investment decisions.

Looking back: The impacts of Covid-19 on transport

The Covid-19 pandemic has led to widespread social, economic and environmental changes. Like most parts of the economy, the transport sector has felt the shock of the pandemic across all modes. National and local lockdowns and other travel restrictions have resulted in unprecedented restraints on the movement of people and goods. The pandemic has affected all national and international transport modes, from private vehicles and public transport in urban areas to buses, trains and flights.

Social-distancing requirements and lockdown policies have also affected public transport ridership and shared mobility services. There has been a significant disruption in global supply chains, and passenger travel by aviation fell by 60% in 2020 (ICAO, 2023[6]). Employment levels have taken a severe hit across all sectors, especially in the retail and tourism industries. Workers in large informal sectors in emerging and developing countries suffered, in particular, experiencing more limited access to social safety nets than workers in formal sectors (World Bank, 2020[7]).

In the first months of the pandemic in 2020, essential service workers experienced restrictions and limited public transport options. As an immediate response, governments adopted protocols allowing these workers to make exceptional use of available transport services. Policy makers initially focused on ensuring equitable and continued access to basic services and the movement of essential goods (ITF, 2023[8]).

The transport sector adapted to these changing circumstances. Rail and other public transport providers, bikesharing programmes, taxis and ride-hailing services offered free or discounted rides to health workers. Many bus and train services continued with reduced capacity. A number of measures were taken a few months into the pandemic to create street space for walking and cycling in cities (ITF, 2023[8]).

With the pandemic, many changed the way they travelled. Initially, not just individuals but entire cities and countries came to a halt and supply chains came under heavy strain. As the subsequent waves of the pandemic materialised, countries shifted their focus towards maintaining and restoring the operations of transport services and minimising supply-chain strains. Governments developed financing mechanisms and restructuring packages for transport operators to relieve their financial distress and support their functions in a post-pandemic world.

Post-pandemic recovery has been faster than expected but challenges remain

The *ITF Transport Outlook 2021* assumed a set of potential challenges and opportunities for decarbonising transport arising from the Covid-19 pandemic. It presented three scenarios that assessed the impacts of different policy pathways on transport demand, greenhouse gas emissions, local pollutant emissions, accessibility, connectivity and resilience. All three scenarios accounted for the impacts of the pandemic by including assumptions on the economic implications, the expected behavioural shifts and the degree to which the pandemic would affect transport supply and travel patterns in the short and long term.

But economic recovery from the pandemic has been faster than previously estimated. The *ITF Transport Outlook 2021* assumed a global drop in gross domestic product (GDP) projections and trade in 2020. It then assumed that, in subsequent years, countries would return to the kinds of growth rates predicted prior to the pandemic. The modelling approximated this trend by assuming a five-year delay in GDP and trade projections returning to pre-Covid-19 levels (ITF, 2021[9]). As the pandemic progressed, however, solutions were found that allowed trade flows to continue.

By 2021, GDP in several countries had already returned to pre-pandemic levels. Among the Group of Seven (G7) countries, by the fourth quarter of 2021, Canada had exceeded its pre-Covid-19 GDP level by 0.2%, compared to the fourth quarter of 2019. The United States and France had already reached their pre-pandemic GDP levels in the second and third quarters of 2021, respectively (OECD, 2022[10]). For the Group of Twenty (G20), while there were significant differences between countries, the GDP for the group returned to pre-pandemic levels in the first quarter of 2021. India, the People’s Republic of China and

Türkiye were the first countries in the G20 to do so by the end of 2020. Australia, Brazil and Korea also returned to pre-Covid-19 levels in the first quarter of 2021 (OECD, 2021[11]).

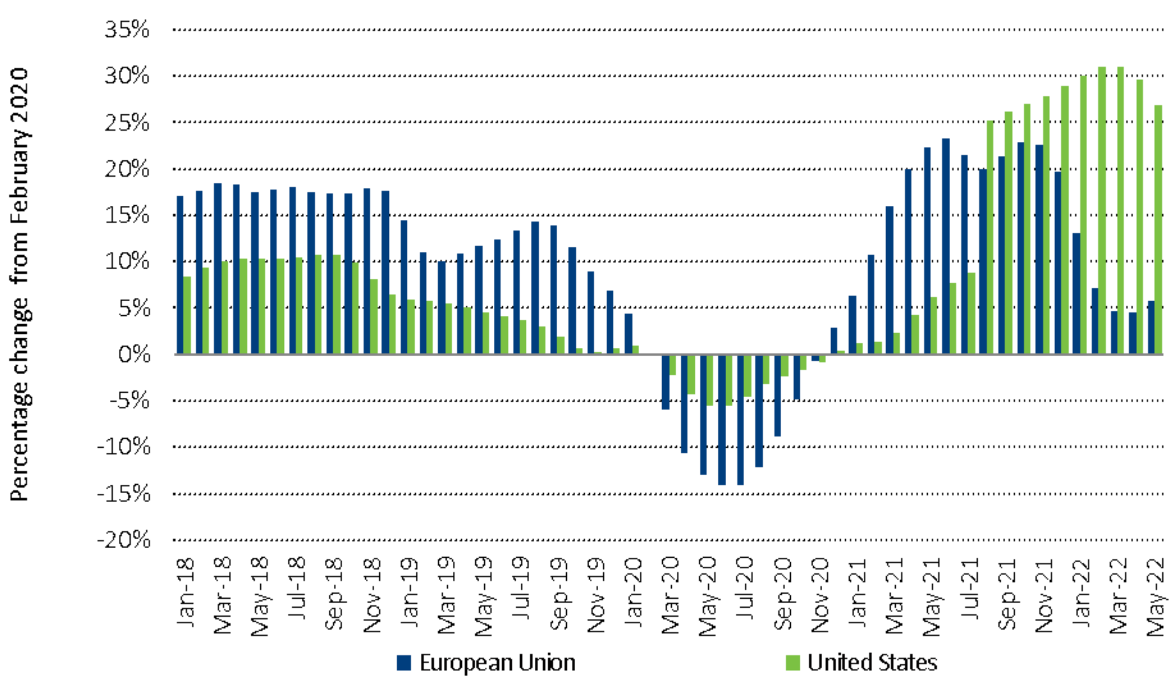
The economic recovery across the world continued strongly in 2021. Still, it slowed down towards the end of the year due partly to the Delta variant of the coronavirus and to continued pandemic-related supply disruptions (IMF, 2021[12]). The International Monetary Fund (IMF) made a downward revision in the growth prospects for 2021 for advanced economies due to inventory drawdowns and softening consumption in the third quarter of the year. At the same time, the IMF made an upwards revision for emerging economies, driven by stronger than anticipated domestic demand. This revision differed from the underlying assumptions for the *ITF Transport Outlook 2021*, which expected a slower economic recovery.

International trade and freight transport are intrinsically linked

International trade had been recovering strongly from the lows of the Covid-19 pandemic when the war in Ukraine in 2022 caused it to nose-dive again. The pandemic resulted in some of the most considerable reductions in trade volumes since the Second World War (OECD, 2022[13]). The decline in international trade in the post-pandemic period was similar to the 2008 global financial crisis. Air freight volumes in April 2020 fell by 53% in European Union countries and 3% in the United States, compared to the pre-financial crisis peak of June 2008 (ITF, 2020[14]).

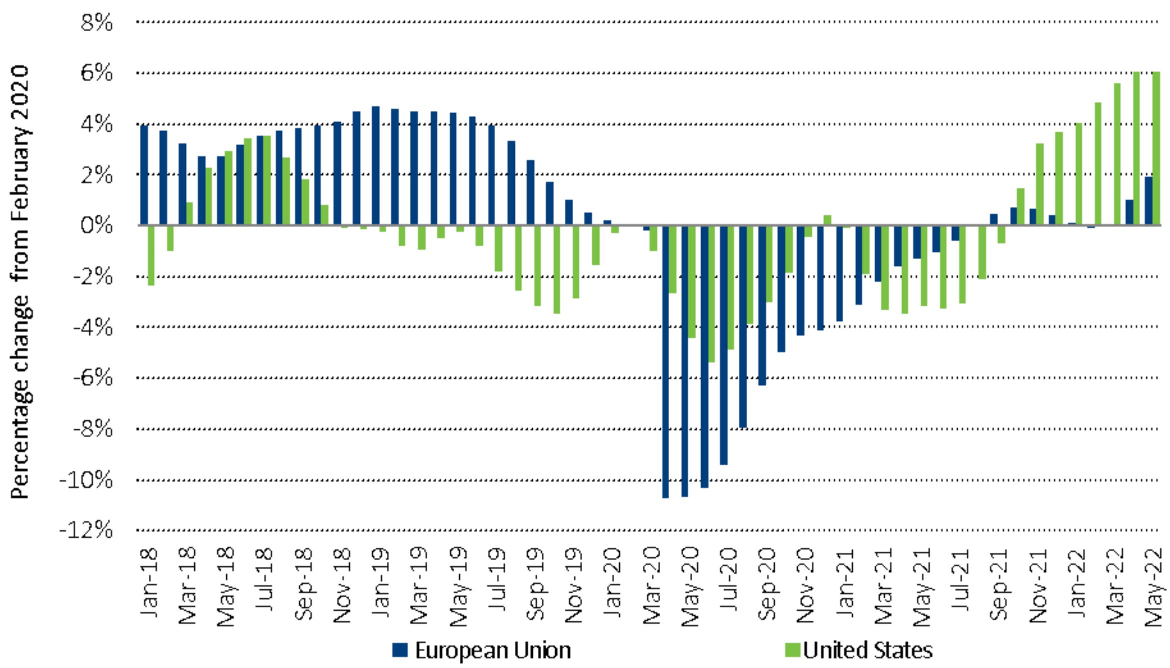
With lockdown measures and restrictions on movement, travel was one of the worst-hit sectors of the economy. While the initial decline in trade was comparable to that due to the 2008 global financial crisis, it was able to make a V-shaped recovery by 2021. ITF data (ITF, 2022[15]) shows that sea- and air-freight volumes had fully recovered by the third quarter of 2021. Figure 1.1 and Figure 1.2 capture the recovery in air and sea trade volumes for the EU and the United States by 2021.

Figure 1.1. External air trade volumes for the European Union and the United States, 2018-22



Source: ITF (2022[15]).

Figure 1.2. External sea trade volumes for the European Union and the United States, 2018-22



Source: ITF (2022[15]).

However, trade gaps for different commodities closed unevenly throughout 2021. Global value chains rely immensely on international container shipping, which continued its recovery in 2021. The pandemic has also had an uneven impact on trade across countries. While exports fell at a similar rate in 2020 across most countries, the recovery was much more varied. Exports from more developed economies recovered much faster than those from less-developed economies (ITF, 2022[15]).

Increased Covid-19 cases due to the Omicron variant in late 2021 and the war in Ukraine in early 2022 brought this recovery to a halt. Trade flows from Europe to Brazil, Russia, India, China and South Africa (the BRICS countries), and Asian countries, fell significantly at the beginning of the war in February 2022. For the EU, exports by sea were 5% lower and imports were 7% higher in May 2022 than in February 2020. Global air trade also began to stagnate by the last quarter of 2021 (ITF, 2022[15]).

By May 2022, imports by the EU were just 2% above February 2020 levels, reflecting a poor performance compared to 2021 (ITF, 2022[15]). In May 2022, the EU's exports by sea to BRICS and Asian countries were 19% and 16% lower, respectively, while imports did not change drastically. As expected, the EU's air-trade flows with the BRICS and Asian countries contracted significantly.

Covid-19 has changed trade and transport policy

Authorities and businesses implemented measures to soften Covid-19's impact, some of which have since become standard policies. For example, higher levels of trade regionalisation have occurred since the Covid-19 pandemic. This trend has brought out the relative advantage of shorter, more resilient supply chains. According to the World Economic Forum (WEF), in the five years before the pandemic, the average trade-weighted distance had been falling and was at its lowest in 2019 since the 2008 global financial crisis (Legge and Lukaszuk, 2021[16]).

In conjunction with this increasing regionalisation, the pandemic exposed the fragility of the global supply chains and showed their susceptibility to disruptions. As soon as borders closed, global and multi-country supply chains broke down. In response, policy makers began to emphasise implementing policies that increase resilience to future emergencies.

The pandemic also highlighted the importance of multilateralism and international co-operation. Regionalisation has again gained traction in the post-pandemic world as a way to safeguard supply chains against future crises. Long-term considerations around investment drivers and determinants are becoming a standard part of ensuring resilience in supply chains (UNCTAD, 2022[17]). Based on these observations, the *ITF Transport Outlook 2023* assumes a higher degree of trade regionalisation than the previous edition.

The Covid-19 lockdowns brought about a revival of walking and cycling in cities, facilitated by supporting measures by city authorities. Measures to promote active mobility in cities during the pandemic have also become part of long-term strategic plans. Examples of such actions include removing parking lanes to make way for walking and cycling paths; enlarging footpaths; allowing cyclists to use bus lanes; and speed-limit reductions for shared lanes (UITP, 2020[18]).

A total of 1 800 cities worldwide have taken action to promote non-motorised transport since the start of the pandemic (Goetsch and Peralta Quiros, 2020[19]). Several cities have since also introduced car-free days, in addition to restricting vehicles in certain zones to reduce motorisation (Shah, Jaya and Piludaria, 2022[20]). The Shifting Streets COVID-19 Mobility Dataset catalogues government responses from over 500 cities that have directly influenced walking, cycling and other non-motorised transport modes (Combs and Pardo, 2021[21]).

Several long-term changes in mobility patterns present opportunities for decarbonisation that policy makers must channel towards the transport sector's green transition. During the pandemic, virtual mobility increased due to the increase in online activities such as teleconferencing, online learning, teleworking and online shopping (de Palma, Vosough and Liao, 2022[22]). Out of these, teleworking is another trend that has continued significantly in several regions even after the lifting of Covid-19-related restrictions (ITF, 2023[8]).

The pandemic also reinforced the pre-existing surge in e-commerce sales. According to the UN Conference on Trade and Development (2022[23]), the rise in e-commerce activity prompted by the Covid-19 pandemic continued in 2021, even though many countries had already started easing restrictions. The highest increases in e-commerce sales have occurred in developing countries. In the United Arab Emirates, the percentage of Internet users who shopped online rose from 27% in 2019 to 63% in 2020. The share also tripled in countries such as Bahrain and Uzbekistan. Greece saw the highest increase (18%) among the developed countries, followed by Hungary, Ireland and Romania, each of which saw a rise of 15% (UNCTAD, 2022[23]).

The *ITF Transport Outlook 2023* assumes that e-commerce activity will continue to grow moderately and reach one-quarter of global retail sales in 2025. More e-commerce activities lead to a rise in freight transport demand, which is linked to increased emissions and congestion in the absence of measures to decarbonise freight activity.

Meeting the next challenge: Decarbonisation in uncertain times

As with the Covid-19 pandemic, the ongoing war in Ukraine has prompted changes in policy responses and disrupted the global economy. The impacts of the war can be seen in the form of economic and human repercussions, including the displacement of millions of people. The war has unleashed a humanitarian crisis in Ukraine, adding to the already record-high global refugee levels (World Bank, 2022[24]) and putting immense pressure on global geopolitical relations.

The war has contributed to a worsening global economy, mainly through further disruption to supply chains, commodity markets and energy prices (World Bank, 2022[25]). Its repercussions point towards a global growth slowdown, rising inflation and increased poverty levels (World Bank, 2022[24]). While the immediate impact, outside of Ukraine, is felt in Europe, the war's effects extend worldwide. The UN Global Crisis Response Group estimates that 1.6 billion people in 94 countries face the combined threat of a cost-of-living crisis, food shortages, energy poverty, and social unrest (UN, 2022[26]). This could create considerable challenges for implementing environmental goals. The *ITF Transport Outlook 2023* considers the current and expected impacts of the war to the extent possible.

Turmoil in energy markets could impact decarbonisation

The war in Ukraine has exacerbated weaknesses in international energy supply chains that had not yet fully recovered from the shocks of the pandemic. The International Energy Agency (IEA) has described the current context as "full-blown energy turmoil", primarily due to Russia's position before the war in Ukraine as the world's largest exporter of fossil fuels. The reduction of supply to Europe and the imposition of sanctions in the region "are severing one of the main arteries of global energy trade" (IEA, 2022[27]).

The ongoing war also influences climate policy worldwide, as energy security has become a top priority for many countries. The impacts of the war on the global energy market have prompted some countries to revise their energy policies – for example, by delaying previous ambitions to phase out fossil fuels (Ember, 2022[28]). Continued dependence on fossil fuels could result in postponed climate action.

Many countries dependent on Russian fossil-based energy do not have formal plans to accelerate clean energy investment or identify alternative energy sources. However, some countries and regional blocs have taken action to simultaneously mitigate the risks of the energy crisis and push for their climate targets (Beyer and Molnar, 2022[29]).

For example, in May 2022 the European Commission published its REPowerEU plan, which aims to phase out Russian fossil fuels by 2027 and boost renewable energy production and energy efficiency measures in the EU (EC, 2022[30]). In July 2022, the EU also agreed on its Winter Plan, a political agreement on a voluntary 15% reduction in natural gas demand during the northern winter of 2022-23, compared to average consumption in the last five years (Council of the European Union, 2022[31]).

Rising energy prices will also significantly impact emerging economies, which could shift their focus towards achieving a stable energy supply at the cost of a green energy transition (Zhang, 2022[32]). It will therefore be necessary to combine reductions in fossil-fuel dependency with energy security planning in order to continue advancing the decarbonisation of transport. Reducing dependence on fossil energy will require focused and sustained policy measures across sectors, combined with international dialogue and co-operation on energy security.

Economic uncertainties resulting from the war also impact the transport sector

Ukraine's economy is currently experiencing severe distress. It is estimated that by mid-2022 the damage to the country's infrastructure, housing and non-residential buildings was over USD 100 billion, with widespread destruction of houses, roads and railways, agricultural land and other productive capacities (Kyiv School of Economics, 2022[33]). The EU will likely feel the most significant impacts outside of Ukraine. This is due to its close economic ties with both Russia and Ukraine. The World Bank (2022[24]) forecasts a contraction of 0.2% in the output in the Europe and Central Asia region in 2022.

The war in Ukraine is a significant contributor to the slowing of global economic growth. This is due primarily to the impacts of rising energy prices and reduced energy supply on a global economy that has not yet fully recovered from the repercussions of the pandemic (IEA, 2022[27]; World Bank, 2022[25]; IMF, 2022[34]; UN, 2022[35]). Indeed, while the OECD (2022[36]) projects a brief improvement in economic activity in the aftermath of the pandemic, global output growth will remain muted in 2022 and slow down further to 2.2%

in 2023. Inflation has also surged worldwide, backed by rising commodity prices and continued supply-chain disruptions.

The Covid-19 pandemic had a dramatic impact on transport. Travel restrictions forced many airlines to leave their aircraft idled. Road transport relies heavily on human resources at various stages and has therefore been hampered due to the pandemic. With the gradual easing of sanitary measures and travel restrictions, air-passenger traffic levels started to return to normal. However, disruptions to global supply chains before the war in Ukraine continued to impact the global transport sector.

In 2021, international air passenger traffic between Russia and the rest of the world accounted for 5.2% of global international traffic. In the same year, 5.7% of all European air traffic travelled to or from Russia, while a further 3.3% travelled to or from Ukraine (IATA, 2022[37]). By March 2022, 36 countries had closed their airspace to Russian airlines. Russia, in turn, banned airlines in most of those countries from entering or flying over its airspace. Several airlines belonging to countries not impacted by sanctions (e.g. countries in Asia) have also temporarily reduced flights to and from Russia. The war in Ukraine halted 2.4% of total international air passenger traffic compared to 2021 data.

The war in Ukraine has also seriously disrupted the transport of essential products, particularly food and energy. Russia and Ukraine are significant agricultural economies and providers of basic agro-commodities, including wheat, maize and sunflower oil (FAO, 2022[38]). Ukraine also exports raw materials, chemical products and machinery. The EU is Ukraine's leading trading partner, accounting for over 40% of Ukraine’s trade in 2019 (EC, 2022[39]). Ukraine ships its highest freight volumes by sea but carries out its freight activities via all modes.

The war in Ukraine is expected to have a lasting impact on global trade. The imposition of sanctions due to the war has led to trade and supply chain disruptions. These disruptions are expected to hamper the global value chains that rely on commodity inputs from Russia. They will primarily affect regional economies that are big importers of these inputs (World Bank, 2022[24]). Countries in Central Asia are highly exposed to risks from supply chain disruptions, with transit on main freight corridors in the region being restricted (ITF, 2022[40]).

The war in Ukraine dampened the global trade recovery of the preceding year. The combined effect of border closures, trade restrictions and increased fuel costs has caused trade patterns and volumes to change significantly. The World Trade Organization (WTO) made a downward revision to expected growth in merchandise trade volumes, from 4.7% to 3% in 2022 and 3.4% in 2023 (WTO, 2022[41]). Some regions will be more acutely affected by the war than others.

Russia and Ukraine are significant actors in the agri-food sectors, accounting for 53% of global trade in sunflower oil and seeds and 27% in wheat (UNCTAD, 2022[42]). The disruption in trade will likely impact Africa and the Middle East the most since they import more than 50% of their cereals from the two countries (WTO, 2022[43]). The price increase is expected to strain low-income net food-importing countries in particular.

High energy prices will further exacerbate the increase in food prices and will also raise the cost of transport. Table 1.1 provides an overview of the WTO’s annual merchandise trade volumes since 2018 and projections for 2022 and 2023. In 2021, all regions saw a sharp recovery from a slump in trade due to the pandemic. They will have muted growth in 2022 and 2023.

Table 1.1. Merchandise trade volume, 2018-23

	Annual change in trade volume (%)					
	2018	2019	2020	2021	2022	2023
Volume of world merchandise trade	**3.0**	**0.2**	**-5.0**	**9.8**	**3.0**	**3.4**
Exports						
North America	3.8	0.3	-8.8	6.3	3.4	5.3
South America	-0.9	-1.2	-4.6	6.8	-0.3	1.8
Europe	1.8	0.6	-7.8	7.9	2.9	2.7
Commonwealth of Independent States	4.0	-0.3	-1.2	1.4	4.9	2.8
Africa	3.1	-0.3	-7.5	5.1	1.4	1.1
Middle East	4.6	-1.9	-9.3	7.3	11.0	2.9
Asia	3.7	0.9	0.5	13.8	2.0	3.5
Imports						
North America	5.1	-0.6	-6.1	12.6	3.9	2.5
South America	4.8	-1.7	-11.2	25.8	4.8	3.1
Europe	1.9	0.3	-7.3	8.1	3.7	3.3
Commonwealth of Independent States	4.0	8.3	-5.5	10.7	-12.0	-5.2
Africa	5.4	3.0	-11.8	4.2	2.5	3.9
Middle East	-4.1	5.2	-9.8	5.3	11.7	6.2
Asia	5.0	-0.4	-1.0	11.1	2.0	4.5

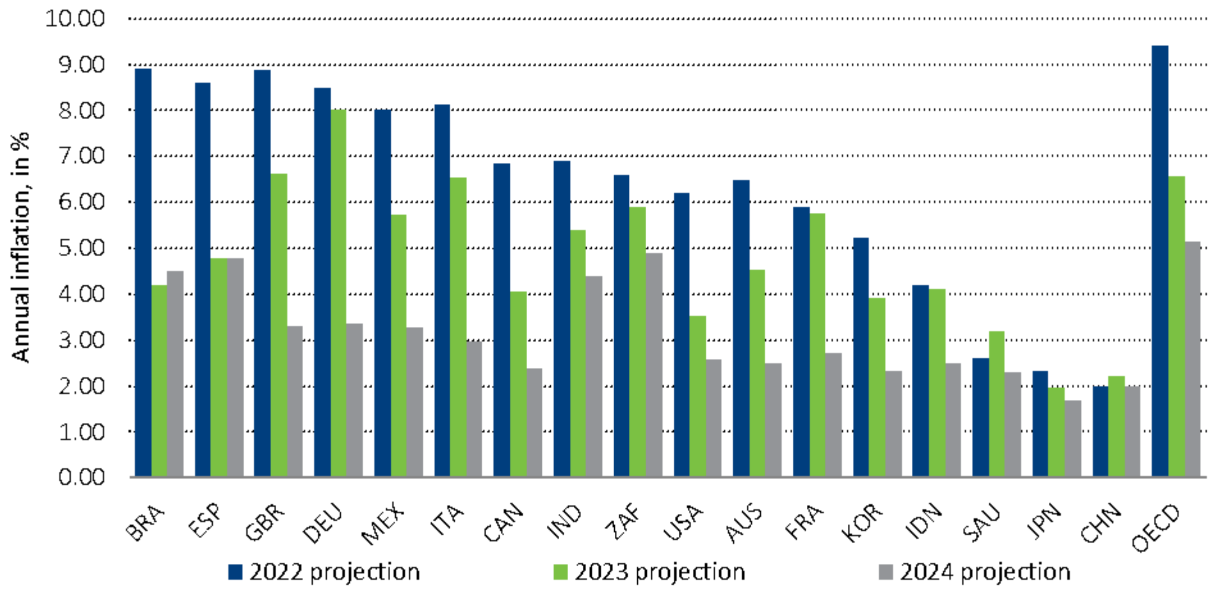
Source: WTO (2022[43]).

The OECD’s (2022[36]) projections suggest that inflation in most countries will have peaked in the third quarter of 2022 and will start declining by the end of the year into 2023. All major commodity markets have experienced the inflationary shock, pointing towards broad-based inflation. This has prompted central banks to respond with tighter monetary policy to bring it back under the target levels. Inflation has become widespread across the world’s regions but to varying extents.

According to OECD estimates, annual inflation in the OECD countries is projected at 6.6% in 2023, falling from 9.4% in 2022 (OECD, 2022[44]). This rate is expected to fall further to 5.1% in 2024. The United Kingdom experienced annual inflation of 8.9% in 2022, up from 2.6% in 2021, one of the steepest hikes in Europe (OECD, 2022[36]). Türkiye’s annual inflation rate was 73.2% in 2022, the highest in the last two decades (World Bank, 2022[45]). China's inflation will remain low and stable, while India is expected to continue experiencing its usual rate of 5-6% in 2023.

The hike in food prices will likely exacerbate income inequality as inflation impacts lower-income households the hardest due to their high share of expenditure on food and fuel (Laborde Debucquet, Lakatos and Martin, 2019[46]). Driven by tight monetary policy and a slowdown in global demand, inflation will likely fall in 2023 but remain above the target levels in many countries. Figure 1.3 shows the projections for annual inflation in 2022, 2023 and 2024. China and Saudi Arabia are the only countries where inflation is expected to be higher in 2023 than in 2022.

Figure 1.3. Projected annual inflation in 2022, 2023 and 2024, selected countries



Notes: BRA: Brazil. ESP: Spain. GBR: United Kingdom. DEU: Germany. MEX: Mexico. ITA: Italy. CAN: Canada. IND: India. ZAF: South Africa. USA: United States. AUS: Australia. FRA: France. KOR: Korea. IDN: Indonesia. SAU: Saudi Arabia. JPN: Japan. CHN: China. OECD: OECD member countries.
Source: OECD Economic Outlook database (2022[47]).

Oil prices had been rising before the war. These rises were fuelled by a combination of the bounce back in global demand and supply uncertainties regarding production by the Organization of the Petroleum Exporting Countries plus closely affiliated non-members (OPEC+) falling short of expectations (IEA, 2022[48]). The war in Ukraine prompted several countries to announce a ban on Russian oil. The EU also embargoed Russian crude oil, starting in December 2022. Prices have since eased slightly with co-ordinated stock releases by the United States and IEA member countries (IEA, 2022[49]). The energy price volatility will likely continue into 2023 (World Bank, 2022[50]).

Energy prices have significant impacts on the transport sector. Fluctuations in oil prices affect the cost of transport, usage levels and behaviours and investment in renewable energy. Higher crude oil prices translate into a higher retail price of transport fuel relatively quickly. This increases the overall cost of transport activity, especially freight activity, due to higher container freight rates. The higher prices across markets can also strain the automotive sector due to shortages and high prices for the raw materials of most vehicle batteries, such as lithium and cobalt (Coface, 2022[51]).

The steep rise in energy prices could also directly affect the rail freight market in the EU. The European Rail Freight Association anticipates that rail freight operators not purchasing enough energy for 2022 and 2023 will face significantly higher prices in future purchases. The cost could be passed on to consumers, or the operators could even be forced to leave the market, posing a threat to the progress made in the freight modal shift (ERFA, 2022[52]).

High and volatile energy prices also temporarily increase the risk of shifting investments towards extractive industries and fossil energy. Several countries have already made plans to expand fossil gas production and infrastructure. It is essential for policy makers to mitigate this risk by deploying more renewables. This would help accelerate the clean energy transition and improve the energy security of countries dependent on Russia's fossil energy. Several countries have recognised this risk and implemented measures to combat it. As noted in the *World Energy Outlook 2020* (IEA, 2020[53]), policy responses to the energy crisis are pushing renewable energy investments faster than before, accelerating the green transition.

The EU and the United Kingdom have announced plans to boost the deployment of renewable energy (Climate Action Tracker, 2022[54]). The EC's REPowerEU plan proposes to update the renewable energy target from 40% to 45% in the overall energy mix by 2030 (EC, 2022[30]). The plan also includes measures to ramp up the production of green hydrogen in the EU. Meanwhile, Germany, New Zealand, Ireland, Italy and some states in the United States have temporarily reduced public transport fares to discourage private vehicle usage and temper fuel demand (Archie, 2022[55]; Euronews.green, 2022[56]; NZ Herald, 2022[57]).

Scanning the horizon: What will drive future transport demand?

Population growth and worldwide economic growth will put greater pressure on transport policy makers to meet subsequent rises in transport demand. Changes in these drivers are bound to influence transport planning and investment decisions in the coming years. Governments must address the twin challenge of catering to increases in demand and meeting the transport sector's emission-reduction goals.

A growing population means growth in transport demand

The UN Department of Economic and Social Affairs (UN DESA) projects (2022[58]) that the world population will reach 9.7 billion by 2050 and 10.4 billion by 2100, up from 8 billion in 2022. This increase will be driven by falling mortality rates, the relatively youthful structure of the current population and sustained global fertility rates. A rapidly rising population implies the need for increased travel. Governments will have to ensure that this rise in travel demand is met in an equitable and environmentally friendly manner.

A growing majority of the population lives in urban areas globally. By 2050, an additional 2.5 billion people will live in urban areas, with Africa and Asia accounting for about 90% of this increase (UNDESA, 2019[59]). Urbanisation can also lead to urban sprawl, which has implications for increased land use and car dependency (ITF, 2022[60]). As urbanisation increases, the number of more populous cities also increases. In 2018, there were 33 cities with over 10 million inhabitants (so-called megacities) worldwide. By 2030, there will be 43 megacities, primarily in developing regions (UNDESA, 2019[59]). This will put pressure on policy makers to ensure the integration of transport and land-use policies that enhance access to sustainable transport in and around cities.

Over the next three decades, the population distribution of the world’s regions will change significantly, and this will further impact the type and distribution of transport demand. UN DESA (2022[58]) projects that more than half of the projected rise in global population up to 2050 will be from eight countries: the Democratic Republic of the Congo, Egypt, Ethiopia, India, Nigeria, Pakistan, the Philippines and the United Republic of Tanzania. During the same period, 61 countries are likely to experience a population decline of 1% or more during the same period. Bulgaria, Latvia, Lithuania, Serbia and Ukraine are expected to experience some of the most prominent relative falls in population by 2050, each with a decline of 20% or more, compared to 2022. An absolute population decline is also expected in China in 2023.

The age distribution of a population also impacts transport policy decisions. Countries with increasingly ageing populations must adapt their transport systems to address their needs. At the same time, countries with an increasing working-age population will have to cater to growing travel demand. In 2050, the global population aged 65 years or above will rise to 16%, up from 10% in 2022. Using UN DESA’s regional classifications (2022[58]), by 2050, the regions with the highest percentage of the population aged 65 years or over will be Europe and North America (27%) and East and South-eastern Asia (26%). This will also pressure countries with a higher proportion of aged populations to adopt policies that enhance the sustainability of social security and pension schemes.

Growth in demand for transport goes hand in hand with economic growth

In most parts of the world, there is a close relationship between GDP and demand for freight and passenger transport. Despite the prevailing uncertainty in the current economic climate, economic growth is projected to persist in the long term. Therefore, long-term transport demand is expected to rise simultaneously with economic growth in the coming years.

Before the war in Ukraine, the OECD estimated that economic recovery from Covid-19 would continue in 2022 and 2023 (OECD, 2022[10]). Continued global vaccination efforts, supportive macroeconomic measures in major economies, and favourable financial conditions would aid this recovery. However, the war hindered global growth and aggravated inflationary pressures. This generated a new negative supply shock for the global economy, just as the supply-chain challenges due to the pandemic appeared to be fading.

Due to its dependence on Russian oil and natural gas, the EU appears to be highly exposed to the economic impacts of the war in Ukraine. There is no likely short- to medium-term substitute for Russia's natural gas supply to Europe, and current price levels will adversely affect inflation. While some countries are more reliant than others on natural gas from Russia, the trade interdependence of Eurozone countries points to a general slowdown (Coface, 2022[51]).

According to the OECD (2022[36]), growth remained muted in the second half of 2022 before dropping further in 2023 to a growth rate of 2.2% annually. Compared to OECD forecasts from December 2021, global GDP will fall by USD 2.8 trillion in 2023. The OECD projects slow GDP growth in most G20 economies in 2022 and 2023. In Europe, there is likely to be marginal growth (0.3%) in 2023.

Within the EU, Germany and Italy are expected to have negative growth in 2023. The United States is expected to grow but at only 0.5% in 2023. Similarly, Argentina and Brazil will grow by 0.4% and 0.85, respectively. China, India, Indonesia and Saudi Arabia are relatively less affected, with growth rates of between 4.7% and 6% in 2023. Table 1.2 gives an overview of the GDP growth projections assumed in the ITF's models for the world's regions up to 2025.

Table 1.2. Gross domestic product growth projections by world region, 2019-25

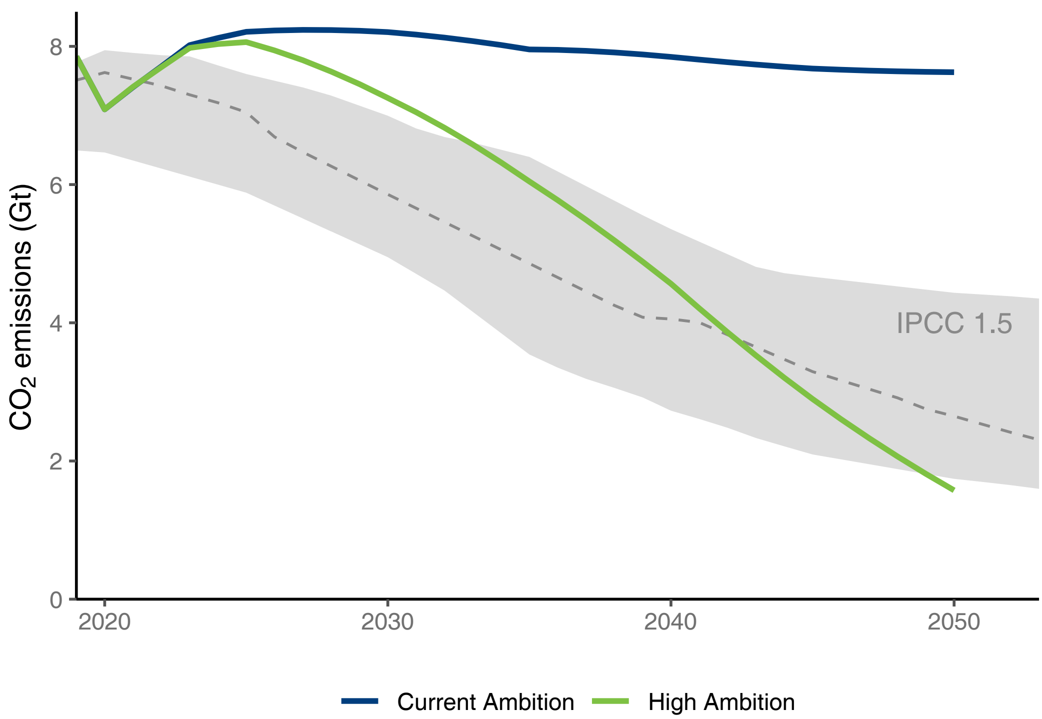
	GDP growth projection (%)							
Region	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Compound annual growth rate 2025-50**
Europe	2.2	-3.9	4.6	0.8	1.8	1.8	1.9	2.0
ENEA	4.9	-2.5	8.2	3.5	4.0	3.9	3.8	2.5
LAC	2.7	-19.7	2.9	2.9	3.1	2.9	2.9	2.6
MENA	3.1	-13.1	5.1	3.4	3.5	3.5	3.5	3.5
SEA	4.7	-6.4	2.8	4.5	4.6	4.4	4.4	3.7
SSA	3.0	-9.4	4.2	3.5	2.6	4.2	4.2	4.9
SSWA	6.2	-7.8	5.2	5.6	6.2	6.0	5.9	4.7
TAP	2.0	-11.6	2.8	-8.1	1.5	1.6	1.7	2.1
UCAN	2.7	-2.7	3.9	1.5	1.8	1.9	1.9	2.2
Global	**3.6**	**-5.6**	**5.3**	**2.4**	**3.2**	**3.2**	**3.2**	2.8

Notes: ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand. GDP: Gross domestic product.
Source: Data are based on the OECD ENV Linkages model, http://www.oecd.org/environment/indicators-modelling-outlooks/modelling.htm.

Decarbonisation goals: Progress on action under the Paris Agreement

Globally, the transport sector is not on track to reach its decarbonisation goals. In 2015, parties to the United Nations Framework Convention on Climate Change (UNFCCC) concluded the Paris Agreement, a legally binding treaty to combat greenhouse gas (GHG) emissions. By 2022, 193 countries plus the European Union had ratified it (UN, 2015[61]). Under the agreement, countries have agreed to a goal to limit the increase in global average temperature to well below 2 degrees Celsius (°C) compared to pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C.

Figure 1.4. Carbon dioxide emissions under the Current Ambition and High Ambition scenarios



Note: Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. IPCC 1.5˚C represents the emission levels needed to limit warming to 1.5˚C as introduced by the Intergovernmental Panel on Climate Change. The levels were calculated based on data sourced from the International Assessment Modelling Consortium.
Sources: (IAMC, 2019[62]); IPCC (2018[63]).

StatLink https://stat.link/owi68q

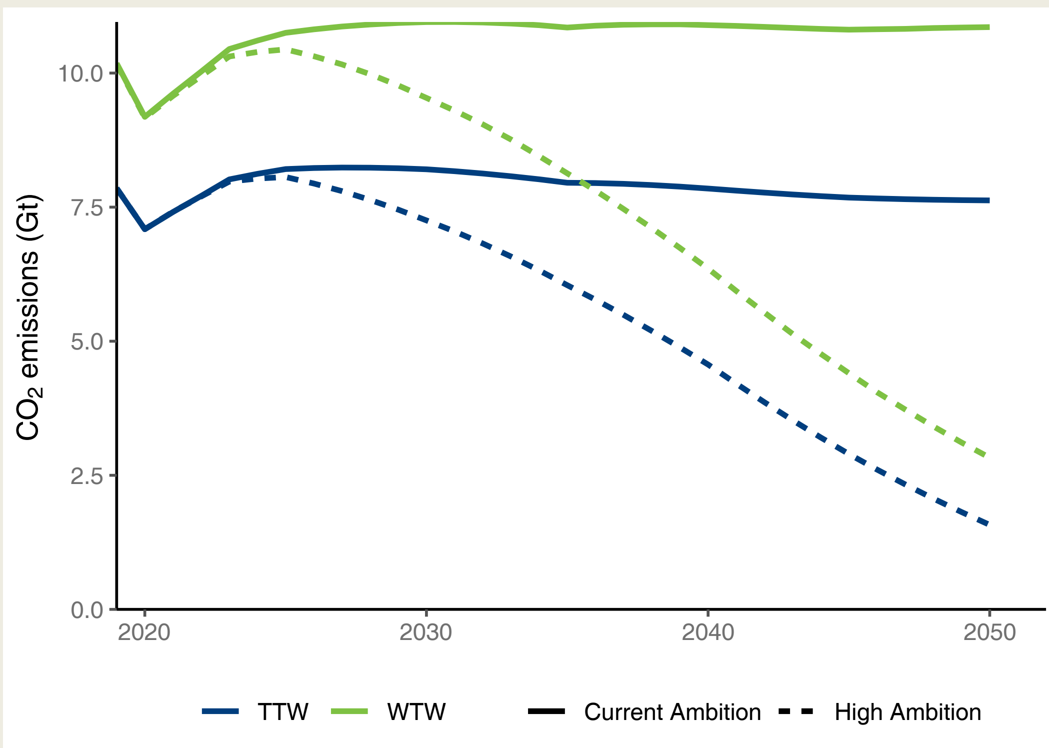
To achieve this long-term goal, countries aim to reach global peaking of emissions as soon as possible to achieve a climate-neutral world by mid-century. The agreement also recognises that not all regions can decarbonise at the same rate, citing “equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances” as guiding principles (UN, 2015[61]).

However, as shown in Figure 1.4, based solely on commitments made to date, global transport emissions will not fall fast enough to meet the Paris Agreement goals. In fact, although several regions have taken concrete actions to deliver on their ambitions, continuing along the path will result in a continued rise in the transport sector’s tank-to-wheel (TTW) CO_2 emissions during the 2020s, culminating in a slight fall (of 3%) by 2050 (see Box 1.1).

Box 1.1. Accounting for all of the transport sector's emissions

The modelling in this report refers to tank-to-wheel (TTW) emissions, defined as any emissions due solely to the energy used during a trip. However, there are also upstream emissions associated with transport activity. The emissions inherent in the production of the energy or fuel source used in the vehicle fleets are referred to as well-to-tank (WTT) emissions. Well-to-wheel (WTW) emissions include both TTW and WTT emissions and represent the total emissions associated with a vehicle's activity.

Figure 1.5. Well-to-wheel and tank-to-wheel emissions under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, representing two levels of ambition for decarbonising transport. Tank-to-wheel (TTW) emissions (or tailpipe emissions) are generated from the use of transport vehicles. This excludes well-to-tank emissions, which make up part of the total well-to-wheel (WTW) emission pathway.

StatLink https://stat.link/vupyw5

As shown in Figure 1.5, global WTW emissions were 30% higher than TTW emissions in 2019. As vehicle fleets become more efficient, WTT emissions will make up a larger share of total transport emissions than TTW emissions. The *ITF Transport Outlook* focuses on TTW emissions to identify specific policies that will speed up decarbonisation in the transport sector. However, greater collaboration with the energy sector to decarbonise fuel and energy production and distribution remains critical to achieving global climate goals.

Source: ITF (2021[9]).

Intergovernmental Panel on Climate Change (IPCC) estimates provide a sobering benchmark. Restricting the global average temperature increase to 1.5°C will require reducing total transport emissions to just 2-3 gigatonnes by 2050 (IPCC Working Group III, 2022[64]; IPCC Working Group II, 2022[65]). Additionally, the IPCC analysis suggests that transport needs to decarbonise faster than any other sector – a reduction of 70-80% below 2015 amounts – to achieve the necessary levels for the Paris Agreement.

The IEA states that decarbonisation needs to begin immediately, with transport CO_2 emissions already needing to fall by 3% per year through to 2030 to achieve Net Zero by 2050 (IEA, 2021[66]). The High Ambition scenario modelled for this edition of the Outlook suggests that the world could reduce its transport emissions by 80% by 2050. Achieving this reduction will require more ambitious policies and faster actions that combine a mixture of mode shift, demand management and vehicle and fuel improvement measures.

International co-operation will be needed to meet ambitious goals

The Paris Agreement includes a mechanism for countries to put forward plans for decarbonising their economies, and how they will play their part in delivering the goals of the agreement, known as Nationally Determined Contributions (NDCs; see Box 1.2). Under the agreement, parties to the UNFCCC were to renew their NDCs in five-year cycles, thereby showing increasing ambition and updated targets over time.

The Conference of the Parties to the UNFCCC held in Glasgow, Scotland, in 2021 (COP26) marked the end of the first five-year cycle of NDCs. ITF analyses of the NDCs submitted at COP26 (ITF, 2018[67]; ITF, 2021[68]) show that a number of countries increased their commitments to transport decarbonisation in time for the conference. Notably, by COP26, the number of countries mentioning transport had "risen by 19 percentage points, those who list measures by 22 percentage points and those setting targets by eight percentage points" compared to countries' initial NDC submissions (ITF, 2021[68]).

However, at COP26, updates on overall GHG reduction targets were deemed to be insufficient. As a result, the COP26 agreement now requires countries to update their NDCs on an annual basis. In the year following COP26, only 32 parties to the UNFCCC (or 16%) provided updates to their NDCs in time for COP27. Some of these parties had failed to provide updates in time for the previous cycle. The UN notes that countries' efforts to bend the emissions curve downward are not yet enough to limit the global temperature rise to 1.5°C by the end of the century (IPCC Working Group III, 2022[64]).

Box 1.2. Tracking national climate commitments and actions

The ITF launched its Decarbonising Transport initiative in 2016, shortly after the signing of the Paris Agreement. Since then, the ITF has tracked countries' submissions to the United Nations Framework Convention on Climate Change (UNFCCC). These submissions, known as Nationally Determined Contributions (NDCs), define countries' pledges to reduce greenhouse gas emissions. The ITF's Transport NDC Tracker, available online, provides information on the NDCs' transport content.

ITF Transport NDC Tracker: https://www.itf-oecd.org/ndc-tracker/en.

The ITF's Transport Climate Action Directory, launched in 2020, provides policy makers with a tool to identify transport CO_2-reduction measures that can translate their decarbonisation ambitions into actions and achieve their climate objectives. The UNFCCC has endorsed the directory as a tool that can help decision makers define measures when revising their NDCs or defining national transport decarbonisation plans.

ITF Transport Climate Action Directory: https://www.itf-oecd.org/tcad.

Table 1.3. 2030 Breakthrough Goals for decarbonising the transport sector

Transport sector/industry	Breakthrough Goal
Internal combustion engine (ICE) buses	Zero-emission vehicles (ZEVs) make up 100% of bus sales in leading markets by 2030
ICE heavy-goods vehicles	ZEVs make up 100% of heavy-goods vehicles sales in leading markets by 2040
ICE passenger vehicles	ZEVs make up 100% of passenger vehicle and van sales in leading markets by 2035
Shipping	Zero-emission fuels make up 100% of shipping fuels by 2050
Aviation	Sustainable aviation fuels make up 100% of fuels globally by 2050

Note: The four leading markets are the People's Republic of China, the European Union, Japan and the United States. The goals for internal-combustion-engine vehicles exclude hybrid vehicles.
Source: UNFCCC (2021[69]).

While transport has been acknowledged in 82% of NDCs, only 18% include a specific emission-reduction target for transport (ITF, 2023[70]). At an international level, governments, businesses and non-governmental organisations have been working to set up processes to support international collaboration to overcome shared challenges and maximise the shared benefits of decarbonising the transport sector.

The UN Climate Change High-Level Champions and the Marrakech Partnership have developed a series of high-level roadmaps (or "Breakthroughs") for over 30 sectors of the economy and transition goals to be achieved by 2030 to stay on track with the Paris Agreement goals (UNFCCC, 2021[69]).

The 2030 Breakthroughs set ambitious targets for the transport sector, focusing on energy transitions for road transport, aviation and shipping with the aim of creating economies of scale due to the alignment between countries' domestic policies. These goals focus specifically on technology shifts, rather than efforts to change demand or modal shift. Table 1.3 outlines the 2030 Breakthrough Goals and policy recommendations to move forward in the transportation policy landscape.

Setting priorities: What matters besides transport decarbonisation?

Although decarbonisation of the transport sector is an international priority, in many countries, it is only one among many priorities for governments looking to improve their economies and the quality of life of their citizens. For many developing countries, reducing transport emissions must be considered in the context of other strategic priorities. Examples include enhanced connectivity, better road safety (see Box 1.3), improved road networks, digitalisation and provision of public transport and basic transport infrastructure.

Low-carbon transport measures have many potential co-benefits. Crucially, they can help achieve other economic and social objectives – including include enhanced equity and accessibility, improved health and safety, reduced air and noise pollution and reduced congestion – while accelerating the sector's green transition. Policy makers must aim to maximise opportunities that meet the overall goals of the transport sector while moving to a low-carbon future.

The ITF is also involved in the cross-sectoral Energy Demand changes Induced by Technological and Social innovations (EDITS) project. This project looks at a low energy demand scenario for the future, which incorporates "major lifestyle, behaviour, infrastructure, and business model transformations" to reduce global energy use by 2050, but also improve equity and the outcomes of the Sustainable Development Goals (Grubler et al., 2018[71]).

Box 1.3. No trade-off between cleaner and safer transport

The United Nations Sustainable Development Goals acknowledge road safety as a prerequisite for sustainable development (UNECE, 2020[72]). Governments have different ways of tackling this challenge. It could entail adapting road infrastructure to technical standards, establishing and applying harmonised standards to vehicle design, designing legislation that addresses road user behaviours, or developing comprehensive support systems for post-crash response (WHO, 2021[73]).

Low- and middle-income countries currently account for most road traffic deaths (WHO, 2021[73]). Consequently, taking action to improve road safety is high on the agenda of these countries. Interventions such as safe interchange designs, limiting central urban road traffic, expanding public transport and paying particular attention to vulnerable groups can deliver road safety goals while improving sustainability outcomes (ARUP, 2020[74]).

Australia, the European Union and New Zealand all have a long-term goal to achieve, to the extent possible, "Vision Zero", which aims to eliminate all traffic fatalities and severe injuries, while increasing safe, healthy and equitable mobility for all (Action Vision Zero, n.d.[75]; CINEA, 2022[76]).

Increased regional connectivity enhances resilience and well-functioning markets

Increased regional connectivity helps advance economic development and boost supply chain resiliency (ESCAP, 2020[77]). Increasing connectivity through enhanced road and railways network is one of the most common priorities across different regions. New investments in expressways projects and rail corridors have continued after the pandemic.

A number of Latin American countries, including Argentina, Brazil, Colombia and Mexico, have earmarked funds for the rehabilitation of rail networks and the construction of new roads and highways (Ministry of Transport of Argentina, 2020[78]; Woof, 2020[79]; Government of Mexico, 2018[80]; Oxford Business Group, 2017[81]).

Several countries in Asia, including Bangladesh, Cambodia, India, Malaysia, Nepal, the Philippines and Viet Nam, currently have major connectivity projects in the works (ITF, 2022[82]; ITF, 2022[83]). In Asia, these projects often aim to improve connectivity to regions and remote areas within the countries and boost regional connectivity.

Improved connectivity is one of the top priorities for North and Central Asia countries. Almost all countries in the region are workings towards enhancing their road and rail network. These developments are prompted by the need to facilitate the movement of people and increase trade flows (ITF, 2022[84]). If such Infrastructure investments are green, it mitigates the risk of locking in emissions through carbon-intensive infrastructure. It will be necessary for policy makers to ensure that these priorities are met in a way that is aligned with the environmental goals of the sector globally.

The EU also stresses enhancing the interoperability of the national rail systems to strengthen connectivity (Council of the European Union, 2021[85]). Its Trans-European Transport Network (TENT-T) aims to establish a comprehensive, reliable and seamless network that provides sustainable connectivity throughout the region (EC, 2021[86]). The United States has also made significant investments. Its *Inflation Reduction Act* has led to substantial investment in freight and passenger rail connectivity and the road network (CleanEnergy.gov, 2022[87]; US Federal Railroad Administration, 2022[88]).

Trade corridors feature relatively highly in the list of priorities for many countries. The importance of seamless regional trade facilitation for economic development drives this prioritisation. Many countries in Africa, Asia, Europe and Latin America are investing significantly in trade and economic corridor projects to improve freight flows and reduce trade costs (ADB, 2019[89]; ITF, 2022[83]; ITF, 2022[82]; EC, 2013[90]; Oxford Business Group, 2022[91]). These projects aim to overcome infrastructure bottlenecks through high-capacity transport systems, especially in the aftermath of the Covid-19 pandemic. Given the environmental goals of the transport sector, any development of these corridors must have sustainability at its core.

Electrification and rail modernisation as a decarbonisation strategy has remained a priority in several regions. Several countries have also earmarked funding for it and the extension of networks (IEA, 2022[92]). This includes establishing high-speed rail links, modernising tracks, and upgrading and digitalising passenger and freight rail network signalling systems. All of these measures improve efficiency and reduce CO_2 emissions from the sector.

China, the EU, India and the United States have targeted funding towards the electrification of existing networks (IEA, 2022[92]; The White House, 2021[93]). A significant share of high-speed rail tracks for passenger travel also exists in China, Japan, Korea and the EU (IEA, 2019[94]). Some significant high-speed rail development projects are underway in Australia, China and India.

Seamless multimodal connectivity helps improve operational efficiency and reduces emissions. Improved logistics and upgrading multimodal hubs are other trends common to many countries. Several developing and emerging economies face high logistical costs due to inefficient transport and inventory management. Investment in integration and optimisation of operations throughout the logistics chain through improved warehousing and storage and digitalisation of processes is a priority for many emerging economies.

Countries in Africa and Asia perceive multimodal connectivity as a crucial element for supply chain efficiency and reduced costs (Okyere et al., 2019[95]; ITF, 2022[82]; ITF, 2022[83]). Strengthening inter-modal and multimodal transport also improves accessibility and connectivity, and is a prerequisite to shifting the transport demand towards cleaner modes.

Improved public, shared and active transport services will accelerate decarbonisation

With rapid urbanisation and the continued increase in demand for both passenger and freight transport, governments also have the pressure of increasing investment in urban transport infrastructure to meet this growing demand. Expanding urban areas, especially in developing and emerging economies, necessitate the construction of urban road networks, transit systems and transport terminals.

Cities worldwide are seeking to adapt to the increase in demand for transport sustainably. Examples include efforts to create bus rapid transit (BRT) corridors, light rail transit, and expansion and electrification of public transport fleets. Integrated land-use planning and planning for transit-oriented development also help ensure that the increased demand is met while improving access and sustainability of urban mobility.

An integrated, connected and inclusive active-transport system contributes significantly to a clean mobility vision. Besides improved public transport alternatives, enhancing the infrastructure for active mobility is a priority for many European countries and some countries in Asia and Latin America (European Parliament, 2020[96]; UITP, 2020[18]). The focus in these countries has been the improvement of active mobility options through enhanced cycling and walking infrastructure and the reallocation of urban space.

Finally, low-carbon solutions remain on transport ministries' global agendas. Examples of these solutions include electrification and encouraging the switch to cleaner fuels to reduce the sector's climate impact. Since the transport sector is a driver of economic growth and social inclusion, for several countries, the priority remains towards ensuring that it contributes to these outcomes. However, being a high-emitting sector, it will be essential to ensure that it plays its role in climate change mitigation and adaptation.

Developing and emerging economies face the dual challenge of providing equitable access to affordable mobility and improved freight flows while minimising their carbon footprints. Achieving the sustainability goals of the transport sector necessitates bearing in mind the entire scope of outcomes throughout the different stages of planning, designing and delivering projects and programmes. Investments in solutions such as cleaner technologies and fuels, high-quality public transport fleets, well-planned and connected cities, and widely available active mobility options can help achieve transport ministries' development goals and simultaneously fulfil their climate targets.

Key takeaways

- The transport sector's recovery following the pandemic has been faster than expected but significant challenges remain.
- Turmoil in energy markets and cost-of-living crises complicate efforts to decarbonise transport.
- Despite some progress, transport emissions will not fall fast enough in the coming years to meet international climate objectives.
- Mechanisms exist to advance decarbonisation goals but they need to become more ambitious.
- Governments face the challenge of balancing multiple priorities while meeting climate commitments.

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2 Decarbonising transport: Scenarios for the future

This chapter introduces the policy assumptions for the two modelling scenarios in the *ITF Transport Outlook 2023*. The Current Ambition scenario takes into account existing policies and forthcoming policy commitments, while the High Ambition scenario imagines a policy pathway with accelerated implementation timelines, or increased scale. The chapter then gives an overview of the projections for passenger and freight transport demand, and their associated carbon emissions, under the Current Ambition and High Ambition scenarios.

In Brief

As time runs out to meet climate goals, the case to accelerate action is undeniable

The transport sector is a significant part of the global economy. It provides access to opportunities that contribute to countries' and individuals' economic and social well-being. But transport faces a critical challenge: how to meet increasing demand while reducing carbon dioxide (CO_2) emissions. Tackling poor air quality, reducing congestion and improving equity are equally important tasks for the sector globally.

The transport sector accounts for 23% of the world's energy-related CO_2 emissions. Transport also indirectly contributes to increased demand for energy. Transport infrastructure construction, vehicle manufacturing and fuel production generate greenhouse gas emissions. And the sector locks in future emissions because of the longevity of vehicle fleets and infrastructure.

This edition of the *ITF Transport Outlook* models two scenarios for future transport policies and their potential impacts on demand and emissions through to 2050. The Current Ambition scenario represents the business-as-usual approach. It projects the potential effects of existing commitments, including Nationally Determined Contributions made under the Paris Agreement.

In contrast, the High Ambition scenario assumes policy makers take accelerated action to decarbonise transport. This scenario models the impact of specific policy objectives, including providing alternatives to private motorised vehicles, enhancing public transport services, improving walking and cycling facilities, and improving the efficiency of the movement of goods.

Some regions' current efforts will make a difference over time and overall transport CO_2 emissions will fall slightly by 2050. However, a business-as-usual approach will not make enough difference to deliver against the Paris Agreement goals. The projections also show that the carbon-intensity of passenger activity falls faster than freight's under the Current Ambition scenario.

Without decisive action, the transport sector will continue to contribute significantly to the world's CO_2 emissions. The need to break the link between emissions and transport activities is increasingly urgent. Achieving decarbonisation in the transport sector will require increased policy ambition and international co-operation. But solutions for specific transport types, and economic and geographic contexts, will vary.

Key takeaways

- Transport is central to economic development and social opportunity, but it also contributes significantly to the world's CO_2 emissions.
- This report models two scenarios for the future transport demand and CO_2 emissions to 2050, one informed by announced or existing policies (Current Ambition scenario), the other assuming more ambitious decarbonisation measures (High Ambition scenario).
- Overall, the scenarios show that current policies will begin make a difference over time at a global level, with transport CO_2 emissions falling slightly by 2050.
- However, continuing on the current path will not make enough of a difference for the transport sector's CO_2 emissions to deliver against the Paris Agreement goals.
- The urgent need to break the link between transport activities and emissions requires increased ambition and more international co-operation.

Every two years, the International Transport Forum (ITF) provides an overview of current trends and future prospects for the global transport sector based on its in-house transport models. The *ITF Outlook 2023* presents long-term projections for freight and passenger transport demand. It also quantifies the transport sector's projected carbon dioxide (CO_2) emissions using two alternative policy scenarios: a Current Ambition and a High Ambition scenario.

The ITF's modelling makes it possible to assess changes in freight and passenger flows under these two scenarios. The modelling also accounts for externalities caused by disruptions and policy interventions. For each policy scenario, the Outlook examines the impact of GDP patterns, changing populations and population centres on transport demand. It also outlines the potential roles different policy levers could play in decarbonising transport.

This chapter outlines the actions assumed by the ITF's modelling under the Current Ambition and High Ambition scenarios. It then provides a high-level summary of this edition's findings on passenger and freight transport demand and emissions.

Raising policy ambition: Transport's central role

Transport is crucial to the three pillars of sustainable development: the economy, the environment and society. Transport provides access to opportunities, services and social life; it enables the movement of goods and people. The transport sector's centrality to the core areas of human life makes it especially vulnerable to global crises. The restrictions on travel and movement throughout the Coronavirus (Covid-19) pandemic have directly affected the sector, while the current world energy crisis is causing massive increases in fuel costs (see Chapter 1).

Since the last Outlook was published in 2021, the world has experienced more extreme weather events, including devastating floods, record high temperatures, and extensive wildfires. As well as the catastrophic loss of life, livelihoods and habitats, these events, also have devastating economic impacts, underlining the urgency of taking action. Transport is responsible for roughly 23% of the world's energy-related CO_2 emissions (IEA, n.d.[1]), making it a critical focus area for decarbonisation. The results in this Outlook show that the transport sector is still not on track to decarbonise, but actions can be taken to put this right.

Trends in population, economic growth and land use influence transport activity. But these trends are often beyond the scope of transport policy measures. In the case of economic growth, for example, higher gross domestic product (GDP) represents a positive trend for many governments, independent of its impact on emissions. Therefore, it is necessary to identify transport policy pathways and levers that recognise wider goals, alongside decarbonising the associated transport activity, and accounting for the needs of different regions.

Decarbonising the transport sector also represents a significant shift away from a "business-as-usual" mindset and offers opportunities to reimagine transport systems and reconsider the wider benefits of cleaner air, reduced oil dependency, and more liveable cities. Achieving the transition to greener, cleaner and more resilient transport systems needs to include affordable, safe and inclusive services. The UN predicts that 68% of the world's population will live in cities by 2050 (UN DESA, 2019[2]).

Transport tailpipe emissions were responsible for ~385,000 premature deaths in 2015 (Anenberg et al., 2019[3]). Transport has the highest reliance on fossil fuels of any sector (IEA, n.d.[4]). Decarbonisation of the transport sector will require an energy transition of the vehicle fleet away from fossil fuels. The transition to zero-emission cars and vans was estimated to avoid nearly 1.7m barrels of oil a day in 2022 (BloombergNEF, 2022[5]). Planning for low-carbon transport systems that shift away from technologies that emit harmful pollutants also helps ensure cities become more liveable as urban populations grow.

Decarbonising transport: Two scenarios for the future

This edition of the *ITF Transport Outlook* focuses on how the global transport sector can meet the ambition to reduce CO_2 emissions in line with the Paris Agreement between now and 2050. Using the ITF's in-house global transport models (see Box 2.1), it projects the potential effects of two specific policy scenarios: a Current Ambition scenario and a High Ambition scenario.

The Current Ambition scenario provides insights into how transport demand and emissions could evolve over the coming decades if transport policy continues along its current path. The High Ambition scenario, by contrast, looks at the impact of adopting more ambitious policies to decarbonise the transport sector.

This report models the projected effects of the Current Ambition and High Ambition scenarios across four main sectors: urban passenger demand and mode choice, non-urban passenger demand and mode choice, freight demand and mode choice and the transition to cleaner vehicle fleets. The following sections describe the two scenarios in detail. Chapters 3-6 examine how these two scenarios could play out in different world regions between now and 2050, as well as some of the co-benefits arising from the reduction of CO_2 emissions from transport.

For passenger activity, the demand is grouped into three activity types: 1) urban, denoting activity within urban areas, 2) regional, denoting domestic travel outside of urban areas and 3) international and intercity, denoting travel across international borders, or domestically between two cities (see Infographic 1). For freight activity, there is a similar split: 1) urban, denoting activity within urban areas, 2) domestic, denoting activity outside urban areas but within national borders and 3) international, denoting activity across international borders).

Non-urban passenger travel represents a greater variety of trip types than urban travel. There are international and intercity trips, which would potentially have high volumes of people travelling between the same start and end points. Then there are regional trips, which have a more dispersed pattern and could have lower densities of people for every origin and destination. On average, non-urban trips also tend to cover longer distances. This combination of different travel patterns and greater distances means non-urban travel has proven harder to abate than its urban counterpart.

Box 2.1. The ITF modelling framework

The ITF has developed a set of modelling tools to build its own forward-looking scenarios of transport activity. Covering all modes of transport, as well as freight and passenger activity, the tools are unified under a single framework to test the impacts of policies and technology trends on transport activity and carbon dioxide (CO_2) emissions.

Urban passenger transport model

This model combines data from various sources, forming an extensive database on global city mobility to account for 18 modes. It produces estimates on urban passenger trip numbers, travel distances, modal splits, modal trip shares, passenger- and vehicle-kilometres (pkm, vkm) and related CO_2 and pollutant emissions, as well as indicators for accessibility, space consumption and crash risk.

Non-urban passenger transport model

This model provides estimates for passenger trip numbers, pkm and related CO_2 emissions for all modes available for travel between urban areas (both intercity and international travel) and locally in non-urban areas (regional travel), accounting for multimodal passenger activity.

Urban freight transport model

This model produces estimates on urban freight trip numbers, travel distances, modal splits, tonne-kilometres (tkm), vkm and cargo weights and their related CO_2 and pollutant emissions. It applies innovative methods to overcome the general lack of data describing urban freight movements.

Non-urban freight transport model

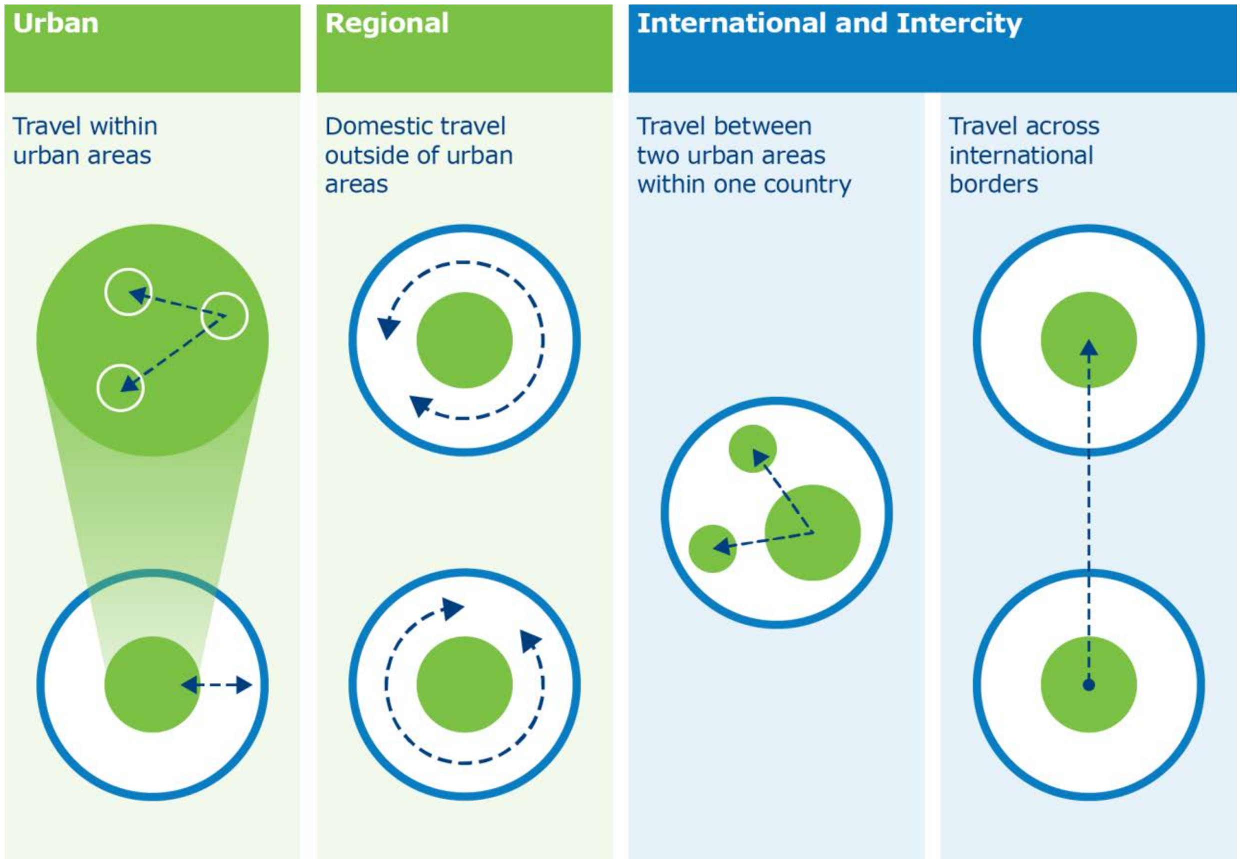
This network model assigns freight flows of all major transport modes to specific routes and network links. It combines data on national freight transport activity (in tkm) with trade projections from the OECD ENV-Linkages trade model to provide estimates on tkm and vkm by mode and commodity type.

Fleet model

This model, newly developed for the *ITF Transport Outlook 2023*, combines data on the age and technologies of vehicle fleets around the world with forecasts of vkm from the ITF passenger and freight models for every vehicle type and region. It uses these to estimate how vehicle fleets will evolve over time using scrappage probabilities. Projected future fleets are combined with scenarios on technology adoption and energy efficiencies to estimate CO_2 and pollutant emissions.

Source: https://www.itf-oecd.org/itf-modelling-framework-1.

Infographic 1. ITF Transport Outlook classification of passenger activity types



Note: Each green dot represents a functional urban area. Solid blue lines represent national borders. Arrows and dotted lines represent specific trip types.

The Current Ambition scenario: Projecting the impact of existing commitments

The Current Ambition scenario reflects a general recognition that the transport sector needs to decarbonise. It takes into account existing policies and forthcoming policy commitments in national and regional governance directives, government strategies and laws. It incorporates assumptions about current global political and economic conditions. It also reflects the reality that many decarbonisation plans are progressing slowly and will be even slower in terms of worldwide implementation.

The Current Ambition scenario accounts for the early actions that have been taken to translate existing ambitions into action. However, the scale of these actions varies greatly from region to region.

The measures in the Current Ambition scenario include policies or technological developments aimed at replacing internal combustion engine (ICE) vehicles; demand management and encouraging mode shift; investment in attractive and sustainable alternatives to the private car; and improving efficiency and operations to reduce carbon intensity. The following subsections and the accompanying tables outline the policy pathway assumed under the Current Ambition scenario over the next three decades.

Urban passenger demand and mode choice under the Current Ambition scenario

The Current Ambition policy scenario for urban passenger demand (see Table 2.1) assumes that governments and other actors gradually introduce economic instruments, transport infrastructure enhancements, transport service improvements, and regulatory and other measures to decarbonise the transport sector. All of these actions reflect current policy commitments, and the scenario assumes that they are fulfilled.

Under the Current Ambition scenario, urban policies include several pricing-based measures, including congestion pricing, parking pricing and carbon pricing. Access restrictions to urban spaces and parking for private motorised vehicles are also introduced in many regions along with investments in expanding bicycle and pedestrian infrastructure. Authorities are expected to enforce existing and new regulatory measures (e.g. speed limits, and parking and urban vehicle restrictions) more strongly as 2050 approaches.

Land-use planning, and transit-oriented design, begin to be introduced gradually in some regions with population density increasing. In some emerging economies, however, where urban populations are expected to grow rapidly, the absence of these measures would result in lower population densities in the 2030s and 2040s. Some increase in teleworking is expected to continue after the trend shifts observed during the Covid-19 pandemic. This is especially visible in high-income countries with industries that lend themselves to remote working.

Authorities also introduce improvements to transport infrastructure gradually under this scenario. Investments in public transit systems also increase, but at a more modest scale. Some expansion of express bus lanes occurs and integrated ticketing in some regions contributes to reduced fares for public transport use.

Public transport operators, authorities and regulators make moderate improvements to public transport coverage, routing and frequency to match demand to service levels. However, in some regions, a lack of policies to improve public transport actually sees service levels decline over the coming decades. While shared vehicles become more common, carpooling leads to only slightly higher occupancy rates.

Non-urban passenger demand and mode choice under the Current Ambition scenario

The Current Ambition policy scenario for non-urban passenger demand (see Table 2.3) assumes that governments and other actors will go some way towards decarbonising this hard-to-abate activity. The policy scenario focuses on investments in rail infrastructure, carbon pricing for non-urban travel modes, air travel ticket pricing and the eventual implementation of short-haul flight bans.

Under the Current Ambition scenario, investment in non-urban rail networks begins in the 2030s, with some high-income countries investing in important service improvements where the business case exists and in electrification of their rail services. By the 2040s, some middle-income countries have followed suit. While plans for better rail in high-income countries progress, there is no equivalent push to incentivise shared and collective non-urban passenger modes.

Governments in all regions implement carbon-pricing policies in the 2020s, with the introduction of carbon taxes within the range of USD 15-35 per tonne of carbon dioxide (CO_2). The price of carbon then rises to a maximum of USD 100 per tonne of CO_2 in the 2030s, and up to USD 200 per tonne of CO_2 in the 2040s. Over the same timeframe, ticket taxes begin to apply to air travel, starting at 2.5% of the value of a ticket in the 2020s, and reaching up to 15% by the 2040s.

Freight demand and mode choice under the Current Ambition scenario

The Current Ambition policy scenario for freight demand (see Table 2.5) assumes that governments implement a variety of sustainable urban logistic measures for urban freight deliveries. Measures aimed at decarbonising urban freight are already in place, with more pick-up and drop-off locations for parcels, the emergence of restricted access zones and an explosion in the use of electric cargo bikes for last-mile distribution. By the 2040s, these new modes and measures have become embedded in the urban logistics space.

For non-urban freight, measures to improve efficiency and reduce the carbon intensity of freight activity, along with transport network improvement plans, are rolled out gradually over the next three decades.

Distance-based pricing of road transport, another measure that can be used to encourage greater efficiency in freight transport, is already the subject of policy discussions in the 2020s but is not introduced until the 2030s. Carbon pricing is not introduced in the freight sector until the 2030s, and even then with prices set at varying levels in different regions. By the 2040s, carbon pricing continues to vary by region, and between sea-based transport modes and other modes. The price of carbon in 2050 is projected to range between USD 150-250 per tonne of CO_2.

Slow steaming and smart steaming are two examples of measures that reduce emissions in the shipping sector. In the 2020s, under the Current Ambition scenario, governments begin to provide incentives for operators to switch to these lower-emitting practices. By the 2030s, overall reductions in the speed of vessels produce a 5% improvement in efficiency. By the 2040s, this efficiency improvement has risen to 10%, compared to the baseline of 2019.

In the 2020s, digital solutions emerge for the management of journeys that use more than one mode. This leads to a reduction in transfer times between modes, particularly for rail and waterways. While intermodal solutions become more viable, improvements under this scenario in the 2030s and 2040s are not sufficient. Concurrently, transport network improvement plans for rail, waterways and port infrastructure begin to be phased in and funded.

Beyond transport policy, the Current Ambition scenario also assumes a decrease in the 2020s in the trade in (and consumption of) oil- and coal-based commodities. This reduction is projected to have a direct impact on the demand for fossil fuels in freight transport and on trade-associated freight activity. Over the 2030s and 2040s, however, the trade in oil and coal grows, albeit to a lesser extent than the trade in other commodities.

The transition to cleaner vehicle fleets under the Current Ambition scenario

The Current Ambition policy scenario for the transition to cleaner vehicle fleets (see Table 2.7) assumes governments enact a series of measures to encourage the switch to zero-emission vehicles (ZEVs). The rate of change reflects historical trends in the turnover of vehicle fleets and existing progress and policies in innovations in alternative fuel sources, including biofuels and sustainable aviation fuels (SAFs).

Vehicle fleets in the 2020s continue to turn over in line with past trends, meaning that ZEVs will make up a growing proportion of the world's vehicle fleets. By the 2030s, countries have begun to meet their own aspirational ZEV targets, with some even reaching 100% ZEV sales. This trend continues into the 2040s.

In contrast, when it comes to medium- and heavy-duty vehicles (i.e. freight fleets), progress is slower. It is not until the 2030s that signatories to a global memorandum of understanding designed to encourage the shift to ZEVs in this sector begin to meet their targets. Even then, only 30% of vehicles in this sector are ZEVs by the end of the decade, while the 100% sales target is expected to be met some time in the 2040s.

Meanwhile, in the 2020s a number of countries set targets to encourage the uptake of road fuels containing biofuel, which produce fewer emissions and are becoming increasingly economically viable. For aviation, in the 2020s, the EU and the United States enact mandates for the use of sustainable aviation fuel (SAF), which become more successful over time. By 2050, SAFs make up 85% of aviation fuels in Europe and 100% of aviation fuels in the United States.

The High Ambition scenario: The necessary pathway to decarbonisation

The High Ambition scenario takes the Current Ambition policies and imagines a policy pathway with accelerated implementation timelines, or increased scales. It factors in the impacts of bolder policies aimed at encouraging more sustainable developments and travel behaviour. It also takes into account the scale of ambition set by the goals of the 2030 Breakthroughs for the global transport sector (UNFCCC, 2021[6]).

The 2030 Breakthroughs include ambitious targets for ending new sales of ICE vehicles for both passenger and freight road fleets, the rollout of sustainable aviation fuels and the uptake of zero-emission fuels for maritime shipping. The following subsections and the accompanying tables outline the projected impact of the policy pathway assumed under the High Ambition scenario over the next three decades.

Urban passenger demand and mode choice under the High Ambition scenario

The High Ambition policy scenario for urban passenger demand (see Table 2.2) assumes that comprehensive urban mobility strategies are put in place to ensure that the most sustainable mode, and cleanest vehicles, are used. Of all the policy measures considered in this edition of the Outlook, urban passenger travel has the greatest number of measures aimed at achieving mode shift and demand management, in addition to those for encouraging the uptake of ZEVs.

This scenario assumes that authorities gradually introduce economic instruments, transport infrastructure enhancements, transport service improvements, and regulatory and other measures to decarbonise the transport sector. In contrast to the Current Ambition scenario, however, these actions and measures accelerate as the 2030s and 2040s progress.

Under the High Ambition scenario, urban authorities are assumed to introduce congestion charging and parking pricing. Carbon pricing is also introduced to encourage the use of cleaner vehicles. Restrictions on access for private motorised vehicles are introduced, along with a reduction in parking capacity within the urban area. These measures are aimed at reducing the dominance of cars in urban settings and addressing some of the external costs of car use. The pricing measures could also represent an important source of revenue to fund improvements to public transport and active mobility infrastructure. Authorities ramp up regulatory measures aimed at increasing urban safety and liveability under this scenario and by the 2040s, speed limits have been reduced by one-third.

At the same time, the alternatives to private motorised vehicles are improved to make them more appealing. Public transport networks and services are enhanced, including increased frequency, the introduction of express lanes for buses, integrated ticketing and the expansion of infrastructure for active modes, bus rapid transit (BRT) and rail-based modes. The High Ambition scenario sees a much higher level of investment in bicycle and pedestrian infrastructure compared to the Current Ambition and a significantly higher spend on public transport systems.

Importantly, the High Ambition scenario assumes long-term systemic changes to urban planning. This sees integrated land-use and transport planning introduced, to ensure a greater availability of social and employment opportunities, as well as public transport stops and stations, available in greater proximity for urban dwellers. These measures see an increase in urban population density and changes to the land-use mix. In regions where the prevailing industries support it, teleworking also increases.

Non-urban passenger demand and mode choice under the High Ambition scenario

The High Ambition policy scenario for non-urban passenger demand (see Table 2.4) assumes that governments and other actors make greater efforts to decarbonise this type of travel. There is a greater focus on investments in rail infrastructure shared and collective modes (including coaches), carbon pricing, air-travel ticket taxes and the implementation of short-haul flight bans.

In high-income countries, rail investment is accelerated compared to the Current Ambition scenario, with these countries taking action in the 2020s to invest in the improvement and electrification of networks. This leads to improvements in the frequency and speed of non-urban rail services, and lower CO_2 emissions from rail travel. Over the 2030s and 2040s, rail investment grows worldwide, with planning for high-speed rail taking shape in some countries.

In tandem with these accelerated rail investments, short-haul flight bans are brought in a decade earlier than in the Current Ambition scenario for direct air links shorter than 500 kilometres where there is an adequate rail alternative. As in the Current Ambition scenario, governments also begin to apply ticket taxes to air travel in the 2020s. However, under the High Ambition scenario the tax rate increases more dramatically, starting at 5% of the value of a ticket in some regions in the 2020s, and reaching up to between 5% and 30% of the value of a ticket bought by a single passenger by the 2040s.

The net for alternatives to private motorised vehicles is also cast more widely under the High Ambition scenario. Incentives are introduced to encourage the use of other collective modes (e.g. coaches and ridesharing) for regional and intercity travel. Additionally, widespread implementation of carbon-pricing schemes occurs in the 2030s, with higher initial prices than under the Current Ambition scenario but an equivalent price ceiling of up to USD 200 per tonne of CO_2 in the 2040s.

Freight demand and mode choice under the High Ambition scenario

The High Ambition policy scenario for freight demand (see Table 2.6) assumes that governments implement the measures outlined in the Current Ambition scenario for this sector according to a more accelerated timeframe, with correspondingly faster results. Furthermore, the High Ambition scenario assumes the trade in and use of fossil-fuel commodities will decrease more rapidly, and the price on carbon, while not uniform across regions, will be higher than under the Current Ambition scenario.

Under the High Ambition scenario, measures designed to decarbonise urban freight are introduced faster and at a greater scale. This leads to cargo bikes and asset sharing doubling the growth seen in the Current Ambition scenario, and a corresponding 60% higher use of pick-up and drop-off locations for parcels. By the 2040s, electric vehicles are three times as likely to be used to transport goods in cities.

Non-urban freight includes several hard-to-abate sectors: road freight, aviation and shipping. With mode choice being heavily reliant on cost and commodity type. The trip lengths involved limit the number of viable mode shift options. Demand management measures could also be sensitive as freight activity is closely linked with economic growth. The High Ambition scenario aims to decrease the carbon intensity of freight activity through improved efficiencies and ensuring the most sustainable mode is always chosen.

To support and encourage this, the High Ambition scenario assumes that high-capacity vehicles are introduced, along with improved intelligent transport systems that support asset sharing. Distance-based pricing is encouraged from the 2020s and expands in the 2030s, with rates increasing in the 2040s. As with the Current Ambition scenario, carbon pricing is introduced in the 2030s, with prices varying by region. Under the High Ambition scenario, the maximum price of carbon in the 2040s rises to up to USD 500 per tonne of CO_2 –that is, double the maximum price assumed under the Current Ambition scenario.

Incentives designed to encourage slow steaming and smart steaming in the maritime shipping sector come on track under both scenarios in the 2020s, but achieve greater efficiencies under the High Ambition scenario. Improved digital systems, with better data, support improved efficiencies too, making the interface between modes smoother and reducing dwell times. In the 2030s, intermodal solutions become increasingly attractive. By 2050, truck-to-port, truck-to-rail and rail-to-port dwell times each decrease by 45%, and inland waterways dwell times decrease by 25%.

In terms of exogenous factors, the High Ambition scenario assumes that a low-carbon policy position is also adopted for energy supplies, reducing the trade in and consumption of petroleum- and coal-based commodities. Both scenarios assume this trade will decrease in the 2020s but the High Ambition scenario then assumes an annual decrease in demand for oil- and coal-based products from the 2030s onwards. This decrease amounts to 50% yearly in the 2040s.

The transition to cleaner vehicle fleets under the High Ambition scenario

The High Ambition policy scenario for the transition to cleaner vehicle fleets (see Table 2.8) assumes governments enact far more ambitious measures to encourage the switch to ZEVs. Innovations in biofuels and SAFs are also introduced far more rapidly, achieving a more significant market share by 2050 than under the Current Ambition. All new trains in leading markets are zero emission by 2050.

Passenger vehicle fleets in the 2020s continue to turn over in line with past trends. Unlike the Current Ambition scenario, the High Ambition scenario assumes that by 2050 almost all new passenger cars, buses and heavy-duty vehicles in the world are ZEVs. This achievement is not evenly distributed, however, with emerging regions meeting 100% ZEV sales targets 10-15 years later than high-income regions. This is an acceleration of policies that are already making a difference, even under the Current Ambition scenario.

The High Ambition scenario also assumes that ambitious policies are also extended to medium- and heavy-duty vehicles (i.e. freight fleets) and progress is somewhat faster than under the Current Ambition scenario. Under both scenarios, signatories to a global memorandum of understanding designed to encourage the shift to ZEVs in this sector achieve sales targets of 30% in the 2030s and 100% by 2040. But under the High Ambition scenario, even non-signatories have also reached the 100% sales target by 2050.

Finally, while SAFs begin to emerge in Europe and the United States in the 2020s under both scenarios, the High Ambition scenario assumes that this roll-out spreads to all other world regions in the 2030s and that alternative fuels begin to come down in price. Electric aircraft also begin to replace conventionally powered aircraft on short routes. By the 2050s, SAFs make up 85% of aviation fuels worldwide. Similarly, by 2050, 100% of shipping fuels are zero-emission.

While the advances in cleaning the road fleet represent an acceleration of existing policy pathways, the rate of acceleration for shipping and aviation fuels development and uptake in the High Ambition scenario should be considered even more ambitious relative to existing policy dialogues.

Table 2.1. The Current Ambition policy scenario specification for urban passenger demand and mode choice

2020s	2030s	2040s
Economic instruments including carbon pricing, road pricing and parking pricing are gradually set up or enhanced worldwide.	Carbon pricing is implemented, and the carbon price reaches USD 35-100 per tonne of carbon dioxide (CO_2). When implemented, road pricing can increase non-energy-related car-use costs by up to 2.5%. Parking prices are expected to increase by up to 20%.	Carbon pricing is implemented, and the carbon price reaches USD 65-200 per tonne of CO_2. When implemented, road pricing can increase non-energy-related car-use costs by up to 5%. Meanwhile, parking prices are expected to increase further, by up to 40%.
Transport infrastructure enhancements, including the expansion of bicycle and pedestrian networks, the development and expansion of public transport systems, and express lanes for buses, are set up or enhanced worldwide.	Bicycle and pedestrian infrastructure networks increase by 6-100%, while public transport systems expand by up to 34%. Meanwhile, express or priority lanes comprise up to 14% of bus networks and public transport fares decrease by 0.5-2.5%, thanks to integrated ticketing.	Bicycle and pedestrian infrastructure networks increase by 13-200%, while public transport systems expand by up to 67%. Meanwhile, express or priority lanes comprise up to 27% of bus networks and public transport fares decrease by 1-5%, thanks to integrated ticketing.
Transport service improvements, including public transport service optimisation, shared mobility incentives, carpooling policies and support for Mobility as a Service (MaaS) systems, are set up or enhanced worldwide.	Public transport service levels change by between -4% and 10%. The number of shared vehicles per capita is boosted by 0-67%. The average private vehicle occupancy rate grows by 1.1-2.8%. Meanwhile, MaaS systems decrease fares for public transport and shared mobility by 0.3-3.4%.	Public transport service levels change by between -7% and 20%. The number of shared vehicles per capita is boosted by 0-134%. The average private vehicle occupancy rate grows by 2.3-5.6%. Meanwhile, MaaS systems decrease fares for public transport and shared mobility by 0.6-6.7%.
An extensive set of regulatory measures, including speed limitations, parking restrictions, and urban vehicle-restriction schemes, are gradually enforced more strongly.	Speed limits decrease by 0.6-10%. Between 1.6 and 17% of urban surface areas are subject to parking constraints. Car ownership decreases by 5.9%.	Speed limits decrease by 1.3-20%. Between 3.3 and 34% of urban surface areas are subject to parking constraints. Car ownership decreases by 11.7%.
Additional measures, including land-use policies and transit-oriented development, are gradually improved. Exogenous changes such as teleworking are maintained after the pandemic.	The average population density ranges between -3.4% and 6.7%. There is a 1.7% increase in the land-use mix. Exogenous changes such as teleworking are maintained after the pandemic. Between 0.8% and 6.7% of the active population teleworks regularly.	The average population density ranges between -6.7% and 13.4%. There is a 3.3% increase in the land-use mix. Exogenous changes such as teleworking are maintained after the pandemic. Between 1.6% and 13.4% of the active population teleworks regularly.

Table 2.2. The High Ambition policy scenario specification for urban passenger demand and mode choice

2020s	2030s	2040s
Economic instruments including carbon pricing, road pricing and parking pricing are gradually set up or enhanced worldwide.	Carbon pricing is implemented and the carbon price reaches USD 65-150 per tonne of carbon dioxide (CO_2). Road pricing increases non-energy-related car-use costs by 0.8-9%, while parking prices increase by 6-50%.	Carbon pricing is implemented and the carbon price reaches USD 130-200 per tonne of CO_2. Road pricing increases non-energy-related car-use costs by 1.8-18%, while parking prices increase by 13-100%.
Transport infrastructure enhancements, including the expansion of bicycle and pedestrian networks, the development and expansion of public transport systems, and express lanes, are set up or enhanced worldwide.	Bike and pedestrian infrastructure networks increase by 13-167%, while public transport systems expand by up to 67%. Meanwhile, between 3% and 20% of bus networks are prioritised and public transport fares decrease by 0.5-4.2%, thanks to integrated ticketing.	Bike and pedestrian infrastructure networks increase by 26-334%, while public transport systems expand by up to 134%. Meanwhile, 6-40% of the bus networks are prioritised and public transport fares decrease by 1-8.4%, thanks to integrated ticketing.
Transport service improvements, including public transport service optimisation, shared mobility incentives, carpooling policies and support for Mobility as a Service (MaaS) systems are set up or enhanced worldwide.	Public transport service levels increase by between 3% and 17%. The number of shared vehicles per capita is boosted by 1-100%. The average private vehicle occupancy rate grows by 2.5-5.6%. Meanwhile, MaaS systems decrease fares for public transport and shared mobility by 0.6-6.7%.	Public transport service levels increase by between 6% and 34%. The number of shared vehicles per capita is boosted by 3-200%. The average private vehicle occupancy rate grows by 5.1-11.2%. Meanwhile, MaaS systems decrease fares for public transport and shared mobility by 1.3-13.4%.
An extensive set of regulatory measures, including speed limitations, parking restrictions, and urban vehicle-restriction schemes, are gradually enforced more strongly.	Speed limits decrease by 1.6-16.7%. Between 2.3% and 25% of urban surface areas are subject to parking constraints. Car ownership decreases by between 1.1% and 8.4%.	Speed limits decrease by 3.3-33.4%. Between 4.6% and 50% of urban surface areas are subject to parking constraints. Car ownership decreases by between 2.3% and 16.7%.
Additional measures, including land-use policies, transit-oriented development and teleworking-promotion policies, are gradually improved.	The average population density increases by up to 13.4%. There is a 2.5% increase in the land-use mix. Between 1.1% and 10% of the active population teleworks regularly.	The average population density increases by up to 26.7%. There is a 5% increase in the land-use mix. Between 2.3% and 20% of the active population teleworks regularly.

Table 2.3. The Current Ambition policy scenario specification for non-urban passenger demand and mode choice

2020s	2030s	2040s
	Outside of urban areas in most high-income countries, there is **investment in rail** and electrification of rail networks, leading to frequency and speed improvements. Some high-income countries make plans to develop high-speed rail connections.	Outside of urban areas in most high-income countries and some middle-income countries, there is investment in rail and electrification of rail networks, leading to frequency and speed improvements. Some high-income countries make plans to develop high-speed rail connections.
No targeted action to encourage **coaches** or **shared modes** outside of urban areas.	No targeted action to encourage coaches or shared modes outside of urban areas.	No targeted action to encourage coaches or shared modes outside of urban areas.
Carbon-pricing policies are implemented via a carbon tax of USD 15-35 per tonne of carbon dioxide (CO_2) across all regions.	Carbon pricing policies are implemented via a carbon tax of USD 35-100 per tonne of CO_2 across all regions.	Carbon pricing policies are implemented via a carbon tax of USD 65-200 per tonne of CO_2 across all regions.
Air travel ticket taxes, applied as a percentage of the airfare, ranges from 0% to 2.5% across all regions.	Air travel ticket taxes, applied as a percentage of the airfare, ranges from 1% to 7.5% across all regions.	Air travel ticket taxes, applied as a percentage of the airfare, ranges from 2% to 15% across all regions.
		In high-income regions, **a ban on short-haul flights** (i.e. for distances less than 500 kilometres) is introduced to encourage the uptake of rail where good-quality connections exist.

Table 2.4. The High Ambition policy scenario specification for non-urban passenger demand and mode choice

2020s	2030s	2040s
Outside of urban areas in most high-income countries, there is greater **investment in rail** and electrification of rail networks, leading to frequency and speed improvements.	Greater investment in rail and electrification of rail networks becomes a priority in all world regions. Rail transport becomes a more competitive alternative, with increased frequency and speed. Ambitious plans to develop high-speed rail connections in some countries.	Outside of urban areas, continued investment in rail sees a growth in viable transport links that qualify for the short-haul flight ban. Rail electrification and improvements in frequency and speed persist, and new high-speed rail connections continue to be deployed.
Incentives are introduced to encourage the use of **collective modes** such as coaches and ridesharing for regional and intercity travel.	Incentives to encourage the use of collective modes such as coaches and ridesharing remain in place for regional and intercity travel.	Incentives to encourage the use of collective modes such as coaches and ridesharing remain in place for regional and intercity travel.
Carbon-pricing policies are implemented via a carbon tax of USD 35-50 per tonne of carbon dioxide (CO_2) across all regions.	Carbon-pricing policies are implemented via a carbon tax of USD 65-150 per tonne of CO_2 across all regions.	Carbon-pricing policies are implemented via a carbon tax of USD 130-200 per tonne of CO_2 across all regions.
Air travel ticket taxes, applied as a percentage of the airfare, ranges from 0% to 5% across all regions.	Air travel ticket taxes, applied as a percentage of the airfare, ranges from 3% to 15% across all regions.	Air travel ticket taxes, applied as a percentage of the airfare, ranges from 5% to 30% across all regions.
	In high-income regions, a **ban on short-haul flights** (i.e. for distances less than 500 kilometres) is introduced to encourage the uptake of rail where good-quality connections exist.	A ban on short-haul flights is introduced for journeys shorter than 500km where an alternative rail connection of adequate quality is available. This is to encourage the uptake of rail where good-quality connections exist.

Table 2.5. The Current Ambition policy scenario specification for freight demand and mode choice

2020s	2030s	2040s
Decarbonisation measures for urban freight are slowly introduced. The uptake of pick-up and drop-off locations for parcels, and asset sharing, increase linearly. Restricted access zones also start to become more widely implemented. Meanwhile, the use of electric cargo bikes for last-mile distribution of various commodities grows exponentially.	The uptake of cargo bikes keeps growing exponentially until 2035, when this growth slows but continues to progress linearly. Restricted access zones expand at a linear rate half of what was observed in the 2020s. The use of pick-up and drop-off locations for parcels, and asset sharing, continue to increase at the same rate.	All of the developments from the 2020s and 2030s have cemented their place in the urban logistics system. All measures continue to expand their share at the same rate.
Incentives for high-capacity vehicles (road tractors) encourage a transition in interurban freight. By 2025, there is a 10% increase in the average load utilisation (load factor) of road freight.	Road tractors begin to have a larger impact, increasing the truck loads and decreasing the cost per tonne-kilometre.	Load factors continue to increase, ending up 25% higher in 2050, compared to 2019.
Distance-based charges are encouraged for road transport and introduced in policy discussions.	Distance-based charges are introduced in 2030 and begin to grow continuously.	Distance-based charges rise further in the 2040s.
Slow and smart steaming are incentivised in the shipping sector to reduce emissions.	Vessel speed reductions lead to a 5% improvement in efficiency.	Vessel speed reductions lead to a 10% improvement in efficiency compared to the baseline (2019).
Digital transformation strategies leveraging near-real-time data are used to reduce intermodal dwell times in journeys with sections undertaken by rail or on waterways.	Improvements in travel times make intermodal solutions more attractive but do not improve to the same extent as under the High Ambition scenario.	Travel times for intermodal solutions continue to reduce at a slower rate than under the High Ambition scenario.
Transport network improvement plans for rail, waterways and port infrastructure begin to be phased in and funded.		
	Carbon pricing is introduced but with prices set at varying levels in different regions.	Carbon pricing continues to vary by region, and between sea-based transport modes and other modes. The price of carbon ranges between USD 150-250 per tonne of carbon dioxide (CO_2).
The **trade in and consumption of petroleum- and coal-based commodities begins to decrease**, directly impacting freight transport demand for fossil fuels and the freight activity associated with the trade of these commodities.	While the trade in other commodities continues to increase, the trade in oil and coal grows to a lesser extent.	While the trade in other commodities continues to increase, the trade in oil and coal grows to a lesser extent.

Table 2.6. The High Ambition policy scenario specification for freight demand and mode choice

2020s	2030s	2040s
Sustainable urban logistics measures are implemented more widely than under the Current Ambition scenario. Cargo bikes and asset-sharing double the growth observed in the Current Ambition scenario. The use of pick-up and drop-off locations for parcels is 60% higher than in the Current Ambition scenario. Restricted access zones are stricter, increasing by a factor of three the likelihood that electric vehicles are used to transport goods in cities.		
Incentives for high-capacity vehicles (road tractors) encourage a transition in interurban freight. By 2025, there is a 10% increase in the average load utilisation (load factor) of road freight.	Road tractors begin to have a larger impact, increasing the truck loads and decreasing the cost per tonne-kilometre.	Load factors continue to increase, ending up 25% higher in 2050, compared to 2019.
Distance-based charges are encouraged for road transport and introduced in policy discussions.	Distance-based charges are introduced in 2030 and begin to grow continuously.	Distance-based charges rise further in the 2040s.
Slow and smart steaming are incentivised in the shipping sector to reduce emissions.	Vessel speed reductions lead to an average 10% improvement in efficiency which reduces dwell times and environmental impacts.	Vessel speed reductions lead to a 25% improvement in efficiency compared to the baseline (2019).
By 2025, **digital transformation strategies** leveraging near-real time data cause truck-to-port and truck-to-rail dwell times to decrease by 20%. Meanwhile, rail-to-port dwell times decrease by 15% by 2025. Inland waterways dwell times decrease by 5%.	Reductions in dwell times across road, rail and inland waterways result in a reduction in travel times associated with intermodal trips, making intermodal solutions more attractive. The improvements continue to increase.	Travel times for intermodal solutions continue to reduce. Truck-to-port and truck-to-rail dwell times decrease by 45% by 2050. Rail-to-port dwell times decrease by 45% by 2050. Inland waterways dwell times decrease by 25%.
The acceleration and expansion of investments in **transport network improvement plans** is greater than under the Current Ambition scenario.		
	Carbon pricing is introduced but with prices set at varying levels in different regions.	Carbon pricing continues to vary by region but at higher values than under the Current Ambition scenario. The price of carbon ranges between USD 300-500 per tonne of carbon dioxide (CO_2).
The **trade in and consumption of petroleum- and coal-based commodities begins to decrease**, directly impacting freight transport demand for fossil fuels and the freight activity associated with the trade of these commodities.	While the trade in other commodities continues to increase, there is a yearly decrease in demand for coal and petroleum.	There is a 50% yearly decrease in demand for coal and petroleum.

Table 2.7. The Current Ambition policy scenario specification for the transition to cleaner vehicle fleets

2020s	2030s	2040s
The **turnover of vehicle fleets** continues in line with historical trends. New vehicle efficiency improvements continue, driven by existing fuel economy standards and in line with historical trends.	Mandatory and aspirational zero-emission vehicle (ZEV) sales targets are met. European Union member states and signatories to the COP26 Accelerating to Zero Coalition declaration reach 100% ZEV sales by 2035.	Mandatory and aspirational ZEV sales targets are met in countries and regions with stated targets.
	Signatories to the **Global Memorandum of Understanding (MOU) on Zero-Emission Medium- and Heavy-Duty Vehicles** reach the target of 30% ZEV sales for heavy-goods vehicles (HGVs) in 2030.	Signatories to the Global MOU on Zero-Emission Medium- and Heavy-Duty Vehicles reach the target of 100% ZEV sales for HGVs in 2040.
Biofuel blending targets for road fuels are met in countries with defined targets, including Finland, India, Indonesia and the United Kingdom.	Biofuel blending targets for road fuels are met in countries with defined targets, including Argentina, Finland, India, Indonesia and the United Kingdom.	
Sustainable aviation fuel (SAF) mandates are introduced in the EU and the United States according to the ambitions set out in the ReFuel EU and SAF Grand Challenge initiatives, respectively (see note).	Mandates for SAFs increase in Europe and the United States.	By 2050, SAFs make up 85% of aviation fuels in Europe and 100% in the United States.

Note: The carbon intensity of fuels is estimated according to Yoo, Lee and Wang (2022[7]) and Ueckert et al. (2021[8]).

Table 2.8. The High Ambition policy scenario specification for the transition to cleaner vehicle fleets

2020s	2030s	2040s
The **turnover of vehicle fleets** continues in line with historical trends and to meet travel demand. New vehicle efficiency improvements for road vehicles double from historical trends, driven by more stringent fuel economy standards. Meanwhile, aviation efficiency improvements increase to 3% per year.	By 2035, 100% of sales of new passenger vehicles and vans in East and Northeast Asia (ENEA), Europe, and in the United States, Canada, Australia and New Zealand (UCAN) are zero-emission vehicles (ZEVs). This is in line with the Global Fuel Economy Initiative (GFEI) ZERO Pathway. By 2030, 100% of new bus sales in high-income regions (ENEA, Europe and UCAN) are ZEVs. Meanwhile, by 2035, 100% of new two- and three-wheelers in all regions are ZEVs.	By mid-decade, 100% of sales of new passenger vehicles and vans in emerging markets are ZEVs, in line with the GFEI's ZERO Pathway. By 2040, 100% of new bus sales in the remaining markets are ZEVs. Also by 2040, 100% of sales of new heavy-duty vehicles in high-income regions are ZEVs. Meanwhile, emerging markets will reach this 100% target by the end of the decade.
	Signatories to the **Global Memorandum of Understanding (MOU) on Zero-Emission Medium- and Heavy-Duty Vehicles** reach the target of 30% ZEV sales for heavy-goods vehicles (HGVs) in 2030.	Signatories to the Global MOU on Zero-Emission Medium- and Heavy-Duty Vehicles reach the target of 100% ZEV sales for HGVs in 2040. Non-signatories reach the target of 30% of ZEV sales for HGVs in 2040 and 100% in 2050.
		By 2040, all **new trains** in high-income regions (UCAN, ENEA, and Europe) are zero-emission. The remaining markets reach this target by 2050.
Sustainable aviation fuel (SAF) mandates are introduced in the EU and the United States according to the ambitions set out in the ReFuel EU and SAF Grand Challenge initiatives, respectively (see note).	The roll-out of SAF mandates continues and alternatives to conventional fuels begin to come down in price. SAF mandates also expand to other regions. Aircraft with electric powertrains become available and begin to take share for short-haul flights with low passenger capacities.	Commercial applications of electric aircraft emerge in niche sectors. SAFs make up 85% of aviation fuels globally by 2050 (see note).
	Initial deployment of **zero-emission shipping fuels** occurs in green corridors.	By 2050, zero-emission fuels make up 100% of shipping fuels. Also by 2050, the electrification of short sea shipping routes occurs (see note).

Note: The carbon intensity and lifecycle emissions of biogenic and synthetic pathways are estimated according to Yoo, Lee and Wang (2022[7]) and Ueckert et al. (2021[8]). The electrification of short-sea shipping is in line with Kersey et al. (2022[9]).

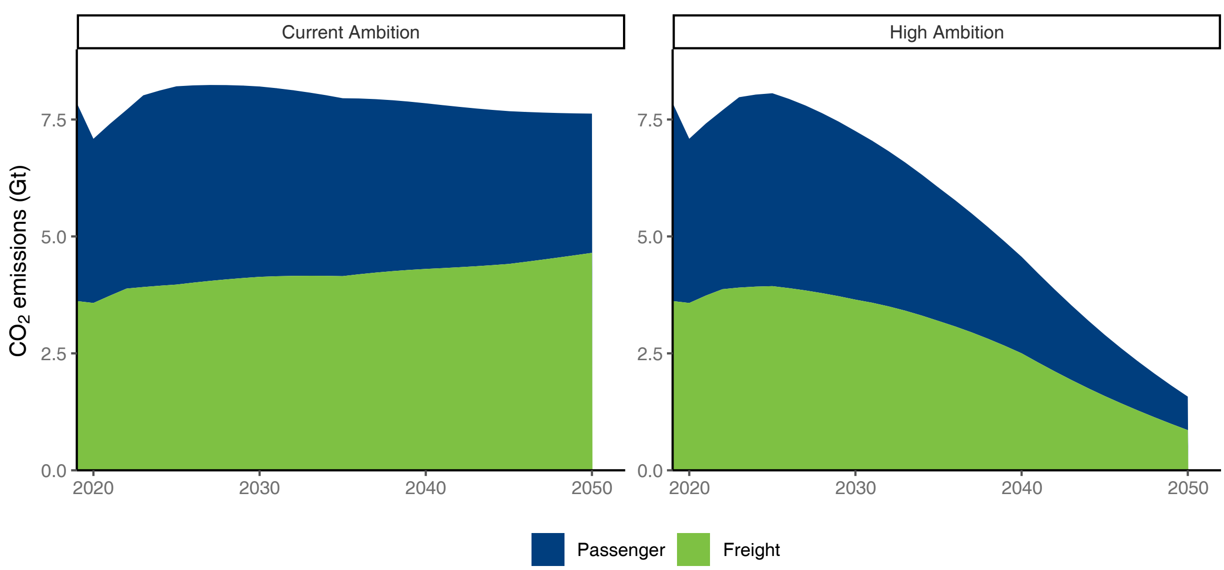
Breaking the link: Increased activity with fewer emissions?

The transport sector will continue to contribute significantly to the world's CO_2 emissions without decisive action to decarbonise. Achieving decarbonisation in the sector will require international co-operation and increased ambition on the part of policy makers. It will also require cross-sector collaboration to shift away from its dependence on fossil fuels. Chapters 3-6 of this edition of the *ITF Transport Outlook* present the policy pathways that will be needed to transition to greener, cleaner and more resilient transport systems.

This section presents the projected passenger and freight emissions for both the Current and High Ambition scenarios. It outlines the main trends in demand and emissions from both the passenger and freight sectors. It also examines regional trends, as well as differences in demand and emissions in different settings, or activity types. These are defined based on their potential applicability for different policy measures.

Emissions are nearly evenly split between passenger (54%) and freight (46%) in 2019, although the two sectors decarbonise at different rates over time (see Figure 2.1), with passenger activity already decarbonising under the Current Ambition scenario. By 2030, the two sectors contribute equally to transport's CO_2 emissions. By 2050, under the Current Ambition scenario, freight emissions are higher than they were in 2019, reaching a 61% share, while passenger have achieved some decarbonisation. Under the High Ambition scenario, by 2050 total emissions are only 20% of what they were in 2019, although freight emissions still account for a larger share than passenger emissions.

Figure 2.1. Passenger and freight emissions under the Current and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

StatLink https://stat.link/mi14kn

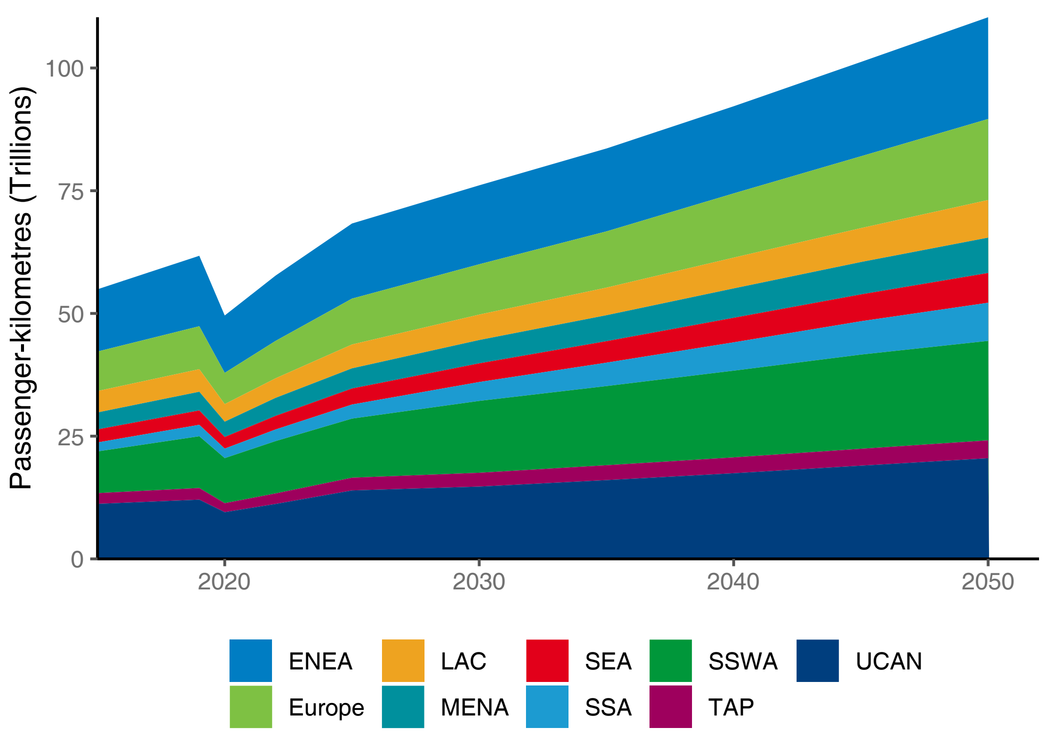
Passenger demand will continue to grow

Demand is set to keep growing, for both passenger and freight transport, increasing the challenge for strategies aimed at CO_2 mitigation. Passenger transport demand will increase by 79% by 2050 compared to 2019, under the Current Ambition scenario (see Figure 2.2) and by 65% under the High Ambition scenarios. Global passenger-kilometres will increase under the Current Ambition scenario from around 61 trillion in 2019 to about 110 trillion in 2050. Under the High Ambition scenario, global passenger-kilometres in 2050 will be lower than under the Current Ambition scenario, at approximately 102 trillion.

Emerging economies will see the greatest growth in passenger demand over the coming three decades. By 2050, passenger transport demand in Sub-Saharan Africa (SSA) will more than triple compared to 2019. Demand will also more than double in Southeast Asia (SEA). Meanwhile, passenger demand will grow by 89% in the Middle East and Northern Africa (MENA), 92% in South and Southwest Asia (SSWA), 67% in Latin America and the Caribbean (LAC) and 54% in Transition economies and other Asia-Pacific (TAP) countries.

Among high-income economies, Europe has the highest growth (89%), followed by the United States, Canada, Australia and New Zealand (grouped in this report as the UCAN countries) with 70%. East and Northeast Asia (ENEA) and Europe will have the lowest growth of all regions, increasing by 44% under the Current Ambition scenario.

Figure 2.2. Passenger transport demand by region under the Current Ambition scenario, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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Table 2.9 Share of passenger transport demand by activity type, 2050, Current Ambition and High Ambition scenarios

	2019	2050	
Activity type	Baseline	Current Ambition scenario	High Ambition scenario
International and Intercity	29%	44%	44%
Regional	35%	21%	22%
Urban	36%	35%	34%

Note: Table depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

Between 2019 and 2020, global passenger-kilometres decreased by 20% due to the Covid-19 pandemic. The pandemic hit non-urban travel especially hard, with demand decreasing by 24% between 2019 and 2020, compared to a decrease of about 13% in urban settings.

However, the post-pandemic recovery period has seen passenger-kilometres increase by around 8% year-on-year in 2021 and 2022. In 2019, the largest segment of passenger activity was urban travel (36%) very closely followed by regional travel (35%). However, over time, international and intercity travel grows rapidly to reach 44% of passenger activity by 2050 under both policy scenarios (see Table 2.9).

Passenger emissions will not grow at the same pace as demand

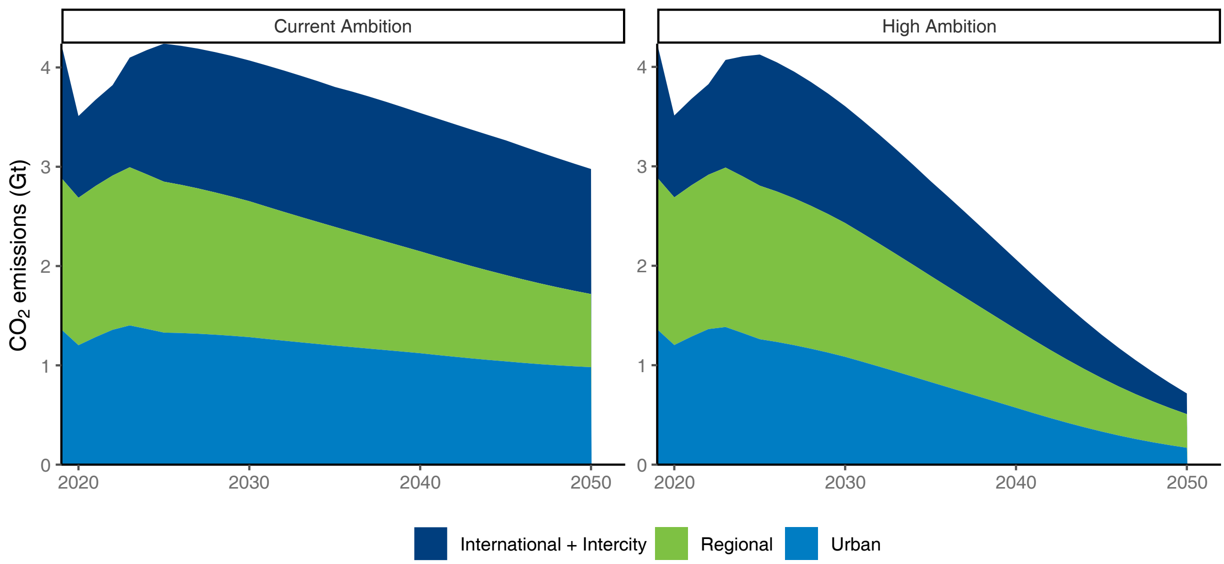
Passenger transport carbon intensity will decrease over the coming years, even if transport policy stays on its current path, but this is not enough. While increased recognition of decarbonising transport in national and regional policies have some effect under the Current Ambition scenario, emissions due to passenger activity will fall by 30%.

Urban transport activity accounts for roughly one-third of emissions due to passenger travel, varying by year and scenario (see Figure 2.3). Under the High Ambition scenario, emissions fall by 1 190 trillion tonnes of CO_2 between 2019 and 2050, compared to a drop of only 379 trillion tonnes of CO_2 under the Current Ambition scenario. Non-urban passenger emissions will reduce in both scenarios, driven by a decrease in emissions in regional trips in high-income countries.

Emissions due to regional travel account for the highest share of emissions (36%) for a single segment in 2019. This share falls to 25% under the Current Ambition scenario, as regional demand falls and international and intercity activity increases. However, under the High Ambition scenario, the urban and international and intercity segments decarbonise faster and regional travel ends up with the highest share of emissions in 2050.

Emissions from international and intercity travel reduce by 7% between 2019 and 2050 under the Current Ambition scenario. This reduction occurs in the context of demand nearly tripling, meaning that even on the current policy pathway, the carbon intensity of these trips is reducing. By contrast, under the High Ambition scenario, emissions due to these trips could reduce by 85% while demand still grows by a factor of 2.5.

Figure 2.3. Total passenger transport emissions, 2019-50, under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. International+Intercity: travel across national borders; Regional: non-urban travel within national borders.

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Freight demand increases with economic growth

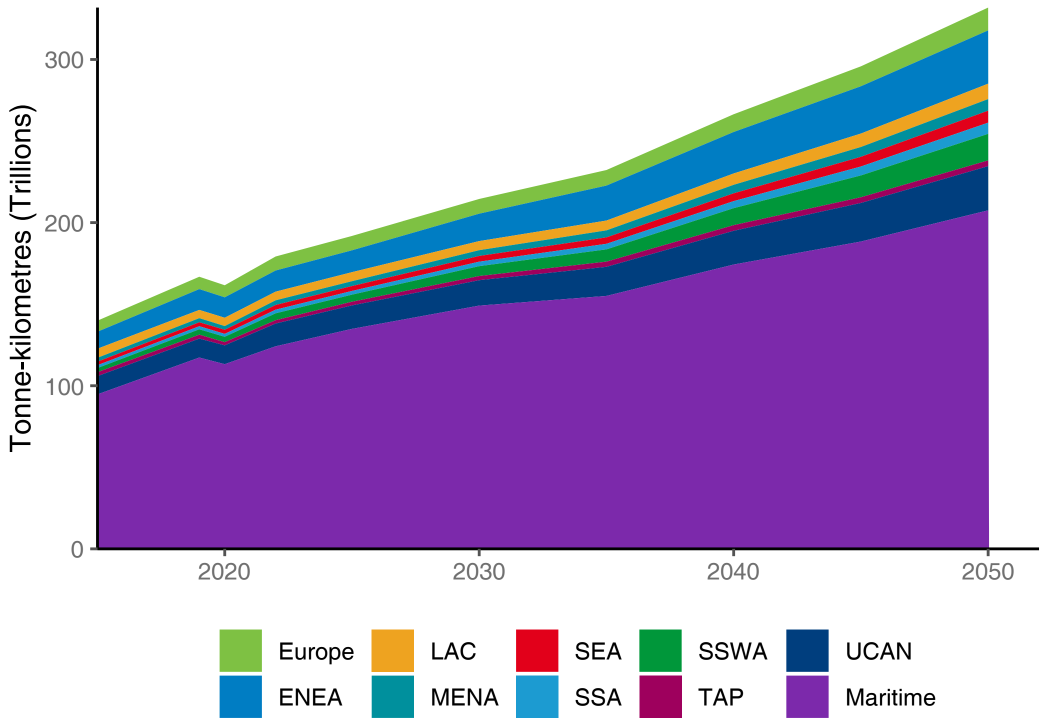
Freight activity also grows in every region under the Current Ambition scenario, with worldwide tonne-kilometres nearly doubling between 2019 and 2050 (see Figure 2.4). Under the High Ambition scenario, demand grows by 59% globally over the same period. The reduction in tonne-kilometres is not entirely linked to the transport policies in the High Ambition scenario, with changes in trade and the commodities being transported around the world also having an impact.

Demand grows most strongly in emerging regions, where the greatest economic growth is expected over the next three decades. Demand more than triples under both policy scenarios between 2019 and 2050 in Southeast Asia (SEA) and Sub-Saharan Africa (SSA), and grows by a factor of 4.9 in South and Southwest Asia (SSWA) over that time.

In East and Northeast Asia (ENEA) and the Middle East and North Africa (MENA), freight activity will also more than double under both scenarios through to 2050. The United States, Canada, Australia and New Zealand (grouped in this report as the UCAN countries), and Europe both see increased activity, although it grows at a more sedate pace.

The Transition economies and other Asia-Pacific (TAP) countries will see the lowest growth in tonne-kilometres under both scenarios, increasing by 47% under the Current Ambition scenario and by 34% under the High Ambition scenario.

Figure 2.4. Freight activity by region under the Current Ambition scenario, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) refers to one of the two policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand. Maritime: International waters and inland waterways.

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The majority of global freight is carried by sea (see Table 2.10). This will remain the case over time and under both scenarios. Road modes account for 22% of the mode share in 2019, growing to 27% in 2050 under the Current Ambition scenario and 31% under the High Ambition scenario (although tonne-kilometres are lower under the latter).

Table 2.10. Shares of tonne-kilometres by transport mode in 2050 under the Current Ambition and High Ambition scenarios

	2019	2050	
Vehicle type	Baseline	Current Ambition scenario	High Ambition scenario
Aircraft	Less than 1%	Less than 1%	Less than 1%
Ships	70%	62.5%	56.0%
Rail	7%	10%	13%
Road	22%	27%	31%
Non-motorised	Less than 1%	Less than 1%	Less than 1%

Note: Table depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

Road modes also grow at a greater rate than maritime, with tonne-kilometres carried by road more than doubling between 2019 and 2050, under both scenarios. Among the main modes – road, rail, air and maritime – rail grows most strongly over the three decades. Tonne-kilometres carried by rail in 2050 are roughly 2.7 times the amount in 2019, under both scenarios.

Given their much lower starting points (so small they are not visible at the global scale), non-motorised modes are the fastest-growing mode. Non-motorised urban freight solutions are projected to carry 8.9 times as much in 2050 compared to 2019 under the Current Ambition scenario, and 20.5 times as much under the High Ambition scenario.

Freight emissions will grow, particularly in urban areas

International freight activity dominates freight emissions, but domestic and urban freight are growing faster (see Table 2.11). Non-urban freight accounts for both domestic and international freight flows, while urban freight accounts for freight activity within urban areas.

International freight activity accounts for 42% of total freight emissions, and nearly three-quarters of total freight tonne-kilometres. Domestic activity accounts for 35% of emissions and 21% of tonne-kilometres. Finally, urban freight accounts for 28% of emissions and only 5% of tonne-kilometres. Under the Current Ambition scenario in 2050, urban freight emissions grow significantly (a 37% increase) as cities grow in emerging economies.

Under the High ambition Scenario, international freight activity will account for the lowest share of freight emissions, domestic the highest, followed by urban. This is a result of decarbonisation efforts and changes in trade flows (see Chapter 3).

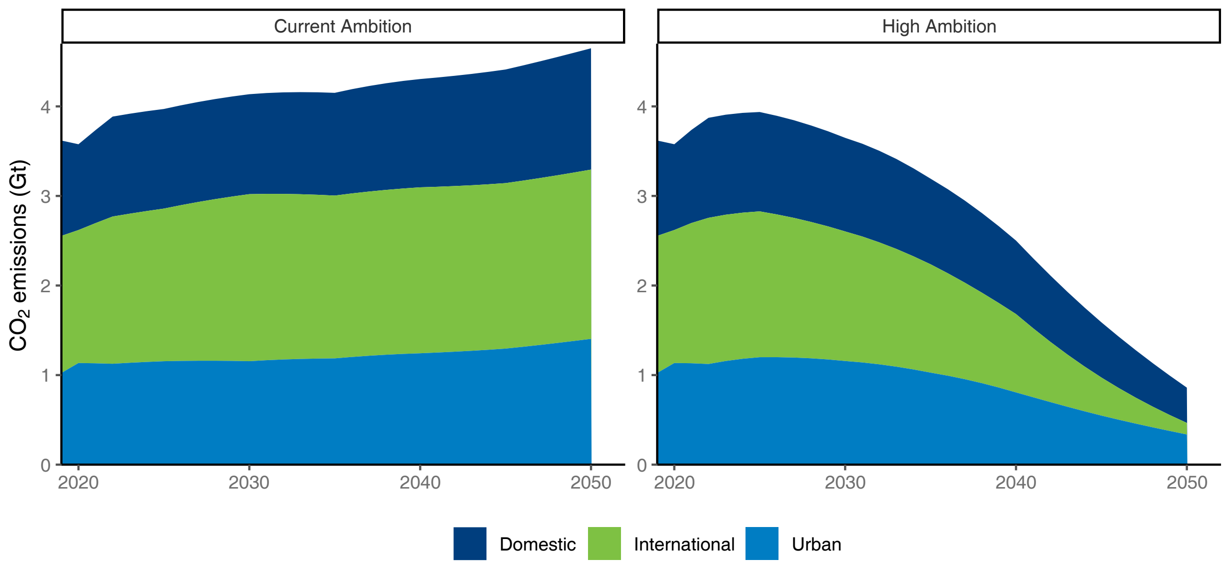
By 2050, total freight emissions are expected to grow by 28% in the Current Ambition scenario, compared to a 76% decrease in the High Ambition scenario (see Figure 2.5). International freight emissions are expected to decrease by 92% under the High Ambition scenario, the most significant decrease of the three activity types. Domestic freight emissions are expected to decrease by 63%, and urban emissions by 67%.

Table 2.11. Share of freight emission by activity type, 2050, Current Ambition and High Ambition scenarios

	2019	2050	
Activity type	**Baseline**	**Current Ambition scenario**	**High Ambition scenario**
International	42%	41%	15%
Domestic	29%	29%	46%
Urban	28%	30%	39%

Note: Table depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. International: between national borders; Domestic: non-urban, within national borders.

Figure 2.5. Total emissions in freight transport by activity type, 2019-50, Current Ambition versus High Ambition scenario



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. International: between national borders; Domestic: non-urban, within national borders.

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Key takeaways

- Transport is central to economic development and social opportunity, but it also contributes significantly to the world's CO_2 emissions.
- This report models two scenarios for the future transport demand and CO_2 emissions to 2050, one informed by announced or existing policies (Current Ambition scenario), the other assuming more ambitious decarbonisation measures (High Ambition scenario).
- Overall, the scenarios show that current policies will begin make a difference over time at a global level, with transport CO_2 emissions falling slightly by 2050.
- However, continuing on the current path will not make enough of a difference for the transport sector's CO_2 emissions to deliver against the Paris Agreement goals.
- The urgent need to break the link between transport activities and emissions requires increased ambition and more international co-operation.

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3 Managing transport demand: Offering attractive choices

This chapter analyses the drivers of transport demand. It explores the role policy levers aimed at managing demand ("Avoid" measures) and encouraging the shift to sustainable modes ("Shift" measures) could play in a low-carbon transport future. Specific sections analyse measures targeted at urban transport, regional travel, international and intercity travel, and non-urban freight movements.

In Brief

A mix of policies is needed to promote sustainable choices in different contexts

Demand for passenger and freight transport will continue to grow in the coming decades across all world regions, regardless of the scenario. Without appropriate policies, unmanaged growth could result in increased urban sprawl, longer average trip distances and a lack of any meaningful emission reductions.

International and intercity passenger travel will grow fastest under both scenarios, more than doubling between 2019 and 2050. Urban transport demand will also grow considerably: by 74% under the Current Ambition scenario and 54% under the High Ambition scenario. Meanwhile, regional travel will increase by only 5% Freight demand will also grow in both policy scenarios, with international movements accounting for the greatest share of activity, measured in tonne-kilometres.

A mix of policies increasing the efficiency of the transport system and of individual trips could significantly change how people move in cities. Denser and more compact urban areas increase the travel options available to users, putting public transport and essential services within reach. The total distance travelled in cities could fall without significantly reducing the number of trips people actually make.

Yet this will require integrating land-use and transport planning to avoid urban sprawl and expand access to sustainable modes. Public transport will be at the heart of these future urban transport systems. More flexible on-demand services such as ride-hailing and shared vehicles can complement public transport; adding them reduces private motorised vehicle use more than investing in public transport alone.

Authorities should combine policies to discourage private motorised vehicles with investment in multimodal transport. These investments should strengthen links between public transport, shared mobility and active mobility. With such policies, walking, cycling and public transport use could grow in every world region. Outside urban areas, opportunities to shift passenger demand to more sustainable modes are heavily influenced by trip length.

For freight transport, authorities and operators can work together to avoid unnecessary freight movements within and outside cities. High-capacity vehicles, intelligent transport systems and asset sharing can make freight transport operations more efficient and contribute to limiting the growth of freight vehicle-kilometres to 2050.

Urban deliveries are comparatively easy to decarbonise. Shifting deliveries to non-motorised modes (e.g. cargo-bikes) or more efficient vehicles will reduced motorised vehicle-kilometres. Introducing parcel pick-up points will limit delivery movements in cities. Shifting goods to sustainable modes is more challenging for longer-distance freight. Coherent approaches to pricing can encourage efficiencies and increase the use of railways and waterways for multimodal delivery journeys.

Policy recommendations

- Take a long-term view of urban development and adopt integrated approaches to transport and land-use planning to avoid future sprawl in growing cities.
- Adopt holistic sustainable urban transport plans that combine investment, pricing and access or space restrictions to encourage sustainable choices.
- Support multimodal and sustainable transport networks.
- Combine pricing measures in a coherent manner and allocate funds to sustainable modes.

Developments in transport systems and accompanying infrastructure will shape cities and communities for years to come, for better or worse. Regardless of the policy scenario, global passenger and freight transport demand will continue growing in the coming decades. This growth reflects changes in economies and populations, partly resulting from ambitions to increase freight and passenger connectivity.

On the passenger side, if authorities do not consider the long-term need for low-carbon transport at the design stages, urban areas and communities will suffer from baked-in car dependency. On the freight side, if the world sticks with its current policy pathway, the emissions associated with freight activities will also continue to grow.

This chapter analyses the drivers of transport demand. Using the popular "Avoid, Shift, Improve" paradigm, it explores the role policy levers aimed at demand management ("Avoid" measures) and mode shift ("Shift" measures) could play in a low-carbon transport scenario. For an analysis of "Improve" measures to reduce transport emissions, see Chapter 4.

Policy interventions: Tailoring measures to the appropriate activity type

The in-house ITF models produce projections for global passenger and freight transport demand over time, under given policy scenarios. According to the modelled outputs for the Current Ambition and High Ambition scenarios considered in this Outlook, passenger and freight transport demand will rise under both policy scenarios (see Chapter 2 for full descriptions).

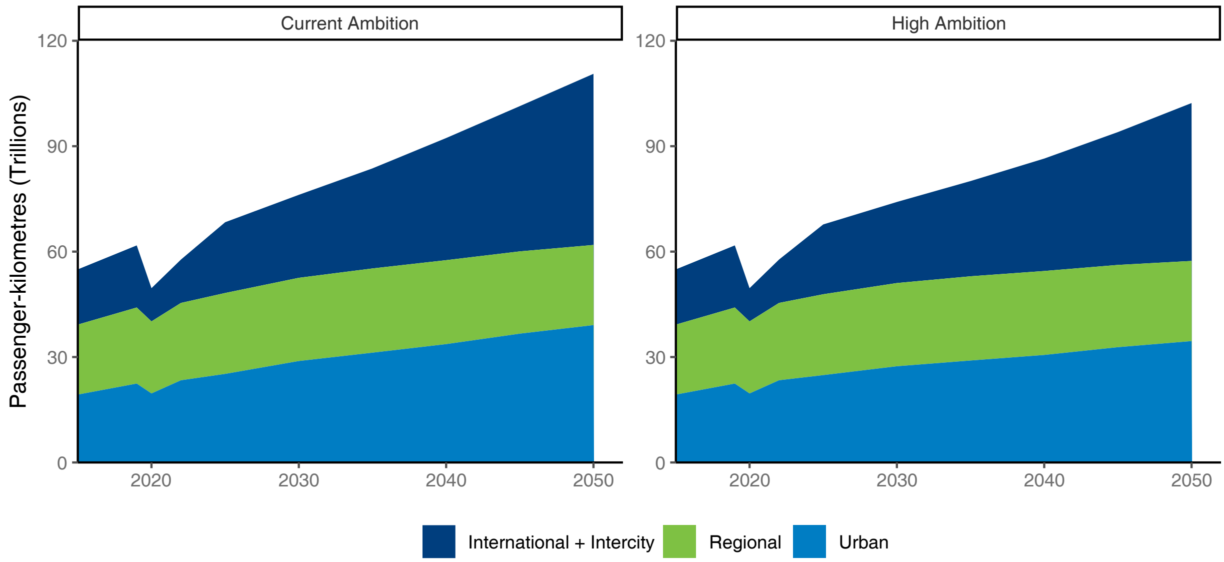
The demand for passenger transport is grouped into three types of activity: urban (activity within urban areas), regional (domestic travel outside of urban areas), and international and intercity (travelling between two cities, or across international borders).

Urban passenger transport demand will increase under both the Current Ambition and High Ambition policy scenarios explored in this edition of the Outlook (see Figure 3.1). Under the Current Ambition scenario, urban passenger-kilometres grow by 74% between 2019 and 2050. Under the High Ambition scenario, they grow by 54% over the same period. Urban passenger trips are typically shorter than the other activity types and take place in higher-density regions. There are more policy measures to tackle demand management and mode shift available in urban settings when it comes to decarbonising transport. However, urban transport currently only accounts for 36% of transport demand worldwide.

Regional transport grows by only 5% under both scenarios. Regional travel currently accounts for about 35% of transport demand worldwide. However, as it does not grow by much, its share of passenger-kilometres will shrink over time. International and intercity travel accounts for the smallest share of passenger-kilometres in 2019 (at 29%). But it is also the activity type that grows fastest over the coming years and will account for 44% of passenger-kilometres by 2050, under both scenarios.

The trips taking place under the international and intercity activity types are typically much longer on average, and the trip patterns are more dispersed, especially in the case of regional travel. Because of the nature of regional, and intercity and international travel, there are typically fewer well-established policy levers for demand management and mode shift available.

Figure 3.1. Passenger-kilometres grouped by activity type under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two scenarios modelled, which represent two levels of ambition for decarbonising transport. International+Intercity: travel across national borders; Regional: non-urban travel within national borders.

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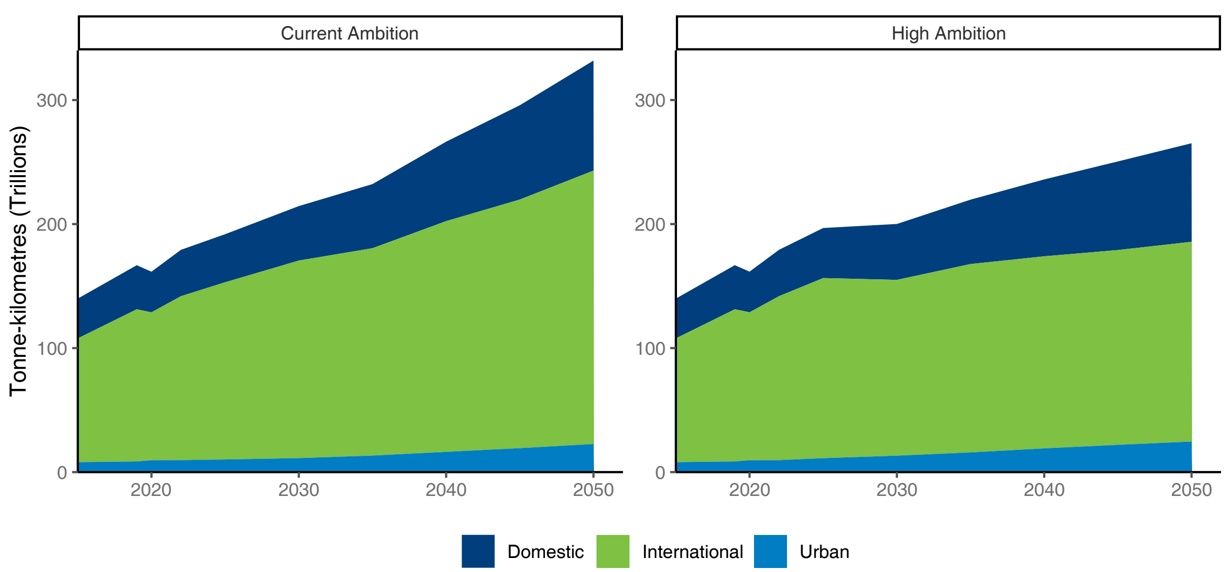
Figure 3.2. Tonne-kilometres grouped by activity type under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two scenarios modelled, which represent two levels of ambition for decarbonising transport. International: between national borders; Domestic: non-urban, within national borders.

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For freight, the vast majority of activity takes place outside of urban areas, both in 2019 and by 2050 and under both scenarios (see Figure 3.2). As with passenger activity, the mode-shift and demand-management tools available at the urban level are harder to deploy outside of urban settings. For non-urban freight (both domestic and international), measures to shorten supply chains (and therefore reduce tonne-kilometres) go beyond just transport policy as they are driven by trade regionalisation. Under both scenarios, international freight accounts for the largest share of transport demand, meaning that regulation and enforcement for many measures will require multilateral co-operation.

Urban transport: Making sustainability the most attractive option

Many regions will see their urban areas grow in the coming years as the world urbanises and populations increase. Authorities should act now to prevent those cities from sprawling and becoming car-dependent. In more developed cities, authorities need to revise the traditional planning hierarchies that saw streets and urban environments designed for motorised vehicles at the expense of residents and more sustainable modes.

A strategic and integrated approach to transport and land-use planning will be needed to support sustainable transport decisions in the future. While many different policy approaches exist, a combination of measures will likely be most successful. Demand-management and mode-shift policies are very effective in urban contexts, for both passenger and freight transport. They also have a vital role in urban liveability (see Chapter 5).

As urban populations grow, so does the risk of urban sprawl

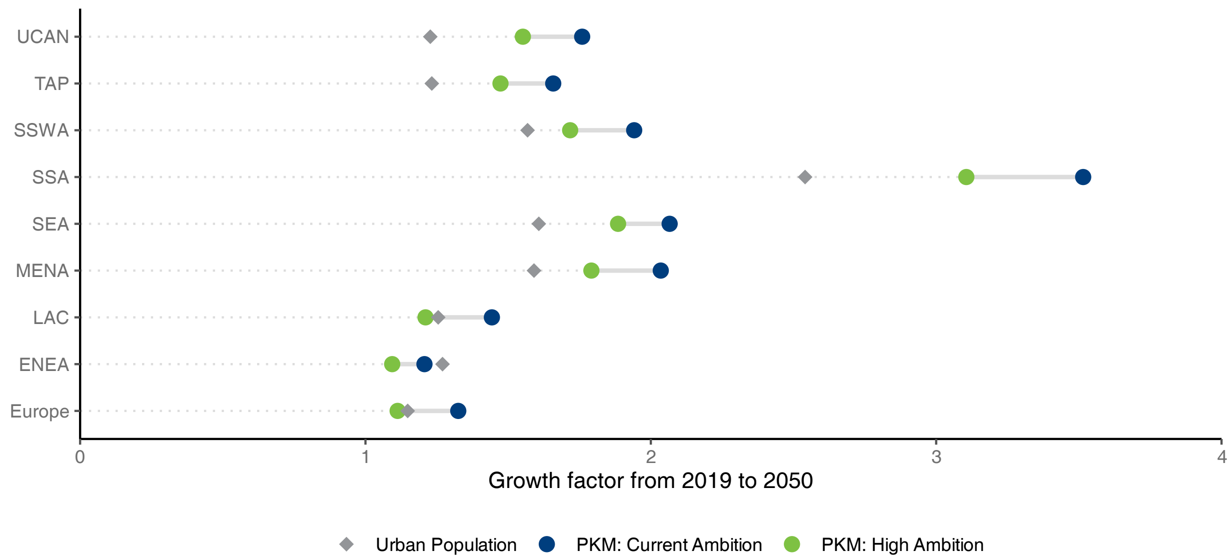
Passenger transport demand will continue to increase in all world regions, regardless of the policy scenario. Urban passenger demand will substantially rise in the coming years, especially in lower-middle-income and low-income regions. Fast-paced urbanisation will increase the share of urban residents in upper-middle-income and lower-middle-income regions. However, the most significant increases will occur in Sub-Saharan Africa (SSA), a low-income region where the number of urban inhabitants will more than double by 2050 compared to 2019 levels (SWAC, 2020[1]).

Furthermore, per-capita gross domestic product (GDP) in SSA will almost double, and more than double for East and Northeast Asia (ENEA) and Southeast Asia (SEA), between 2019 and 2050. Based on OECD-ENV and UN DESA data, in South and Southwest Asia (SSWA), GDP per capita will roughly triple over the same period (OECD, n.d.[2]; UNDESA, 2022[3]). This economic growth will bridge part of the income gap between city inhabitants in these regions and inhabitants in developed regions such as Europe, and the United States, Canada, Australia and New Zealand (grouped in this report as the UCAN region).

But it will also heighten the risk of increased private motorised vehicle use (especially cars and motorcycles). A recent World Bank analysis found that an income increase of 10% in 18 non-OECD countries directly correlated with a 17% increase in overall transport consumption. Tellingly, while the rise in public transport use in these countries was a relatively modest 10%, the use of private vehicles increased by 20% (Lebrand and Theophile, 2022[4]).

Urban passenger activity will accelerate faster than urban population growth in most world regions (see Figure 3.3). In the high-income regions of Europe and ENEA, and the upper-middle-income region of LAC, demand grows roughly in line with, or slower than, population growth under the High Ambition scenario. For ENEA, urban population growth outstrips passenger demand growth under both scenarios. UCAN bucks the trend for the high-income regions, with passenger-kilometres growing faster than population growth under both scenarios. The emerging economies also see their passenger-kilometres grow faster than their urban population. However, in all cases, the policies under the High Ambition scenario result in lower passenger-kilometre growth.

Figure 3.3. Urban population and passenger-kilometre growth under the Current Ambition and High Ambition scenarios



Note: PKM: passenger-kilometres. Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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As urban populations grow, the risks of urban sprawl and car dependency increase. Urban areas at risk of sprawl are those where 1) the cost of car use is low, 2) the cost of land is lower in periphery areas than in urban centres, and 3) fiscal systems result in net benefits from outward expansion (OECD, 2017[5]). As a result of these settlement patterns, which tend to be more pronounced in the UCAN region, urban areas tend to be continuous (i.e. conurbations), with less discernible boundaries between the peripheries of neighbouring cities, leading to higher car dependency (Mattioli et al., 2022[6]).

The risk of urban sprawl in fast-growing urban areas is even higher in emerging regions. According to previous analysis, doubling a developing city's population leads to a tripling of its surface area (Angel et al., 2010[7]). Similarly, the modelling for this Outlook suggests that peripheral areas of cities in SEA and SSA with less than one million inhabitants in 2019 will grow to around three times their current size by 2050. One cause of sprawl in these developing regions is the movement of new and existing urban dwellers towards urban peripheries. Private vehicles can be one of the only options for residents in these areas – apart from informal, paratransit services – seeking to access opportunities in central areas (Yiran et al., 2020[8]).

Mitigating the risk of urban sprawl requires strategic planning to manage urban passenger demand and encourage more sustainable mobility behaviour (ITF, 2021[9]). The modelling for this edition of the Outlook highlights the positive impacts that better land-use and transport planning can have on the sustainability of urban settlements. Unlike the Current Ambition scenario, the High Ambition scenario includes transport and land-use planning measures that promote more compact, mixed-use and denser environments. By 2050, under the High Ambition scenario, increases in urban densities will reduce the growth of the physical expansion of city areas.

Table 3.1. Changes in passenger-kilometres in 2050 under the High Ambition scenario compared to the Current Ambition scenario

Region	Difference in PKM per trip under High Ambition scenario in 2050 compared to Current Ambition scenario (%)	Difference in trips per-capita under High Ambition scenario in 2050 compared to Current Ambition scenario (%)
East and Northeast Asia	-8	-1
Europe	-14	-3
Latin America and the Caribbean	-15	-1
Middle East and North Africa	-11	-1
South and Southwest Asia	-8	-1
Southeast Asia	-11	-1
Sub-Saharan Africa	-10	-1
Transition and other Asia-Pacific	-11	-1
UCAN	-8	-4

Note: Table depicts ITF modelled estimates. PKM: Passenger-kilometres. UCAN: United States, Canada, Australia and New Zealand.

The approach to urban planning and transport system design assumed in the High Ambition scenario can also decrease transport demand without hampering activity to the same extent, especially in developing contexts. The High Ambition scenario includes transport and land-use planning measures that promote more compact, mixed and dense environments. Under this scenario, trips are shorter than under the Current Ambition scenario, as cities are more compact.

The High Ambition scenario results in a reduction in the average passenger-kilometres per trip in all world regions by 2050 (see Table 3.1), most noticeably in LAC (-15%) and Europe (-14%). By contrast, the average trips per capita reduce significantly less under the High Ambition scenario in 2050. For all regions except Europe (-3%) and UCAN (-4%), the reduction in trips per capita is only around 1%. This decrease is most likely due to the greater prevalence of teleworking in those regions. Despite this, UCAN also has one of the lowest reduction in trip lengths between the two scenarios (-8%), reflecting the already established footprints of cities and the difficulty of implementing compact design policies in these contexts.

Integrated transport and land-use planning make sustainable modes more viable

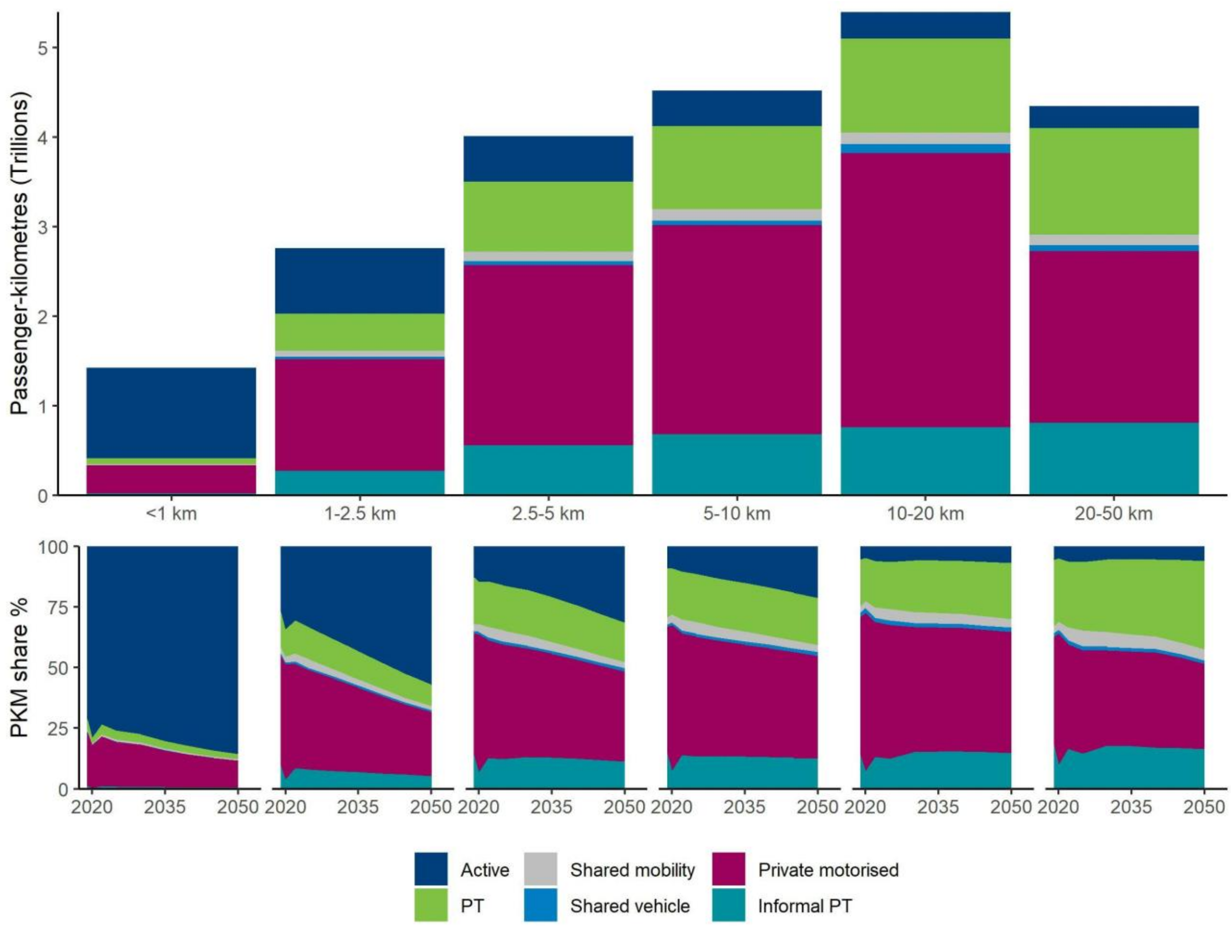
Authorities, particularly in cities in developing regions, can use densification policies to address the risk of urban sprawl and dependency on private motorised vehicle. More compact and denser cities allow for the concentration of opportunities close by, making it easier for people to reach schools, hospitals and workplaces (ITF, 2019[10]). Such environments reduce the need for longer trips, thus decreasing passenger-kilometres without decreasing mobility. In addition, mixed-use environments with more job opportunities and residential options can reduce the pressure on public transport networks compared to other neighbourhood types (Guzman and Gomez Cardona, 2021[11]).

On top of these benefits, more compact and mixed-use environments can decrease transport and infrastructure costs in two ways. First, they make it easier for authorities and operators to meet the critical mass required to make public transport operations financially viable. Second, higher density and closer proximity to opportunities reduce per-unit infrastructure costs and increase the efficient use of roads and public transport (Rode et al., 2014[12]).

Building mixed-use and more compact cities entails balancing working populations, available housing and nearby employment opportunities. This might mean creating urban developments with several centres of economic and residential activity, rather than just one main centre gathering all economic activities where people travel to from surrounding residential areas. Barcelona's superblock model is a good example.

Each 400m² neighbourhood block concentrates residential and economic opportunities allowing people to live, work and move around easily using active and sustainable mobility modes (Postaria, 2021[13]).

Figure 3.4. Urban passenger-kilometres by mode and trip length in 2019 and mode shares over time under the High Ambition scenario, 2019-50



Note: Figure depicts ITF modelled estimates. PKM: passenger-kilometres. Active mobility includes walking, biking, scooter sharing, and bike sharing. Public transport (PT) includes rail, metro, bus, light rail transit, and bus rapid transit. Informal PT includes informal buses and public transport using three-wheelers. Shared vehicle includes motorcycle and carsharing. Private motorised vehicles include motorcycles and cars. Shared mobility includes taxis, ridesharing and taxi buses.

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Figure 3.4 shows the most prevalent modes for different trip lengths in an urban setting under the High Ambition scenario. As can be seen, non-motorised modes have a considerably stronger presence in the modal mix for shorter trip distances. This remains true over time, under both scenarios, although the non-motorised mode share does grow noticeably for trips in 1 km to 10 km ranges under the High Ambition scenario. Beyond 10 km, the share of passenger-kilometres made by non-motorised modes dwindles, demonstrating the importance of proximity of opportunities in encouraging active travel.

Authorities can also gain insights from engaging with public and private employers when developing policies that encourage mixed-use environments and sustainable mobility. In France, for instance, authorities require enterprises with over 100 employees to establish mobility plans that foster sustainable mobility practices among their staff. Examples of measures in such plans include identifying incentives for using public transport and active mobility modes close to offices and pedestrianising spaces in nearby areas (Réseau Action Climat, 2018[14]).

Emerging labour patterns, such as teleworking, could impact the degrees of density of urban areas in the years to come, as well as authorities' capacity to promote certain forms of sustainable mobility. Teleworking could, for instance, foster polycentric and lower-density urban settlements, where the costs of maintaining public transport networks would be harder to recoup because of lower commuting. However, it could also facilitate neighbourhood-centric cities where people would make more non-work-related trips using active mobility and micromobility. The 2019 and 2021 editions of the *ITF Transport Outlook* discuss the implications of teleworking for future passenger transport activities. More research is needed to assess the real-time and evolutionary impacts of teleworking on urban form and correlated mobility patterns (ITF, 2019[15]; ITF, 2021[16]; ITF, 2023[17]).

The High Ambition scenario includes transport and land-use planning measures that promote more compact, mixed and dense environments. Examples of these measures include fostering transit-oriented development (TOD), where neighbourhoods develop in co-ordination with public transport networks. To this end, authorities could set minimum density criteria, give density incentives to developers and require locating new developments near public transport stations (Rode et al., 2014[12]).

In specific developing contexts, reforming maximum density standards would be worthwhile – for instance, by adding minimum space per person criteria to ensure higher densities that go hand in hand with decent living conditions (Rode et al., 2014[12]). In developing and developed contexts, authorities could also set minimum affordable housing provision criteria around emerging public transport stations, for example. Such measures could decrease gentrification and the displacement of lower-income groups due to land-value increases brought about by higher access to opportunities.

Creating more compact, denser and mixed-use settlements where sustainable mobility can thrive requires metropolitan-wide transport and land-use planning and regulatory frameworks. Even with the most ambitious policies, by 2050 the built environment in urban areas worldwide will extend beyond current administrative boundaries. Administrative boundaries, transport planning practices, and regulatory frameworks must adapt to this rapid expansion.

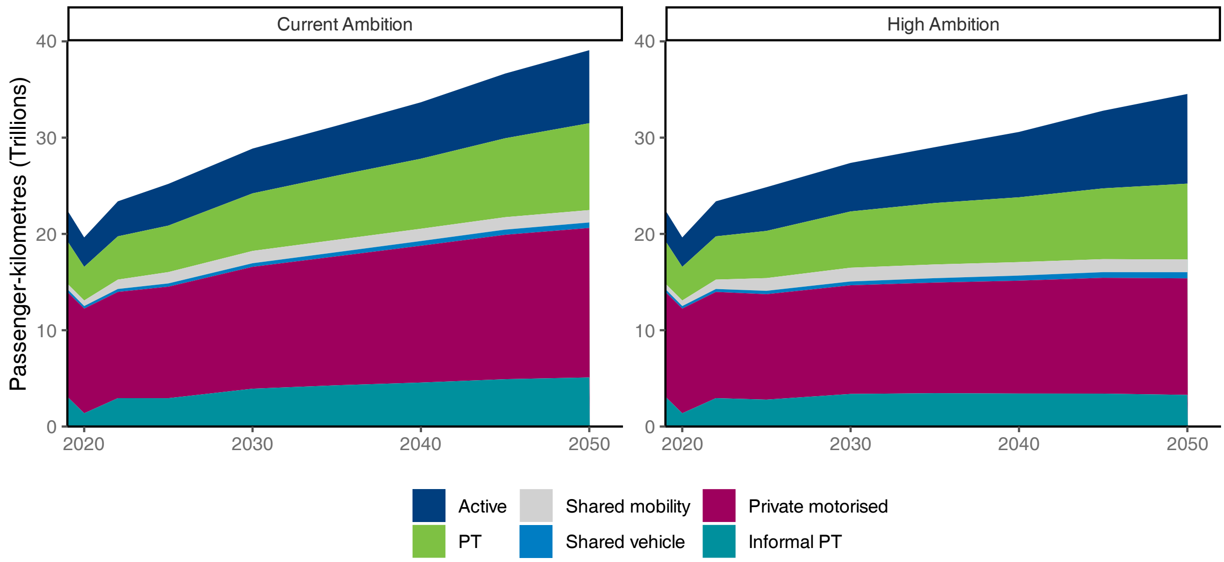
As experiences in Barcelona, London and Paris have shown, building transport governance frameworks that effectively address the policy needs of a metropolitan area is a longstanding, challenging and case-specific process (ITF, 2022[18]). Such processes must be started early, with dialogue between relevant local and national authorities. It will be crucial to include authorities in less-dense areas around urban centres set to become part of future metropolitan areas. Authorities in urban centres for which less-dense areas provide potential work catchment basins area are another important stakeholder group (ITF, 2018[19]).

Effectively encouraging sustainable choices will require a mix of policy approaches

Combining policy measures will help ensure sustainable urban travel choices in the future (ITF, 2023[20]). Under the Current Ambition scenario, private motorised vehicles (cars and motorcycles) will continue to play a significant role in urban areas worldwide in the years to come (see Figure 3.5). By 2050, under this scenario, these vehicles will cover nearly half of global passenger demand. In the UCAN countries, which on average have lower-density cities, private motorised vehicles will have the largest mode share, at 77%.

Meanwhile, in SSA and SSWA, private vehicles will account for only 16% and 24% of demand, respectively, even under the Current Ambition scenario. Under the High Ambition scenario, mode share for private motorised vehicles in SSA falls to only 12%, the lowest of any world region (see Figure 3.6).

Figure 3.5. Urban mode shares under the Current and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. Active mobility and micromobility include walking, biking, scooter sharing, and bike sharing. Public transport includes rail, metro, bus, light rail transit, and bus rapid transit. Informal PT includes informal buses and public transport using three-wheelers. Shared vehicle includes motorcycle and carsharing. Private vehicles include motorcycles and cars. Shared mobility includes taxis, ridesharing and taxi buses.

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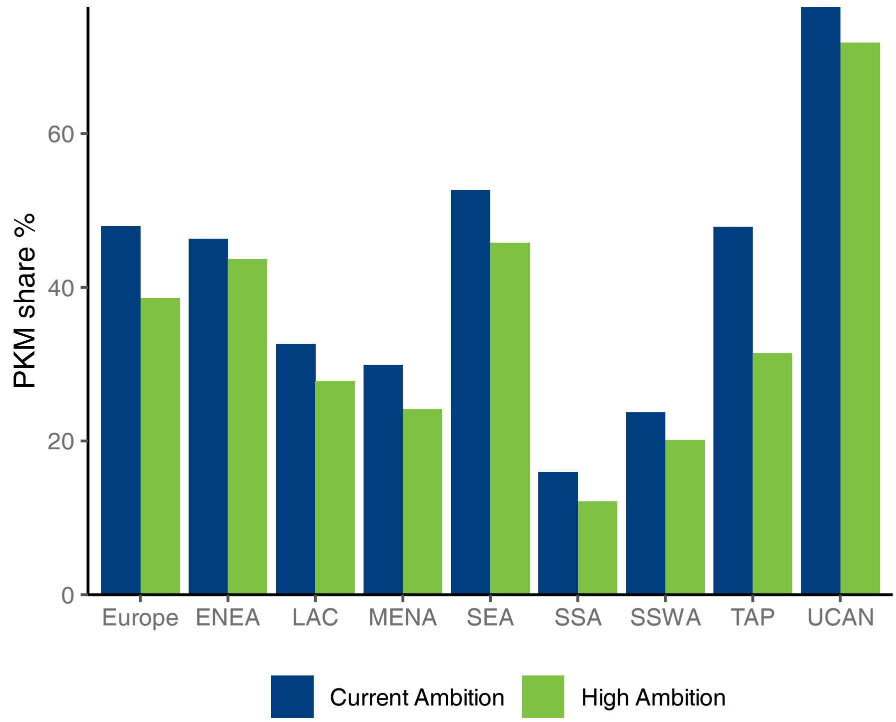
Even under the High Ambition scenario, the mode share of private motorised vehicles remains high (see Figure 3.6). This finding underlines the importance of strategic planning as populations urbanise and designing sustainable travel options in cities to avoid car dependency. The High Ambition scenario includes a comprehensive package of measures to curb the growth in private motorised vehicle use. It combines vehicle restriction and pricing measures with measures promoting active mobility, public transport and emerging digitalised shared mobility. The impact of the type of policies included in the High Ambition scenario on reducing car dependency is well documented (ITF, 2021[9]).

Figure 3.6. Mode shares for urban private motorised vehicle use in 2050 under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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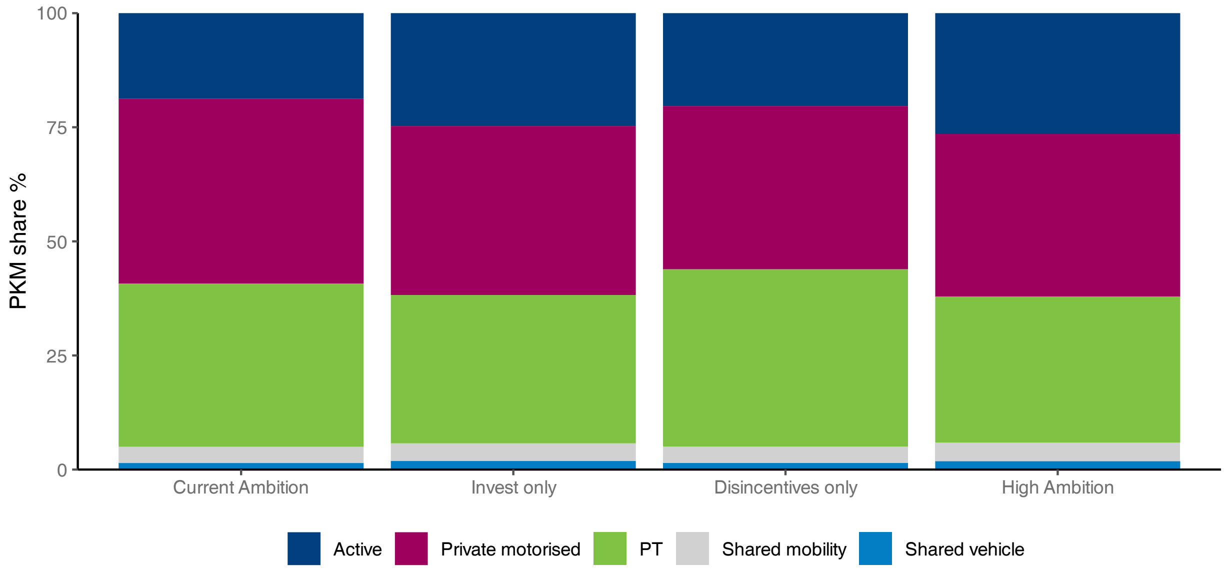
Policy disincentives and higher investments in alternative modes, or a combination of both approaches, can help reduce private vehicle dependency. The modelling for this Outlook also includes a comparison between these approaches to understand their relative impacts. Figure 3.7 shows passenger-kilometres in 2050 under the Current Ambition scenario, the High Ambition scenario and two other policy cases: an Invest Only case and a Disincentives Only case.

The Invest Only case considers the impact of the policies outlined under the Current Ambition scenario (see Chapter 2), but with High Ambition levels of investment in public transport, integrated ticketing, and bicycle and walking infrastructure. It also assumes that policies are in place to incentivise shared mobility and carpooling and the development of multimodal travel services such as Mobility as a Service (MaaS).

Under these conditions, mode share for active travel improves the most, increasing by 6 percentage points. Private motorised vehicles do see a reduction in mode share (-3 percentage points), but so does public transport (by a similar amount), suggesting at least some of the increase in active and shared modes is substituting for previously sustainable public transport trips.

Studies of pricing measures suggest they can effectively reduce city car use. In Milan, Italy, the implementation of a road pricing scheme led to a 12% traffic reduction within the implementation area, and almost 4% outside of it (Rotaris et al., 2010[21]). Likewise, previous examples of vehicle restriction policies have led to reductions of 5-10% in private vehicle travel (ITF, 2021[22]).

Figure 3.7. Urban passenger mode shares in 2050 under the Current Ambition and High Ambition scenarios and two intermediate cases



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. Active mobility includes walking, biking, scooter sharing and bikesharing. Public transport includes rail, metro, bus, light rail transit and bus rapid transit, as well as informal public transport modes. Shared vehicle includes motorcycle and carsharing. Private motorised vehicles include motorcycles and cars. Shared vehicles include taxis, ridesharing and taxi buses.

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The Disincentives Only case assumes the policies outlined under the Current Ambition scenario but adds higher pricing measures, parking restrictions, and urban vehicle access regulations. These measures aim to internalise more of the costs of car use and improve the convenience of sustainable alternatives compared to using the car. Under the Disincentives Only case, public transport (formal and informal) sees a mode share increase of 3 percentage points compared to the Current Ambition scenario. However, in the absence of investment in infrastructure for walking and cycling, the growth of mode share for active travel is only marginal (2 percentage points).

Authorities also need to understand and address the potential adverse effects of restrictive measures on lower-income and underserved groups. Measures that restrict or limit the use of private vehicles can have detrimental impacts on such groups, especially in communities where private vehicle ownership and use is necessary due to a lack of alternatives (Mattioli, 2017[23]; Di Ciommo and Lucas, 2014[24]). However, this is not to suggest that discounts and exemptions should be introduced.

It is recommended to extend concessions to emergency services and public transport. Beyond that, however, experience suggests discounts and exemptions risk undermining the effectiveness of the scheme. Careful spatial and demographic analysis should be conducted as part of the scheme design, to better understand the potential social and distributional effects, and identify if wider mitigation or compensation through the fiscal system is merited (ITF, 2018[25]).

In the longer term, road pricing can contribute to containing urban sprawl and encouraging transit-oriented development and compact cities, as part of a comprehensive policy package. This can also improve urban liveability more broadly (see Chapter 5). The revenues from the scheme can also be used to invest in improvements for public transport and active modes (ITF, 2018[25]; ITF, forthcoming[26]). Earmarking the potential revenues for such improvements in sustainable alternatives and road safety has also been shown to improve the public acceptability of these schemes (Baranzini, Carattini and Tesauro, 2021[27]). Positive communication about the benefits of congestion charges could improve their acceptability (Hsieh, 2022[28]).

Finally, the full High Ambition scenario combines the investment and incentives of the Invest Only scenario and the pricing and restrictions of the Disincentives Only scenario. It also assumes a systemic change in urban planning, resulting in integrated land-use planning, mixed-use developments and higher densities that prevent urban sprawl, reduce trip distances and make public transport more accessible.

As a result, under the High Ambition scenario, by 2050 total passenger-kilometres fall, the mode share for active travel reaches its highest level (27%), and private motorised vehicles' mode share falls to its lowest level (36%). Public transport's mode share also drops, although this likely reflects shortened trip lengths and the attractiveness of active and shared modes. The mix of policy approaches to serve the growing urban travel needs by 2050 under the High Ambition scenario allows for a greater shift to sustainable modes, and as a result, lower overall urban passenger emissions.

Better and safer city streets can help promote active mobility

Promoting active mobility requires a mix of infrastructure investments, improvements in the quality of the mobility experience and information campaigns aimed at behavioural change. The High Ambition scenario includes increases in active mobility infrastructure investment as a first step in promoting active mobility. Examples of such investments include measures that expand networks of cycling lanes, as well as the width and quality of footpaths. In Bogotá, Colombia, for instance, modelling exercises show that walking and cycling infrastructure improvements could more than double the share of cycling in the city by 2050 compared to a scenario with lower policy ambition, while slightly furthering high levels of walking (Papaioannou and Windisch, 2022[29]).

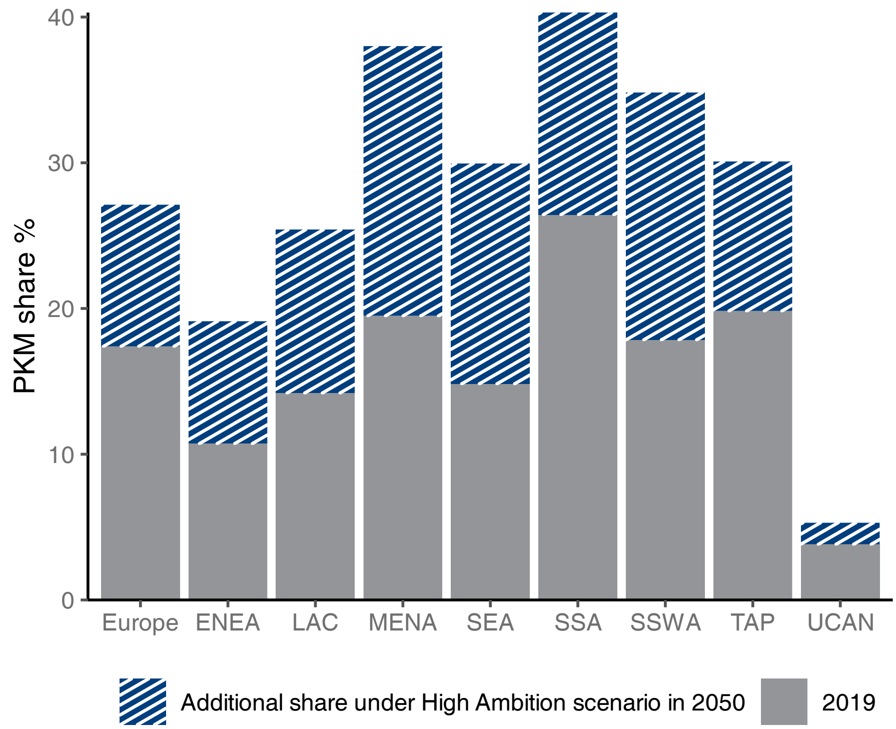
Authorities can also support active mobility adoption by improving pedestrians' experience when walking. For example, measures might aim to improve the perception of safety on city streets, especially for women, through better public lighting or campaigns to decrease sexual harassment (Chant and McIlwaine, 2016[30]). Authorities can also benefit from promoting information campaigns targeted at specific population groups to foster their adoption of active mobility. Such campaigns can also facilitate the public acceptability of "harder" measures, such as infrastructure improvements that reallocate street space to active mobility as opposed to private vehicles (Markvica et al., 2020[31]).

Active mobility is noticeably higher in emerging regions under the High Ambition scenario than the Current Ambition scenario. People's demand for active travel modes (including walking, cycling and other activities) will increase in all world regions and under both scenarios. (see Figure 3.8). The highest potential increases occur in SEA, where active mobility under the High Ambition scenario is 55% higher than under the Current Ambition scenario. In the MENA and TAP regions, the equivalent increases amount to 51% and 41%, respectively.

In contrast, increased demand for active mobility in developed regions is limited under the High Ambition scenario. For example, the increase in demand is 8% in Europe, 13% in ENEA and only around 3% for UCAN countries. Furthermore, active modes in the UCAN countries, where many cities are well-established, retain the smallest mode share under both scenarios.

Ensuring a broad disbursement of walking and cycling infrastructure investments is vital to improving accessibility. For most world regions, more than half of the increases in active mobility uptake assumed under the High Ambition scenario occur in the core of urban areas rather than at their peripheries. This trend can partly result from the greater difficulty in enhancing density in peripheral areas compared to more central ones. However, it can also result from differences in investment between urban core and peripheral areas.

Figure 3.8. Urban passenger-kilometres by active modes under the High Ambition scenario in 2050



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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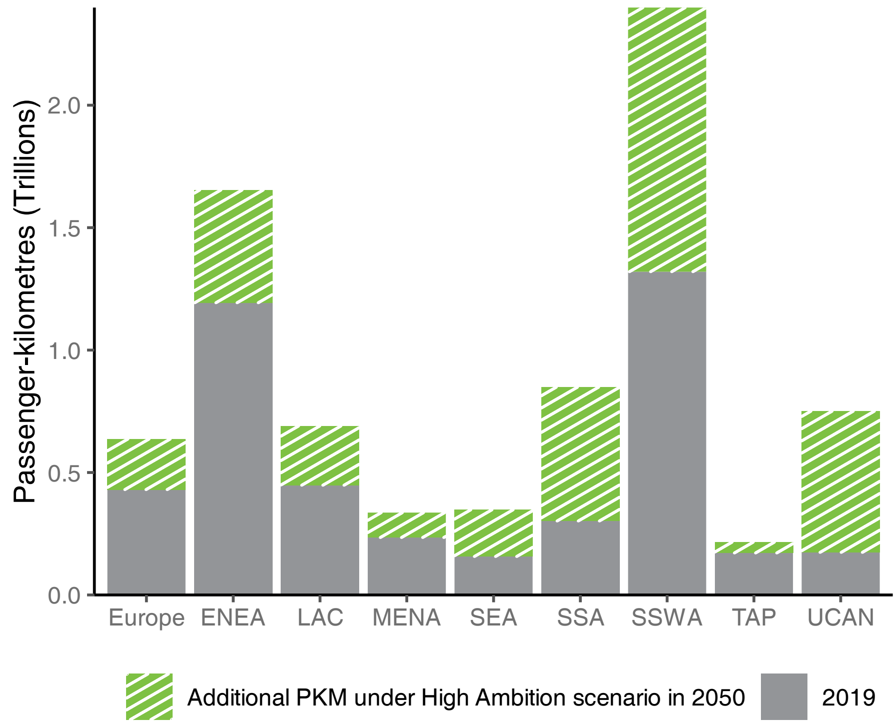
Recent analysis of various European cities shows a high concentration of active mobility infrastructure in central and well-off areas as opposed to lower-income neighbourhoods (Cunha, 2022[32]). This infrastructure gap increases the risk of missing the opportunity presented by cycling to facilitate access in less-densely populated areas where public transport services are difficult to maintain. Bridging the active infrastructure gap between central and peripheral areas will be an essential step towards making active modes attractive for all.

Public transport needs to be appealing and sufficiently funded

Public transport plays a crucial role in decarbonising urban transport. However, public transport networks need to be accessible, frequent, safe and reliable to be attractive. Ensuring the appeal of public transport will therefore require investment. Modelling carried out by the International Transport Workers Federation and the C40 Cities Climate Leadership Group (2021[33]) suggests that investment in public transport can also support job creation. Although the public transport share will not increase in some cities, overall public transport networks will need to carry more people under both policy scenarios explored in this edition of the Outlook. This is due to the increased public transport passenger-kilometres under both the Current Ambition and High Ambition scenarios.

Figure 3.9. Urban passenger-kilometres by public transport under the High Ambition scenario



Note: Figure depicts ITF modelled estimates. Public transport includes rail, metro, bus, light rail transit and bus rapid transit. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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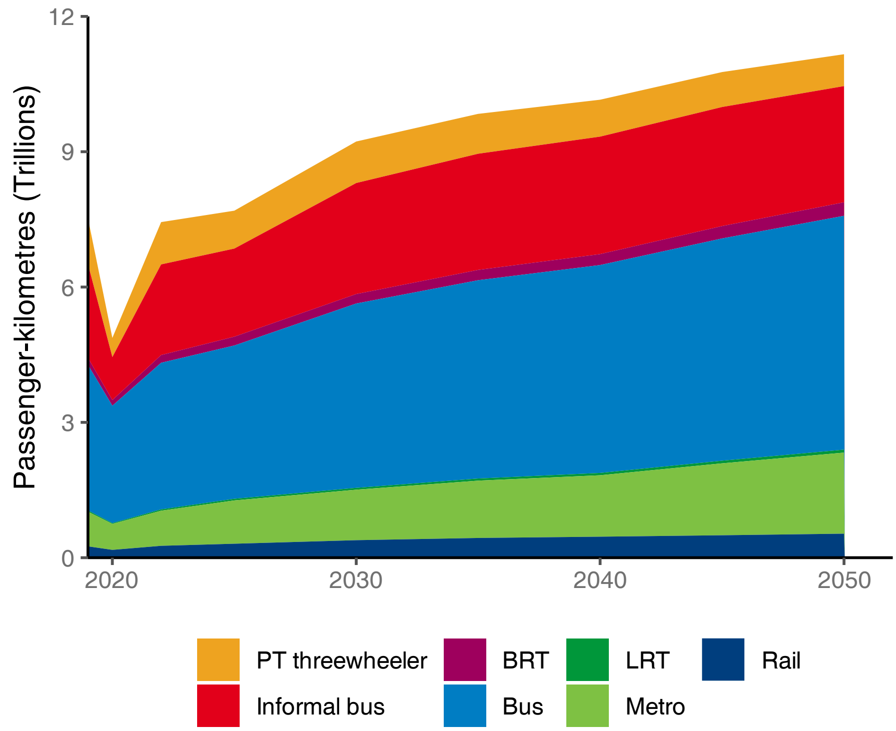
Public transport demand will grow in every region between 2019 and 2050. Under the High Ambition scenario (see Figure 3.9), passenger-kilometres by urban public transport increase in every region. The starkest jump is in UCAN, where public transport passenger-kilometres more than triple. In the other high-income regions, ENEA and Europe, the growth is 38% and 48% in comparison. In SEA, passenger-kilometres roughly triple and in MENA they more than double. This reflects the growing ridership of public transport in these cities, but also the inevitable increase in average trip lengths that will occur as urban areas grow.

Given this increase in demand, public transport planning needs to focus on maintaining existing trips and attracting new trips as urban populations grow. This significant jump for public transport reflects the assumption under the High Ambition scenario of measures to increase investments in buses, BRT and railways. It also results from more compact developments, which make it easier for people to use public transport services.

Figure 3.10 shows the share of passenger-kilometres by public transport mode under the High Ambition scenario over time. Investment in public transport will need to focus on various vehicle types to best respond to the needs of different urban areas. For instance, mass public transport services could benefit from metro or bus rapid transit (BRT) services along trunk lines, complemented by more flexible bus services. For buses, in particular, investments in priority measures and express lanes can support service reliability.

Figure 3.10. Urban public transport demand by public transport mode under the High Ambition scenario



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. PT three-wheelers includes vehicles such as auto-rickshaws. BRT: Bus rapid transit. LRT: Light rail transit.

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Not all investment in public transport will require capital projects. Investment in improving the speed, reliability and frequency of services, for example. Authorities face the challenge of providing affordable services of a high enough quality to be appealing to users and not simply a service that is necessary for those with no alternative. To this end, services should be reliable and allow users to travel safely and comfortably, as well as in the most efficient way possible.

Providing attractive public transport requires funding to maintain services and expand the network. A crucial question is whether public transport investment is guided by long-term strategic plans, supported by medium-term funding envelopes. As discussed in Chapter 6, this edition of the Outlook recommends that policy makers adopt a “decide and provide” approach to investment decisions.

The “decide and provide” approach involves making investments that are strategically aligned to a vision of the future transport system. Adopting such an approach could support strategic choices among investment options and provide certainty. It could also offer the benefits of a consistent investment pipeline, avoiding cost spikes due to changes in demand at particular times.

The funding challenge for public transport is a large one, especially in the context of the mode shift desired under the High Ambition scenario. In most contexts, public transport fares do not cover the service costs, meaning some form of public subsidy is needed. The reliance on subsidies from the general budget contributes to funding uncertainty, and potentially undermines the ability to plan for the longer term.

Recent work has established the range of options for public transport funding (Litman, 2022[34]; ITF, forthcoming[26]) come from fares, taxes, vehicle or road user charges (including parking-related charges), and revenue from property (including rental incomes and land-value capture). The approaches vary by country and region, and an ITF Working Group is currently considering best practice for the future.

Many countries have begun to develop, or investigate, land-value capture mechanisms as a means to fund major capital works projects (ITF, forthcoming[26]). However, public transport investment is not only about these major capital interventions. Operational investment (e.g. in service improvements) will also be crucial to achieving the desired mode share for public transport in the future.

Given the scale of the challenge, all funding options will need to be optimised. This suggests that future strategies should also plan for higher contributions from fares, while maintaining the fares at a level that will not reduce ridership or negatively affect accessibility. This is a potentially contentious point, and can be highly politically sensitive. In this context, clear and transparent fare setting policies need to be established. Appropriate, targeted concessions should also be developed. These principles should seek to balance user funding and public subsidies, to engender efficient user incentives that support the policy objectives of decarbonisation and accessibility (ITF, forthcoming[26]).

The earmarking of taxes, such as revenue from road-user charging, also has the potential to contribute to funding public transport. Another prominent example of an earmarked tax contributing to public transport funding is France's *versement mobilité* [mobility payment, VM]. This tax, payable by employers with more than 11 employees, has existed for over 50 years. The primary rationale is to tax employers for the benefit they get from the availability of a public transport network that allows their employees to commute to work.

Over time, the VM has expanded in scope and scale. It was initially only applied in France's capital region but metropolitan transport authorities can now decide on its application throughout the country. Also, while revenues from the VM were once only used to fund public transport, they can now be applied to other mobility projects (e.g. investments in active travel).

The VM has provided a large and growing funding source that has made it possible to keep fares artificially low, while still increasing services. In practice, the VM has essentially substituted for fare revenue and has contributed a growing proportion of overall funding. This is due to a decrease of approximately 50% in the proportion of operational funding provided via fares over the last 25-30 years compared to previous periods (Cour des comptes, 2022[35]).

Notably, the VM model has not been taken up by any other country, despite having been used consistently in France for decades. This reflects difficulties in political discussions around setting earmarked taxes, particularly those directly affecting employers. It also decreases the potential for significant uptake of earmarked taxes to fund public transport systems in the coming years, despite possible adoption in some cities. It would be necessary to ensure that any such mechanism included rules that prevented the revenues being earmarked solely for capital projects.

Shared mobility and multimodal travel services can enhance the network

Providing widespread, fixed-route public transport in lower-demand locations in urban areas could bring financial challenges. Furthermore, it can be more difficult for authorities and operators to maintain operations in areas where a critical mass is hard to achieve.

In such a situation, multi-modal and integrated sustainable transport networks become more relevant, and emerging on-demand services can help fill the gaps in public transport provision. Enhancing connectivity between public transport, on-demand solutions (e.g. shared mobility) and active mobility solutions will be a crucial lever for authorities in developing and developed countries to provide public transport in lower-demand locations.

Engaging with informal transport operators and integrating their services in urban transport systems will be an important first area of attention, especially in developing regions. Informal transport activities are flexible, demand-based services that, while not officially included in existing public transport services, respond to the transport needs of low- and middle-income residents in developing cities worldwide.

For instance, in Bogotá and Mexico City, informal transport increases the overall accessibility of public transport networks by 35% and 54%, respectively (ITF and IDB, forthcoming[36]; OECD, 2022[37]). Under the High Ambition scenario in this report, around 16% of demand in SSWA by 2050 would be met by informal modes. The equivalent figure for SSA would be around 23%. Mode shares for informal public transport are lower in 2050 in most regions under the High Ambition scenario, while formal shared modes and public transport are marginally higher.

Increased shared mobility could present an opportunity to leverage pre-existing informal, demand-based networks in developing cities by formalising existing services through digitalisation. In Mexico City, previous experiences have shown that informal transport drivers can adapt to application-based mobility services (ITF, 2019[38]; Flores Dewey, 2019[39]). Research focussed on Latin America also found digitalising informal mobility can also strengthen public transport networks and decrease congestion, provided new services collaborate and feed riders to trunk networks, rather than compete with public transport systems (Paternina Blanco, 2020[40]).

There is also potential for shared mobility services to complement public transport in developed economies. In 2050, under the High Ambition scenario, shared mobility services in Europe and ENEA could cover around 5% of demand. If integrated, combined services could provide a less-space-consuming mobility offer with clear benefits for urban congestion and street space (ITF, 2022[41]).

The modelling results make a case for investing in multimodality beyond traditional public transport services. Figure 3.11 reflects potential decreases in vehicle-kilometres by private motorised vehicles under the Current Ambition compared to the High Ambition scenario and two other cases: a Public Transport Investment case and a Multimodal Investment case.

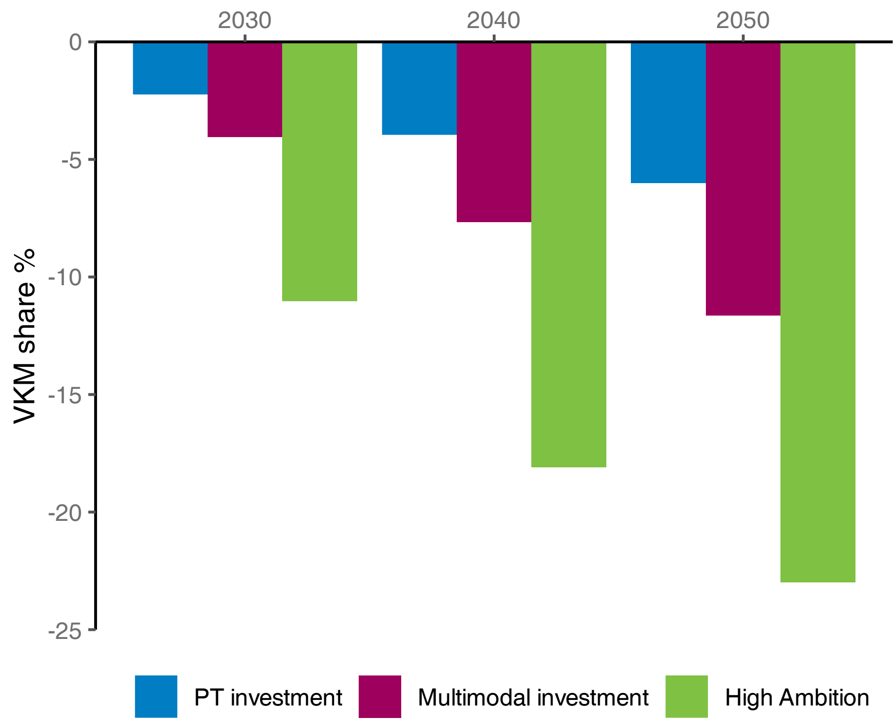
The decreases shown in Figure 3.11 result from investments that facilitate integration between shared, on-demand services and public transport networks; and from the overarching High Ambition scenario, which assumes other measures such as vehicle restrictions. The figure suggests that, by 2050, the potential reduction in private vehicle use due to multimodal investments could be higher than investments in public transport alone. At the same time, an even more ambitious policy agenda (under the High Ambition scenario) that promotes the integration of land-use and transport planning and setting private vehicle access regulations can produce impacts four times greater than multimodal investments.

In the Multimodal Investment case and the High Ambition scenario, MaaS and multimodal transport services are assumed to improve integration between public transport and shared mobility, improving access to public transport and reducing interchange times. This is expected to result in car ownership becoming less attractive. However, the viability of MaaS remains unproven (ITF, 2021[42]).

One of the most common visions of MaaS is one where commercial MaaS providers would develop appealing customer offers in a competitive environment. However, viable business models have not yet emerged. Potential use cases such as tourism or employee travel management could help define test markets (ITF, 2021[42]).

More pilots and case studies are needed to shed light on the day-to-day potential and impacts of MaaS services. Given the uncertainty, governments may consider it more expedient to take a leading role in the development of integrated multimodal services, to realise more quickly their potential benefits for decarbonisation and accessibility policy objectives. An ITF Working Group is currently exploring this subject (ITF, 2023[43]).

Figure 3.11. Change in vehicle-kilometres by private motorised vehicles under the High Ambition scenario and two other investment cases



Note: VKM: vehicle-kilometres. Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. The PT investment case includes High Ambition levels of investment in public transport priority measures and express lanes, as well as service and public transport infrastructure improvements, but with all other measures maintaining Current Ambition levels. The Multimodal investment case reflects High Ambition levels of encouragement of shared mobility and investment in multimodal travel such as integrated public transport ticketing and multimodal travel platforms such as Mobility as a Service.

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Urban logistics must form a part of strategic planning

Urban areas are essential nodes in global supply chains, particularly in cities with (or in proximity to) ports and their hinterlands (Wang et al., 2016[44]). Urban authorities tend to take a passive approach to managing and regulating urban freight activities. However, tools exist to ensure that freight activities align with a city's strategic goals – for instance, by regulating the spaces through which freight passes (ITF, 2022[45]).

By 2050, urban freight activity will increase by a factor of 2.6 worldwide compared to 2019, growing in every region. While the SSWA and SSA regions have the highest increases, urban freight demand also sees strong growth in ENEA, MENA and SEA. These regions have rapidly urbanising populations and growing economies through to 2050. Growing middle classes in some emerging regions are expected to lead to a consumption boom, which is already visible in SEA (ITF, 2022[73]; WEF and Bain & Co., 2020[74]). Urban freight in ENEA is expected to triple, consistent with the high rates of urbanisation in the coming years.

Growing urban freight volumes can contribute to higher urban congestion. It also contributes to urban sprawl and compounds the pressure logistics activities place on scarce urban land and street space (ITF, 2022[45]).

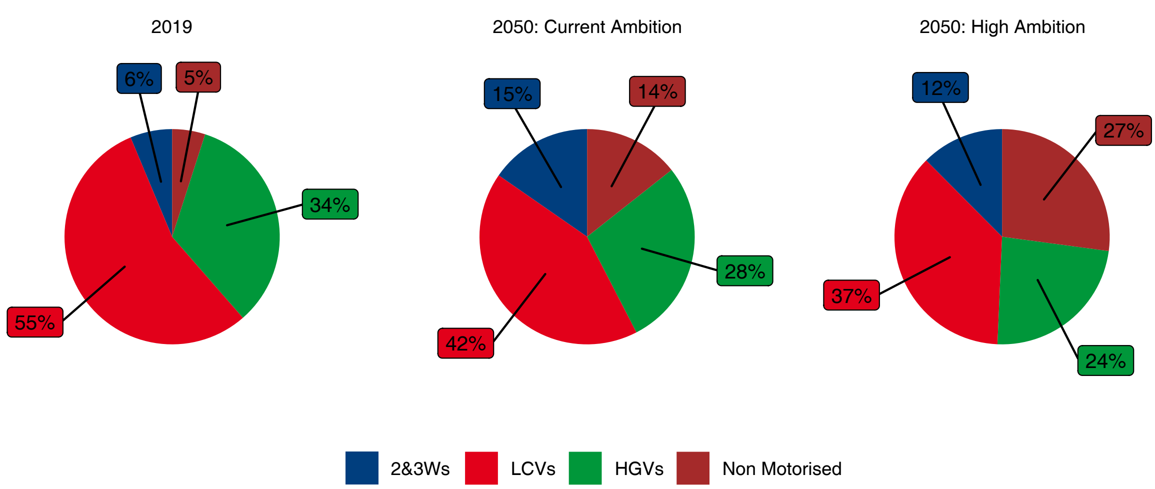
For instance, online retailers have considerably increased their urban and metropolitan-wide logistic footprints recently. Travel restrictions and other policies responding to the Covid-19 pandemic have enhanced this trend (Schorung and Lecourt, 2021[46]). Authorities will need robust regulatory frameworks to manage and deal with the consequences of increasing logistic activities (ITF, 2022[45]). Mandatory planning documents, such as sustainable urban logistic plans (SULPs), can provide a framework on which to build metropolitan-wide logistics capacities and public governance (Aifandopoulou and Xenou, 2019[47]).

Under the Current Ambition scenario, motorised modes carry most urban freight. In 2019, various types of motorised vehicles transported almost all tonne-kilometres in cities worldwide. Regarding vehicle-kilometres, non-motorised and micromobility modes (including two and three-wheelers) accounted for around 11% of urban freight flows. This figure increases to 29% in 2050 under the Current Ambition scenario and 39% under the High Ambition scenario.

Lorries catered to the highest share of tonne-kilometres (89%) transported via motorised urban freight modes in 2019 under the Current Ambition scenario (see Figure 3.12). However, HGVs represented less than 30% of the total vehicle-kilometres travelled, as they have a higher capacity to transport heavier loads. They are less suitable for lighter loads, including parcel deliveries.

Light commercial vehicles (LCVs) are the preferred option for parcel delivery, explaining their 55% share of vehicle-kilometres in 2019. HGVs would be responsible for a smaller percentage of vehicle flows and a higher share of tonne-kilometres due to their use for heavier goods and commodities. Improving the efficiency of deliveries can reduce motorised freight movements and consequent CO_2 emissions per delivery.

Figure 3.12. Vehicle-kilometre shares of motorised urban freight transport activities under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. LCVs = light commercial vehicles. HGVs = heavy goods vehicles.

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The High Ambition scenario includes measures that promote increases in freight efficiencies among freight carriers, avoiding the need for unnecessary travelled distances. Examples of these measures include incentives for asset-sharing schemes between freight carriers, or between freight shippers and carriers. Such incentives could lead to higher truckloads, decreased instances of empty running and lower travelled distances. Previous analyses have shown that load pooling could reduce travelled miles in dense cities by around 30% and decrease delivery times and costs by approximately 25% (Bouton et al., 2017[48]).

Authorities can help enhance collaboration between freight carriers to achieve freight efficiencies. For instance, they can facilitate the creation of shared physical urban logistic hubs and foster common data-sharing mechanisms. Other relevant demand-management measures not included in this scenario seek to manage the times when deliveries occur (ITF, 2022[45]). To this end, collaboration with freight receivers and carriers is essential (Holguín-Veras and Sánchez-Díaz, 2016[49]).

The shift towards non-motorised modes can also reduce urban freight emissions. By 2050, the flows of urban freight transported using motorised vehicles will be around 7% lower under the High Ambition scenario than the Current Ambition scenario. Non-motorised modes will also grow considerably in every region, especially in ENEA, SEA, SSA and SSWA.

Under the High Ambition scenario, which assumes the promotion of cargo bicycles for last-mile deliveries, tonne-kilometres carried by non-motorised modes more than doubles in every region in 2050, compared to the Current Ambition scenario. Switching deliveries to bicycles can also reduce operator energy costs (Prato Sánchez, 2021[50]) and reduce noise and congestion externalities for the city (Cairns and Sloman, 2019[51]; Koning and Conway, 2016[52]). Electric cargo bikes can also increase loading capacity and distance range, compared to non-electric models. However, mode shift could also have negative externalities for operators. For instance, it could impact staff costs if bicycle deliveries increase travel time for drivers (Arnold, F. et al., 2018[53]).

Urban authorities could invest in cycling infrastructure enhancements to encourage the uptake of bicycle deliveries. They could also introduce differentiated access restrictions for higher-polluting vehicles and preferential space allocation for non-motorised deliveries. Facilitating the building of logistic transhipment facilities to shift loads from larger vehicles to cargo bikes would make cargo bikes a more viable option due to shorter final legs.

However, incentives for mode shift towards non-motorised modes need to be thought through to ensure adoption, considering their impacts on freight carriers' business models. Authorities also need to implement these measures in parallel to increasing freight efficiencies. This co-ordination of actions will help ensure the use of larger vehicles at their maximum capacity when relevant while encouraging the use of smaller vehicles for shorter distances whenever possible (ITF, 2022[45]).

Drop-off and pick-up locations, such as parcel lockers or relay points allowing users to collect their deliveries, can also reduce motorised freight activity in urban settings. Recent ITF analysis indicates that, if such infrastructure was available, it could account for around 20% of a city's parcel collections (ITF, 2022[45]). The modelling for this Outlook suggests that total vehicle-kilometres for parcels would be reduced by up to 38% by 2050 under the High Ambition scenario. Since this measure is immediately implementable, introducing pick-up points alone would be expected to reduce vehicle-kilometres for parcels by 3% in 2025 and 13% in 2030.

Pick-up points can facilitate non-motorised modes if people use these alternative modes instead of private vehicles to pick up their parcels. But this is easier in cities with a high density of pick-up locations. In Graz, Austria, for instance, an analysis of users of pick-up and drop-off locations revealed that around half would be willing to walk or use bicycles to reach them (Hofer et al., 2020[54]). The potential of such a measure for promoting sustainable urban mobility can be lower if end users pick up their packages by private motorised vehicles such as cars. This highlights the relevance of considering freight and passenger mobility simultaneously when it comes to e-commerce-related flows.

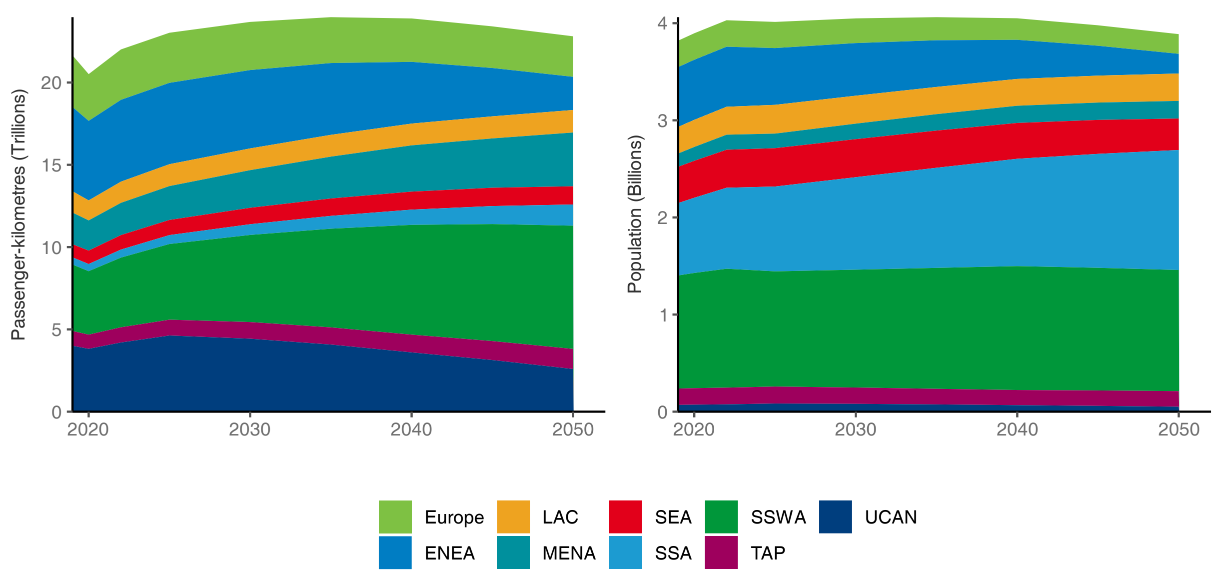
Regional travel: Addressing the car dependency of rural populations

The global rural population will decrease in the years to come. In most world regions, rural populations will remain stable or decline in the years leading to 2050, particularly in high-income regions, including ENEA, Europe and UCAN. In these regions, rural populations will decrease on average by 50% due to a combination of populations peaking and declining in many countries, or high urbanisation in countries such as the People's Republic of China. In upper-middle-, lower-middle- and low-income regions, rural populations are set to remain stable or only slightly increase between 2019 and 2050.

Future passenger demand trends in non-urban areas will closely reflect evolutions in rural populations almost everywhere (see Figure 3.13). In high-income regions such as ENEA, Europe and UCAN, transport demand outside urban areas will decrease between 2019 and 2050, falling by 61% in ENEA, 22% in Europe and 35% in UCAN. Elsewhere, considerable growth in per-capita GDP in developing regions will contribute to continued increases in regional demand, albeit at a slower pace than urban demand.

Decreasing regional transport demand could make it difficult to fund and maintain accessible and sustainable transport solutions in less-densely populated regions. Any decline in regional transport demand may also affect the financial sustainability of regional transport services. Developing on-demand transport services and furthering shared and active travel targeting rural areas can contribute to maintaining access levels. Other measures might include developing countrywide accessibility policies that take into account both urban and rural areas – for instance, through sustainable regional mobility plans (ITF, 2021[55]). Overall, it will be necessary to comprehensively rethink and plan for regional transport activities to respond to the future accessibility needs of rural and low-density peri-urban dwellers.

Figure 3.13. Regional transport demand and rural populations by world region under the Current Ambition scenario



Note: Figure depicts ITF modelled estimates. Indexed scales vary by region, making it possible to compare trends in results across all regions while also including differences in population and evolution of passenger-kilometres over time. Current Ambition (CA) and High Ambition (HA) refer to the two scenarios modelled, representing two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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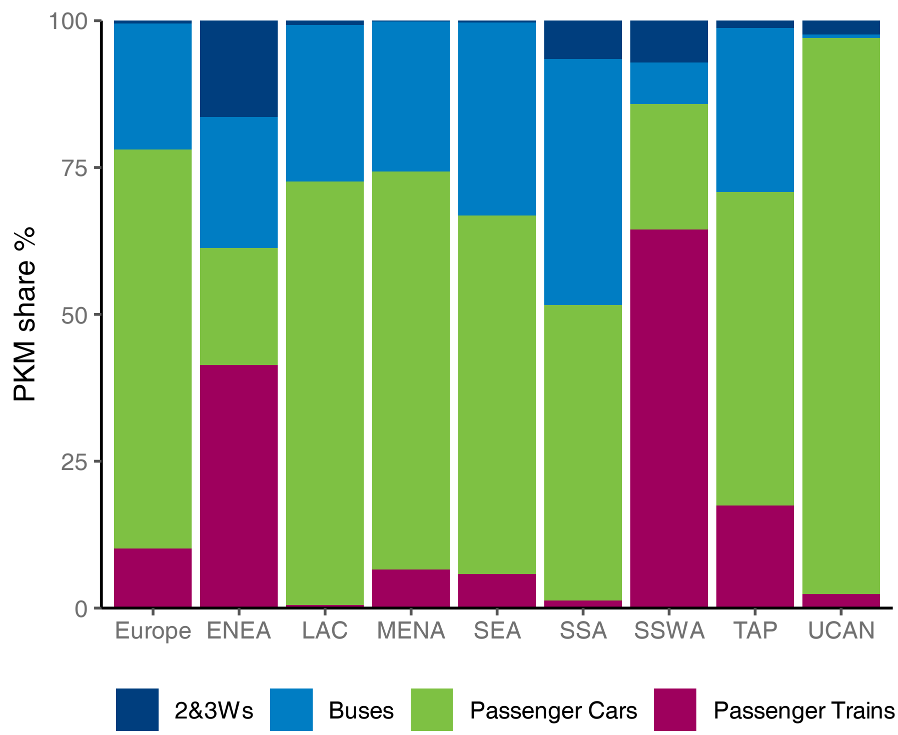
Cars will remain a fixture in regional travel for the foreseeable future

Private cars are the primary mode of regional transport in most regions. More than half of all global regional passenger-kilometres in 2019 took place by private cars. This was a trend across most world regions: the share amounted to roughly 70% in Europe, LAC and MENA under both scenarios, in 2019 and 2050. In UCAN, passenger cars retain a roughly 95% mode share in 2050 under both scenarios. The only exceptions were ENEA and SSWA, where private cars accounted for less than 30% of demand. Yet, even in these regions, the use of two- and three-wheelers for regional travel accounted for more than 16% (ENEA) and 7% (SSWA), respectively, of passenger-kilometres.

Even under the High Ambition scenario, passenger cars will dominate regional travel until 2050 (see Figure 3.14). Between 2019 and 2050, under the High Ambition scenario, passenger-kilometres travelled by private cars will decrease by more than 20% in Europe, more than 30% in UCAN and more than 60% in ENEA. These decreases are just slightly higher than under the Current Ambition scenario. The fact that change over time is greater than the difference between scenarios points to the relative lack of widely established policy interventions for regional travel.

Figure 3.14. Mode share for regional transport under the High Ambition scenario in 2050



Note: Figure depicts ITF modelled estimates. 2&3Ws: Two- and three-wheelers. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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However, even as regional demand overall falls in Europe and UCAN, the share of passenger-kilometres covered by passenger cars in 2050 in these regions will remain high. In ENEA, passenger cars have a 20% mode share in 2050. In emerging regions, even with the High Ambition scenario, mode share for passenger cars will only increase – almost doubling in the MENA region and more than tripling in SSA. Because of this, private motorised vehicles remain the primary mode of regional transport in most developing regions, bar SSWA.

It is important to highlight the shift towards rail transport over time. Passenger-kilometres by rail grow under both policy scenarios, rising by more than 60% between 2019 and 2050. The increase outpaces the overall growth in regional passenger-kilometres of 5%. This result underlines the importance of rail in non-urban settings regardless of the policy ambition. The mode shift to rail is mainly encouraged by the increasing cost of car use when carbon pricing is introduced.

The persistently high mode share for cars reflects the difficulty of achieving mode shift in predominantly low-density areas with more dispersed travel patterns. Recent work by the European Commission (EC, 2019[56]) found that the use of internal combustion engine (ICE) vehicles in uncongested rural areas had significantly lower external costs than car use in congested urban areas. Zero-emission vehicles (ZEVs) in these uncongested rural contexts had even lower externalities.

This suggests that it is possible to decarbonise regional travel by accelerating the uptake of ZEVs outside of cities and investing in rail and collective modes where appropriate. Carbon pricing in this context will be a crucial policy measure for managing the technology transition away from ICE vehicles. It is essential to design pricing measures equitably to ensure that low-income households are not disproportionately disadvantaged. However, as discussed in the previous edition of the Outlook (ITF, 2021[16]), particular care and advanced impact analysis are necessary when designing these schemes. It is also possible to couple them with more progressive incentives for the uptake of ZEVs (see Chapter 4).

Increased ZEV uptake will help achieve decarbonisation. But relying on private motorised modes (even if they do not produce emissions) will not improve accessibility for those who cannot afford (or are unable) to use a car. A 2021 ITF report on rural mobility (ITF, 2021[55]) found that better governance and more flexible regulations are needed to foster novel regional solutions. Innovative financing and funding solutions are also required; financial support should be linked to their impact rather than how “high-tech” they happen to be.

As the results in this Outlook demonstrate, such solutions will likely remain in the lower-occupancy modes, with greater flexibility. The Working Group also recommended increasing funding for shared modes and boosting investment in active mobility. A new ITF Working Group is currently developing recommendations for sustainable accessibility (ITF, n.d.[57]).

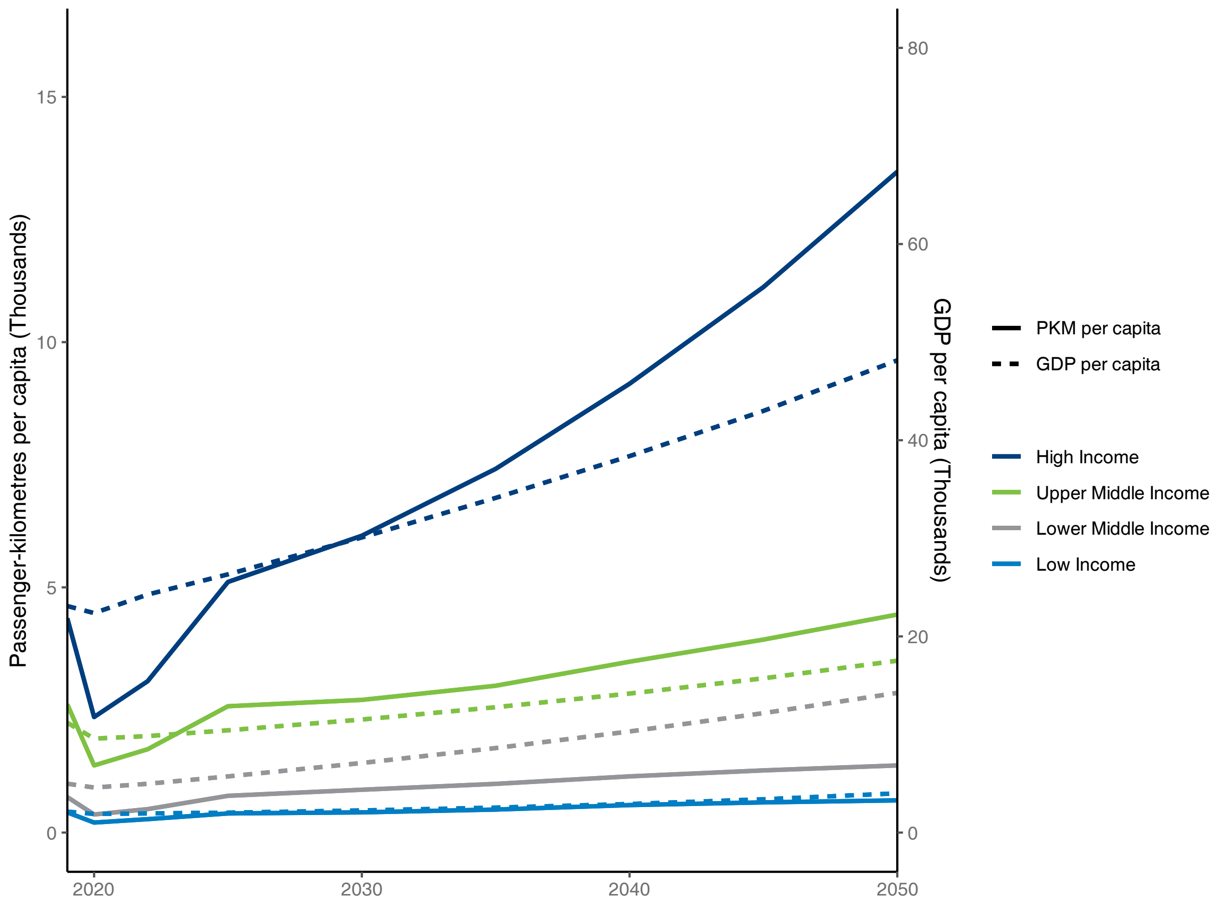
International and intercity travel: Growing incomes, more trips

Inhabitants of high-income regions will be responsible for most intercity and international demand between 2019 and 2050 under both policy scenarios. ENEA, Europe and UCAN account for more than two-thirds of all international and intercity passenger-kilometres over time and across both scenarios.

As Figure 3.15 illustrates, the average person living in a high-income global region (e.g. ENEA, Europe or UCAN) in 2019 generated nearly 5 000 passenger-kilometres through international and intercity travel. This equals 67% more demand than the average person living in an upper-middle-income region such as LAC, or more than 10 times that of the average person living in the low-income region of SSA.

Under the Current Ambition scenario, inhabitants of lower-income regions will slowly bridge the gap in international and intercity passenger demand with those living in higher-income regions, mainly driven by increases in per-capita GDP.

Figure 3.15. Per-capita gross domestic product and passenger demand for intercity and international transport in income-based global regions under the Current Ambition scenario



Note: PKM: Passenger-kilometres. GDP: Gross domestic product. Income classifications based on the World Bank's *World Development Index*. A reporting region is denoted as "Low-income", "Lower-middle-income", "Upper-middle-income" or "High-income" based on the World Bank category into which the majority of the economies in the region fit. GDP data are ITF estimates based on the OECD-ENV linkages model.
Source: World Bank (2022[58]). OECD ENV Linkages model: http://www.oecd.org/environment/indicators-modelling-outlooks/modelling.htm.

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In lower-middle-income and low-income regions, per-capita GDP will grow by factors of 3 and 2, respectively. This growth will go together with proportional increases in per-capita travel demand. However, demand in high-income regions, including ENEA, Europe and UCAN, will also continue to rise. Under the Current Ambition scenario, demand will roughly triple by 2050 in high-income regions.

The High Ambition scenario includes demand-management measures such as ticket taxes for aviation and, more generally, carbon pricing. It also assumes the introduction of a short-haul flight ban for flights of less than 500 km where a rail alternative of reasonable quality exists. These measures decrease the attractiveness of carbon-intensive modes. By 2050, aviation-related passenger-kilometres will be lower under the High Ambition than the Current Ambition scenario for all regions. Parallel to this, the High Ambition scenario increases the adoption of railways in all world regions compared to the Current Ambition scenario.

The potential for mode shift in international and intercity travel depends on trip length

Passenger cars and aircraft are the main overall modes used for international and intercity travel (see Figure 3.16) but are also more carbon-intensive than other modes. Therefore, shifting transport activity to more sustainable modes, where feasible, could reduce emissions. However, the predominant mode of travel varies depending on the trip length, and alternative modes are not always realistic.

Rail and car are the most prevalent modes for short-distance trips of less than 500 km. People strongly rely on the private car for middle-distance trips (between 500 km and 3 000 km) under both the Current Ambition and High Ambition scenarios. In contrast, air transportation accounts for most long-distance activity (i.e. trips longer than 3 000 km). In reality, although mode shift is a frequently cited policy objective, the switch to lower-emitting forms of transport has been slow to materialise (ITF, 2022[59]).

Intercity and international trips of less than 500 km show the greatest variety of modes used, with rail transport, ferries, cars and motorbikes, buses and aviation all present in the modal mix. Even in 2019, collective surface transport modes met considerably higher shares of travel demand in this distance category, with around 29% of demand carried by intercity buses and a further 21% carried by rail. By 2050, collective surface modes could cover more than half of demand under both scenarios. Promoting mode shift for trips shorter than 500 km is more relevant in some regions than others.

Aviation is the most carbon-intensive transport mode. This reality makes a shift away from air travel a frequent candidate for intervention in decarbonisation discussions. Given the prevalence of alternative modes for short-distance trips, the High Ambition scenario for this Outlook includes a policy banning direct flights for distances shorter than 500 km where a good-quality rail alternative exists. Some countries are already considering such a measure to tackle carbon-intensive short-haul travel. For example, the European Union recently approved France’s banning of some domestic flights (EC, 2022[60]), although this measure only impacts three routes at present (Eccles, 2022[61]).

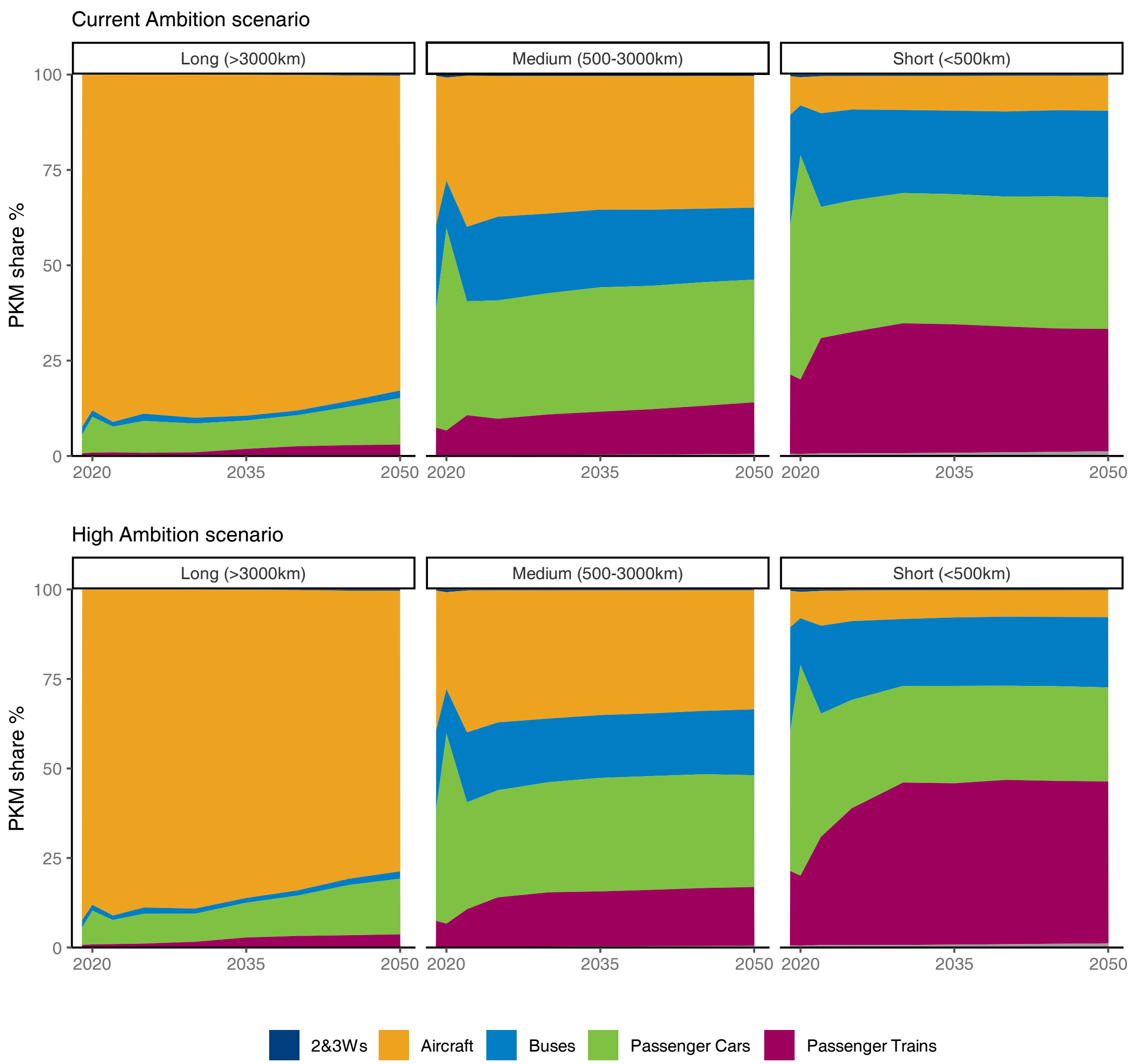
Implementing such a short-haul flight ban could potentially shift 49% of passenger-kilometres generated by short-haul flights to rail by 2050. However, reaching this figure relies on further expansion of the global rail network and improvements in the quality of intercity routes and connections between central railway stations and airports. This Outlook assumes that the global rail network expands to supply all viable connections from a demand and cost perspective, leading non-urban rail passenger-kilometres to increase by a factor of 2.8 between 2019 and 2050.

The effectiveness of a short-haul flight ban measure also varies by region. The highest potential impact could occur in ENEA, Europe and UCAN, where countries have, or plan to invest in, existing rail networks, meaning that availability and quality will increase over time. In these regions, the potential impact rises to roughly 64% of short-haul flight passenger-kilometres. In other regions, the lack of rail infrastructure presents a barrier to this measure taking effect.

Furthermore, short-distance travel accounts for less than 11% of international and intercity trips, and short-haul flights are 2.6% of total passenger-kilometres for air. Therefore, shifting passengers from short flights to rail would only affect 1.2% of the total passenger-kilometres generated by air travel. This result is based on the application of a ban when a reasonably low bar of good quality rail is available. If a high-speed alternative were required for the flight ban to take effect, the proportion of passenger-kilometres of short-haul flights affected would fall further to 3%, representing just 0.1% of total air passenger-kilometres.

The High Ambition scenario assumes investment in rail of a standard sufficient to meet the threshold for the short-haul flight ban. However, emerging economies will require funding to support infrastructure development measures contributing to mode shift for medium and short intercity and international transport. The infrastructure gap in developing regions currently affects how much they can shift demand towards more sustainable collective surface modes for short-distance intercity travel.

Figure 3.16. Intercity and international passenger mode share for various distances under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. 2&3Ws: Two- and three-wheelers. PKM: Passenger-kilometres. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

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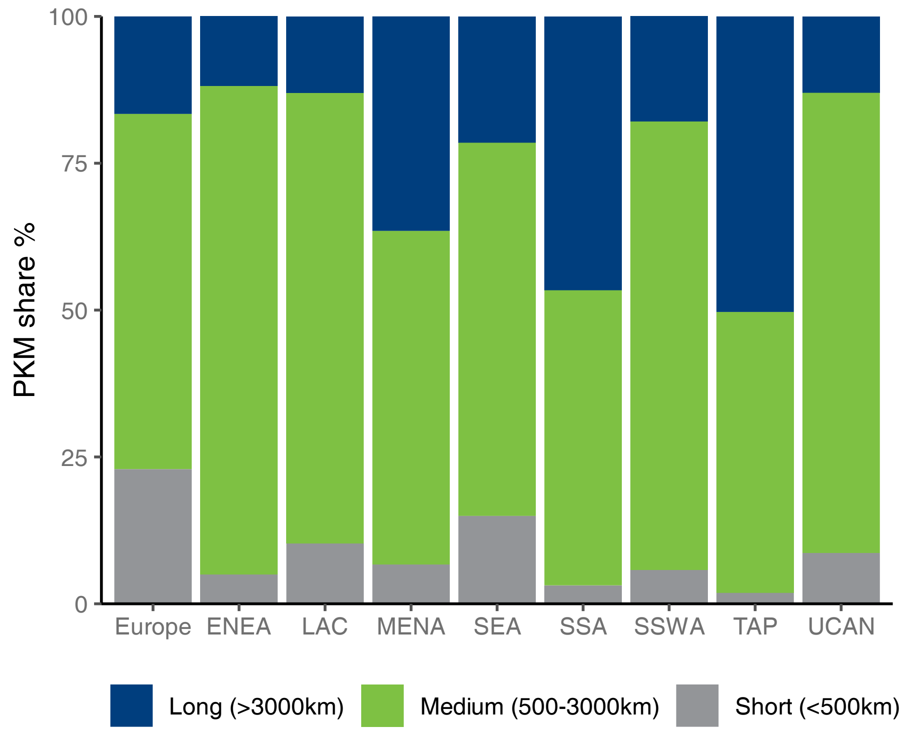
Bangladesh, for instance, has identified a USD 124 billion financing need to support its conditional and unconditional transport mitigation measures, as part of its Nationally Determined Contribution (NDC). Almost 90% of this financing would require international support, while around one-third of that support would need to target measures to improve intercity connectivity by surface collective sustainable modes, including railways (SLOCAT, 2022[62]). Increasing the funding available is essential to ensure that developing regions can achieve the potential decarbonisation savings and benefits offered by shifting demand towards more sustainable modes.

Figure 3.17. International and intercity travel demand by region under the Current Ambition scenario in 2050



Note: Figure depicts ITF modelled estimates. PKM: passenger-kilometres. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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The need to decarbonise aviation becomes apparent when considering that most of the world's international and intercity long-distance travel is limited to air. Mode-shift policies become less applicable as trip distances grow, and fewer viable alternative modes exist. Decarbonising long-distance travel can only be achieved by reducing either vehicle emissions or the travel itself, which has potential equity impacts. Figure 3.17 presents intercity and international demand for various regions, by trip distance, in 2050.

As Figure 3.17 highlights, medium-length and long-distance travel – where aviation and car travel dominate – will account for the majority of the demand in most regions. The figure also reflects the fact that a higher share of international and intercity travel in many emerging regions occurs in the longest distance category. Furthermore, trips of more than 3 000 km account for half of intercity and international demand in some world regions. However, these trips are generally only taken by air transport, eliminating the possibility of shifting demand to other modes.

Passenger-kilometre reductions could be promoted by substituting trips for shorter ones (e.g. through a shift towards more local tourism) or eliminating travel needs altogether (e.g. by replacing business trips with teleconferencing). However, such measures have potential consequences for people and countries, particularly those reliant on tourism, economic development and air connectivity. If passenger travel is to grow without a corresponding rise in emissions, it becomes imperative to accelerate the technology and fuel transition of aviation and road fleets to low- and zero-emission modes (see Chapter 4).

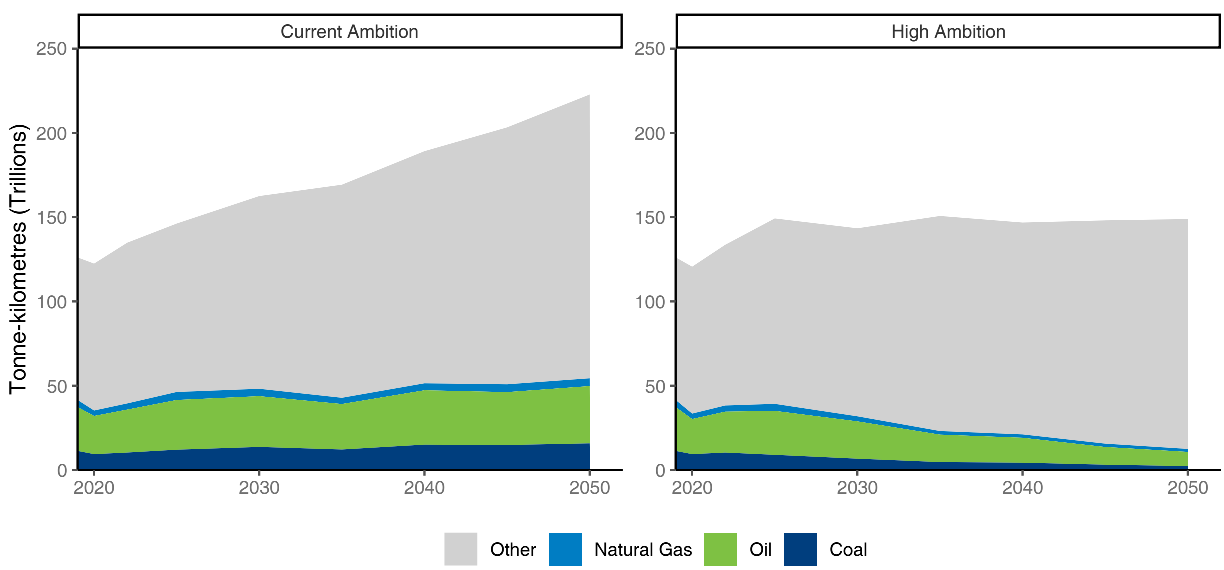
Non-urban freight: Policies to improve efficiency and sustainability

Non-urban freight demand will increase by 52% between 2019 and 2050 under the High Ambition scenario and by 95% under the Current Ambition scenario. Under the High Ambition scenario, ambitious policies aim to improve the operational efficiencies of freight activities to avoid unnecessary travel. Furthermore, transport activity can be avoided if countries act on their commitments to phase out fossil fuels. Pricing measures will also be important to facilitate mode shift wherever possible. Overall, tonne-kilometres under the High Ambition scenario are 22% lower in 2050 than under the High Ambition scenario.

The energy transition has cross-sectoral benefits

The reduction in tonne-kilometres is not entirely due to transport policies. The phasing out of fossil fuels would reduce the emissions associated with the extraction and burning of those fuels, and the freight movements associated with the fossil-fuel supply chain. Under the Current Ambition scenario, the trade assumptions would lead to a growth in the volume of fossil fuel extracted and moved (see Figure 3.18). Under the High Ambition scenario, the overall amount of fossil fuels carried in 2050 is only one-third of what it would be under the Current Ambition scenario. This sharp decrease would help reduce tonne-kilometres travelled, even as volumes of other commodities grow.

Figure 3.18. Tonne-kilometres of fossil fuels carried under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates based on the OECD ENV-Linkages model. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. Commodities exclude non-energy products derived from fossil fuels, such as bitumen.
Source: Data are based on the OECD ENV Linkages model, http://www.oecd.org/environment/indicators-modelling-outlooks/modelling.htm.

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Intelligent transport systems and high-capacity vehicles can improve efficiency

Improving operational efficiencies can help avoid unnecessary non-urban freight movements, decreasing emissions and costs by reducing the vehicle-kilometres associated with transporting tonne-kilometres. Examples of such improvements include using higher-capacity vehicles that transport the same volume of goods in fewer vehicles, asset sharing, and reducing the number of vehicles that run empty. The High Ambition scenario assumes policy measures and intelligent transport systems (ITS) are introduced that enable increased asset sharing and the use of high-capacity vehicles (HCVs).

Asset sharing (the sharing of resources such as vehicles or ware houses, for example) could increase full truckloads and decrease overall empty travel, depending on initial load factors, previous operational characteristics and the commodity type being transported (Venegas Vallejos, Matopoulos and Greasley, 2022[63]; Ballot and Fontane, 2010[64]). Asset sharing is beneficial for optimising the use of cubic space in vehicles and ports and consolidating freight activity. Beyond its space-capacity benefits, asset sharing can also maximise the use of the weight capacities of vehicles, thereby increasing transported tonnes.

Digitalisation can support asset sharing but will require collaboration between sector actors to provide flexibility for shippers and carriers, and better data (ITF, 2022[65]). The High Ambition scenario also assumes higher investments in information and communication technologies and systems for improving the efficiencies of freight transport operators. These types of investments can increase load factors – for example, by optimising routing to decrease travelled distances (GeSI and Accenture, 2015[66]; Samaras et al., 2016[67]; Lewis, Le Van Kiem and Garnier, 2019[68]).

Optimising freight operations can also risk producing a rebound effect leading to trade growth and increased freight activity. However, the scale of the rebound is estimated to be less than the overall benefit produced through the measures (ITF, 2019[69]). Nevertheless, governments should consider cross-sector asset-sharing approaches that encourage a shift to lower-emission freight modes such as rail. This approach would also require improvements to freight interchanges to reduce intermodal dwell times and transit times.

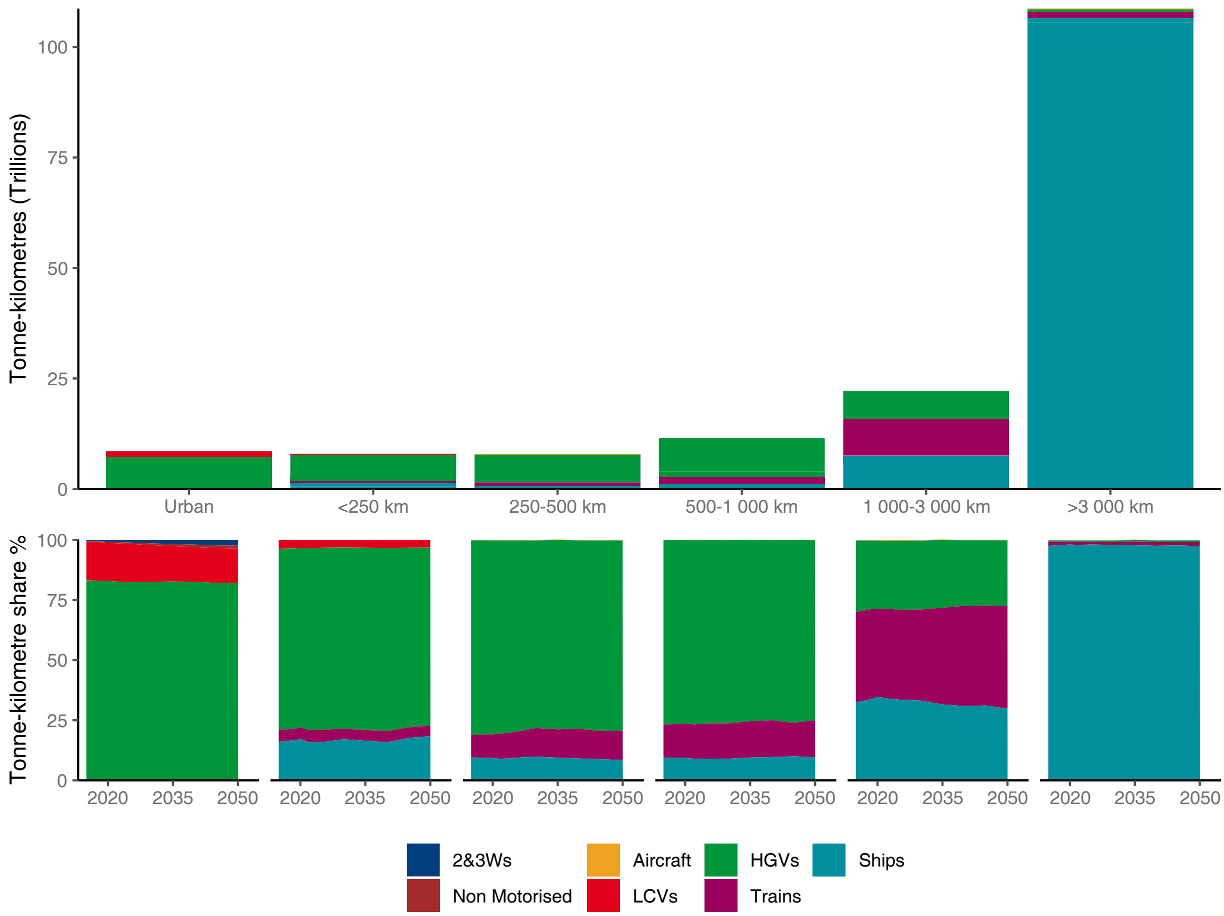
HCVs increase the possibility of reducing emissions by lowering fuel consumption and emissions per unit of cargo transported. Using such vehicles also reduces the truck movements required to move the same amount of freight, resulting in HCVs contributing to reduced nitrous oxide emissions, and lower road and bridge wear (provided the trucks used have a higher number of axles to avoid overloading). There are some concerns about the risk of mode shift to road from rail if HCVs are introduced and rail becomes less cost-competitive. Studies suggest the mode shift to be somewhere in the region of 1.2-1.8%, but with a net social benefit. However, real life experience, and *ex-post* analysis, is limited so far and further research is needed (ITF, 2019[69]).

The combination of ITS with HCVs can improve monitoring and enforcement, which will be important in generating public support for the measures. Furthermore, targeting the roll-out of HCVs to routes with appropriate infrastructure and fewer competing modes can also help to reduce barriers to their implementation. However, even so, the introduction of these vehicles will rely on buy-in from, and collaboration among, many different “stakeholders from industry, transport companies, forwarders and politicians” (ITF, 2019[69]).

Adopting a coherent approach to pricing measures across modes

Maritime transport carries the majority of tonne-kilometres of freight and is overwhelmingly the main mode for distances of more than 3 000 km (see Figure 3.19). This result applies to both scenarios through to 2050. Freight trains and maritime transport modes carry the highest share of tonne-kilometres travelling in the 1 000-3 000 km range, while road transport prevails for all shorter trips.

Figure 3.19. Freight demand in 2050 by mode, distance and share under the High Ambition scenario



Note: Figure depicts ITF modelled estimates for tonne-kilometres by trip distance in 2019 and mode shares between 2019 to 2050 under the High Ambition scenario. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. 2&3Ws: two- and three-wheelers. HGVs: Heavy goods vehicles. LCVs: light commercial vehicles.

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Even with higher policy ambition, road-based transport will continue to dominate medium- and short-haul transport by 2050. For distances between 250 and 3 000 km, road-based transport would account for more than half of tonne-kilometres. High shares for road-based transport, especially over shorter distances, are expected. This is due to the fact that existing investments in expansive road networks give road-based modes higher flexibility for freight operations than alternative modes, which are more constrained by limited infrastructure.

Aviation, generally the most expensive of the available modes, carries the fewest tonne-kilometres and is most prevalent for distances greater than 3 000 km. Most high-value and time-sensitive long-distance shipments travel by air, as aviation is the fastest available transport mode. However, despite accounting for less than 1% of non-urban freight tonne-kilometres, aviation was responsible for nearly 11% of the associated CO_2 emissions in 2019.

In contrast, maritime transport emits just over 40% of CO_2 emissions associated with non-urban freight, despite carrying approximately three-quarters of the tonne-kilometres in 2019. Rail has the smallest share of emissions in 2019 (about 2%) and in the future (remaining at roughly 2% in 2050 under the High Ambition scenario or nearly 4% under the Current Ambition scenario). The share of total tonne-kilometres carried by rail increases by 6 percentage points under the High Ambition scenario compared to the Current Ambition scenario. However, as a share of total tonne-kilometres, freight trains still only carry 14%.

Pricing measures are a mechanism to help ensure users carry the actual costs of road use, including negative externalities such as carbon emissions, congestion, and air-quality impacts. While different modes have different externalities, the negative externalities of road transport are "generally higher than [those of] other modes" (ITF, 2022[70]). They also help to ensure that the most sustainable, viable mode is chosen for each multimodal transport logistic chain segment.

Road pricing can encourage greater efficiencies in freight, reducing overall road-based tonne-kilometres. One study estimated that introducing a distance-based toll in the Netherlands decreased road tonne-kilometres by up to almost 5%, depending on the pricing scenario (de Bok et al., 2022[71]). Charges could also partially mitigate declining fuel taxes (OECD, 2019[72]).

The non-urban freight sector demand is relatively inelastic to cost changes. The mode choice depends on many factors, including distances, quantities, available infrastructure, commodity types, and costs. As a result, the various mode alternatives are not perfect substitutes for one another. The modelling results for this Outlook suggest that there is some room for mode shift but that, by and large, certain modes are best suited to certain routes and commodities.

However, modest changes in mode share can still be significant for decarbonisation. The various modes have very different emission factors, and small changes in mode share can result in higher reductions in the tank-to-wheel emissions associated with this demand. Nevertheless, interventions to encourage mode shift still need to be coherent across all modes to be effective. They should be consistent with each other. For example, offering subsidies for rail while giving fuel-tax exemptions for road transport should be avoided (ITF, 2022[70]).

The High Ambition scenario assumes two pricing measures for freight: carbon pricing and distance-based pricing. For the purposes of the modelling, some level of carbon pricing was introduced across all transport activities (i.e. not just freight transport), while distance-based pricing was only introduced for road freight.

To test the impact of different cost changes on tonnes carried by the different modes, the costs for each mode were incrementally changed (decreased, then increased) relative to the High Ambition scenario. Cost variations ranged from -50% to +50% on each mode individually to observe the impact on mode choice. It should be noted that this testing assumed the same freight demand and looked at the distribution of tonnes across modes. However, further work would be needed on pricing to investigate the impact of cost increases on demand patterns (e.g. regionalisation and trip length).

The results (see Table 3.2) show that all modes are inelastic to varying degrees, except when road transport is underpriced relative to all other modes. Under these conditions, road transport modes will attract a greater proportional freight volume. The modelling results suggest that pricing measures for road freight could influence the choice of road transport, and could help ensure the most sustainable, viable mode is chosen. Among the remaining modes, rail is more responsive to price changes, but only becomes responsive when rail costs are 50% lower than those of the High Ambition scenario and all other modes remain unchanged.

Table 3.2. Elasticity of demand of freight volumes (in tonnes) carried by different modes

Mode	Cost change relative to High Ambition scenario	Change in tonnes carried compared to High Ambition scenario	Elasticity of weight carried
Air	-50%	+34%	0.59
	+50%	-14%	0.30
Rail	-50%	+56%	0.88
	+50%	-4%	0.08
Road	-50%	+116%	1.47
	+50%	-32%	0.75
Sea	-50%	+2%	0.04
	+50%	-5%	0.10

Note: Table depicts ITF modelled estimates.

Pricing also has a potential role in multimodal freight journeys, particularly regarding the access mode used for ports. Testing of cost variations shows (see Table 3.3) that the access modes used for maritime freight are more elastic than the shipping itself. In other words, on the one hand, the choice to rely on maritime shipping remains stable. However, on the other hand, deciding whether to access a port via a waterway, road or rail connection depends significantly on the availability and costs of alternative options.

This finding is particularly true for choices between road and rail-based modes, where cost changes in either mode affect the tonnage carried by the other to access ports. In certain regions, measures that ease the use of multimodal supply chains combined with efficient road pricing could encourage higher use of more sustainable modes to access ports.

Sensitivity testing on the High Ambition scenario suggests that the weight of freight accessing seaports by road could be halved in 2050. Rail and waterways would pick up the remaining tonnage if 1) the cost of road freight relative to other modes increased further, and 2) governments delivered on the rail investments foreseen in the High Ambition scenario.

Table 3.3. Elasticity of freight volumes (in tonnes) carried by different access modes

	Direction of cost change	Elasticity of weight carried
Sea accessed by road	Decrease	0.48
	Increase	0.81
Sea accessed by rail	Decrease	1.65
	Increase	1.23
Sea accessed by water	Decrease	2.12
	Increase	1.02
River	Decrease	0.21
	Increase	0.05

Note: Table depicts ITF modelled estimates.

Policy recommendations

Take a long-term view of urban development and adopt integrated approaches to transport and land-use planning to avoid future sprawl in growing cities

Authorities should integrate land-use and transport planning to create more compact cities where people have greater access to opportunities close to where they live. This can help avoid urban sprawl and support the emergence of sustainable mobility modes as attractive choices.

In regions with high urban density levels, such as Europe, authorities could focus on improving the quality of collective and active transport services. In regions where high urban sprawl limits the reach of densification policies, such as UCAN, authorities can foster sustainable alternatives to private vehicle use for longer-distance intra-urban trips. In regions where cities are still developing and growing, such as MENA and SSA, there is an opportunity to avoid car-dependent cities with the right development and transport strategies.

Adopt holistic sustainable urban transport plans that combine investment, pricing and access or space restrictions to encourage sustainable choices

Authorities should promote shifts towards more sustainable modes by combining urban private vehicle access restrictions and pricing measures with investments in alternative sustainable modes. Investments should target infrastructure improvements for safer active and micromobility and better public transport infrastructure and services. This also includes encouraging emerging forms of shared on-demand services and vehicles, which should be co-ordinated with public transport services.

In both cases, services and investments should target the central and peripheral parts of urban areas. When setting urban access regulations, authorities will need to make an effort to ensure their public acceptability, for instance by integrating impacted communities in decision-making processes. Authorities should also aim to address adverse impacts on lower-income groups. Revenue raised through congestion pricing could also be reinvested in sustainable modes to aid equity and acceptability.

Support multimodal and sustainable transport networks

For passenger activities in the regions outside of cities, authorities will need to pay attention to evolutions in population densities. Future transport solutions in these contexts are likely to remain focussed on the passenger car and active mobility where appropriate. Passenger cars in uncongested areas, particularly EVs, have relatively low externalities compared to congested settings. However, in the regional context, achieving decarbonisation will not support accessibility if private cars alone continue to make up the majority of zero-emission vehicles. Therefore, new forms of on-demand services will need to be explored. In this context, authorities could help achieve their decarbonisation and accessibility goals by supporting pilots of emerging solutions. Authorities should also invest in active mobility infrastructure to make it safe and appealing outside urban areas.

Measures to manage intercity and international transport demand are limited in their scope and potential impact. Potentially higher-impact measures (e.g. shifting business trips to teleconferences or restricting tourism to more local options) can be challenging to implement and could negatively affect destination territories. Other alternatives include increasing the cost of – or banning – carbon-intensive short-haul flights. Such measures could also promote mode shift to railways, provided decent quality infrastructure is available.

The potential for shifting intercity and international passenger activities to more sustainable modes varies according to the distance. Authorities have more options to promote mode shift for trips shorter than 500 km because of the greater diversity of modes available. However, most intercity and international trips occur over longer distances – primarily by car or aircraft. Measures supporting shifts away from these modes include investing in railway infrastructure, reliable bus networks, and roads.

For freight transport, authorities can contribute to limiting unnecessary movements by supporting increases in carriers' operational efficiencies. Promoting carrier collaboration or using ITS tools to optimise routing and support asset sharing can increase occupancy rates. Properly regulated, high-capacity vehicles can also reduce vehicle flows. Finally, actions to phase out fossil-fuel consumption will also decrease related freight movements if countries act on their international commitments.

Authorities can also support mode shift for non-urban freight, especially at short distances. Road transport carries most freight for distances shorter than 1 000 km, mainly because of its higher flexibility. On certain legs, authorities could provide the conditions for shifts towards other mode alternatives, such as railways and inland waterways. Authorities and shippers will need to support improvements to multimodal interfaces. Examples of measures include setting up dry ports and other multimodal infrastructure, increasing digitalisation and asset sharing, and investing in inland waterways and railway networks.

Combine pricing measures in a coherent manner and allocate funds to sustainable modes

Policies to reduce emissions associated with passenger road transport should include a combination of pricing measures to capture the external costs of car use. Carbon pricing should be maintained for ICE vehicles, with rates per tonne of CO_2 increasing over time. In urban settings, where externalities associated with congestion are higher, congestion pricing should be introduced. Authorities should consider investing revenues from pricing measures into public transport and active mobility infrastructure. Parking pricing should also be set to more fairly capture the external costs of space consumption by static cars in densely populated areas.

Most freight transport modes are relatively inelastic, but coherent policies should be adopted to ensure that the most sustainable, viable mode is always chosen. Road transport is the only mode showing an elastic response to cost decreases. This suggests that measures such as pricing need to be introduced coherently with the same objective across all modes to ensure that road freight does not increase its mode share at the expense of other modes, particularly rail. Carbon pricing can help counteract the impact of fuel-tax exemptions and subsidies for fossil-fuel-based modes where they cannot be phased out. The latter should be phased out wherever possible.

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4 Cleaner fleets: The key to decarbonising transport

New propulsion technologies for vehicles and low-carbon alternative fuels make the greatest difference in reducing transport emissions between the Current and High Ambition scenarios. This chapter describes policy commitments and actions ("Improve" measures) that can lay the groundwork for the transition to zero-emission vehicles and fuels. Specific sections analyse the transition to clean road vehicles, the challenge of decarbonising aviation and maritime transport and the importance of accounting for regional differences.

In Brief

Ambitious timelines for zero-emission vehicles and alternative fuels must be met

A future where clean vehicles and fuels are commonplace is attainable. To reach the Paris Agreement goals, governments must implement policies to improve vehicles and the fuels that power them, and set very ambitious timelines for this transition. They should prioritise policies that interact with and multiply the benefits of measures to manage transport demand and encourage shifts to cleaner transport modes.

Accelerated actions on clean vehicles and fuels account for three-quarters of the difference in emission reductions between the Current Ambition and the High Ambition scenario. But implementation depends on policy support and funding, and also calls for greater cross-sector collaboration and co-ordination.

Progress on cleaner vehicles is already evident in many countries. A transition is clearly underway, with governments in some regions already making firm policy commitments. In fact, the world may have already reached the peak number of internal combustion engine (ICE) passenger vehicles in the 2020s, even under the Current Ambition scenario (which assumes countries honour existing commitments).

Several leading markets have set a target to sell only zero-emission vehicles (ZEVs) by 2035 for new passenger cars. This is not enough to decarbonise road transport: more governments and vehicle types must follow suit. The High Ambition scenario assumes all governments reach 100% ZEV sales targets for new vehicles by 2050. As the purchase-price gap between ZEV and ICE vehicles closes, policy incentives will need to become more targeted to achieve a more equitable transition.

Understanding fleet renewal rates and the global used-car trade can help policy makers identify interim measures for decarbonisation in different contexts. Governments will need to take a different approach to decarbonising larger vehicles such as buses and heavy-goods vehicles. Electric powertrains for heavy vehicles can maximise operational cost savings due to lower running and maintenance costs.

The aviation and maritime sectors are hard to decarbonise. The cost of CO_2 emission reductions is high and the pace of technological improvements slow. Alternative fuels will need to be more widely available and cost-competitive with conventional fuels. This requires targeted policy interventions.

Exemptions from fuel taxes for aviation and shipping work against the sector's goal to decarbonise. They should be discontinued. Carbon pricing will play a crucial role in addressing and removing these structural impediments. Closing the price gap between conventional and low- and zero-carbon fuels could also create sources of revenue for investments in the necessary infrastructure for decarbonisation.

Nevertheless, aviation and maritime transport will not decarbonise overnight. To maximise economy-wide emission savings, policy makers must prioritise alternative fuels in contexts where other measures (including full electrification) are not feasible, particularly given the competition for alternative fuels between industries.

Policy recommendations

- Set targets and collaborate across sectors to decarbonise all vehicle fleets.
- Target incentives and introduce access restrictions in cities for high-emitting vehicles to increase the uptake of zero-emission road vehicles.
- Deploy public charging infrastructure to increase the pace of adoption.
- Use pricing measures to improve the commercial viability of low-carbon alternative fuels.

The global transportation sector will need to implement a combination of technology improvements and measures to manage transport emissions and meet the goals of the Paris Agreement. This chapter looks specifically at what is needed to translate commitments to transition to cleaner fleets into meaningful actions, and the potential opportunities and challenges of this transition.

Using the popular “Avoid, Shift, Improve” paradigm, the chapter explores the transition to clean road vehicles, for both the passenger and freight transport sectors. It then moves on to examine the challenges involved in decarbonising the aviation and maritime transport sectors. For an analysis of (“Avoid” measures) and mode shift (“Shift” measures) measures, see Chapter 3.

Even under the High Ambition scenario, specific local contexts will limit the level of transformation using “Avoid” and “Shift” policies alone. Therefore, “Improve” policy commitments, focused on reducing vehicles’ and vessels’ reliance on fossil fuels, will be critical to decarbonisation. Adopting clean technologies and changing the energy sources to renewable alternatives is also essential, and will require cross-sector collaboration.

Improving vehicles and fuels: Take action now

The *ITF Transport Outlook t*racks the global transport sector’s carbon dioxide (CO_2) emissions over time. Figure 4.1 shows the total projected emissions from different vehicle types up to 2050 under the two policy scenarios explored in this report (see Chapter 2 for full descriptions).

Road transport vehicles – including passenger cars, two- and three-wheelers (2&3Ws), buses, light goods vehicles (LGVs) and heavy-duty vehicles (HDVs) – account for the majority of transport emissions under both the Current Ambition and High Ambition scenarios (see Figure 4.1). This dominance is most pronounced in urban areas for passenger transport and freight transport modes.

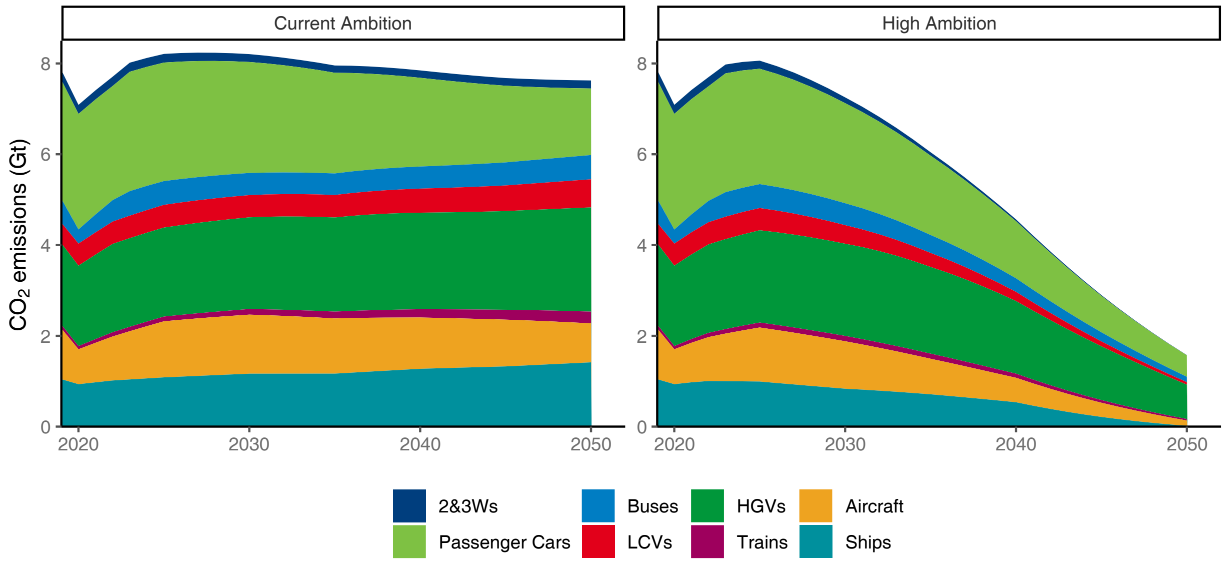
Measures that encourage shifts to cleaner transport modes are most feasible in urban contexts, where various mode choices are available. However, urban emissions only account for 32% of overall passenger CO_2 emissions and 28% of freight CO_2 emissions. Longer trip distances and non-urban transport contexts, where aviation and maritime modes dominate, have fewer options for mode shift policies.

The modelling for this edition of the Outlook also shows that, in the non-urban context, most commodities are already transported using the most cost-effective means (see Chapter 3). Therefore, efforts to decarbonise transport outside urban contexts will rely heavily on the evolution towards cleaner vehicles and fuels.

As governments start implementing policies to shift towards cleaner vehicles, aircraft and vessels, emissions from some vehicle types will start to decrease even under the Current Ambition scenario, but not at the pace required to reach the necessary emission reductions. As outlined in the policies making up the High Ambition scenario, a wider and accelerated adoption of cleaner fleets will be critical.

The pace at which the global fleet transitions to cleaner vehicles will rely on the availability of technology, which varies for different vehicle types. However, it also depends on the renewal rate of the existing vehicle fleet, investment in supporting infrastructure (e.g. electricity grid reinforcements and charging infrastructure), and strong regulatory measures or incentives to promote cleaner vehicles.

Figure 4.1. Emissions by vehicle type under the Current Ambition and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. 2&3Ws: Motorised two- and three-wheelers. HGVs: Heavy-goods vehicles. LCVs: Light commercial vehicles.

StatLink https://stat.link/2cqbkr

Policy makers considering more ambitious or accelerated actions to decarbonise their transport sectors also need to account for energy and technology supply-chain interdependencies. The global energy mix primarily relies on fossil energy and must move towards clean energy. In addition, grid reinforcements will be required, to ensure sufficient additional capacity is in place to support electrification.

Significant volumes of raw materials – particularly critical minerals for batteries – will be needed to meet the demand for technologies enabling the transition to cleaner fleets. Both the timing and levels of investment in mining, critical material production and manufacturing of clean energy technologies will therefore be crucial to the feasibility of the vehicle fleet transition (ITF, 2021[1]).

Transitioning to clean road vehicles: Essential and attainable

In both policy scenarios explored in this edition of the Outlook, road vehicles have the highest share of CO_2 emissions for the passenger and freight sectors, accounting for 71% of transport emissions in 2019 (see Figure 4.1). Trips by passenger cars and buses make up the majority of passenger activity in urban and non-urban contexts. Passenger cars account for 33% of emissions – the largest share of all vehicle types. Buses, by comparison, only account for 7% of emissions, despite supporting significant passenger demand. HGVs account for 23% of emissions in the transport sector, the second-most of any vehicle type. LCVs, by comparison, have a much smaller share of road emissions (6%).

The electrification of vehicles will play a decisive role in decarbonising transport. Increasing the share of zero-emission vehicles (ZEVs) reduces the carbon intensity of transport activities because they emit fewer emissions over their lifecycle than conventional powertrain technologies that use fossil fuels. Even with the current global average electricity mix, the lifecycle carbon intensity of electric vehicles is approximately 40% lower than fossil fuel-powered vehicles (ITF, 2021[1]).

Policy measures to support the transition to ZEVs (for example, measures aimed at decarbonising electricity grids) can help to drive further reductions in transport emissions. However, such policies must also tackle the effects of other emissions associated with a vehicle's lifecycle. These include emissions caused by fuel production and distribution, manufacturing processes and end-of-life disposal.

"Peak ICE" for passenger cars is in sight

Internal combustion engine (ICE) vehicles continue to form the majority of the passenger car fleet worldwide. However, many countries have already implemented policies that support an accelerated uptake of cleaner cars. One specific measure involves setting targets for low- and zero-emission passenger car sales. Based on existing policy commitments, ZEVs should make up one-quarter of the global passenger car fleet by 2035.

While the pace of adoption of cleaner vehicles varies by region, the global peak in ICE passenger car sales may have already been reached (see Figure 4.2). Although vehicle fleets should continue to grow under both scenarios, it is notable that the share of ICE vehicles in the global passenger car fleet is not expected to grow if current ambitions are met. By 2050, under the Current Ambition scenario, one-half of all passenger cars worldwide will be ZEVs. By contrast, under the High Ambition scenario, the share of ZEVs in the global passenger car fleet rises to more than 80% (see Box 4.1).

Box 4.1. High Ambition scenario assumptions about zero-emission vehicle adoption

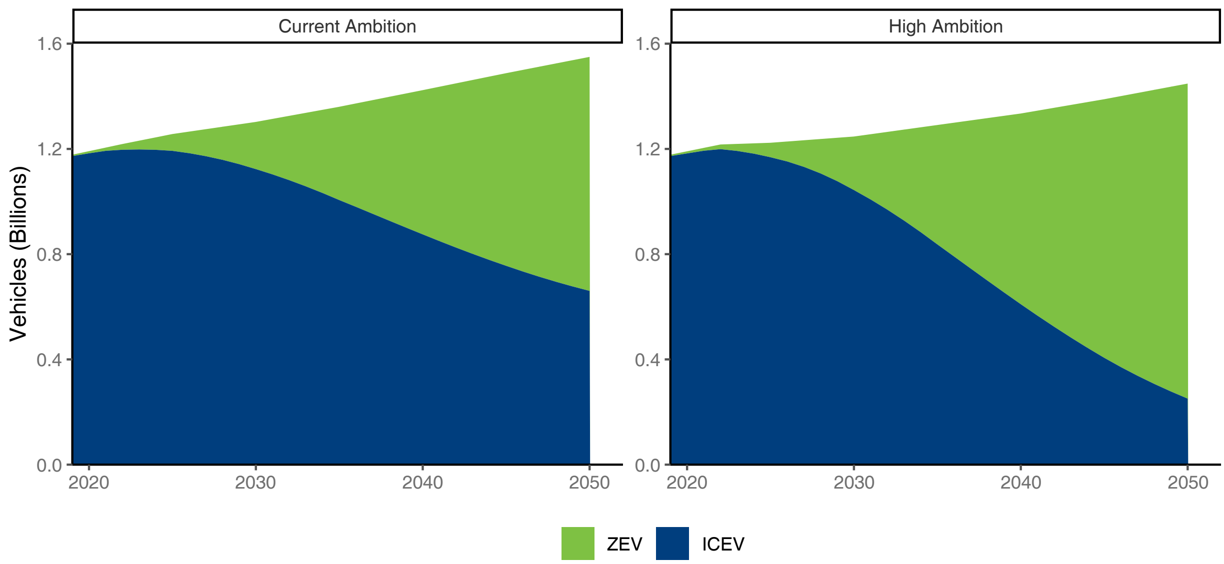
The results in this chapter assume that all newly manufactured vehicles entering emerging economies will be zero-emission vehicles (ZEVs) by 2040, in line with the Global Fuel Economy Initiative's highly ambitious zero pathway (Cazzola et al., 2021[2]). This pace of change assumes a lag between developed and emerging economies in reaching 100% of ZEV sales and recognises that not all countries will be able to transition at the same pace.

In many emerging economies, second-hand vehicles originating from developed economies make up a large share of newly registered vehicles entering the fleet each year. A recent report by the United Nations Environment Programme examined the second-hand vehicle import regulations of 146 countries worldwide, including provisions on bans, age limits, emissions standards and fiscal measures. Of the countries studied, 61 (mostly in Africa) had no import restrictions at all. A further 18 countries restrict the age of imported vehicles, with a maximum age limit of 9-15 years (UNEP, 2020[3]).

This Outlook assumes that used vehicles are exported to emerging economies with an average age of 15 years. This means a significant share of ZEV adoption in emerging economies will occur through second-hand exports from developed economies. Particularly strong growth in travel demand in emerging economies means that many sales will be for additional vehicles entering the fleet rather than replacing old vehicles through fleet turnover. This leads to a rapid growth in the share of ZEVs in the fleets of emerging economies. However, the global trade in used vehicles and its impacts on zero-emission technology uptake is generally poorly understood.

At the time of writing, work is underway at the ITF to better understand the scale of the used-vehicle market and its impact on the uptake of electric vehicles in emerging economies.

Figure 4.2. Global passenger car fleet by powertrain under the Current Ambition and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ZEV: Zero-emission vehicles. ICEV: Internal combustion engine vehicles.

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Several assumptions underpin the High Ambition scenario. One is the assumption that governments implement their policy commitments and that the 2030 Breakthrough Goals (see Chapter 1) are largely met. One of these goals is to reach 100% ZEV sales for light-duty vehicles (LDVs) in four leading markets (the People's Republic of China, the European Union, Japan and the United States) by 2035. Achieving this goal would result in a 30-40% share for zero-emission LDVs by 2035.

Of the leading markets identified in the 2030 Breakthroughs, only the EU has a policy aligned with this target: an agreement to phase out the sale of ICE vehicles by 2035 as part of the "Fit for 55" legislative proposals (EC, 2022[4]). The United States has an interim target of 50% sales share by 2030, which is included in the Current Ambition scenario. In April 2023, this target was increased to 60%. Japan also has a sales share target for 2035, but its policy includes non-plugin hybrid-electric vehicles, which are not classed as ZEVs (METI, 2020[5]).

Regarding sales shares, China and the EU are far ahead of other markets. China's passenger car fleet accounts for 73% of passenger cars in the East and Northeast Asia (ENEA) region. Sales of electric vehicles (EVs) already accounted for over 20% of total passenger cars in China in 2022 (EV Volumes, 2022[6]), a target initially expected to be reached in 2025 (Chinese State Council, 2021[7]). Meanwhile, the EU has also surpassed its 2025 target (European Environmental Agency, 2022[8]). The four leading markets identified in the 2030 Breakthroughs collectively accounted for over half of new passenger car sales in 2021 and have the power to accelerate the global ZEV transition through economies of scale.

Despite a handful of outliers (e.g. Canada, Korea and Norway), EVs accounted for just 1-3% of the passenger car fleet in 2022 in the remaining regions. Even in regions with supportive policies to accelerate the adoption of battery-electric vehicles (BEVs), there remains a lag in the pace of adoption needed to reach the level of decarbonisation set out in the High Ambition scenario. The current trajectory lacks the necessary ambition and concrete interim targets or defined pathways at a global level to achieve the emission reductions needed to reach the Paris Agreement target (UNFCCC, 2021[9]).

Based on current policy commitments, ICE vehicle sales after 2035 will primarily occur in emerging economies, entrenching a two-tier global passenger car market. This finding reflects limited policy support and a range of challenges related to grid reliability, purchasing power and charging infrastructure. Therefore, the transition to cleaner fleets will require interim measures in emerging economies. These measures include replacing old fleets, controlling second-hand imports, and introducing vehicle emission standards (where they are not already available).

A singular focus on passenger cars to transition to cleaner fleets is not a panacea. It can introduce other problems such as significant space consumption and congestion in the urban context. ZEV adoption in the urban passenger fleet is faster for cars than other vehicles (including 2&3Ws and buses). This is because policy incentives focusing on accelerating the adoption of BEVs for passenger cars have succeeded in many regions and form part of many countries' Nationally Determined Contributions (see Chapter 1).

As the gap in purchase costs between BEVs and ICE vehicles closes, blanket applications of purchase incentives for EVs should be reconsidered, as they may not align with the goals of a more equitable transition. Lower-income consumers tend to be more sensitive to price and may rely more on private vehicles for access to work opportunities. Progressive rebate levels based on income can have more equitable outcomes. They may also be more cost-effective than other types of incentives (DeShazo, Sheldon and Carson, 2017[10]).

While policy measures that aim to accelerate the adoption of cleaner passenger cars in urban contexts are important, they should complement measures that decrease passenger car use, such as parking and access restrictions. Policy makers might also consider purchase incentives for 2&3Ws, which have successfully increased their shares of the urban vehicle fleet in some contexts and consume less urban space. Similarly, the demand for electric bicycles (e-bikes) can be more elastic compared to ZEVs. Therefore, purchase incentives for e-bikes may also be more cost-effective and equitable than similar incentives for passenger cars (Bigazzi and Berjisian, 2021[11]).

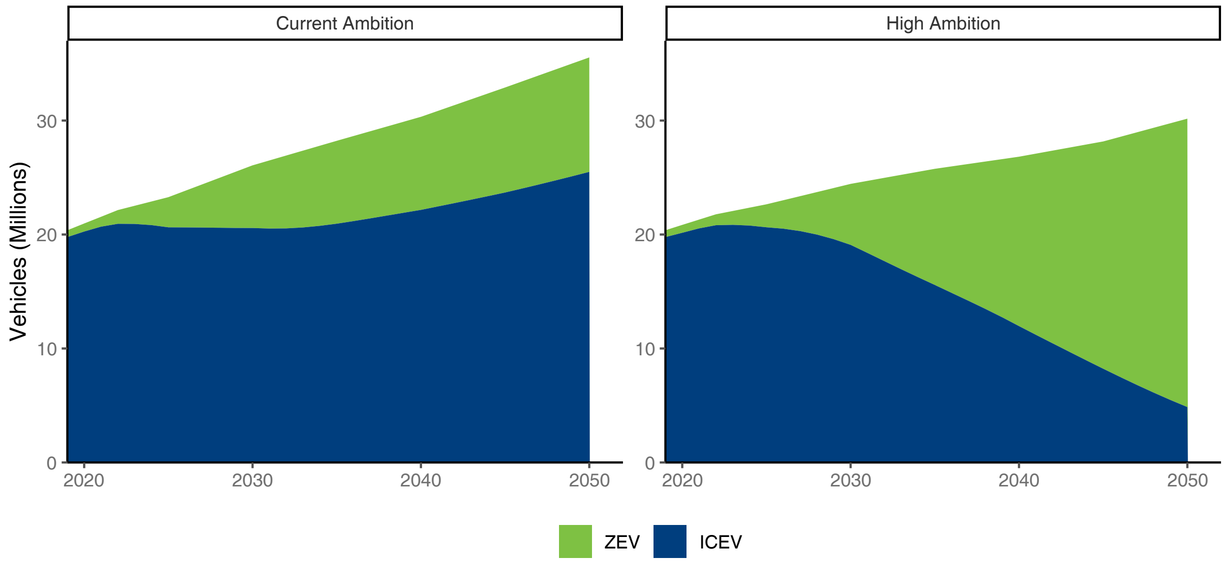
Collective and mass transit fleets offer an opportunity to advance lower-emission vehicles

Under the Current Ambition scenario, emissions from all urban modes (except passenger cars) are expected to increase due to increasing demand. However, while emissions from collective and mass-transit modes (i.e. passenger trains and buses) will increase, they deliver significantly lower CO_2 emissions per passenger-kilometre than passenger cars. Buses are three times as efficient as passenger cars on this metric, while passenger trains cause seven times fewer CO_2 emission per passenger-kilometre.

Around 30% of global track-kilometres are already electric (UIC, 2022[12]; RailwayPro, 2021[13]). However, fossil fuels power most of the world's bus fleets (see Figure 4.3). The main policy commitment targeting the decarbonisation of buses is a global memorandum of understanding (MOU) endorsed by more than 25 countries to reach 100% ZEV sales share for medium- and heavy-duty vehicles by 2040 (TDA, n.d.[14]). Other national and sub-national governments have committed to procuring only zero-emission public fleets. For example, a co-ordinated sub-national programme in India has sanctioned the procurement of over 5 000 electric buses, making it one of the largest markets for this type of ZEV (UITP, 2020[15]).

Latin America is also working towards cleaner bus fleets, with many cities accelerating their deployment of zero-emission buses, notably Santiago, Chile (Galarza, 2020[16]) and Bogotá, Colombia (Bedoya, 2021[17]). Nevertheless, based on existing commitments to transition to zero-emission fleets globally, only about one-quarter of global buses are expected to be battery-electric by 2050 (see Figure 4.3). Therefore, the Current Ambition scenario is far behind the 2030 Breakthrough target for buses, which sets a goal of 100% ZEV sales by 2030 in four leading markets (China, the EU, Japan and the United States). To reach the emission-reduction targets under the High Ambition scenario, buses must transition to low-emission and ZEV fleets.

Figure 4.3. Global bus fleet by powertrain under the Current Ambition and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ZEV: Zero-emission vehicles. ICEV: Internal combustion engine vehicles.

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Public and regulated collective modes offer policy makers direct pathways to influence fleet renewal with lower-emission vehicles and stricter vehicle standards for shared fleets. Urban bus fleets are a prime candidate for the transition to cleaner fleets. Specifically, these fleets are ideal for direct electrification due to their intensive and predictable daily usage. In addition, centralising the charging infrastructure for urban bus fleets is beneficial in dense and space-constrained urban settings.

Given the potential for electric urban bus fleets, the High Ambition scenario assumes over 80% of buses globally can be electric by 2050, resulting in significant decreases in emissions from these fleets in the urban setting. Achieving this goal entails introducing purchase incentives and more stringent emission standards for urban buses. These measures can be paired with infrastructure investments to improve operations in urban environments, such as dedicated lanes and other transit priority measures.

Given the share of passenger trips undertaken using informal public transport in emerging economies, replacing very old vehicles will significantly affect emissions. Therefore, scrappage schemes can accelerate the shift towards cleaner vehicles in these contexts. In addition, economic growth should lead to a shift to more formalisation of transport modes. This shift will bring urban bus fleets under the purview of regulation and standards that will enhance their emission performance.

Policy makers can also improve access to finance for fleet renewal by co-ordinating procurement, as was demonstrated in India, and targeting purchase incentives to savings and credit co-operatives or other small and micro-enterprises operating informal transport fleets. In non-urban settings, policy levers for decarbonising passenger transport activity are far more reliant on transitioning to a cleaner vehicle fleet due to the limited availability of alternative transport options. Policy incentives should target short- and long-distance coach operators in these contexts to renew their fleets.

Transport authorities can incorporate more stringent emission standards, and sustainability and emissions-related criteria, in procuring public and regulated collective vehicles. In concession agreements, they can also offer financial incentives to operators for deploying lower-emission vehicles or stipulate minimum requirements for the vehicles used by the successful bidder (ITF, 2020[18]).

Licensing regulations for taxis, private hire or shared fleets can also include emissions standards. For example, in the United Kingdom, Transport for London (TfL) has incorporated a “zero-emission capable” (ZEC) requirement for taxis licensed since 2018 and has phased out the licensing of diesel vehicles as taxis. Between 2018 and 2021, TfL licensed over 4 000 new ZEC vehicles, accounting for nearly 30% of the private vehicle hire fleet. As of 2023, all new private hire vehicles are expected to be ZEC (TfL, 2020[19]). A permitted maximum age of a vehicle used as a taxi is 15 years.

TfL has also introduced grants to support drivers in purchasing lower-emitting vehicles and is working with partners to install over 300 public rapid charging points (TfL, n.d.[20]). In Belgium, the Brussels-Capital Region has incorporated an “Ecoscore” in its regulations governing carsharing (Government of the Brussels-Capital Region, 2013[21]).

There is scope for a quiet low-carbon revolution in freight activity

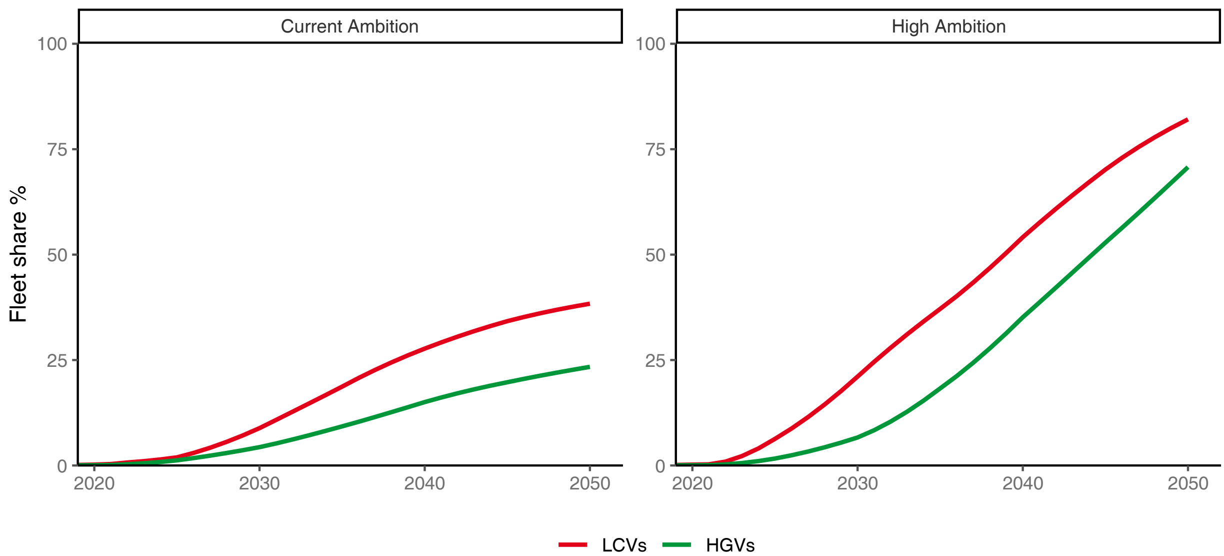
Decarbonising road freight has received less attention than passenger transport modes, but the ingredients are now in place for a quiet revolution in low-carbon logistics. Commercial vehicle operators primarily decide whether to replace their fleets with new vehicles based on financial grounds. EV technologies have developed so that many operational use cases will likely soon be cost-competitive with conventional fossil-fuel-powered vehicles.

The electrification of road freight is likely to begin with small vehicles and scale up gradually to the largest heavy trucks (see Figure 4.4). In many applications, LCVs produced at scale can already be cost-competitive with conventional diesel vehicles, given current battery prices (ITF, 2020[22]). Their operating conditions, which include high annual mileage and predictable range requirements, make them suitable for adopting electric powertrains, particularly in urban environments and over shorter trips. Electrification can maximise operational cost savings since running and maintenance costs are significantly lower than conventional vehicles.

In Europe, electric vehicles with a mass of more than 7.5 tonnes are likely to reach total cost of ownership (TCO) parity with conventional diesel vehicles in the 2030s (ITF, 2022[23]). However, policy measures to reduce barriers to adoption must be in place to solidify confidence in the transition and reduce uncertainty. The 2030 Breakthroughs set a sales target of 100% for HGVs by 2040 in leading markets (China, the EU, Japan and the United States). A total of 25 countries have signed the global MOU for medium- and heavy-duty vehicles, which mirrors this target (TDA, n.d.[14]).

The High Ambition scenario assumes that leading economies which have not yet signed the global MOU meet similarly ambitious targets and that all other countries meet the targets with a 10-year lag to account for contextual barriers. The result is a faster uptake of zero-emission freight vehicles in the High Ambition scenario compared to the Current Ambition scenario (see Figure 4.4).

Figure 4.4. Global shares of zero-emission heavy-goods vehicles and light commercial vehicles under the Current Ambition and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. HGVs: Heavy-goods vehicles, LCVs: Light commercial vehicles.

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With the appropriate policy action to solidify the business case for low-carbon road freight, ZEV uptake can accelerate its pace, as assumed in the High Ambition scenario. Policies to achieve the High Ambition scenario include purchase subsidies, road-user pricing measures, and carbon and fuel taxes. These policy instruments will need to evolve at different stages of the transition.

In the early stages, purchase incentives and road-toll exemptions for ZEVs can increase initial uptake and kick-start economies of scale to reduce purchase costs. These measures should also target smaller owner-operated enterprises to offset ZEVs' higher upfront purchase costs. In the urban context, freight activity overwhelmingly relies on motorised vehicles, even for first- and last-mile deliveries. Demand is also expected to grow, meaning that incentives for ZEVs will need to be balanced with urban space regulations to shift the activity towards zero-emission 2&3Ws and cargo bikes (see Chapter 3).

In later stages of the transition, policy instruments can shift towards measures that more proactively discourage the continued use of ICE vehicles, or ban new ICE sales altogether, to reach government-proposed targets. In addition to regional or national policies for phasing out the sale of new ICE vehicles, urban authorities can adopt measures to encourage faster adoption of cleaner vehicles.

Restricted access zones – also known as low-emission zones (LEZs) or environmental zones – limit the access of certain vehicles to specific areas to reduce pollution and other environmental emissions. Vehicles entering LEZs must meet certain emissions criteria or standards, depending on the design and objective of the zone.

A new generation of zero-emission zones (ZEZs) will emerge in the upcoming years as countries enact national regulations to promote the adoption of ZEVs in cities. In the past, the main objective of such zones was often to reduce pollutant emissions (e.g. particulate matter) by encouraging decreased traffic and renewed fleets (Ellison, Greaves and Hensher, 2013[24]). In the future, they can include reducing CO_2 in their focus to bring about vehicle fleet changes.

These policies, if enacted by urban authorities, can achieve dual benefits: reducing congestion that may result from the lower costs associated with operating ZEVs and prioritising collective and shared modes in urban environments. Chapter 5 goes into further detail regarding the co-benefits that can be achieved with cleaner vehicle fleets in urban environments.

Charging and refuelling infrastructure: Make or break

The pace of deployment of charging and refuelling infrastructure could create a bottleneck in the transition to cleaner vehicles and will require stronger commitment and investment from policy makers. Globally, there were approximately ten electric LDVs per publicly available charger in 2021, and just over 2.4 kilowatts of available electricity per EV. The global growth in charging infrastructure has mostly been driven by the high deployment of publicly available fast chargers in China (IEA, 2022[25]).

Installing an EV charging point can take up to one year, or much longer for fast chargers. As greater policy support leads to increases in BEV sales, there is, therefore, a risk of a growing gap between the number of BEVs on the roads and the number of publicly available charging points. While home-based EV charging will be an important part of the solution to this problem, public charging options will be necessary to reduce range anxiety.

Various governments have committed to investing in the necessary EV charging infrastructure through capital and operational subsidies, public-private partnerships, and developing regulations and pilot programmes. As a result, over 1.8 million publicly available EV charging points were already in place worldwide in 2021 (IEA, 2022[25]). However, reinforcing the electricity grid to support the expanding EV charging network will take time, as most countries still only have less than half of the power output required by 2030 to support electric fleets (Rajon Bernard et al., 2022[26]).

Deploying charging infrastructure also requires a network approach, including comprehensive standards and policy and process co-ordination across jurisdictions (e.g. between the transport, land-use and energy sectors). It will be important to ensure that infrastructure rollout does not delay the uptake of cleaner fleets. Therefore, policymakers must increase their understanding of user and operator requirements when planning for and funding EV charging solutions (ITF, 2022[23]).

For larger vehicle classes and longer-distance freight activity, the range requirements make charging solutions more complex. For other vehicles, including passenger cars, urban bus fleets and LCVs operating in urban environments, overnight charging can be sufficient. For public transport authorities and freight operators in these contexts, depot and warehouse charging can suffice. Instead, policy makers could target incentives at small and medium-sized enterprises, which may be slow to install infrastructure due to the capital costs involved (ITF, 2022[23]).

Where depot and warehouse charging are inadequate to meet the range needs, en-route public charging infrastructure will be required. Wired stationary charging is the most widely available option, but this may pose challenges for operations and delay the transition for long-distance coaches or freight operators who require flexibility in their operations. Charging infrastructure along vital corridors serving trips in non-urban settings will accelerate the transition to ZEVs.

For example, the US Federal Highway Administration (FHWA), through its Alternative Fuels Corridor (AFC) programme, designates an inter-state network of facilities for charging or refuelling vehicles using alternative fuels (e.g. EV charging or hydrogen refuelling). Through the AFC programme, the FHWA can work with public and private partners to deploy refuelling infrastructure in places that require collaboration between several jurisdictions. The programme also takes a network approach to providing refuelling infrastructure, which can alleviate range anxiety for users considering switching to ZEVs (USDoT FHWA, 2021[27]).

The European Commission's proposed alternative fuels and infrastructure regulation (part of the "Fit for 55" package) also includes mandatory requirements for recharging and refuelling infrastructure for road vehicles. Co-ordinated cross-jurisdictional approaches to deploying charging infrastructure can address major barriers that may otherwise delay the accelerated uptake of ZEVs. These barriers include grid capacity, complex permitting processes, land-use designations, and funding constraints.

Some jurisdictions are also considering electric road systems (ERS), which allow for the transfer of electricity between moving vehicles and the road, due to their potential benefits (in terms of reduced battery sizes for heavy-duty vehicles) and efficiency (compared to stationary charging). China, Europe and the United States are all testing different types of ERS. The capital costs of such systems are high but could potentially be the lowest cost technology pathway compared with high power stationary charging (Rogstadius, 2022[28]).

Recouping these costs will depend on the rate of utilisation of ERS. Cross-sectoral collaboration with the energy sector and across jurisdictions will be a prerequisite to successfully deploying ERS. As an example, France is exploring a national ERS roadmap, which would be similar to the network approach of the FHWA's AFC programme (Ministère de la Transition écologique, 2021[29]).

There is a potential financial risk of low utilisation in the early stages of ZEV adoption. Public road authorities can also explore concession agreements with private entities for ERS design, financing, construction, operation and maintenance to address this risk. Such agreements could be paired with road-pricing measures to finance the infrastructure, modified to target users of the ERS. The financial implications of deploying EV charging infrastructure are described further in Chapter 6 of this report.

A way to go: The challenge of decarbonising ships and aircraft

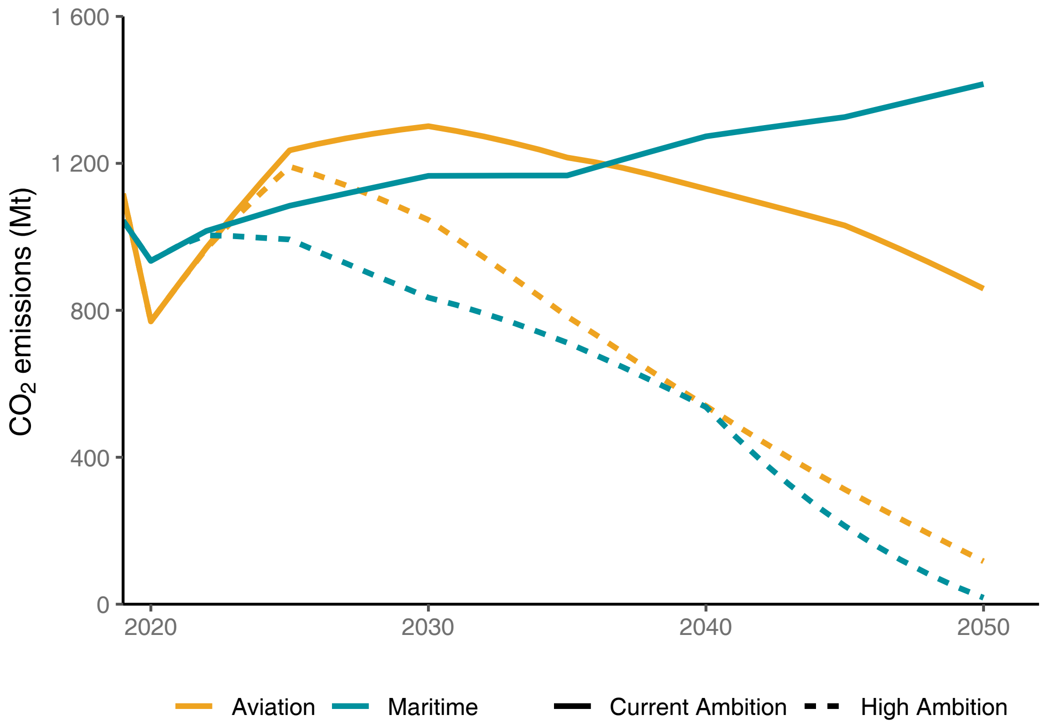
The aviation and maritime sectors are considered "hard-to-decarbonise" due to the high costs of emission-reduction measures and their comparatively low technological readiness. Furthermore, most emissions produced by ships and aircraft occur on long-distance journeys, which are difficult to electrify and require high-density fuels.

The aviation sector accounts for 14% of global transport emissions. Passenger and freight emissions from aviation are linked: nearly half of all air freight is transported in the fuselages of passenger aircraft (JADC, 2021[30]). By 2050, in the Current Ambition scenario, emissions from aviation are expected to decrease by 24% (see Figure 4.5). The main reason for this is the significant improvement in the carbon intensity of the fuel mix assumed in the Current Ambition scenario.

The Current Ambition scenario includes assumptions based on highly ambitious policies to decrease the carbon intensity of fuel, notably the EU's "ReFuel EU" policy and the Sustainable Aviation Fuel Grand Challenge in the United States. The policies envisage a massive scale up in the share of low carbon aviation fuels in their respective regions. These ambitious policies and continuing energy efficiency improvements to new aircraft are able to more than offset the strong increase in demand. The High Ambition scenario applies similar levels of ambition in decarbonising aviation fuels globally, rather than being limited to the UCAN and European regions.

While the maritime sector does not produce a significant share of global passenger emissions, it accounted for 29% of freight emissions in 2019. Under the Current Ambition scenario, maritime freight emissions will increase by 35% by 2050. (see Figure 4.5). These estimates are derived from a voyage-based assessment, which allocates emissions from the port of origin to the port of destination for shipping voyages. Increasing transport activity in the sector is the prime driver of these changes.

Figure 4.5. Aviation and maritime freight transport emissions under the Current Ambition and High Ambition scenarios, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

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Efforts to decarbonise the aviation and maritime sectors are expected to rely on the large-scale adoption of alternative low-carbon fuels, especially over longer distances (IEA, 2020[31]). Examples of such fuels include biofuels compatible with existing infrastructure and electrofuels (e-fuels), which are currently only in the early stages of development. Scaling up the production of alternative low-carbon fuels through targeted policy support will decrease costs and thus increase market penetration by reducing long-term uncertainties.

However, the emission-saving potential of alternative fuels depends on their production pathways. In the case of alternative fuels from biogenic pathways (biofuels), the carbon footprint needs to include indirect changes in land use, together with the electricity required for hydrogen production. For e-fuels, which are produced using electricity, the carbon intensity of the electricity mix determines the e-fuel's carbon footprint. Sourcing the carbon feedstock (e.g. direct air capture) and producing hydrogen (e.g. water electrolysis) require large amounts of energy.

Properly regulating the carbon intensity of alternative fuels will therefore be crucial to ensuring net emission savings compared to fossil fuels. Policy makers also need to introduce so-called additionality criteria to ensure the installation of new renewable energy capacities for hydrogen production rather than allocating existing green electricity, which would deteriorate the carbon intensity of the energy mix (ITF, 2023[32]).

Finally, there will be significant competition for alternative fuels between industries. To maximise economy-wide emission savings, policy makers must prioritise alternative fuels when cost and technology barriers make other technologies (e.g. electrification) unfeasible.

A significant constraint affecting the transition to zero-emission fleets for the aviation sector is the availability of technology that can be deployed at the scale required. The commercial viability of alternative fuels and energy sources is a more significant constraint for the maritime sector. To transition these sectors towards zero-emission futures, policy makers must explore a range of measures that can accelerate the development of technology solutions while targeting demand. Examples of such measures include investment in research and development, fuel-blending targets to reduce the carbon intensity of fossil fuels, and carbon-pricing measures to reduce the price gap between fossil fuels and alternative fuels.

Sustainable aviation fuels will be a mainstay of emission reductions

The aviation sector acknowledges that it needs to decarbonise. Both industry groups and governments have pledged to reach net zero by 2050. Representatives of the world's major aviation industry associations and largest aircraft and engine makers have done so via the 2021 "Commitment to Fly Net Zero 2050" declaration (ATAG, 2021[33]).

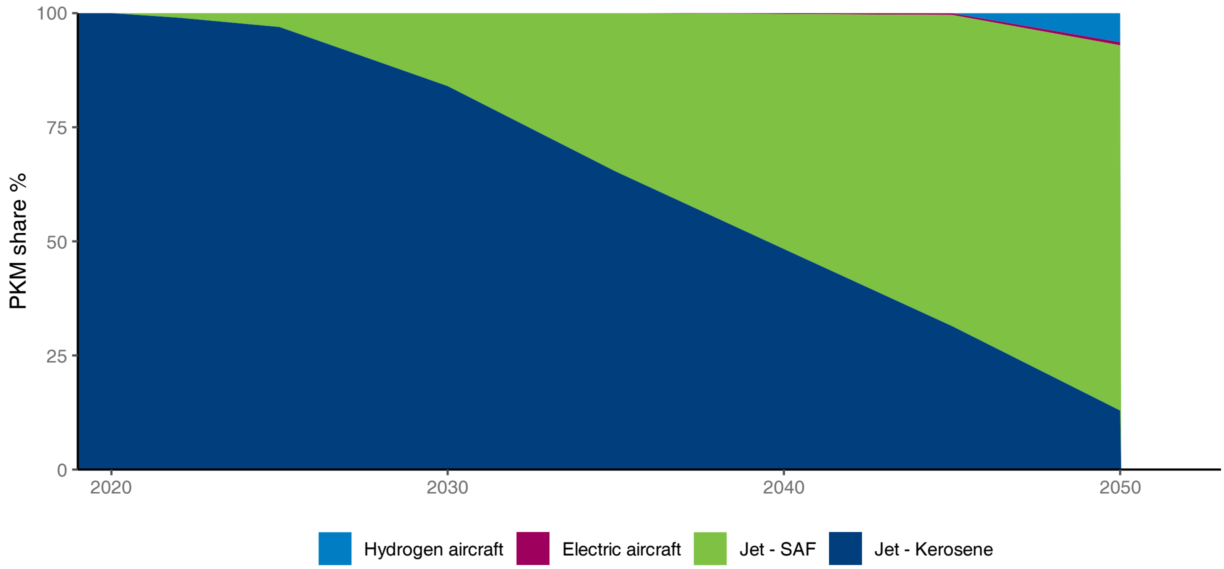
Meanwhile, governments have signed up to the 2022 International Civil Aviation Organisation (ICAO) long-term global aspirational goal for international aviation (ICAO, 2022[34]; IATA, 2021[35]). This net-zero goal is ambitious; reaching it will require several emission-reduction measures, including adoption of low-carbon drop-in fuels, more efficient aircraft and operations, novel propulsion technologies, carbon pricing and offsets for residual emissions (ITF, 2021[36]; ITF, 2023[32]).

The industry expects most emission cuts to come from sustainable aviation fuels (SAFs), which are liquid drop-in fuels compatible with existing aircraft. SAFs are produced from biomass or synthetically from hydrogen and captured carbon using a power-to-liquid (PtL) process. The most market-ready of the various types of SAFs are those produced using first-generation bioenergy. Such fuels could provide an emission-reduction option for the short term if produced from sustainable feedstock. Advanced bioenergy and PtL pathways generally offer larger emission savings but are in an earlier stage of technological development.

Today, SAF costs amount to many multiples of the costs of conventional kerosene, and the supply of SAFs also remains limited. This is why SAFs currently comprise less than 0.01% of the aviation fuels market (ITF, 2023[32]). Nevertheless, industry and policy announcements indicate a strong increase in the coming years. For example, the European Commission is preparing legislation that would lead to an 85% market share for SAFs by 2050 (European Parliament, 2022[37]).

The United States has an even higher target, and the government plans a full transition to SAFs by 2050. This is reflected in the assumptions for both policy scenarios in this edition of the Outlook. The High Ambition scenario also assumes increasing shares of cleaner fuels in compliance with more ambitious global SAF uptake (see Figure 4.6).

Figure 4.6. Share of aviation passenger-kilometres by propulsion technology and fuel type, High Ambition Scenario, 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. SAF: sustainable aviation fuels.

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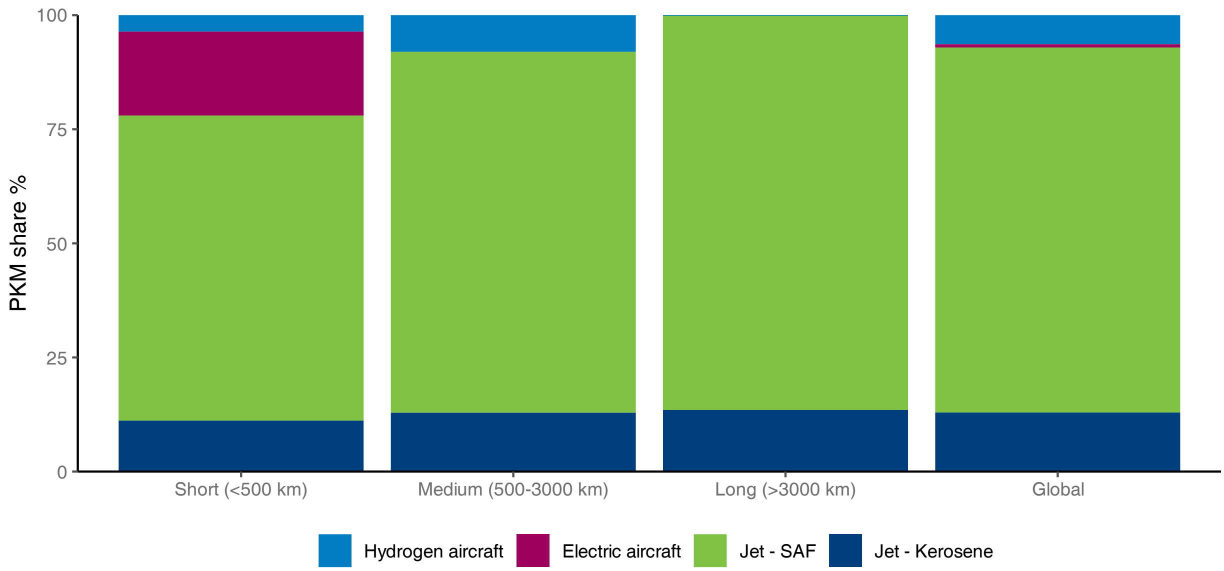
Hydrogen- and electric-powered aircraft use novel propulsion technologies and could complement conventional aircraft fuelled by SAFs in decarbonising the sector. Hydrogen aircraft can either use hydrogen combustion turbines (similar to conventional jet engines) or onboard fuel cells to convert hydrogen to electricity to propel the aircraft. Due to technological limitations, they are only viable for short- to medium-haul flights and are less likely to substitute for long-haul flights (see Box 4.2).

Several manufacturers are working on both hydrogen propulsion technologies and electric aircraft, which could enter the market in the 2030s. Although these technologies are currently unavailable, existing analyses estimate that under the High-Ambition scenario's rate of technology development, the maximum range of a hydrogen aircraft capable of transporting 165 passengers could be 3 400 kilometres, while the range of a battery-electric aircraft carrying 19 passengers could be 350 kilometres (Mukhopadhaya and Graver, 2022[38]; Mukhopadhaya and Rutherford, 2022[39]).

The High Ambition scenario explored in this edition of the Outlook also assumes an ambitious rate of technological development. Under this scenario, by 2050, hydrogen aircraft could account for an estimated 8% of global medium-distance passenger-kilometres and 4% of short-distance passenger-kilometres. Meanwhile, under the same conditions, battery-electric aircraft could account for 18% of short-distance aviation passenger-kilometres (see Figure 4.7). These figures cover a high share of flights, but only a small share of energy use and emissions in the sector, most of which come from long-distance flights.

However, the High Ambition scenario does not account for several challenges associated with novel aircraft propulsion technologies. These challenges increase uncertainty about when such technologies will become available. For example, airports would need to be equipped with new refuelling infrastructure to service aircraft fitted with such technologies. Implementing the technologies themselves could also require adaptations to current operating practices (ITF, 2023[32]).

Figure 4.7. Share of aviation passenger-kilometres by propulsion technology, fuel type and trip distance under the High Ambition scenario, 2050



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. SAF: sustainable aviation fuels.

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Incentives can assist the SAF industry in delivering the emission savings needed to reach the aviation sector's 2050 Net-Zero objective. Supporting an early scale-up of production and deployment can promote cost reductions today to assist mass adoption tomorrow. Strict requirements for transparent emission savings and other sustainability criteria would help safeguard the environmental performance of SAFs. In addition to their low-emission profile, SAFs provide opportunities for industrial development and increasing fuel-supply resilience. Countries investing in SAF production can create value at home and evolve from fuel importers to exporters (ITF, 2022[40]).

A switch to more efficient aircraft will complement the switch to SAFs. New aircraft generations are usually 25-30% more efficient than previous generation models. Airlines generally invest in more efficient aircraft to reduce fuel costs, while aircraft manufacturers introduce improvements, particularly in more efficient engines (Eurocontrol, 2020[41]). Improving the efficiency of existing aircraft technologies will remain important even as the market share of low-carbon fuels increases. This is because more efficient aircraft buffer against fuel cost increases related to the more expensive SAFs.

Reducing fuel use can prevent feedstock supply bottlenecks for SAF production. Improving aircraft operations can also reduce emissions from the sector. For example, pooling responsibility for air-traffic control between countries can support more direct flight paths. This operational improvement could reduce fuel use in Europe alone by 9-11% (Eurocontrol, 2020[41]).

Box 4.2. Modelling novel propulsion technologies and fuels for aviation

First presented in 2019, the ITF's non-urban passenger model simulates the development of transport activity, mode shares and carbon dioxide (CO_2) emissions for intercity and regional transport to 2050. The model divides the world into almost 1 200 zones, each with a city's airport or airports at the zones' centre. It then estimates passenger numbers, passenger-kilometres, mode combination, energy consumption and CO_2 emissions by mode for each zone and all routes between zones. The model covers the following transport modes: air, bus, ferry, rail and road (including cars and motorcycles). For air and ferry-based transport modes, only intercity activity data is available.

The model undergoes constant updates and improvements. For this edition of the Outlook, it has been adapted to better represent the use of novel propulsion technologies such as electric- and hydrogen-propelled aircraft, and sustainable aviation fuels (SAFs). The prospects for electric and hydrogen aircraft depend heavily on developing the respective technologies and costs. The availability of cheap renewable electricity and green hydrogen are prerequisites for scaling up both technologies.

Electric and hydrogen aircraft technological limitations, fuel efficiency and capital expenditure for aircraft replacement are crucial factors determining which conventional flights become replaceable. Carbon taxes also increase the cost advantage of electric and hydrogen aircraft over kerosene use in conventional aircraft. The prospects for SAFs depend on government and industry mandates that progressively enforce the use of fuel blends in routes supplied by conventional aircraft.

For each air route, the model assesses the optimal propulsion technology and fuel type every five years in three steps:

1. It verifies that the route complies with the technological limitations of electric and hydrogen aircraft (range and passenger capacity per flight).
2. When SAF mandates exist at the route origin, it updates the fuel cost of conventional aircraft to account for the added cost of using SAF.
3. It evaluates whether the fuel cost of conventional aircraft and carbon taxes exceed the costs associated with electric and hydrogen aircraft (capital expenditure and fuel costs). If so, new aircraft replace conventional ones on all flights that operate on the route.

The High Ambition scenario explored in this edition of the Outlook reflects more advanced aspirations for technology deployment, fuel mandate implementation, carbon taxation and evolution of fuel costs. In the High Ambition scenario, battery technology for electric aircraft reaches 500 watt-hours per kilogramme (Wh/kg), allowing 19-passenger aircraft to operate routes of 350 kilometres and 90-passenger aircraft to cover 300 kilometres by 2050 (Mukhopadhaya and Graver, 2022[38]).

Meanwhile, hydrogen aircraft with a capacity for 165 passengers and a range of 3 400 km are assumed to become available in 2035 (Mukhopadhaya and Rutherford, 2022[39]). However, high fuel costs relative to conventional kerosene (Mukhopadhaya and Rutherford, 2022[39]) and additional capital expenditure requirements compared to conventional aircraft could delay the widespread adoption of hydrogen-powered aircraft until 2050 (Fuel Cells and Hydrogen 2 Joint Undertaking, 2020[42]).

Access to low-carbon alternative fuels will be critical for shipping

Like the aviation sector, the maritime sector and its international regulator, the International Maritime Organization (IMO), recognise the need to reduce emissions from shipping and associated activities. The IMO's emission-reduction strategy, adopted in 2018, with a level of ambition of at least 50% lower absolute emissions by 2050, compared to 2008 (IMO, 2020[43]). The strategy identifies short-, medium- and long-term candidate measures to reach this level of ambition. Several other measures to improve new ships' energy efficiency have been in place since 2015, becoming more stringent every five years, while voluntary guidance on operational measures aims to improve efficiency.

The IMO also agreed on additional measures in 2021, including a technical requirement to improve the energy efficiency of existing ships and requirements for reductions in the operational carbon intensity of existing ships. However, the emission reductions resulting from these additional measures are not expected to be significant. They are not likely to contribute to efforts to reach the level of ambition stipulated in the IMO Initial GHG Strategy (ITF, 2022[44]).

The High Ambition scenario assumes a cleaner maritime fleet, achieved via the complete adoption of low-carbon alternative fuels for all shipping activity, in line with the 2030 Breakthroughs goal for 2050. It also assumes that 15-20% of shipping will be electric-powered, expanding on existing electrification projects in short-sea shipping and coastal shipping activities.

Like the aviation sector, the maritime sector must rely on a combination of measures to achieve the emission reductions outlined in the High Ambition scenario. These measures include low-carbon drop-in fuels, investments in zero-emission propulsion technologies (including wind power), onboard energy-efficiency measures, retrofitted vessels, and investments in port infrastructure. Policy makers will need to consider alternative fuels' availability and carbon intensities, the commercial viability of zero-emission ships, and the costs of supporting port infrastructure.

Although not yet widely used, there is increasing interest among shipping companies in low-carbon and alternative fuels. These include biofuels – widely used in road transport and compatible with existing technologies and infrastructures – and synthetic fuels produced from PtL pathways. While the latter can also be compatible with existing infrastructures and technologies, they are much costlier than other fuels and only at an early stage of technological readiness. Policy makers could explore fuel-blending mandates for drop-in fuels to ensure low-carbon alternative fuels are increasingly used in shipping and begin incentivising synthetic fuel development through support for research and development.

Methanol, which has been trialled in several pilot projects, is another promising application of low-carbon alternative fuels. It is compatible with modified conventional engines on its own or in conventional diesel blends. The IMO approved methanol in its Interim Guidelines for Low Flash Point fuels. Various shipping companies have ordered methanol vessels, and the fuel is available through existing infrastructure in various ports globally. However, given current production levels and techniques, the lifecycle emissions of methanol would be higher than conventional shipping fuels (ITF, 2023[32]).

These alternative fuels will only significantly contribute to decarbonising the maritime sector if the energy required for their production comes from low-carbon sources. Given the current high carbon-intensity of the production of these fuels, policy makers can play a role in addressing the production challenges. For example, increasingly stringent fuel standards could be introduced as part of a combination of measures to incentivise the use of alternative fuels. The FuelEU Maritime standard is one example and is similar to a proposal for a global fuel standard presented to the IMO (ITF, 2022[44]).

Policy makers can also work with private actors to establish an evidence base for new technologies and identify opportunities to bring feasible options to scale. For example, in 2015 the Norwegian government and shipping companies formed a public-private partnership, the Green Shipping Programme (GSP), to act as a test bed for decarbonising shipping. The programme has completed various pilot projects and continues to develop an evidence base for scalable solutions (Green Shipping Programme, n.d.[45]).

Another challenge in accelerating the uptake of low-carbon alternative fuels is the rate of renewal for vessels. Ships have lifetimes of up to 25 years, meaning that a significant share of the vessels in service today are likely to still be in service in the next decade (ITF, 2020[46]). As such, the low commercial viability of zero-emission ships can create a bottleneck that slows the uptake of zero-emission fuels and technologies. Ensuring all ships have access to zero-emission fuels will require policy support in the form of investments and adjustments to port infrastructure to accommodate the transition.

More specific examples of required adjustments include deploying new bunkering infrastructure, electric charging systems where battery-powered ships can operate, and energy supply infrastructure. Port infrastructure costs are expected to be high; therefore, the timing of investments will need to be co-ordinated to help facilitate the uptake of low-emission ships. Ship owners must also retrofit existing ships with energy-efficient technologies and make them zero-emission-ready.

Training for seafarers in the handling of new fuels and technologies will also be needed as port of any strategy to decarbonise the shipping sector. Hundreds of thousands of seafarers could need some level of extra training for the new fuels and engines that would be introduced. However, uncertainty about the future of shipping fuels is delaying the sector being able to start the training. Despite this, it is still possible to begin preparing training establishments for future needs in recognition that, regardless of the fuels, there is a “general trend towards “higher-skilled” seafarers” being needed in the future (Kaspersen, Kalsen and Helgensen, 2022[47]; Maritime Just Transition Task Force, 2022[48]).

Policy makers will need to work with private actors to mitigate some of the costs of the transition and can play a crucial role by providing cross-jurisdictional support for technical design requirements. A combination of measures will be needed to accelerate the decarbonisation of the maritime sector. Given the rate of fleet turnover, fuel standards and technical and design measures to improve the efficiency of ships should be combined with market-based measures, which can improve the cost-competitiveness of alternative fuels.

Pricing and regulation will play crucial roles in decarbonising hard-to-abate sectors

In the short term, in addition to increasing production capacity for low-carbon alternative fuels, policy measures can focus on closing the price gap between these fuels and high-carbon fuels. Carbon pricing, in particular, can reduce price differences in the aviation and maritime sectors, in which fuels are currently generally exempt from taxation. Furthermore, existing carbon-pricing schemes often exclude shipping or are limited to regional flights (ITF, 2020[46]; ITF, 2021[36]).

So long as fuel tax exemptions (a form of subsidy) remain in place for aircraft and ships, alternatives to current conventional fuels are at a disadvantage. These exemptions run counter to the goal of decarbonisation and should be eliminated. Carbon pricing can also generate significant revenues. When paired with more stringent targets for low-carbon fuel production, it can encourage improvements in the fuels and fleets used in the aviation and maritime sectors (ITF, 2022[44]; ITF, 2021[36]).

Carbon-pricing schemes for the aviation sector exist at the national and regional levels. However, as shown by the example of the EU’s Emissions Trading System (ETS), the success of such schemes depends on establishing the correct price; under-pricing carbon will not produce the desired impetus for change (ITF, 2021[36]). The modelling for this edition of the Outlook, which suggests that under-pricing air travel compared to other modes results in a slight increase (0.2 percentage points) in aviation’s mode share, supports this lesson.

Any established carbon price needs to be adequately high to be effective and support the further development of alternative fuels, especially in a carbon pricing scheme’s early years (ITF, 2021[36]). A global approach to pricing instead of regional or multilateral taxation would avoid market distortions. It would also reduce the risks of production activities being transferred to regions with less stringent climate policies or of planes carrying excess fuel on board “to avoid refuelling in countries with higher fuel costs, [which leads] to excess fuel burn and CO_2 emissions” (ITF, 2021[36]).

For the maritime sector, a global pricing scheme implemented by a body such as the IMO would minimise the effect of pricing on relative competitiveness. It could be more palatable than national or supra-national schemes that include shipping (ITF, 2022[44]). Shippers will also need access to low-carbon fuels, and infrastructure for refuelling, and recharging will be required at ports.

An additional benefit of introducing global maritime carbon pricing is the opportunity to allocate revenues to these actions, particularly in small island developing states and least-developed countries highly exposed to the effects of climate change. Revenues from carbon pricing can also help increase production capacities for low-carbon alternative fuels and technologies (Dominioni and Englert, 2022[49]).

The IMO is currently considering several carbon-pricing proposals that address the revenue gap created by the maritime sector's exemption from carbon taxes. These proposals were evaluated as part of the ITF's Common Interest Group on Decarbonising Shipping (see Box 4.3). Carbon pricing mechanisms designed as so-called feebate schemes (to reward early adopters of zero-emission operations), as well as regulations related to technical design requirements for ships, and standards for low-carbon fuels, could form a comprehensive suite of measures (ITF, 2022[44]). Introducing a feebate system in the short term would be especially beneficial in addressing the challenge of commercial viability for new technologies and alternative fuels.

Box 4.3. The ITF's Transport Decarbonisation: Driving Implementation Project

The ITF project "Transport Decarbonisation: Driving Implementation" (DT Implement) aims to help identify ways to cut carbon dioxide (CO_2) emissions in three hard-to-decarbonise areas of transport: aviation, shipping and heavy-duty road freight. Their successful transition to low-carbon (and, ultimately, zero-carbon) operation is vital to achieving the international community's climate goals.

Decarbonising these three areas will require approaches that differ from those available for other transport modes. Unlike urban demand management, or electrifying household cars, these hard-to-abate sectors face more significant challenges to achieving a cost-effective transition. There is debate over which emission-reduction technologies to pursue for these modes, and some are not yet ready for implementation. Therefore, policy support and international co-operation to decarbonise these modes effectively is crucial for success.

The work for the DT Implement project is carried out by three Common Interest Groups. These are country-led stakeholder fora focusing on one mode of transport each. The Common Interest Groups bring together experts from governments, industry, the research community and non-governmental organisations. Through peer-to-peer exchange, the groups will help identify areas of agreement and where further work needs to be done.

The aim is to set common priorities in research and innovation that will support the decarbonisation of aviation, shipping or heavy-duty road freight, and to facilitate the deployment and commercialisation of relevant solutions. Common Interest Groups are open to ITF member countries, other invited countries, industry and major transport stakeholders. Currently, 31 countries take part in the three Common Interest Groups.

The DT Implement project is part of the ITF's wider Decarbonising Transport initiative. It is funded by the European Commission.

Source: https://www.itf-oecd.org/dtimplement.

Mind the differences: Why regional disparities could delay decarbonisation

Europe and UCAN have historically produced the highest share of transport emissions but are now beginning to decouple their passenger transport emissions from the associated transport activities (Saidi Kais, 2016[50]). They have also made ambitious policy commitments to transition to ZEVs. As income and population grow in low-income and low-middle income countries, so will demand for travel. Without higher policy ambition and support to transition to cleaner fleets in these regions, emissions will continue to grow.

To reach the Paris Agreement target, the decoupling of transport activity and emissions must happen sooner in all regions and transport sectors. The difference in emissions between the two scenarios is greatest in low and low-middle-income countries. This indicates how much greater a change they have to divert from the current trajectory to achieve the objectives of the High Ambition scenario (see Figure 4.8).

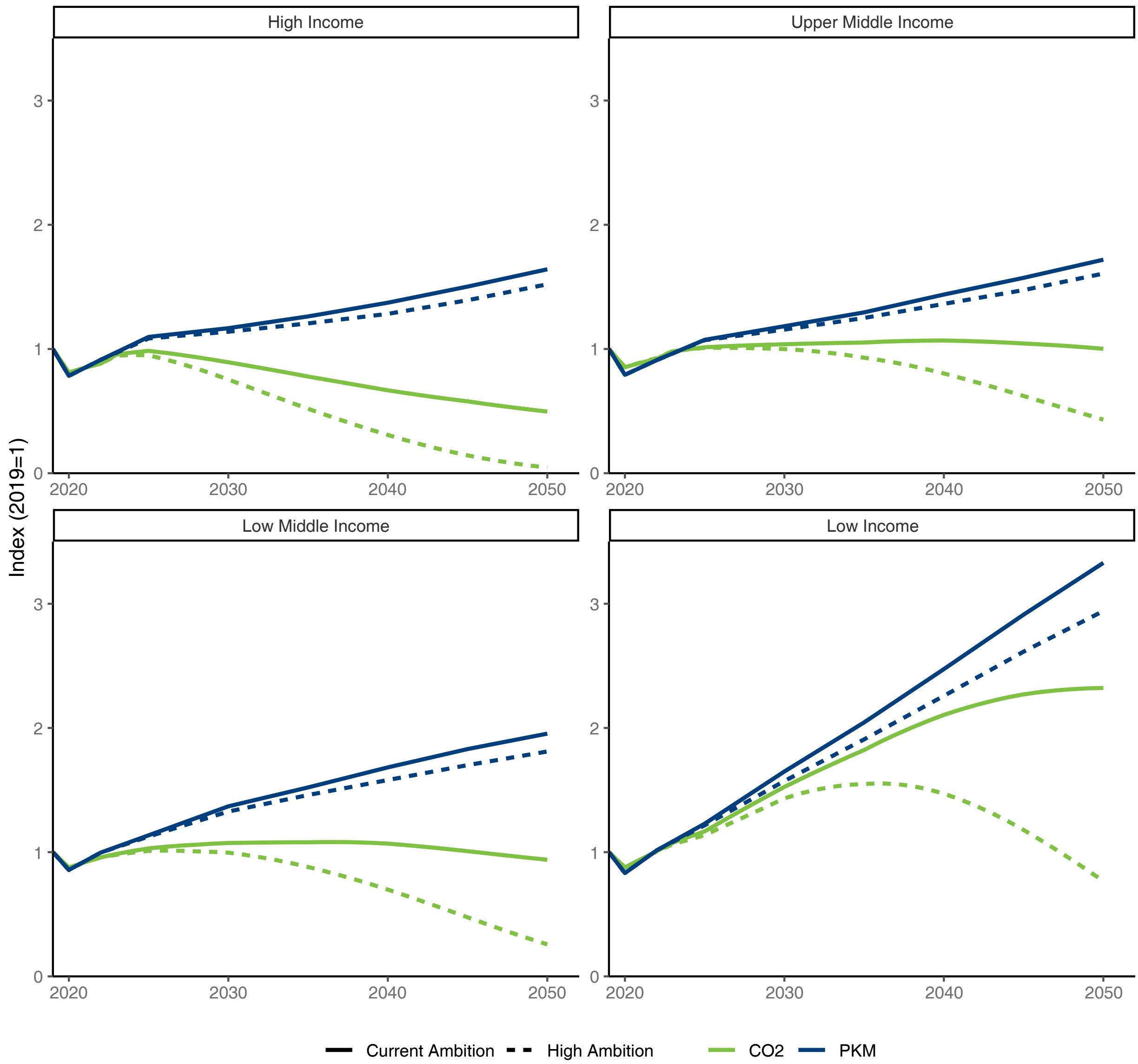
Policy makers have an opportunity to bridge this gap with targeted action. Urban contexts continue to provide some of the best opportunities for the transition to cleaner fleets. For example, collective fleets, typically within the direct control of public authorities, make it possible to optimise charging infrastructure (ITF, 2021[1]).

Financial support from development partners will play a role if global decarbonisation is to be achieved. High capital costs remain a challenge for the transition, compounded by the difficulties in attracting investment due to perceived risks. The perceived institutional and regulatory capacity of recipient countries can demonstrate the financial viability needed to attract institutional investment (OECD, 2022[51]). For example, the co-ordinated procurement of electric buses in Chile, Colombia and India can demonstrate supportive regulatory frameworks and project implementation capacity.

Similar approaches can be pursued in other contexts, provided there are accessible funding sources. Public climate finance is instrumental in improving large investments' financial viability and mobilising private finance. In 2010, the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) adopted the goal of raising USD 100 billion annually to support climate action in emerging economies across all sectors.

The annual target was due to run until 2020 but has since been extended until 2025. So far, the funding target has not been reached in any single year. However, the global transport sector has received 17% of the finance available for climate mitigation, while the energy sector has received a further 46% (OECD, 2022[51]). In 2016-20, lower-middle-income and upper-middle-income countries were the main beneficiaries of climate financing allocations, typically for “shovel-ready” projects with associated revenue streams.

Figure 4.8. Passenger-kilometres compared to passenger carbon dioxide emissions by region



Note: All values are indexed to 2019. Figure depicts ITF modelled estimates. PKM: passenger-kilometres. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. The classifications in this figure are based on the World Bank's *World Development Index*. A reporting region is denoted as "Low-income", "Lower-middle-income", "Upper-middle-income" or "High-income" based on the World Bank category into which the majority of the economies in the region fit. GDP data are ITF estimates based on data from the OECD-ENV linkages model.
Source: World Bank (2022[52]). OECD ENV Linkages model: http://www.oecd.org/environment/indicators-modelling-outlooks/modelling.htm.

StatLink https://stat.link/drew7o

This focus on "shovel-ready" projects can create barriers to access for low-income countries, which may experience institutional constraints and require adaptation activities such as capacity building before committing to larger-scale projects. Many countries have identified the lack of technical and staffing resources as barriers to regularly reporting on funded activities. This, in turn, creates a lack of transparency and becomes another barrier to accessing funds.

In these contexts, climate financing should also focus on enabling local actors to develop comprehensive plans and prioritisation frameworks that identify “quick-win” projects when funding is available (OECD, 2022[51]). Policy makers in these contexts can benefit from various tools to guide investment decisions in their transport sectors and establish the groundwork to access funding (see Box 4.4).

The decoupling of freight emissions from transport activity is more complex due to the role of international trade on production- versus consumption-based emissions. That is, emissions from freight can be associated with where goods are produced, or where they are consumed. It is worth noting that historical data shows that the elasticities for emissions and output have been reducing in recent years (on the production side), particularly in countries with national policies aimed at decarbonising their economies (Gail Cohen, 2018[53]).

As a result, emissions in emerging economies are lower than, or comparable to, those of developed economies when they were at the same level of development. However, the barriers are greater in countries with larger shares of their gross domestic product (GDP) dependent on primary and secondary sectors, such as extraction and manufacturing (Gail Cohen, 2018[53]). Nonetheless, ambitious policies in emerging economies and low-carbon technologies can chart less carbon-intensive development pathways in the future.

Box 4.4. Life-cycle analysis of passenger transport modes in India

As part of its Decarbonising Transport in Emerging Economies and NDC Transport Initiative for Asia projects, the ITF has developed a life-cycle assessment (LCA) tool for the Indian transport sector. The tool can be used to estimate the energy consumption and greenhouse gas (GHG) emissions associated with different modes of transport. It takes into account vehicles’ characteristics, powertrain technologies, energy vectors, manufacturing and disposal, and the infrastructure required to operate them.

In a recent joint study, the ITF and the World Bank investigated the extent to which India’s battery electric vehicles (BEVs) are clean, and the impacts of the energy mix and local operating conditions on GHG emissions across different modes (ITF/World Bank, forthcoming[54]). The study analyses 25 passenger BEV and internal combustion engine (ICE) transport modes, including two- and three-wheelers, private cars, taxis, metro and bus models that cover urban and intercity travel.

Preliminary results from the study suggest that manufacturing can contribute up to approximately 37% of life-cycle GHG emissions in the case of BEVs, due to the emission intensity of battery manufacturing. At the same time, if India achieves its current clean energy policy goals, the GHG emissions of BEVs will be lower than ICE variants across vehicle types.

Furthermore, three-wheelers offer the maximum percentage (roughly 57%) of per-vehicle GHG savings by transitioning from ICE to BEV. In addition, the GHG emissions per passenger-kilometre generated by new ICE urban buses on a lifecycle basis are lower than even BEV variants of cars, taxis and private motorcycles. In other words, in India, investments in ICE and BEV buses are likely to deliver more GHG savings than the electrification of cars and two- and three-wheelers.

The study highlights another practical application of the tool: namely, the way in which it can be used to assess the implication of a given transport mode on energy consumption and related emissions. The insights from these results provide evidence to guide policy-making and investment decisions in the transport sector.

Source: https://www.itf-oecd.org/ndc-transport-initiative-asia.

Policy recommendations

The pace at which the global transport fleet can transition to zero-emission technologies relies on a co-ordinated approach across sectors. The success of this approach will determine the extent to which the High Ambition scenario is achievable.

Set targets and collaborate across sectors to decarbonise all vehicle fleets

The global energy mix primarily relies on fossil energy but will need to move towards clean energy. In addition, grid reinforcements will be required to implement the additional capacity needed to support electrification. Meeting the demand for technologies needed to transition to cleaner fleets depends on a significant supply of raw materials – particularly critical minerals for batteries. Ensuring sufficient capacity to transition the vehicle fleet will depend on the timing and level of investments in mining, critical material production and manufacturing of clean energy technologies. Higher-ambition policies will also require cross-sector co-ordination, considering the energy and technology supply chain interdependencies.

Target incentives and restrict access for high-emitting vehicles to increase the uptake of zero-emission road vehicles

Decarbonising road transport is challenging in different regions due to grid reliability, purchasing power, insufficient charging infrastructure, and limited policy support. This means that not all countries can achieve the decarbonisation objectives at the same pace. A comprehensive combination of policy instruments, which evolve as the transition progresses, will be necessary.

In the early stages of the transition, as the gap in purchase costs between BEVs and ICE vehicles closes, blanket incentives can support early adopters of clean vehicles. In later stages, these incentives could give way to more targeted solutions, such as income-based progressive rebates (e.g. for passenger cars, 2&3Ws and e-bikes) for example, which should be designed to have more equitable outcomes. However, further work will be needed to develop effective and equitable incentives. Purchase incentives for freight vehicles can also target smaller owner-operated enterprises to offset the higher upfront purchase costs of vehicles. Access-restriction policies and differentiated road-user pricing would then be longer-term measures.

In urban contexts, the focus should be on introducing incentives aimed at collective and shared fleets and their supportive infrastructure to reduce congestion caused by passenger cars. Transport authorities can incorporate more stringent emission standards and sustainability and emission-related criteria in procuring public and regulated collective vehicles. Restricted access zones, for example, limit the access of certain vehicles to specific areas to reduce pollution and other environmental emissions. These policies can achieve dual benefits: reducing congestion that may result from the lower costs associated with operating ZEVs and prioritising collective and shared modes in urban environments.

An equitable transition will require a better understanding of barriers in different contexts. Emerging economies can combine co-ordinated procurement and scrappage schemes with targeted incentives for small and micro-enterprises operating informal transport systems. Understanding fleet renewal rates and the global trade in used vehicles can help policy makers identify interim decarbonisation measures that do not risk locking in sub-optimal solutions for specific contexts.

Deploy public charging infrastructure to increase the pace of adoption

Insufficient publicly available charging infrastructure can delay the adoption of ZEVs. Investments in public EV charging networks can reduce range anxiety and encourage the adoption of ZEVs, particularly for freight activities and long-distance non-urban travel. However, the existing grid capacity, complex permitting processes, land-use designations and funding constraints present obstacles to the deployment of charging infrastructure. Policy makers will need a better understanding of user and operator needs when planning for and funding charging solutions.

A network approach will be necessary, including comprehensive standards and policy and process co-ordination across jurisdictions. The electricity grid will need reinforcing to support the rollout of charging infrastructure, which will also require cross-sectoral collaboration. Public roads authorities can also explore concession agreements with private entities to address the potential financial risk of low utilisation in the early stages of ZEV adoption. These agreements (e.g. for the design, financing, construction, operation and maintenance of public EV charging infrastructure) could be paired with road-pricing measures to finance the infrastructure, modified to target users of the infrastructure.

Use pricing measures to improve the commercial viability of low-carbon alternative fuels

In the aviation sector, the novel aircraft propulsion technologies that will drive the shift to cleaner fleets are still in the early stages of development, and uncertainties persist regarding their range and scalability. Similarly, although technological readiness is not as significant a factor in the maritime sector, the commercial viability of zero-emission vessels is still a significant barrier.

These two sectors will rely on adopting low-carbon alternative fuels to decarbonise. However, this poses a dual challenge regarding production capacity and wide-scale application. The high energy required for their production must come from low-carbon sources to make these alternative fuels potential candidates for decarbonisation. Collaboration with the energy sector will therefore be imperative in reducing the carbon intensity of fuel production.

Industries will also compete for access to alternative fuels. Policy makers should prioritise the use of these fuels in contexts where technologies such as electrification are not feasible. This will help maximise economy-wide emissions savings. Finally, measures to promote cleaner fleets and the widespread adoption of low-carbon alternative fuels will not be effective so long as direct and indirect subsidies for fossil fuels exist. Carbon pricing measures will play a role in resolving this conflict by closing the price gap between conventional and low-carbon fuels.

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5 Liveable cities: The broader benefits of transport decarbonisation

The global urban population is expected to continue growing rapidly. Enhancing the quality of life in urban areas will present an especially important challenge in the coming decades. This chapter describes how transport policy and investment can produce liveability benefits beyond reductions in carbon emissions and traffic congestion. The analysis quantifies the benefits of the High Ambition scenario relative to the Current Ambition scenario and isolates the effect of specific transport policies, such as carbon taxes and demand management, across several urban performance indicators.

In Brief

Holistic policies will play a crucial role in improving the quality of urban life

Liveable cities provide their residents with easy access to the various opportunities an urban environment offers. Transport options therefore dramatically affect liveability. They contribute to the range of social activities accessible to city-dwellers but also to negative aspects such as the quantity of pollutants in air they breathe. Transport policies that reduce CO_2 emissions and moderate travel demand can also make cities more liveable.

With the policies currently in place, emissions of toxic pollutants from city traffic are expected to grow over the coming decades in all but the high-income world regions, even as more fleets become cleaner. Substantially reducing transport-related pollutant emissions in urban areas requires ambitious fleet and demand policies. The combination of policies under the High Ambition scenario – including road pricing, fuel economy standards, green procurement and electrification of freight and passenger vehicles – can reduce CO_2 emissions in urban areas by more than 78% by 2050 relative to 2019.

Encouraging active mobility is one important focus of urban decarbonisation policies. With this, however, the risk that pedestrians and cyclists will be exposed to conflicts with other road users is likely to rise. Mitigating or reversing this risk requires major investments in active mobility infrastructure and new restrictions on vehicle speeds in cities. By 2050, crash risk grows 4.5 times more under a continuation of today's policies compared to the High Ambition scenario.

Transport will only be accessible and inclusive if it is affordable. Making shared modes more widely available in urban spaces can make them accessible to more users and combining this with integrated payment systems (including public transport and shared modes) will put them within reach of more users.

High-coverage public transport networks are a critical component of accessible and affordable urban mobility. Increased investment in public transport links connecting historically underserved neighbourhoods will address issues of inclusion and equity. By giving priority to public transport over cars, ambitious decarbonisation policies can shorten travel times for public transport users, making it more convenient to access opportunities across the city for those who do not drive.

Transport policy can also make cities more liveable by contributing to a more human-centric use of urban space. Space-efficient transport systems make room for more parks, new services and opportunities for recreational activities. The measures assumed in the High Ambition scenario would limit demand for private motorised transport and result in 2-10% lower road occupancy in 2050, compared to the Current Ambition scenario. Public support for such ambitious measures will be crucial to their acceptance and success.

Policy recommendations

- Create attractive alternatives to private motorised vehicles to encourage the shift to sustainable transport and reduce pollution.
- Consider equity impacts when developing new transport policies, investments and programmes.
- Prioritise people, not vehicles, in urban design to improve safety for all road users.
- Set ambitious goals for reducing pollutant emissions and take actions to achieve them.

Ensuring that emerging, ageing and growing urban areas continue to enable a high quality of life presents a global policy challenge and an opportunity. Interest in planning for liveable cities has grown substantially in recent years, due to a convergence of demographic and geographic trends. In 2014, the then United Nations Secretary-General, Ban Ki-moon, stated: “Liveable cities are crucial not only for city-dwellers but also for providing solutions to some of the key aspects of sustainable development” (United Nations, 2014[1]).

Transport affects almost every aspect of life. Because it enables access to opportunities, transport is inextricably connected to liveability. Moreover, transport systems indirectly affect other core components of liveability, including safety, social cohesion and the availability of public space. There are many views and definitions of liveability that vary across the globe (Paul and Sen, 2020[2]). Lowe et al. (2015[3]) define a liveable city as one whose neighbourhoods are:

> *“…safe, attractive, socially cohesive and inclusive, and environmentally sustainable; with affordable and diverse housing linked by convenient public transport, walking and cycling infrastructure to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities.” (Lowe et al., 2015[3])*

This chapter focuses on the components of liveability most affected by transport: health and safety, access to opportunities, equitable mobility, and urban space. These four themes align with UN Sustainable Development Goal 11 (SDG 11), which calls on cities to provide “safe, affordable, accessible and sustainable transport” with an emphasis on road safety, air quality and disadvantaged populations (Hosking et al., 2022[4]). The following five sections explore each theme in detail. Note that transportation cannot contribute to all aspects of liveability: focusing on liveability as a planning process outcome risks contributing to gentrification and displacement (Tolfo and Doucet, 2022[5]). These are important urban issues but are not discussed in this chapter.

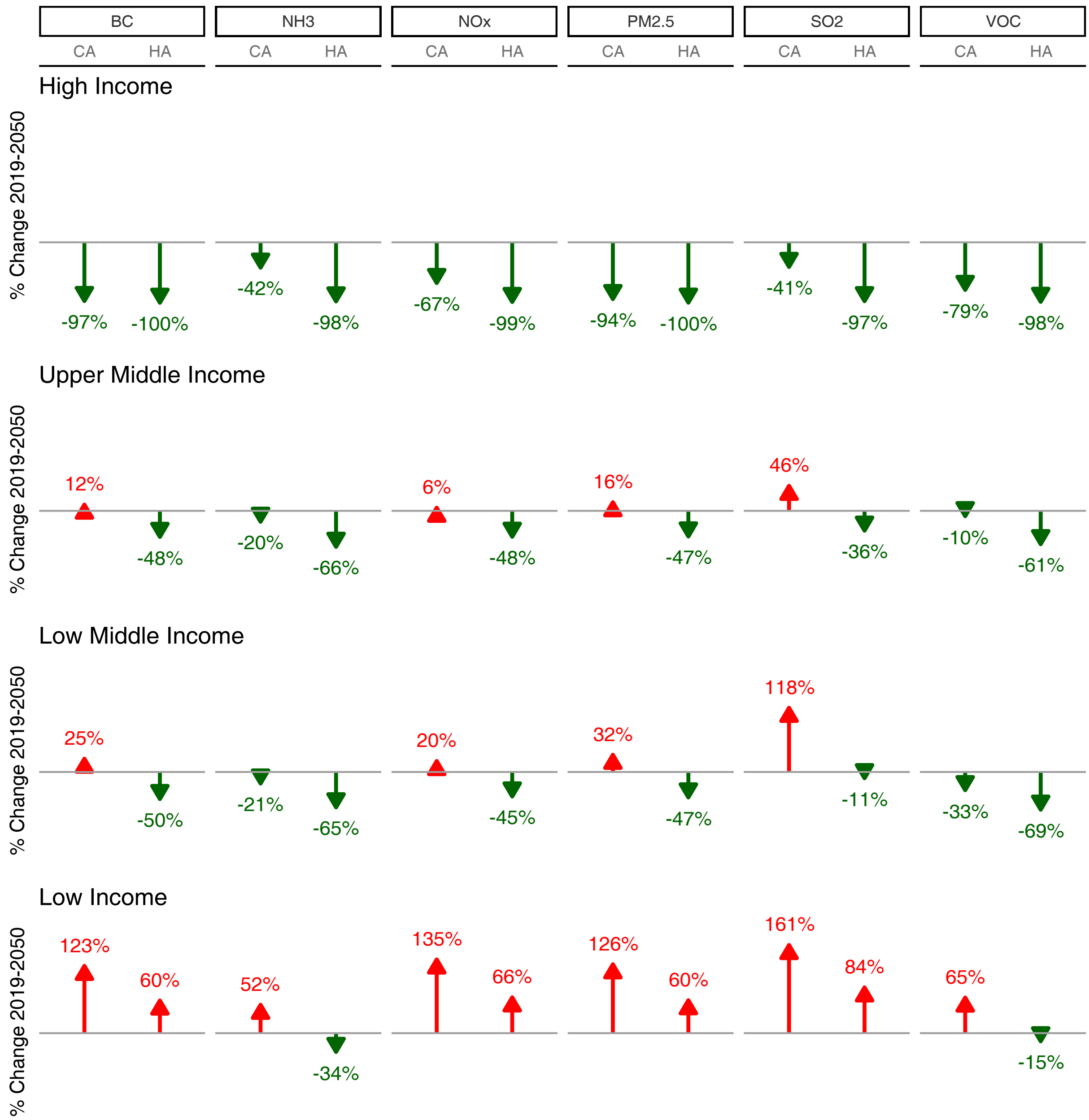
Cleaner air for healthier cities: The impact of transport on public health

The transport sector is a leading cause of many urban health concerns (Lowe et al., 2022[6]). Passenger and freight vehicles emit toxic pollutants into the atmosphere, including nitrous oxide, volatile organic compounds, and particulate matter. Public health indicators are widely used to evaluate the performance of transport systems; the global indicator framework for the UN SDGs includes transport-related outcomes such as exposure to fine particulate matter in urban areas (Giles-Corti, Lowe and Arundel, 2020[7]). The World Health Organization (WHO) estimates that 90% of the global population is exposed to significant air pollution (WHO, 2021[8]) and that air pollution is concentrated most heavily in urban areas.

Transport decarbonisation policies can reduce urban pollutant emissions

The ITF’s urban passenger model (see Chapter 2) measures the contribution of transport to public health using estimated urban pollutant emissions by region and by policy scenario. Pollutant emissions are a function of both the demand for transport and the characteristics of the vehicle fleet. The model includes separate indicators for six toxic pollutants emitted by transport vehicles: black carbon (BC), ammonia (NH_3), nitrous oxide (NO_x), fine particulate matter of 2.5 microns or less in diameter (PM2.5), sulphur dioxide (SO_2) and volatile organic compounds (VOCs).

Figure 5.1. Evolution of urban pollutant emissions from 2019 to 2050 by scenario and region group



Note: Figure depicts ITF modelled estimates of the change in total annual air pollutant emissions (by mass) from passenger cars, light commercial vehicles, buses and heavy goods vehicles between 2019 and 2050 by scenario and region. Emissions from two- and three wheelers are not included. Values include only on-road emissions produced by urban transportation stemming from fuel burn. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. BC: black carbon. NH_3: ammonia. NO_x: nitrous oxide. PM2.5: particulate matter. SO_2: sulphur dioxide. VOC: volatile organic compounds. Estimates are by mass and are therefore not directly proportional to concentrations and urban air quality. Air-pollutant emissions estimated using fuel-pollutant factors (grams of pollutant per litre of fuel) provided by the International Council on Clean Transportation. Income classifications based on the World Bank's *World Development Index* (2022[9]). A reporting region is denoted as "Low-income", "Lower-middle-income", "Upper-middle-income" or "High-income" based on the World Bank category into which the majority of the economies in the region fit.

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These pollutants can have severe health impacts on urban residents and visitors alike. As highlighted in the *ITF Transport Outlook 2021*, NO_x, SO_2 and PM2.5 are notorious for their adverse effects on public health (ITF, 2021[10]). Note that the ITF model only estimates the tailpipe pollutants produced by burning fuel. It does not include additional pollutants generated by wear on tyres and brakes, or other vehicle components. The levels of BC, NH_3, NO_x, PM2.5, SO_2 and VOC emissions from 2020 to 2050 evolve differently under the High Ambition and Current Ambition scenarios and between regions (see Figure 5.1).

As shown in Figure 5.1, high-income regions, which have relatively new vehicle fleets and transition to zero-emission technologies first, are expected to see significant drops in air pollutant emissions in the Current Ambition scenario. In the High Ambition scenario, emissions fall even faster, with a rapid transition to zero-emission vehicles (ZEVs) and alternative transport modes.

Middle-income regions are likely to experience higher levels of air pollution over time in the Current Ambition scenario, as increasing travel demand offsets the benefits from the gradual turnover of the vehicle fleet to newer vehicle technologies. Conversely, a rapid adoption of ZEV technologies and shifts away from private vehicles in the High Ambition scenario are likely to significantly improve air pollution levels.

Low-income regions are most at risk of significant increases in air pollution emissions due to the rapid increase in travel demand and a reliance on old, imported vehicle fleets with poor emissions control systems. Helping low-income regions transition towards lower-emission technologies and shift away from private passenger vehicles can halve the expected increases in many air pollutants under the High Ambition scenario.

Disaggregating the results by vehicle type illustrates just how difficult it will be to fully mitigate the public health risks caused by urban transport, even with ambitious policies. Heavy-duty vehicles, such as freight trucks and buses, produce approximately two thirds of NO_x, BC, $PM_{2.5}$ and SO_2 urban air pollutants by mass, even though they only account for less than 5% of all vehicles on the road. Shifting urban transport to buses will play an important role in reducing private vehicle use. However, it is essential to also limit their air-pollutant emissions by renovating vehicle fleets and adopting new powertrain technologies.

Operators and transport authorities will need to address the logistical challenges of electrifying public transport, such as restructuring bus operations to account for the shorter range of battery electric buses relative to diesel buses and building maintenance and charging facilities for servicing battery electric buses (Sclar et al., 2019[11]). These results highlight how even an ambitious shift towards more sustainable modes such as public transport is a necessary but not sufficient condition for eliminating the public health risks posed by urban transport emissions.

Transport policies can target air pollution directly, for example through low-emission zones (LEZs) and zero-emission zones (ZEZs) where vehicles operate in zero-emission mode. London's Ultra Low Emission Zone (ULEZ) is estimated to have reduced NO_x emissions in the city centre by 31% in its first six months of operation, compared to a scenario in which the ULEZ did not exist (Greater London Authority, 2019[12]).

Similar restrictions on vehicle emissions have been enacted or planned in dozens of urban areas worldwide, although predominantly in Asia and Europe (Cui, Gode and Wappelhorst, 2021[13]). Implementation is often complex, and many jurisdictions have chosen to start with less onerous restrictions (e.g. time-specific restrictions or limits applied solely to freight vehicles) to test their design and build popular support. LEZ regulations may have distributional equity impacts by encouraging highly polluting vehicles to travel through other parts of an urban area. The equity impacts of LEZ regulations can be addressed through complementary policies, such as stringent vehicle emissions standards that limit the sale of highly polluting vehicles.

Low-emission vehicles are only one part of the solution

Not all air pollutants from tailpipe emissions are the by-products of burning fossil fuels. Some electric vehicles are crucial for limiting transport-related CO_2 emissions but also release dangerous particulate matter into the atmosphere (OECD, 2020[14]). This example underscores the importance of considering urban liveability and climate change impacts when developing transport policy. Both public health and urban liveability would benefit from policies that limit travel distances through improved accessibility and encourage shifts towards active modes.

Shifting urban travel demand to active and shared modes that emit fewer pollutants per passenger will remain an important goal in creating healthy, liveable cities even after there are more electric vehicles in the fleet. Policies encouraging active travel can also lead people to exercise more often and improve health outcomes (Aldred, Woodcock and Goodman, 2021[15]). For example, a comprehensive review of the health and safety impacts of cycling found that the monetised health benefits from maintained or increased cycling-related physical activity outweighed the negative health impacts from crashes by up to a factor of 18:1 (OECD/ITF, 2013[16]). Box 5.1 summarises ongoing public health issues in urban areas and how active transport helps urban residents lead healthy lives.

Transport affects public health in several other important ways that the ITF model cannot measure. Mental health is one example. Stress caused by road congestion, fear of exposure to crime and violence during travel, and access to opportunities for social connection – all of which affect mental health – are related to the performance of the transport system (Whitley and Prince, 2005[17]; Mackett and Thoreau, 2015[18]; Nadrian et al., 2019[19]).

Furthermore, noise pollution generated by road, rail and air transport impairs cognitive functioning and increases stress levels, which leads to long-term physiological and psychological harm (Veber et al., 2022[20]). Decarbonisation measures, including vehicle electrification and active mode shift, have the co-benefit of reducing noise pollution from transport. These additional health impacts of transport, while not covered in detail in this report, should be considered as part of any holistic transport policy strategy.

The difference in pollutant emissions between the two policy scenarios explored in this edition of the Outlook is a stark example of how ambitious transport policy can bring benefits beyond addressing climate change and traffic congestion. The model estimates that the High Ambition scenario would result in 8.9 mega tonnes fewer NO_x emissions in 2050 than under the Current Ambition scenario.

Based on the methodology used by Muller and Mendelsohn (2007[21]), these emission savings would produce an annual global public health benefit valued at USD 2.4 billion in 2050 due to reduced urban morbidity and mortality. When including the morbidity and mortality costs associated with NH_3 (USD 3 810/tonne), PM2.5 (USD 3 000/tonne), SO_2 (USD 1 360/tonne) and VOCs (USD 450/tonne), the value of the High Ambition scenario for public health alone is over USD 5.4 billion in 2050 relative to the Current Ambition scenario.

Designing safer streets: The link between traffic safety and decarbonisation

Approximately 1.3 million people are killed in road crashes annually (WHO, 2022[22]). Like urban air quality, road safety is a crucial component of liveability (ITF, 2021[23]). There is much potential for improvement over the status quo. Road deaths in urban areas have generally declined much more slowly relative to suburban and rural areas (ITF, 2021[23]). Traffic deaths persist in urban areas because urban streets feature a much greater share of cyclists, pedestrians, mopeds and other users exposed to higher-speed vehicle traffic.

A recent ITF study of 35 urban areas found that vulnerable road users made up 85% of all traffic fatalities (ITF, 2022[24]). Another contributing factor is the presence of large freight vehicles on urban streets, which can impede other uses and create safety hazards while picking up and delivering goods. While road safety reports typically focus on road fatality statistics because the data are more readily available, data on serious injuries, when available, provide additional insights into the overall safety of urban roads.

Box 5.1. The connection between transport planning and physical activity

Approximately one-third of all adults in OECD and European Union countries are insufficiently active, with national figures ranging from just under 20% of adults in Finland to up to 46% of adults in Portugal (OECD, 2021[25]). Low levels of physical activity reflect factors such as advances in communication technology and changes to the built environment that have given people fewer reasons to move (OECD, 2019[26]). For example, across the EU, cars are the predominant form of urban transport (Eurostat, 2021[27]).

Low levels of physical activity contribute to high rates of obesity, mental ill health, and illness, including cardiovascular diseases, commonly occurring cancers and type 2 diabetes. Several OECD countries have introduced policies to encourage active modes of transport to boost physical activity levels. These policies include investments in walking and cycling paths, green spaces and car-free zones.

As part of its Best Practices in Public Health project, the Health Division of the OECD's Directorate for Employment, Labour and Social Affairs assesses the health, economic and mode-shift impacts of real-life initiatives promoting active transport modes, including the following examples from Denmark, France and Spain (OECD, 2022[28]).

Denmark: Cycle Superhighways

In 2009, Denmark introduced Cycle Superhighways, an intervention providing cyclists with infrastructure to ride safely between municipalities across the country. Cycle highways differ from regular cycling lanes as they are exclusively available to cyclists. Furthermore, cycle highways cover long distances and include maintenance stations for cyclists needing minor repairs or air pumps. Since 2010, on average, upgrading cycle routes to cycle superhighways has resulted in a 23% increase in cyclists, with 14% of new cyclists previously having travelled by car (Cycle Superhighways, 2019[29]).

Paris, France: *Vélib' Métropole*

Vélib' Métropole is one of the world's first and largest bikesharing schemes. Created in 2007, *Vélib'* (a portmanteau of the French words for bicycle and liberty) encourages residents to use active modes of transport more frequently. As of 2023, there were 1 800 *Vélib'* bicycle stations across Paris and other parts of Île-de-France (the region around Paris, encompassing 60 municipalities). The stations provide access to 20 000 bikes, of which 40% are equipped with electric assistance technology (Vélib', 2022[30]).

Barcelona, Spain: Superblocks

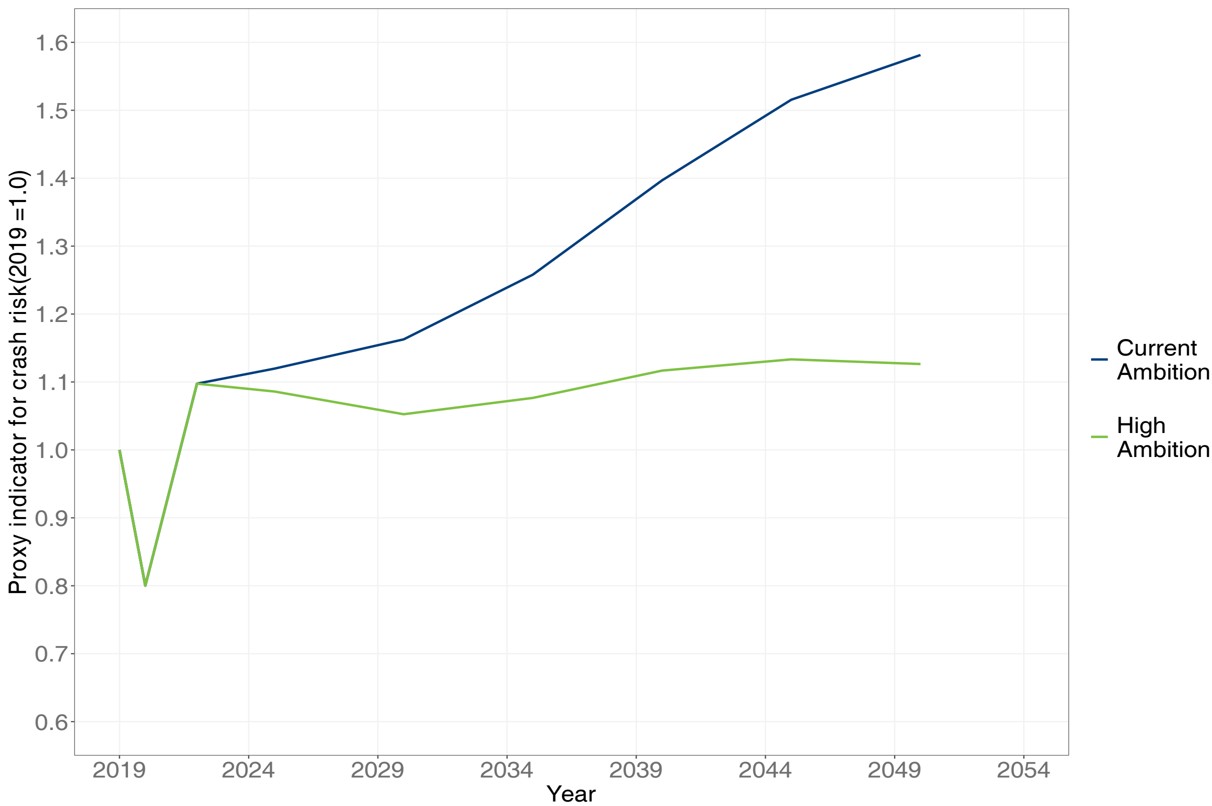
The Superblock model in Barcelona uses the city's existing grid-like urban design to reorganise traffic circulation. Specifically, the intervention breaks Barcelona into several superblocks comprising nine blocks of enclosed inner streets that allow residents to drive in and out at a maximum speed of 10 kilometres per hour while restricting outside traffic from passing through. Estimates show that implementing Superblocks in all eligible regions in the OECD would, by 2050, reduce the incidence of disease by 1.8 million cases. As a result, Superblocks could lead to annual savings equivalent to 0.01% of total health expenditure in the Barcelona metropolitan region.

Source: OECD (forthcoming[31]).

Vulnerable road users face growing risks

Traffic safety for pedestrians and cyclists in urban areas could worsen over time. The risk will be higher if transport policies are limited to current climate commitments for modal shift without complementary policies to improve road safety. Figure 5.2 shows the anticipated trends for a proxy indicator for overall crash risk that captures the risk of potential conflicts between passenger vehicles and vulnerable road users. In the Current Ambition scenario, the risk of conflicts is expected to grow steadily until 2050, due to increasing pedestrian and cyclist volumes, and limited policies to protect them from conflicts with passenger vehicles.

Figure 5.2. Change in proxy indicator for crash risk over time under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. The proxy indicator for crash risk measures the exposure to potential conflicts between vulnerable road users and passenger vehicles. It incorporates vehicle volumes, the difference in speed between modes and the degree of longitudinal separation between modes. Lower values represent less risk of exposure to conflicts. These indicators only account for conflicts with passenger cars, not freight vehicles. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.

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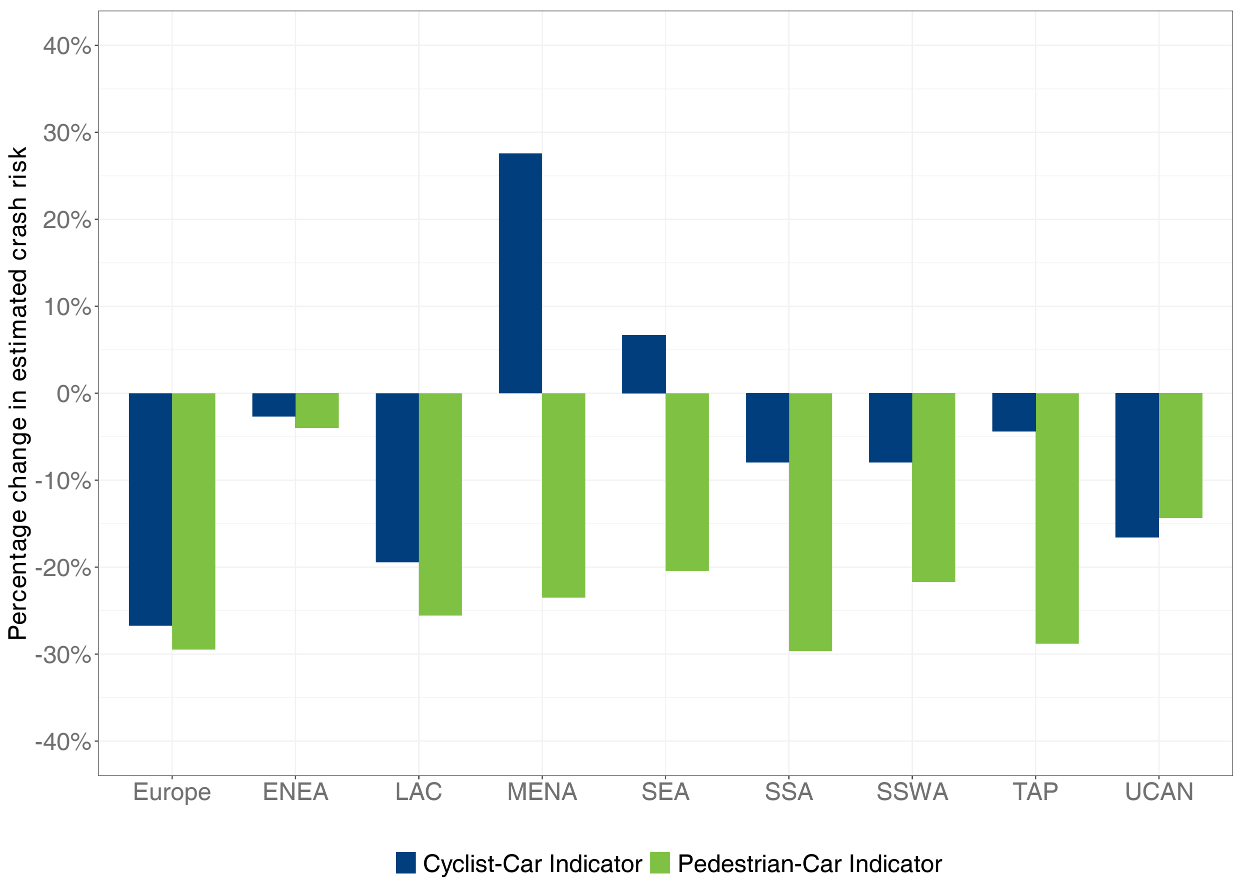
By 2050, the global average exposure risk will be nearly 60% higher than in 2019 under the Current Ambition scenario. The High Ambition scenario, which includes the rapid expansion of separated cycle lanes and vehicle speed restrictions, mitigates this rise in conflict exposure risk. Under the High Ambition policy bundle, the overall risk of exposure to conflicts grows more slowly than in the Current Ambition scenario. However, the growth in the risk indicator under both scenarios reinforces the importance of additional dedicated active travel and road safety policies as part of a Safe System approach (ITF, 2022[32]).

The proxy indicator for crash risk presented in Figure 5.2 and the mode-specific indicators in Figure 5.3 are new to the ITF Transport Outlook series. They estimate the risk of potential conflicts between pairs of travel modes (e.g. pedestrians and passenger cars) using the same street. The indicators account for total vehicle volumes, the difference in average travel speed between the modes, and the degree of longitudinal separation between the modes. However, they do not include potential conflict with urban freight vehicles.

The pedestrian-car and cyclist-car conflict safety indicators calculated for the Current Ambition and High Ambition scenarios make it possible to compare the effect of transport policies on exposure risk by region. The indicators are divided by total travel demand for the vulnerable mode to estimate the exposure risk per kilometre walked or cycled. A recent ITF report (2022[33]) provides a detailed methodology.

Figure 5.3. Change in pedestrian and cyclist safety indicators under the High Ambition scenario compared to the Current Ambition scenario in 2050



Note: Figure depicts ITF modelled estimates. The traffic safety indicator measures the exposure to potential conflicts between two travel modes. It incorporates vehicle volumes, the difference in speed between modes and the degree of longitudinal separation between modes. Negative values represent a reduced risk of exposure to conflicts. These indicators only account for conflicts with passenger cars, not freight vehicles. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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The results in Figure 5.3 show that ambitious decarbonisation policy measures are expected to reduce the exposure of vulnerable road users to crashes in urban areas compared to the Current Ambition scenario in most regions. The rapid expansion of footpaths and lower speed limits in the High Ambition scenario offset the increases in exposure for pedestrians in every region to some extent. The measures included in the High Ambition scenario mitigate an increase in the exposure to conflict and produce a safer street environment for pedestrians than the Current Ambition scenario. In Europe, Sub-Saharan Africa (SSA) and the TAP region, the exposure to conflicts for pedestrians falls by nearly 30% relative to the Current Ambition scenario.

Cyclists also see some level of improvement under the High Ambition scenario in most regions. They could expect a slight decrease in exposure to conflicts due to additional separated bike lane infrastructure and lower car speeds. However, the increase in mode share for cycling produces a greater risk of conflict exposure in two regions: the Middle East and North Africa (MENA) and Southeast Asia (SEA).

These trends suggest that the co-benefits of decarbonisation policies are not sufficient to address growing safety concerns for vulnerable road users. Some regions urgently require the rapid construction of infrastructure for vulnerable road users to keep pace with the growth in the number of cyclists and passenger vehicles on urban streets, along with stringent enforcement of speed limits. Urban areas where road networks are not yet mature should consider reserving some new infrastructure for light and active mobility. Additional road safety policies (e.g. on motorcycle helmets) will also be needed.

Ambitious policies can transform cities and increase safety for all road users

The results for the High Ambition scenario demonstrate how ambitious transport policies should play a transformative role in creating safer cities in all regions. Moreover, achieving the modal shift required to meet the policy goals of the High Ambition scenario will not be possible without investment in safer environments for walking, cycling, and light mobility more broadly.

Despite the benefits of the High Ambition policies for climate change, road safety for vulnerable users will decline substantially in many regions without additional policies that can improve urban traffic safety. The Safe System approach to road safety encompasses a wide variety of such policies. Under this framework, human error is considered inevitable. The joint design of infrastructure, traffic management, vehicles and post-crash care to eliminate death and serious injury as a consequence of human error complement the traditional policy emphasis on regulating behaviour. Thus, transport infrastructure design should work to minimise risks when crashes occur. Safe System design approaches include protected infrastructure for walking and cycling, traffic calming, improved road surface quality, and joint responsibility for the design and management of the road by all authorities involved (ITF, 2020[34]; ITF, 2022[32]).

The proxy indicator presented in Figure 5.3 captures the estimated exposure to potential conflicts but not the severity of these conflicts. Vehicle size and weight, like speed, are important factors in the severity of crashes involving vulnerable road users. Larger and heavier passenger vehicles have contributed to the alarming rise in severe injury and death rates among vulnerable road users in the United States (Edwards and Leonard, 2022[35]).

Vehicle weight considerations, especially for cars and vans, are critical as electric vehicles become more widespread; electric vehicles are often heavier than similarly sized fossil fuel-powered vehicles due to the added weight of the battery pack (OECD, 2020[14]). Weight-based fees for heavy passenger vehicles have been used to incentivise the purchase of lighter vehicles in France and in Washington, DC (Zipper, 2022[36]), and the European Union has begun to require protective measures for pedestrians and cyclists in new vehicle designs (ETSC, 2019[37]). Vehicle weight has increased over the past decades. Reversing this trend would significantly enhance vehicle efficiency, bring carbon dioxide (CO_2) and pollutant reductions and contribute to road safety (ITF, 2017[38]).

Targeted road safety policies are needed to reduce risks

Designing safer streets involves reducing vehicle speeds and increasing the separation between vehicles and vulnerable road users. Lower speed limits should be combined with traffic-calming infrastructure and enforcement (Wilmot and Khanal, 2010[39]). Examples of traffic-calming infrastructure proven to reduce travel speeds include narrower travel lanes, chicanes and raised crosswalks (Damsere-Derry et al., 2019[40]). These treatments also have the benefit of inducing a shift towards sustainable modes by making them safer and, therefore, more attractive (Clarke and Dornfeld, 1994[41]). The ITF has recently published a guide to street design and traffic management solutions for safe streets (ITF, 2022[42]), which complements an extensive global guide by the World Resources Institute (Welle et al., 2015[43]). All urban road safety plans should take into account the evolution of both road fatalities and serious injuries.

Separated infrastructure for pedestrians and cyclists is a proven measure for reducing the rate of on-road injuries and fatalities (Reynolds et al., 2009[44]; Gössling and McRae, 2022[45]). Research has also shown that dedicated infrastructure is perceived by users as more comfortable and safe than high-volume shared lanes, and that more and targeted dedicated infrastructure encourages the adoption of active modes and micromobility (Clean Air Asia Center, 2013[46]; Ton et al., 2019[47]). Dedicated freight infrastructure (e.g. loading zones) that creates separation between freight vehicles and passenger vehicles can also be used to reduce conflicts, leading to improved overall traffic safety (McDonald and Yuan, 2021[48]).

In the future, the widespread adoption of autonomous vehicles could reduce or eliminate driver error as a cause of vehicle crashes. Automated vehicles may nonetheless display unanticipated and dangerous driving behaviours. Furthermore, technological progress has proven to be slower than expected, and considerable uncertainty remains around future adoption curves. Many forecasts expect it will be several decades before automated vehicles achieve high market penetration rates (Lavasani et al, 2016[49]). In the interest of maximising urban liveability in the short and long term, this section has focused primarily on opportunities to limit the frequency and severity of crashes involving human-operated vehicles.

Putting the city within reach: Transport policies for improving accessibility

A liveable city needs a transport system that performs its core function effectively: moving people around the urban area. This section analyses how cities and their transport systems can provide efficient access to the activities that residents want or need to pursue. These activities include necessities such as grocery shopping, work and health care, and urban amenities such as restaurants and entertainment. The section primarily focuses on "accessibility" in reference to access to opportunities, consistent with previous ITF publications on this topic (ITF, 2019[50]).

Reducing journey times for public transport expands access to opportunities

Demand for transport is typically derived, meaning that the need to travel usually results from the desire to pursue an out-of-home activity. The near-endless number of possible activities and work opportunities is one reason cities are such desirable places to live and why people continue to move to urban areas. Travelling to pursue activities at distant locations can be time-consuming, especially as urban areas grow larger and transport networks become congested. As a result, the inconvenient location of some activities can effectively render them unavailable.

The ability of residents to enjoy the benefits of urban living by travelling throughout an urban area is thus a function of the spatial accessibility the transport system enables. Moreover, certain destinations may only be accessible using specific travel modes (e.g. by driving a private car) and thus restricted to a subset of the population with access to that mode.

Many different indicators exist that quantify spatial accessibility. Weibull (1976[51]) proposed a set of technical criteria for any accessibility indicator: increasing attractions should improve accessibility; increasing travel times should reduce accessibility; and opportunities that do not provide value should not affect accessibility. Morris, Dumble and Wigan (1979[52]) also propose several practical criteria: an accessibility indicator should be based on behaviour, technically feasible, and easy to interpret.

The ITF Accessibility Framework (see Box 5.2) meets each of these criteria. It involves cumulative accessibility indicators that count the total number of destinations within a certain travel time threshold for each mode. Cumulative indicators are commonly used in comprehensive accessibility studies (Wu et al., 2021[53]). Proximity-based indicators are another means of measuring accessibility. Proximity-based accessibility indicators include the minimum travel time needed to reach the nearest activity location (e.g. a hospital) from a given origin location.

The ITF Accessibility Framework requires detailed transport network data for every urban area, which is not feasible to estimate as part of a global outlook. Instead, the Outlook uses two alternative indicators as a proxy for accessibility. The first is average travel speed by car and public transport. Travel speed by mode is used to illustrate how the performance of the transport system compares between policy scenarios. The second alternative indicator is the modal mix available in an urban area. This indicator evaluates the distribution of trips across mode categories to understand the potential impact of a disruption.

Figure 5.5 shows the average difference in journey time for passenger car and public transport between the Current Ambition and High Ambition scenarios in 2050 for each region. This indicator shows how long, on average, it takes to cross the city by each mode. The policies associated with the High Ambition scenario reduce the average journey time for public transport in every region except for SSA. These widespread benefits are unsurprising, given that many High Ambition policy measures directly aim to improve the performance of public transport systems. The decline in public transit speeds in SSA is roughly 5%.

Most regions could also expect an increase in average car journey times as road space is reallocated towards sustainable modes under the High Ambition scenario. Specific High Ambition policy measures, such as lower speed limits, could be expected to cause slower travel for passenger cars. Europe, MENA and UCAN see journey times improve for both cars and public transport. This is a combination of decreased congestion on the road network, caused by a steady modal shift to active and shared modes, and more opportunities available in close proximity due to changed land use planning practices.

This means that trip distances to access those opportunities will be shorter, although the journey time improvements in Europe, MENA and UCAN are still better for PT than for car. If the High Ambition policy measures are enacted, urban residents in these regions can expect more convenient travel by car and public transport, enabling them to reach more employment, social and recreational opportunities.

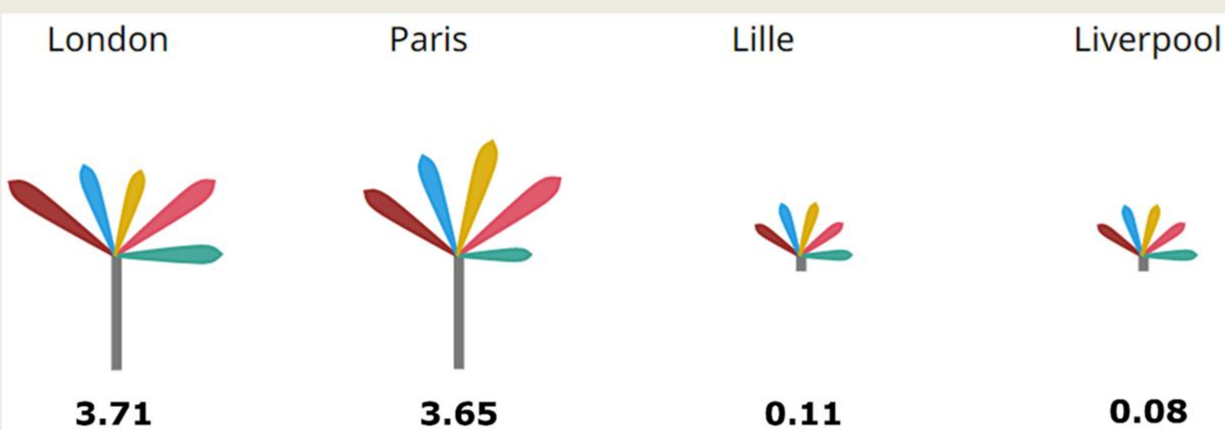
Box 5.2. Measuring accessible cities: The ITF Accessibility Framework

The ITF Accessibility Framework benchmarks the urban accessibility of the world's cities (ITF, n.d.[54]). For a given location, it identifies how many destinations can be reached within a certain time by different travel modes: on foot, by bicycle, by public transport or by car. It then measures how many destinations lie within a certain geographic distance. The ratio of accessible destinations to nearby destinations determines the performance of each transport mode. This methodology for calculating accessibility differs from previous studies, as it captures transport performance independent of city size. It also uses a harmonised definition of a city that can be applied worldwide, providing a consistent benchmark for comparison.

An initial study (ITF, 2019[55]) used the framework to calculate accessibility to schools, hospitals, food shops, recreational opportunities and green spaces across 121 cities in 30 European countries (see Figure 5.4). It found that cities consistently offer higher accessibility than surrounding commuting zones. While cars provide better accessibility than public transport or cycling, especially for longer travel times and in commuting zones, bicycles and other micromobility modes perform better for trips of 15 minutes. Although congestion reduces transport performance, dense cities can still reach high levels of accessibility because many more destinations are located nearby. This underlines the fact that accessibility can be increased not only by policies that improve transport systems but also by policies that bring people closer to their destinations.

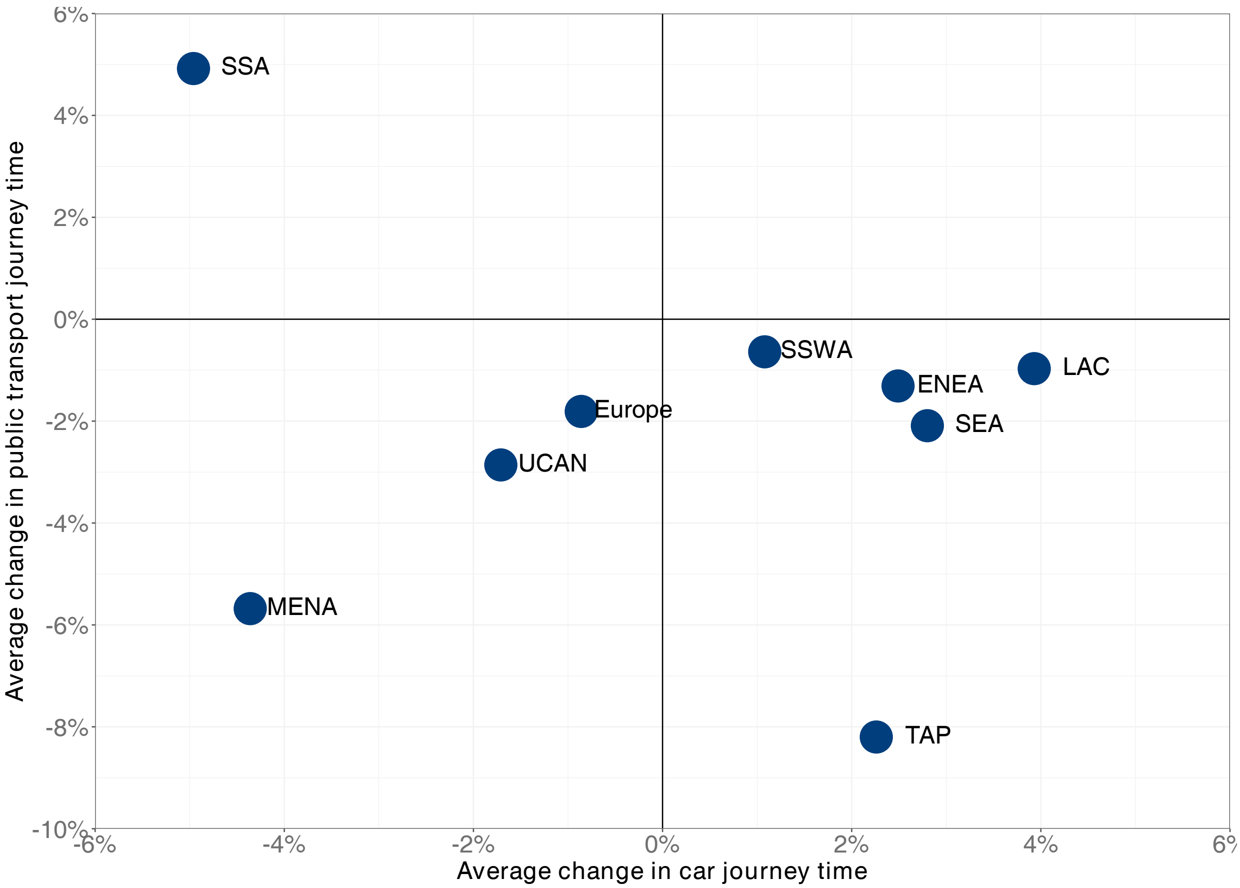
The ITF Accessibility Framework is now being improved and applied to different regions. In a collaboration with the OECD's Sahel and West Africa Club, the ITF has measured the accessibility for walking, driving and informal public transport in Accra and Kumasi, Ghana's two largest cities. The framework now uses gender-differentiated population and travel-behaviour data to capture gender differences in accessibility. For another study, the ITF is applying the framework to the Seoul Metropolitan Area in Korea. The study applies an equity lens by incorporating socio-economic population characteristics (e.g. age, gender, income and car ownership). Specific scenarios analyse the needs of particular population groups for access to essential destinations (e.g. access for the elderly to leisure facilities or access to jobs by public transport for lower-income households).

Figure 5.4. Visualising the accessibility of public transport for European cities



Note: The ITF Accessibility Framework visualisation tool, "How accessible is your city?", enables comparison across cities. The five-coloured petals show the relative accessibility of population, schools, hospitals, food shops and green spaces, respectively, using public transport within a 30-minute travel time. The stem size and the number below each stem reflect the city's overall accessibility score.
Source: ITF (n.d.[54]).

Figure 5.5. Change in journey time for passenger cars and public transport in 2050 from the Current Ambition to the High Ambition scenario, by region



Note: Figure depicts ITF modelled estimates. The average travel speed is calculated for a typical trip from the city centre to the edge of the urban area. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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Transport policy, accessibility and urban design are inextricably linked

Improving accessibility is increasingly recognised as a critical goal for urban planning (OECD, 2020[56]). Two popular urban design philosophies, transit-oriented development (TOD) and the "15-minute city", seek to maximise access to opportunities through distinct but complementary approaches. The general goal of TOD is to create mixed-use communities within walking distance of a core commercial area that features a high-capacity transit station (Calthorpe, 1993[57]). A 15-minute city, on the other hand, is defined as an urban area where residents' daily needs can be met by walking or cycling for no more than 15 minutes (Allam et al., 2022[58]).

In both concepts, the overarching emphasis is on sustainable mobility, mixed land-use development and reduced reliance on private motorised transport. Originally conceived as a sustainable option for suburban contexts in the United States, TOD focuses on public transport. In contrast, the 15-minute city relies on walking, cycling and micromobility as core modes providing access to nearby needs and amenities. TOD requirements in Dhaka's development plans have been shown to create better access to a range of urban amenities across one of the world's most densely populated cities (Rahman, Ashik and Mouli, 2022[59]).

Accessibility depends on the transport system's effectiveness and the density of potential activities. Accessibility is also a function of congestion in the transport network and can vary by time of day. As discussed in Chapter 3, investment in efficient transport systems and policies that encourage short travel distances, such as compact land-use planning and robust public transit systems, are needed to produce highly accessible cities (Wu et al., 2021[53]).

The 15-minute cities and TOD concepts do not always improve urban equity, but their aims are often combined with social equity goals to ensure that all urban residents share the benefits (Lung-Amam, Pendall and Knaap, 2019[60]). Careful planning and complementary measures (e.g. inclusionary zoning to mitigate displacement of existing residents, social housing policies) are necessary to ensure that the benefits of accessible neighbourhoods are available to all. By reducing travel distances, improved accessibility facilitates a shift towards micromobility, active and shared modes, which are much more space-efficient. This mode shift allows for repurposing transport infrastructure for other uses, such as green space, which makes an urban area more liveable.

The transport system is only one element of accessibility. Therefore, this measure cannot reflect changes in land-use patterns. The policy measures in the High Ambition scenario, such as broader adoption of mixed-use development, would be expected to produce greater density and distribution of opportunities within an urban area. As a result, the change in travel speed between the Current Ambition and High Ambition scenarios is likely to underestimate the total improvement in urban accessibility produced by the High Ambition policy measures.

A mix of transport modes can improve liveability

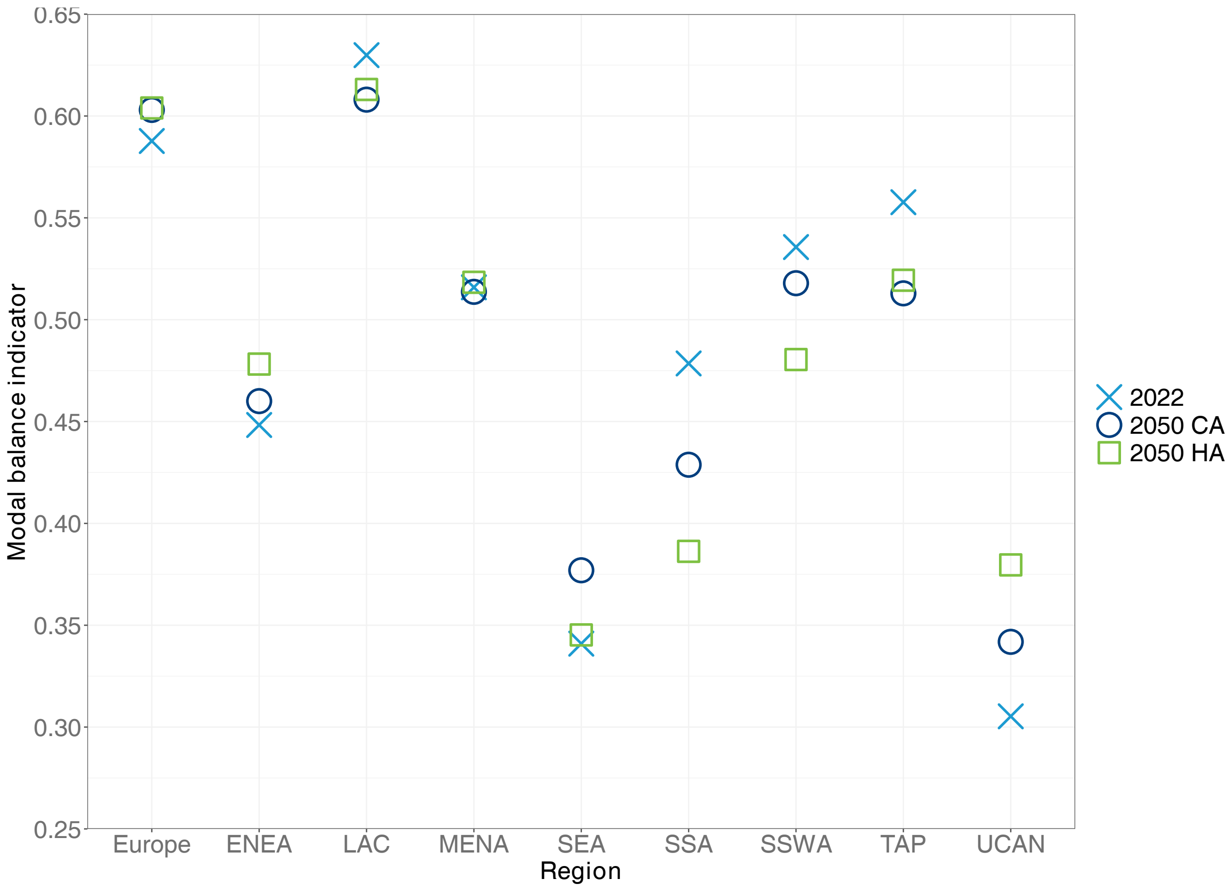
The ITF has also developed a trip-based modal balance indicator to look at the diversity of modes available to urban inhabitants. The modal balance indicator is conceptually related to accessibility as it quantifies the transport network's ability to provide access to opportunities under disruptions. Possible disruptions include inclement weather or crashes that impede travel. The indicator has been normalised on a scale from 0 to 1 such that a perfect balance of trips across travel mode categories would produce a score of 1, while total reliance on a single mode would produce a score of 0.

The modal balance in the United States, Canada, Australia and New Zealand (grouped in this report as the UCAN region) would notably improve under a High Ambition scenario compared to both the Current Ambition and current year scores (see Figure 5.6). Many North American cities are highly accessible by car but less accessible by public transport and active travel modes (Wu et al., 2021[53]). The overall accessibility of such cities for those who do not use cars is, therefore, poor. In addition, road network disruptions limit the transport accessibility of such cities, given the lack of alternative travel modes.

However, new mobility modes such as micromobility and shared mobility can improve accessibility and resilience by opening up a more comprehensive range of options to travellers, including adaptive vehicles for those with mobility impairments (Abduljabbar, Liyanage and Dia, 2021[61]). The regional benefits observed in UCAN are a product of a shift away from overreliance on private cars, which account for more than 80% of trips in 2022, to a greater share for metro and active modes.

An urban area would be quite vulnerable to a severe disruption to the road network if passenger cars were the overwhelmingly dominant travel mode and other modes lightly used or unavailable. More even modal balance would help to limit the impact of a disruption to the road network in the UCAN region, which is critical for climate adaptation. For Europe, LAC and MENA, the modal balance indicator is largely unchanged between 2022 and 2050, and the High Ambition policy measures have little effect. Other regions, such as ENEA and UCAN, see an improvement in modal balance due to the High Ambition policies.

Figure 5.6. Changes to regional modal balance between 2022 and 2050



Note: Figure depicts ITF modelled estimates. This indicator measures the trip-based modal balance across four categories of modes, where 1 represents a perfect balance across all mode categories and 0 represents all trips within a single mode category. The mode categories are light road users (walking, cycling, motorcycles, three-wheelers, scooter sharing, bikesharing and motorcycle sharing), heavy road vehicles (cars, taxis, buses, informal buses, ridesharing, carsharing and taxi buses), light public transport (bus rapid transit and light-rail transit), and heavy public transport (suburban rail and metro). Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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In the SEA, SSA and South and Southwest Asia (SSWA) regions, the High Ambition policy measures reduce the modal balance indicator relative to the Current Ambition scenario. This is because the High Ambition policies boost the already disproportionate shares of walking, cycling and other forms of micromobility in these regions.

These results demonstrate how policies that produce a more sustainable modal split can also result in a concentration of trips across similar modal categories. Infrastructure disruptions are less likely to be a concern because these modes are relatively nimble compared to large buses or rail vehicles. However, active and other non-active micromobility modes may be affected by inclement weather, so maintaining convenient alternatives such as public transport is essential for the robustness of the transport system.

The High Ambition measures, including increased availability of shared modes, better infrastructure for active and non-active micromobility modes, and mixed-use development, result in a smaller role for informal bus transport in emerging economies relative to the Current Ambition scenario. Informal buses are quite flexible and address a critical market need in many urban areas. However, their travel times can also be unreliable, and vehicles are often overcrowded (Sohail, Maunder and Cavill, 2006[62]).

Making lighter shared and active vehicles available for some trips is expected to complement the informal bus network and provide new transport options for short and medium-length trips (Loo and Siiba, 2019[63]). For example, users described a public bikeshare system, introduced in Manila in 2015 to provide an alternative to informal buses for university students, as “reliable”, “comfortable” and “convenient” (Sharmeen, Ghosh and Mateo-Babiano, 2021[64]). Mixed-use development would allow people to pursue a wider range of activities close to home, thus making active modes more attractive and reducing the mode share of informal buses (Rahman et al., 2023[65]).

One crucial consideration when quantifying modal balance is the choice of categories. Different modal categories will measure vulnerability to different types of disruptions. For example, the indicator used in this chapter uses categories based on their ability to respond to infrastructure disruptions: light road users (e.g. walking, motorcycles and micromobility), heavy road vehicles (e.g. cars, taxis and buses), light public transport (including bus rapid transit (BRT) and light-rail transit) and heavy public transport (metro and suburban rail). These categories produce an indicator that measures the vulnerability of regional transport systems to infrastructure-related disruptions. Another option would be to categorise modes based on ownership (e.g. shared, private or public modes). Such an indicator could help evaluate the vulnerability of a transport system to disruptions in funding sources, such as the failure of a private bikesharing operator or discontinued subsidies for public transport.

Recent lifestyle changes have mixed impacts on accessibility and liveability

Emerging technologies and social trends have begun to change how public officials and scholars measure urban accessibility. The first is the substitution of in-person shopping by e-commerce. In one sense, this has improved accessibility for the shopper by eliminating travel time for shopping trips. A trip by the delivery platform is still required, however. As a result, e-commerce is not simply an unconditional improvement in liveability. Still, under the right circumstances, e-commerce platforms can efficiently meet people’s needs while reducing overall travel. Policies that strongly incentivise sustainable, efficient and safe urban freight networks ensure that deliveries do not increase urban greenhouse gas emissions or traffic congestion.

The ITF model results show that ambitious freight policies can reduce urban freight vehicle-kilometres for parcel deliveries. The results for this Outlook show that asset sharing across operators, which has been shown to improve freight efficiency in the past (Vanovermeire et al., 2014[66]), produces a 23% reduction in urban package vehicle-kilometres relative to a baseline scenario with no asset sharing. Consolidated package pickup and drop-off locations (also referred to as “package lockers”) reduce vehicle-kilometres by 27% compared to the baseline scenario with only door-to-door deliveries. While large platforms have succeeded in consolidating orders from small vendors to improve operational efficiency, asset sharing across platforms has not achieved widespread adoption in practice (Karam, Reinau and Østergaard, 2021[67]).

Shifting last-mile deliveries to cargo bikes for feasible trips reduces motorised VKM by 35%, although overall VKM increases due to a significant increase in non-motorised trips. Non-motorised freight modes such as cargo bikes have a smaller impact on urban safety, air pollution levels and space consumption. Therefore, they represent a liveability improvement relative to large, motorised freight modes.

The second emerging trend is the rise in remote work catalysed by the Covid-19 pandemic. Remote work is similar to e-commerce in that it has made access to some forms of work possible without the need to travel. This improvement in accessibility comes without changing the transport system or land use. Nevertheless, an uptake of remote work may not always improve liveability. Many remote workers have moved away from city centres as they no longer need to commute five days per week (Ramani and Bloom, 2021[68]). There are often fewer options for sustainable travel in suburban and rural areas, so these remote workers may begin to drive more often and further than before, increasing their carbon footprints.

Even for remote workers who continue to make sustainable travel choices, the lack of a commuting trip to anchor the daily travel schedule can induce multiple shorter trips for other daily activities (Budnitz, Tranos and Chapman, 2020[69]; Wöhner, 2022[70]). Land-use policies that allow these activities to take place close to home would mitigate the impact of remote work on liveability. Improving urban accessibility to meet the daily travel needs of remote workers is a new and challenging task for planners and policy makers. A recent ITF report (2023[71]) offers specific actions for adapting to these emerging mobility patterns.

Liveability for all: Promoting equitable and inclusive transport

Transport policy helps guide the allocation of scarce resources through public investment in infrastructure and operations. As transport is inherently place-based, resource allocation choices are likely to benefit some urban residents over others. Social equity, described as the fair and appropriate distribution of costs and benefits within society, is an essential component of transport policy. In the context of liveability and transport, "fair and appropriate" means that every neighbourhood should have similarly convenient access to activities. It also means that the negative externalities of transport should be shared across the urban area. A broad distribution of amenities allows all residents to flourish as individuals while creating social cohesion and a sense of community.

Equitable transport policy addresses past injustices

Equity is a broad term that encompasses many different ideas. The concept of transport equity has become increasing prominent in planning and policy discussions, but the impacts of a long legacy of inequitable policies are still felt today. The concentration of environmental burdens is one example. Communities that experience disproportionate environmental harms and risks due to transport infrastructure are often referred to as "environmental justice communities" in the United States and increasingly around the globe (Correa, 2022[72]).

Certain countries and regions have taken proactive measures to reduce the number and extent of such communities, including prioritising the construction of new sustainable transport infrastructure in designated areas (Louis and Skinner, 2021[73]). Other past policies have created communities that are disproportionately affected by a lack of transport investment relative to the rest of the urban area (Amar and Teelucksingh, 2015[74]) or that have suffered displacement due to the construction of new transport infrastructure (Perry, 2013[75]).

Another important aspect of transport equity is "vertical transport equity", which assumes that fairness involves providing treatment to improve the conditions of disadvantaged and underserved people (Di Ciommo and Shiftan, 2017[76]). There are many dimensions of vertical transport equity. For example, vertical transport equity with respect to income would involve policies specifically designed to reduce the transport cost burden for lower-income travellers, such as investment in affordable modes or income-based fare subsidies for public transport (Rosenblum, 2020[77]).

Racial and gender transport equity addresses past injustices that disproportionately affect certain groups. Transport is not gender-neutral (ITF, 2019[78]). Integrating gender differences into transport planning remains a relatively uncommon practice despite known disparities in needs and outcomes (Carvajal and Alam, 2018[79]). In 2022, as part of a research workstream dedicated to gender equity, the ITF launched a Gender Analysis Toolkit for Transport Policies. The toolkit provides a resource for introducing gender equity considerations into transport policy development (ITF, 2022[80]). Evaluating transport investments and policies through a racial equity lens is also becoming more widespread (Verlinghieri and Schwanen, 2020[81]).

Transport affordability is a crucial component of equity

Another important equity consideration is the relative affordability of travel by mode. Policies that reduce the generalised cost of travel also lessen the financial and time burden placed on lower-income households and make more opportunities available for the same travel cost. Improved affordability has a similarly positive effect on liveability: improved accessibility for lower-income households is an example of vertical transport equity concerning income. Many transport policy measures (e.g. road pricing and low-income fare discounts) directly impact affordability. Integrated public transport ticketing also affects affordability by reducing the time cost (and, in some cases, the fare) of transfers between modes.

The ITF model estimates the generalised cost of an average trip for different modes, which incorporates both the travel time and the financial cost. Financial costs involve fares for public transport and shared modes, and operating and maintenance costs for private modes, including any pricing measures. These trip costs are then normalised by regional per-capita gross domestic product (GDP) to estimate the relative affordability of travel by mode.

Figure 5.7 illustrates how policy measures that improve the integration of public transport and shared modes could affect trip affordability in different regions by 2050. Making shared mobility vehicles more widely available and increasing the availability of mobility-as-a-service subscriptions and pay-as-you-go models have a strong impact on the affordability of bikesharing and carsharing. Increasing the number of available vehicles reduces the time cost of accessing a vehicle, thus improving affordability.

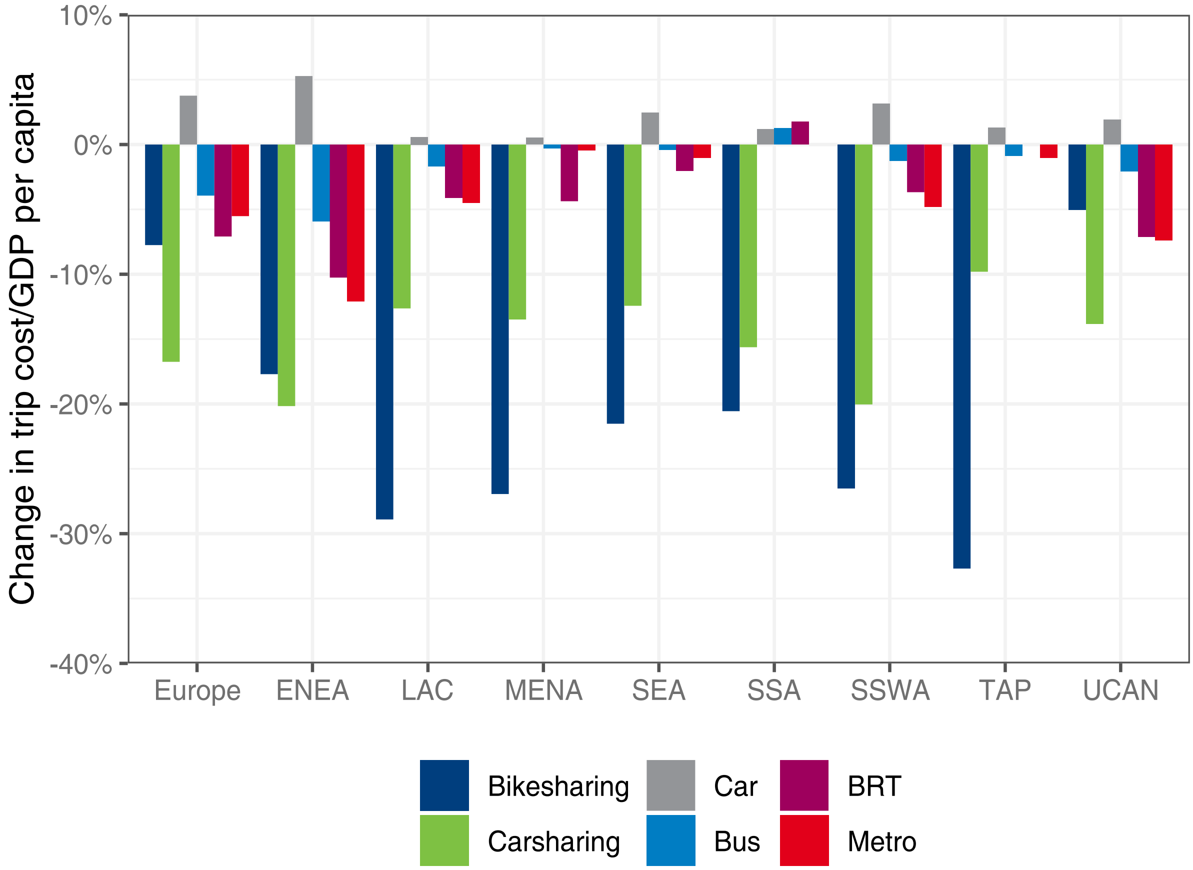
At the same time, multi-modal travel services, such as Mobility as a Service, are expected to increase the demand for shared mobility, resulting in operational efficiencies passed on to the user through lower fare costs. As discussed in Chapter 3, this will be contingent on viable business models being identified. Trip costs for bikesharing decrease by more than 25% in the Latin America and the Caribbean (LAC), MENA, SSWA and TAP regions. Policies encouraging mobility-as-a-service adoption also decrease trip costs for public transport modes in nearly all regions. Furthermore, shared mobility policies indirectly make private car trips somewhat less affordable due to greater competition for road space.

Equity can also apply to the distribution of investment by travel mode. Modal equity is a necessary but not sufficient condition for transport equity (Pereira and Karner, 2021[82]). The United States spends nearly 90% of its transport infrastructure investment on automobile infrastructure (OECD, 2022[83]). As a result, there are often few independent travel options for seniors, adolescents, lower-income households, people with disabilities and other non-drivers (Litman, 2022[84]). Automobile dependency thus forces those who prefer alternative modes into car ownership, or to make other compromises. In contrast, several European countries invest over half of their transport budget on new rail infrastructure (OECD, 2022[83]), which includes urban passenger rail, a mode that is often less expensive on a per-trip basis and accessible to all.

The shared mobility mode share varies across regions, partially due to the uneven availability of certain shared mobility modes in cities in emerging economies (Venter, Mahendra and Hidalgo, 2019[85]). As a result, the accessibility benefits of shared mobility are not equitably distributed across regions. One approach to encouraging modal equity requires that future street maintenance and reconstruction projects integrate multimodal infrastructure. The City of Cambridge, Massachusetts, has taken this approach in its 2019 Cycling Safety Ordinance (City of Cambridge, 2019[86]), which states that cycle lanes must be included in street reconstruction plans.

Equity principles also apply to transport investment and outcomes across metropolitan areas, countries and regions. This is often referred to as spatial or territorial equity. Territorial equity is especially significant for urban transport due to the vast regional differences in transport availability, performance and exposure to negative externalities highlighted throughout this report.

Figure 5.7. Sensitivity of trip affordability to public transport and shared-mode integration policies in 2050, by region and mode



Note: Figure depicts ITF modelled estimates. Trip affordability is defined as the average cost per trip divided by the average per-capita GDP for each region. The operational efficiency policy measures used for the sensitivity analysis are 1) integrated public transport ticketing, 2) increased availability of shared mobility vehicles, 3) increased availability of mobility-as-a-service platforms and 4) increased availability of carpooling. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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The results in Figure 5.7 show how the outcomes of transport policies can vary by region. For example, the affordability of urban public transport modes such as buses, BRT and metro improves most in regions with expansive formal public transport networks. Policies such as integrated ticketing and shared modes for first- and last-mile access are less helpful where formal public transport systems are limited.

Addressing historical imbalances in public transport investment across regions would not only improve the overall quality of the transport system; it would also allow more cities to reap the affordability and liveability benefits of ambitious transport policies. An example of territorial equity applied to transport policy is the European Union's Trans-European Network for Transport, whose objectives include the "reduction of infrastructure quality gaps between Member States" (Aparicio, 2018[87]).

Transport for inclusive societies

People with disabilities have long been excluded from using certain transport modes. Physical barriers, including stairs for accessing public transport and poorly maintained footpaths, often limit access to opportunities for those with mobility and visual impairments. Many cities have enacted policies to improve the physical accessibility of public transport. Still, much work remains to be done to ensure that the advantages of public transport are broadly shared (Bezyak, Sabella and Gattis, 2017[88]).

Micromobility and many shared mobility vehicles and interfaces can be similarly inaccessible for urban residents with disabilities. Regulations that require new mobility operators to provide inclusive or adaptive vehicles as part of their operating fleet have proven moderately successful (LaRosa and Bucalo, 2020). Further public policy work is needed to improve the distribution of inclusive and adaptive vehicles across shared mobility fleets.

Ageing populations are another vulnerable group with limited transport options. Urban populations have grown older in developed and emerging economies alike and are expected to continue ageing in the coming decades (OECD, 2015[89]; UN DESA, 2022[90]). Cities will need to adapt to meet the needs of older residents and improve liveability. Many of the transport policies that improve liveability for those with mobility impairments will also benefit seniors, such as the removal of physical barriers and inclusive design for mobility platforms. Providing quiet public spaces for people to sit down, rest and socialise during travel is also recommended to improve access and make travel easier for the elderly (Yung, Conejos and Chan, 2016[91]).

Prioritising urban space for people: Creating a space-efficient transport system

Space is in high demand in most cities: space is needed for housing, infrastructure, commercial activities and the many other uses that define an urban area. As evidenced by the definitions of liveability provided at the beginning of this chapter, truly liveable cities allocate a considerable amount of their available space to public amenities. Liveability-enhancing amenities include urban parks, community gathering places and public services. Appleyard (1980[92]) describes how even small changes to urban space can improve liveability by producing more socialisation opportunities. Yet once urban development has taken place, it can often be difficult or expensive to reclaim land for public amenities.

Ambitious decarbonisation policies can reduce congestion and limit the space consumed by transport

One method for estimating the change in space consumption that results from transport policies is to quantify the fraction of the urban road capacity used by transport (i.e. road occupancy). When a smaller share of the road space is needed to support travel demand, excess travel lanes can be converted to support uses that improve liveability. The ITF Transport Outlook model estimates road occupancy by dividing the on-street traffic volumes by the capacity of the available road network. Using road occupancy as a proxy measure for street space use is likely to underestimate the magnitude of space consumption changes. It does not consider changes to on-street parking demand that would also result from large-scale modal shifts.

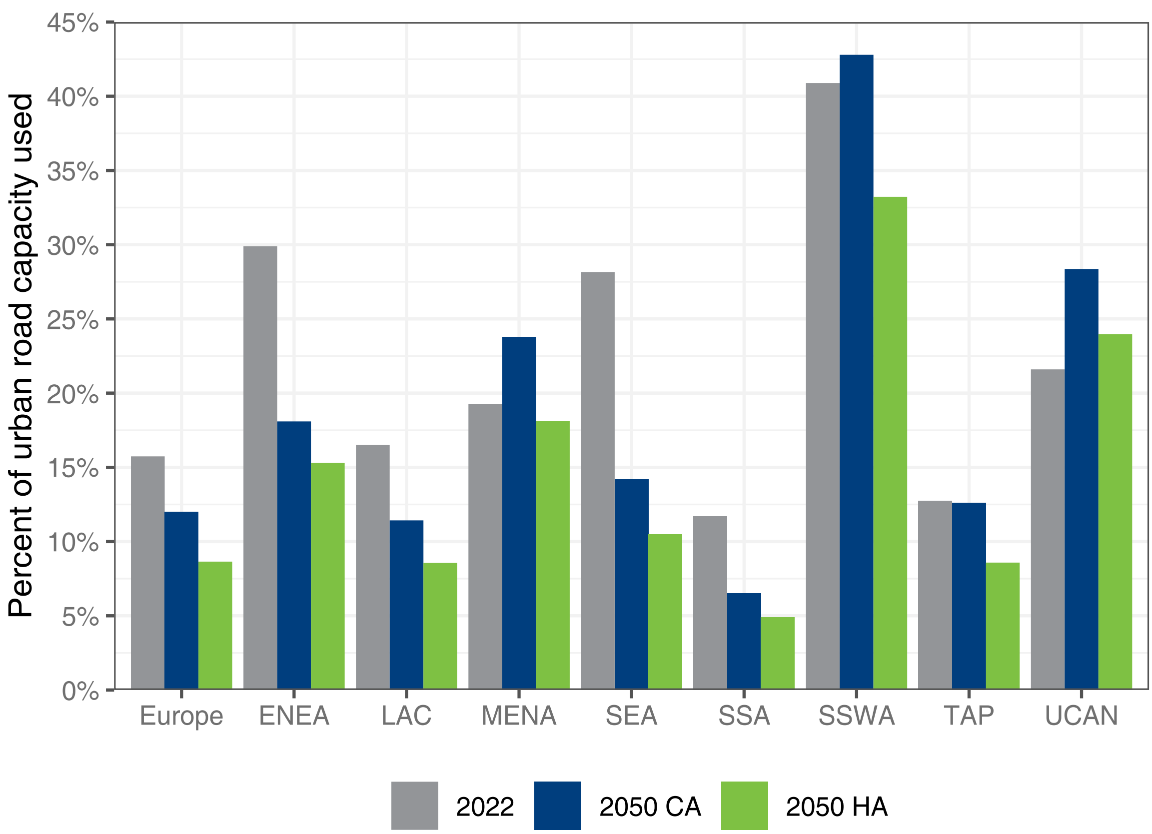
ENEA, one of the regions experiencing the most congestion in 2022, is expected to see significant reductions in road occupancy by 2050 (see Figure 5.8) under both policy scenarios. Due to rising urbanisation and limited mode shift to more efficient travel modes, a range of increases in urban road occupancy are anticipated for the MENA, SSWA and UCAN regions under Current Ambition policies. The

SSWA region will become more congested than any other region in the Current Ambition scenario, but it also benefits the most in 2050 from the High Ambition scenario in terms of the level of reduced congestion.

In 2050, across all regions, the more ambitious transport policies enacted in the High Ambition scenario deliver a substantial reduction in road occupancy compared to the Current Ambition scenario. For the MENA and SSWA regions, the High Ambition policies are sufficient to offset the anticipated increases in road congestion under the Current Ambition scenario and produce less congested roads in 2050 relative to 2022. The only region that is expected to see greater congestion in 2050 under both scenarios is UCAN.

While the percentage changes in Figure 5.8 may appear relatively small, they represent a meaningful shift in the total amount of land needed for transport. The UN Human Settlements Programme provides a harmonised measure for the percentage of urban land dedicated to streets (UN-Habitat, 2013[93]). Large cities such as Chicago and Delhi dedicate over 20% of their total land area to streets (Meyer and Gómez-Ibáñez, 1981[94]; Cervero, 2013[95]). Even in a city with a relatively low proportion of street area, such as Dhaka, the 9.6% reduction in occupancy afforded by the High Ambition scenario would result in over 270 urban hectares becoming available for other uses, including much-needed green space (Labib, Mohiuddin and Shakil, 2013[96]).

Figure 5.8. Percentage occupancy of total urban road capacity in 2050 under the Current and High Ambition scenarios, compared to 2022



Note: Figure depicts ITF modelled estimates. Percentages indicate the reduction in road capacity used under High Ambition scenario compared to Current Ambition scenario. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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The two primary means of reducing space consumption by transport are: 1) incentivising travel modes with lower space consumption per person per trip and 2) increasing the occupancy rates of shared vehicles. Private cars are the predominant travel mode in many upper-income cities, but they are also the least space-efficient for an average single-occupant trip. As a result, there is an opportunity to reduce space consumption by a significant margin. High-capacity public transport vehicles, including buses, trams and passenger trains, require much less space to serve each trip than private cars.

Active transport modes such as cycling and walking, while less practical for long-distance trips, consume much less space per person than the average private car. Ridesourcing and vehicle-sharing platforms, when subject to policies that provide incentives for higher usage, can also reduce space consumption and congestion relative to private cars (Lazarus et al., 2021[97]). These alternative modes also significantly reduce the need for parking at the destination, making it possible to convert public parking spaces to alternative uses.

Recent ITF work on policies to improve space efficiency within urban areas (ITF, 2022[98]) makes it easier to estimate the amount of space consumed by urban passenger transport. Figure 5.9 illustrates how ambitious transport policies will affect the static and dynamic space consumed by passenger transport in 2050. The static space indicator complements the congestion indicator by estimating the space needed for vehicle parking and storage based on mode choice and demand. The dynamic space indicator, on the other hand, estimates the space consumed by traffic. Figure 5.9 shows how both the static and dynamic space consumed by passenger transport reduces under the High Ambition scenario in 2050.

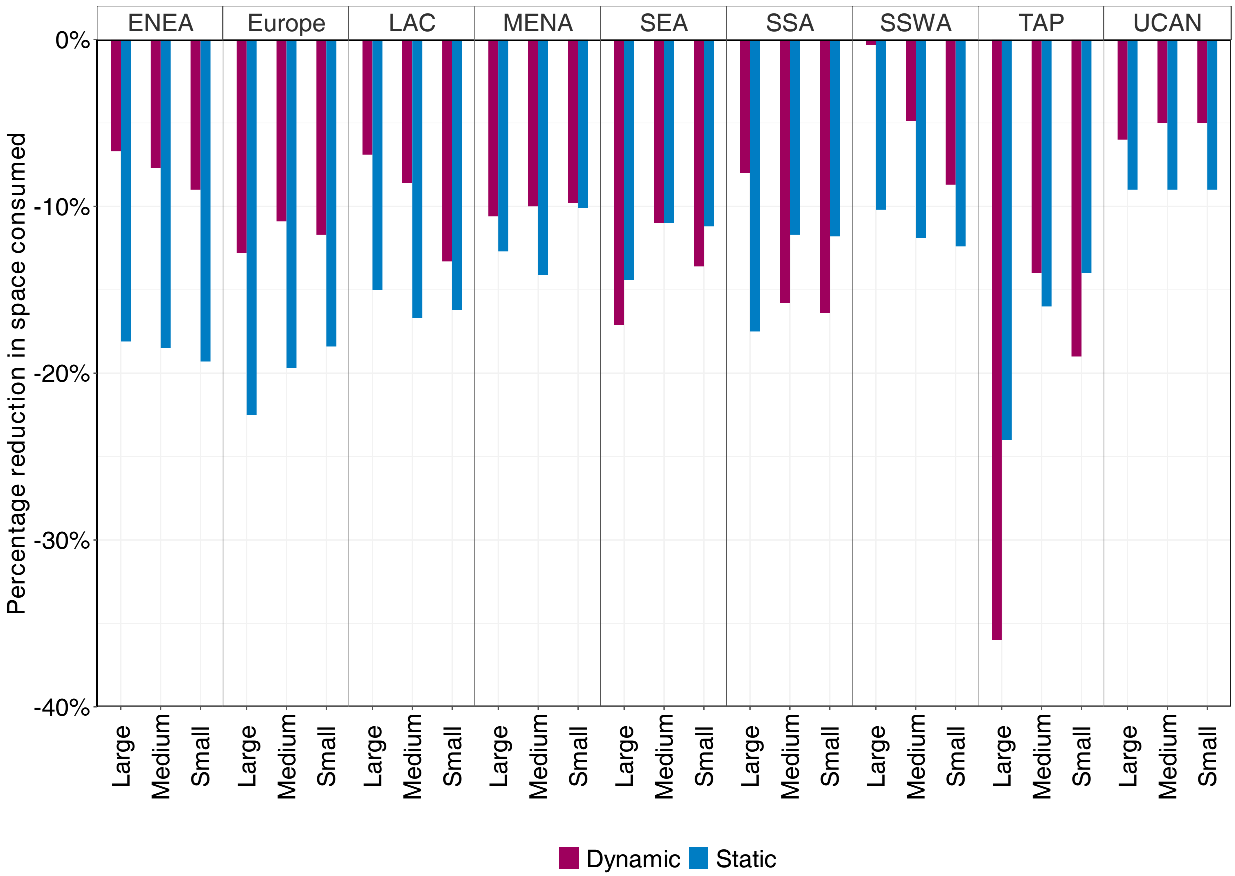
Large cities are already more efficient in their use of space. Car ownership in larger cities is generally less than the national average, and the amount of street space per inhabitant is a fraction of that in smaller cities. Medium-sized and small cities tend to have less dense public transport networks and fewer alternatives to the car. Therefore, although they can save space under the High Ambition scenario, they will still dedicate more street space per capita to passenger mobility than in larger cities.

For most regions, the greatest reductions in space consumption come from reduced on-street parking allocation (see Figure 5.9). Such restrictions reduce the dominance of cars and private motorised vehicles in the streetscape. In UCAN countries, the car is expected to remain a core part of the future urban mobility mix, even under the High Ambition scenario (see Chapter 3). This helps explain the low levels of savings in terms of space consumed by passenger transport in urban areas in these countries for all city sizes.

Shared mobility in very large, developed cities in regions such as Europe or UCAN can decrease the dynamic and static space consumption of passenger travel through increased load factors and reduced standing-time for the vehicles. In emerging regions, shared mobility offers the opportunity to advance a public-like transport system more quickly than would be possible relying solely on development of public transport infrastructure.

Increasing average vehicle occupancy rates could reduce the space consumption of shared modes by serving the same number of trips with fewer vehicles. Promoting carpooling among commuters with similar travel patterns (e.g. via digital driver-passenger matching platforms) is one approach to boosting occupancy rates for private vehicles. Ride-hailing and taxi services also suffer from low average occupancy and spend considerable time cruising for new passengers while unoccupied. Occupancy performance incentives, distance-based fees or other regulations could help address these issues (ITF, forthcoming[99]).

Figure 5.9. Percentage change in static and dynamic urban space consumed by passenger transport in 2050, High Ambition scenario relative to Current Ambition scenario, by city size



Note: Figure depicts ITF modelled estimates. Results reflect the dynamic and static space consumption of passenger vehicles and do not include freight vehicles. For details of the methodology used to calculate space consumption see ITF (2022[98]). Dynamic space refers to the space consumed by traffic. Static space refers to the space consumed on a permanent basis for the use of passenger modes (e.g. parking spaces). City sizes refer to the size of the population of the city: Large: more than 5 million inhabitants; Medium: between 1 million and 5 million inhabitants; Small: fewer than 1 million inhabitants. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

StatLink https://stat.link/3kq4x5

The demand for street space is not limited to passenger transport; urban freight is a large and growing consumer of on-street and curb space. Delivery vehicles are often large and must park for extended periods to pick up goods and make deliveries, consuming considerable amounts of road space within urban areas. There are, however, some promising experiments to encourage the use of smaller vehicles that can easily navigate urban areas. Many cities, including Amsterdam, Bogotá and New York, have deployed electric cargo bike pilot programmes for last-mile goods delivery. These pilots have made deliveries more efficient under certain conditions (ITF, 2022[33]). Box 5.3 provides an overview of the challenges associated with urban freight and several potential solutions to reducing space consumption.

Less space for transport means more space for public amenities

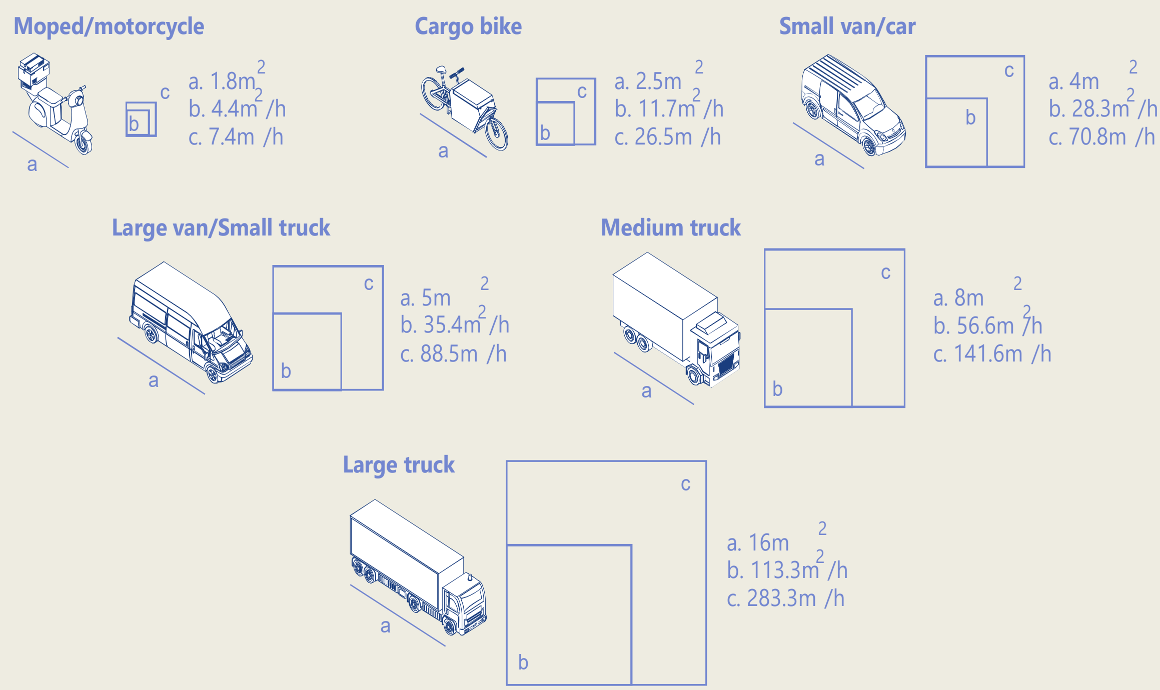
Approaches to increasing urban amenity space include using the existing transport infrastructure more efficiently and freeing up the land occupied by transport for alternative uses. One example is the conversion of on-street parking spaces into temporary restaurant seating, which occurred in many cities during the Covid-19 pandemic (O'Sullivan, 2021[100]). These micro-interventions collectively improved the quality of life of urban residents during the public health crisis (Marks, 2021[101]).

Space conversions can also be more extensive; the city of Seoul has removed 15 elevated expressways since 2002 replacing them with parks and bike lanes and restoring access to an existing stream. These efforts have reduced summer temperatures by more than 3 degrees Celsius in some areas, providing public health benefits for residents (Mesmer, 2014[102]). Similarly, highway removal projects in Spain, Colombia and the United States have made urban areas more liveable by reducing air and noise pollution, lowering crime and providing access to new public spaces (ITDP, 2012[103]; Khalaj et al., 2020[104]).

Box 5.3. The urban freight "space race"

Freight transport activities are a significant and growing competitor for urban street space. Global urban freight demand is expected to double by 2050, accounting for more than 15% of total vehicle-kilometres travelled in many urban areas (ITF, 2021[10]). There are opportunities to reduce the space consumed by parked and moving freight vehicles, for example by managing the types of vehicles used for freight activities (see Figure 5.10).

Figure 5.10. Static and dynamic space usage by freight vehicle type



Note: The dimensions indicated in the figure are (a) vehicle length, (b) dynamic space consumed and (c) static space consumed.
Source: (ITF, 2022[33]).

The ITF has investigated the implications of more than 20 policy measures to improve urban freight vehicles' use of street space by simulating transport activities in a medium-sized urban area (ITF, 2022[33]). The simulations showed that voluntary private-led measures would reduce freight trips by 11%.

In contrast, when public authorities intervene to incentivise space-efficient urban freight distribution, the use of space decreases by more than 30%. Public action is essential for managing freight demand and the timing of deliveries, as is the dynamic allocation of street space for both passenger and freight flows. Fostering shared mobility and integrating some freight and passenger flows could improve space efficiencies by a further 16%.

Policies targeting the use of urban space by freight activities also have substantial liveability co-benefits. Improved load factors, increased use of lighter and smaller vehicles, and electrification could reduce carbon dioxide (CO_2) emissions by more than 60%. Emissions of nitrous oxide (NO_x), fine particulate matter of 2.5 microns or less (PM2.5) and sulphur dioxide (SO_2) would decrease by 78%, 90% and 100%, respectively.

These policies can also improve road safety. In the most ambitious scenario, the exposure risk of conflicts between freight vehicles and pedestrians decreases by more than 40%. In comparison, the exposure risk of conflicts between freight vehicles and cyclists decreases by 60%.

The report makes three recommendations. First, take passenger and freight activities into account when managing curb space, and provide additional curb space for freight vehicles, especially smaller vehicles such as cargo bikes. Second, extend access restrictions to freight services while accounting for the needs of freight carriers. Third, public authorities should develop tools, capacities, partnerships and comprehensive plans to monitor and respond to the complex and rapidly evolving urban freight system.

Ongoing urbanisation, the effects of climate change, and the threat of global pandemics will make urban amenities even more critical in the future. As demonstrated in Seoul, urban green spaces help mitigate climate change effects and improve air quality while offering a cool respite from warming ambient temperatures. Elsewhere, cities are using reclaimed urban space to build flood protection systems, rain gardens and similar climate change adaptation (Kasprzyk et al., 2022[105]).

Amenities that offer opportunities for recreation and socialising will be even more important in rapidly growing urban areas, where homes and apartments are often smaller. The experience of Covid-19 has also demonstrated how outdoor urban space could provide a safe place for physical activity during a global pandemic when indoor group exercise is not permitted.

Pilot programmes demonstrating how urban space can be reimagined are often helpful in generating public support. Urban residents and visitors will not experience the liveability benefits of reduced space consumption unless there is political will to reallocate the space for public use. Temporary pilot programmes can illustrate the benefits and dispel concerns about the downsides of street-use changes. During the Covid-19 pandemic, many cities introduced temporary changes in street use, such as bike lanes in Mexico City (ITDP, 2021[106]) and expanded outdoor dining in Paris (O'Sullivan, 2021[100]), which subsequently became permanent due to popular support. Regularly scheduled "car-free days" in Addis Ababa have inspired neighbourhood redesigns across Ethiopia (ITDP, 2019[107]).

Policy recommendations

Create attractive alternatives to private motorised vehicles to encourage the shift to sustainable transport and reduce pollution

Study after study shows that speed management, traffic calming, and physical separation of pedestrians, cyclists and micromobility users from vehicular traffic are among the most effective ways of reducing on-road injuries and deaths. This demonstrates the crucial importance of building dedicated infrastructure for active mobility and public transport to mitigate safety risks and encourage a modal shift towards less polluting travel modes.

Active travellers and people using non-active micromobility perceive dedicated infrastructure to be more comfortable – and safe – than lanes shared with vehicles in high flow areas, thus making active modes and micromobility more attractive. Shifting travel to these more sustainable modes is critical for limiting the exposure of all urban residents to toxic air pollutants.

New policies that complement dedicated infrastructure are also needed. Conflicts between active modes and micromobility are a growing concern in cities; a solid regulatory and enforcement framework is recommended to ensure micromobility vehicles are used and managed responsibly. Reducing conflicts between freight vehicles and passenger vehicles through dedicated freight loading and offloading zones is another effective policy tool for improving traffic safety.

Investing broadly in infrastructure that supports active transport, light mobility and public transport will also improve connectivity and reduce travel times. Expanding public transport networks and making stations easier to access will make opportunities across the urban area available to all, not just those who can afford a private car. The modelling results in this chapter show that even with highly ambitious transport policies, public transport travel speeds will not be competitive with private car travel speeds in all regions.

Policy makers should seek to deliver new public transport services where existing services are unavailable and improve frequency and running times across the network. Dedicated infrastructure such as bus-only lanes, transit signal priority, and queue-jump lanes can help buses move more quickly and reliably along city streets. Higher frequencies during off-peak hours can help to make public transport a viable travel option for shift workers and non-commuting trips. Proactive development of public transport infrastructure in rapidly urbanising regions is critical to avoid locking in car dependency for those on the urban periphery.

People who do not use private cars need compelling alternatives to car use to increase their access to opportunities. While car trip affordability is expected to improve in some regions by 2050, private car ownership will remain out of reach for large segments of the global population. Improving the performance and attractiveness of alternative modes such as public transport, walking, cycling and other forms of micromobility will improve equity by expanding the opportunities available to everyone.

The trip affordability modelling results show that policy measures such as expanded shared mobility incentives and integrated public transport ticketing lead to lower trip costs for driving alternatives. Land-use policies that encourage dense development around sustainable mobility hubs are an important complementary policy when making opportunities easier to access for those who do not drive.

Minimising trip costs for lower-income travellers is another approach to improving equity. Discounted transit fares for lower-income households have been shown to improve mobility and facilitate otherwise unaffordable regular healthcare trips. The upfront costs of weekly and monthly public transport passes often prevent lower-income riders from enjoying pass-based discounts.

Fare capping, which has recently been implemented in London, New York and elsewhere, eliminates this price inequity and allows everyone to choose the best fare for their travel needs. Shared mobility trips can also be cost-prohibitive for lower-income households. The ITF model results indicate that ambitious transport policies will improve the overall affordability of shared mobility trips in most regions. Nevertheless, targeted policies to make these flexible modes available to all income groups will be necessary for equitable access in the future.

Consider equity impacts when developing new transport policies, investments and programmes

Addressing women's specific transport needs, especially concerning safety and personal security while using active and shared modes, is essential to creating liveable cities for all of society. Developers of new transport policies, investments and programmes should adopt an explicit gender lens . Active measures to boost women's employment in the transport industry are a critical step towards social inclusivity and improved representation in decision-making processes. The ITF's Gender Toolkit for Transport provides an interactive checklist and resources for assessing the gender inclusivity of transport projects.

A greater density of opportunities is complementary to transport performance with regard to increasing accessibility. Policy makers and planners should facilitate a wide distribution of opportunities throughout urban areas to limit the need for long-distance travel and improve accessibility in underserved neighbourhoods. To address a lack of accessibility in areas where urban amenities and social services are scarce, targeted zoning and public infrastructure investment can spur investment. New developments should integrate the planning principles of 15-minute cities and TOD to ensure that an expansion of access to jobs and social amenities accompanies urban growth.

Prioritising sustainable transport investment in previously underfunded or overburdened communities can help address historical inequities. Advancing an equitable geographic distribution of the other themes in this chapter (i.e. health and safety, accessibility and urban space) at the local level should be a top priority for future transport policy.

Equitable approaches include targeted investment in electrification to mitigate disproportionate air pollution exposure in lower-income communities and shared-mobility incentives for operators to maintain vehicle availability in neighbourhoods with few alternative mobility options. These approaches can also improve the affordability of shared modes, making opportunities more accessible to urban residents of all income levels.

Efforts to reduce the concentration of air pollutants and noise in disproportionately impacted neighbourhoods – especially in lower- and middle-income countries – are critically important for promoting equity and quality of life.

Appraisals of new public policies and infrastructure investments should measure their accessibility benefits. Many of the urban policy measures included in the High Ambition scenario are designed for implementation at the local level. Each urban area will face various design decisions and trade-offs during the planning process. Including equitable access as an explicit policy goal will guarantee that liveability considerations are integrated into decision-making processes.

Finally, while access to opportunities can be challenging to characterise in terms of monetary value, there is a growing movement to develop holistic indicators that measure accessibility benefits. Completed projects should also be evaluated on their performance to identify opportunities for further investment and to improve future estimates.

Prioritise people, not vehicles, in urban design to improve safety for all road users

Walking, micromobility and shared modes use much less space for on-road travel and vehicle storage. Incentivising a transition to space-efficient modes helps ensure more urban land is available for other uses. Policies that increase the occupancy rates of shared modes can also produce space savings by serving the same demand with fewer vehicle-kilometres of travel. Cities worldwide could reduce the static space consumption of passenger vehicles by dozens of hectares, creating the opportunity to build new green spaces and other liveability-improving community amenities.

Space consumption is not limited to passenger transport. A mixture of urban freight vehicles is needed to create logistics distribution networks that suit the urban environment. In many urban areas, large trucks and vans make deliveries on narrow, busy streets, presenting a safety hazard to other road users. Freight vehicles are also expected to contribute a significant portion of urban pollutant emissions through 2050.

Experiments with electric cargo bikes and other small vehicles should be replicated and extended in other cities around the globe to understand local challenges and opportunities. Access regulations, subsidies to offset capital costs and improved charging infrastructure could incentivise a shift towards light electric freight vehicles and unlock the associated safety, space consumption and air quality benefits.

Promoting lighter and smaller passenger vehicles would also have traffic safety benefits. Governments should consider incentives and regulations to make vehicles lighter and, therefore, safer for all road users in the event of a crash. Regulators should follow Europe’s example by incorporating measures to protect pedestrians and cyclists into vehicle safety requirements. These considerations will be especially important in the future as electric cars are often heavier than similarly-sized ICE cars.

Policy makers and planners should consider the full breadth of alternatives to the private car when planning urban areas. Vehicle sharing and ridesourcing platforms can increase accessibility for travellers by offering convenient, low-cost alternatives to private car ownership and providing access to areas that are poorly served by public transport. Shared mobility also provides modal alternatives that can make an urban area’s transport system less vulnerable to disruptions, as indicated by the modal balance results.

However, shared mobility can suffer from low utilisation and worsen traffic congestion without adequate regulation. Mileage-based fees or occupancy-based regulatory requirements could incentivise more ride pooling. Policy measures such as more robust support for carpooling and shared mobility are instrumental in achieving the reduced space consumption observed in the High Ambition scenario results.

The severity of a crash increases with travel speed, but speed limits alone are not always sufficient to instigate a behavioural change among drivers. Traffic-calming measures including narrowing travel lanes, and adding chicanes and raised crosswalks where warranted, are recommended strategies for reducing travel speeds and protecting the most vulnerable road users. Like dedicated infrastructure, traffic calming has been shown to induce a mode shift by making sustainable modes safer.

Set ambitious goals for reducing pollutant emissions and take actions to achieve them

Urban authorities can regulate urban emissions directly with LEZs in high-density urban areas. Ambitious LEZ implementation is one of the core policy measures contributing to the relative decrease in pollutants under the High Ambition scenario. When designed well, LEZs are among the most effective regulations for reducing air pollutant emissions from transport, as evidenced by examples across Asia and Europe.

Transitioning to zero-emissions public transport is another direct measure for improving air quality. Highly ambitious fleet measures effectively reduce pollutants. Yet, buses are expected to remain a significant source of toxic air pollutants such as BC, NO_x, PM2.5 and SO_2 in 2050. Transitioning to zero-emission vehicles will require substantial capital investment in vehicles and infrastructure.

International development and foreign aid organisations should consider allocating funds for zero-emission buses in emerging economies to ensure that the pollutant reduction benefits are widely shared. Battery-electric buses are a zero-emission option with a limited operating range. This may require adjustments to public transport routes and schedules. Policy makers should seek to learn from the experiences of other public transport agencies to smooth the transition to electric bus fleets.

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6 Investing in the future: The financial implications of decarbonising transport

This chapter presents estimates of the transport infrastructure investment needs for the Current Ambition and High Ambition scenarios. It outlines the differences in investment profiles between transport modes based on projected transport demand. It also explores the potential investment needs associated with installing electric vehicle charging networks to support the policies of the High Ambition scenario. Finally, it considers the corresponding impact of electrification on fuel tax revenues.

In Brief

A sustainable transport system could require lower core infrastructure investment

Transport competes for investment with other essential services and networks, such as healthcare, energy and water. Conversations about decarbonisation in all sectors often focus on funding or financing needs for the transition to net-zero. Where money is tight, benchmarking the investment needs for a net-zero scenario against those for a business-as-usual approach to infrastructure investment can yield important evidence to support important strategic decisions and set priorities.

In the case of transport, comparing investment needs under the Current Ambition scenario with the High Ambition scenario reveals that a strong push for decarbonising transport is in fact not more expensive: the total capital investment needs of core infrastructure for road, rail, airports and ports are 5% lower with ambitious policies in place than carrying on with business as usual.

The “decide and provide” approach is one example of an ambitious investment policy. Instead of providing infrastructure as a reaction to predicted demand (“predict and provide”), this approach involves investing in infrastructure in a vision-led way, with a view to achieving certain public policy objectives. In a transport decarbonisation context, this means investing in public transport infrastructure and policies that support the move to transport modes with higher occupancy or load factors, and more compact cities. Taking such an approach in a low-carbon future could potentially save governments from spending USD 4 trillion globally on road maintenance and investment (excluding investment in adaptation).

Nevertheless, transport decarbonisation requires significant investment in support infrastructure. The charging-point network, for example, is critical for the electrification of vehicle fleets. Under the High Ambition scenario, this network will require additional investments equaling roughly 0.4% of global gross domestic product over the period 2019 to 2050.

Transport decarbonisation also has an impact on revenues from fuel taxes. This revenue stream has already begun to diminish in many countries as internal combustion engines are becoming more efficient and electric vehicles increase their share of the passenger car fleet. The rate of this decline in revenue accelerates under the High Ambition scenario, as the uptake of zero-emission vehicles accelerates. Because of this, governments will lose income and the behavioural policy lever of taxing car use through fuel consumption.

Therefore, fuel tax regimes need reform. Distance-based pricing gives policy makers a stronger lever for encouraging sustainable travel choices. In addition, maintaining fuel taxes while vehicles with internal combustion engines remain on the roads helps phase out polluting vehicles. That said, policy makers need to design pricing regimes carefully to avoid perpetuating inequities.

Policy recommendations

- Adopt a vision-led “decide and provide” approach to infrastructure planning instead of a reactive “predict and provide” approach.
- Account for the significant additional investment needed for electric vehicle charging infrastructure.
- Reform the current method of taxing car use through fuel excise duty and introduce more distance-based pricing.

Policy decisions to decarbonise transport are made within the context of available budgets and competing priorities. Furthermore, infrastructure investments made now will shape transport choices, access to opportunities and communities for years to come. As highlighted at the ITF 2022 Summit, future transport infrastructure will compete for available budget resources with other essential services and utilities (e.g. sanitation). This is especially relevant in emerging economies, where all sectors will grow simultaneously (Cunha Linke, 2022[1]).

This chapter identifies the elements of infrastructure investment and tax revenue that will most likely be affected when transitioning from the Current Ambition scenario to the High Ambition scenario. The available funding for future infrastructure investments is also critical. Decarbonising the vehicle fleet will diminish revenue from vehicle taxes (including acquisition, ownership and use taxes) based on fuel consumption and carbon dioxide (CO_2) emissions. This will be true under both the Current Ambition and High Ambition scenarios.

Approaches to vehicle taxation vary worldwide; some regimes will be more susceptible than others to changes in the vehicle fleet. However, under the High Ambition scenario, all regions will see concerted efforts to reduce trip lengths and the use of motorised (or at least private motorised) modes. In this context, advance planning for future tax reform will be necessary.

Investing in cleaner transport: Will decarbonisation cost more?

Under the High Ambition scenario described in this edition of the Outlook, public transport modes would receive greater investment. However, any discussion of investing in cleaner transport should include an analysis of the network investments required under a business-as-usual approach.

This section presents the infrastructure investments required under the Current Ambition and High Ambition scenarios. It considers the scale of changes to supply core immovable infrastructure based on projected demand and associated costs of maintenance of existing and future infrastructure networks.

It is important to note that these estimates do not include additional infrastructure costs for new alternative fuels at ports and airports. They also do not include potential transport infrastructure adaptation costs to increase resilience to future climate change impacts.

Infrastructure needs will vary by country and region

Comprehensive data on infrastructure investment is difficult to come by. Investment and planning decisions are made at different levels of government and in various departments, meaning that there is often no single office responsible for collating and processing this information (Fay et al., 2019[2]). In addition, data on private assets and maintenance is not in the public domain. Furthermore, the lack of data at a per-kilometre level across different transport modes makes it difficult to estimate future spending.

Nevertheless, several sources provide insights into overall average spending on transport infrastructure (see Box 6.1). Figure 6.1 presents data on infrastructure investments reported to the ITF for inland infrastructure spending in 2010 and 2020. The World Bank has also conducted comprehensive assessments of infrastructure spending (Rosenberg and Fay, 2018[3]; Foster, Rana and Gorgulu, 2022[4]; Fay et al., 2019[2]) while also acknowledging the difficulty of compiling accurate and detailed infrastructure spending data.

Infrastructure needs will vary by region and country. For example, low- and middle-income countries may need to pave existing roads while emerging regions seek to grow connectivity linked to economic growth. On top of this, global profiles of investment decisions are changing towards more sustainable modes. Infrastructure development will be crucial to the delivery of the Sustainable Development Goals (SDGs) as well as the economic growth of emerging economies, (OECD, 2018[5]).

Box 6.1. Estimating infrastructure costs for the two policy scenarios

The infrastructure cost calculations under the Current Ambition and High Ambition scenarios discussed in this chapter were sourced from a mix of nationally reported data, individual projects and case studies. Most transport network investment data come from the OECD database (OECD, n.d.[6]). Data for urban transportation modes, including bus rapid transit and light-rail transit projects, came from the Institute for Transportation and Development Policy (ITDP, n.d.[7]). City-specific projects were evaluated and broken down per unit to serve as proxies for countries with less-developed public transport systems.

For airports, information on the costs of recent infrastructure projects reflects total investment, capacity and mode share for passengers and freight. The Centre for Aviation analyses major airline projects globally, capturing corresponding timelines, funding sources and capacities (CAPA, n.d.[8]). Port cost estimates come from the UN Economic Commission for Latin America and the Caribbean, government agencies and regional news services (CAAR, 2022[9]; Energy, Capital and Power, 2022[10]; UN ECLAC, 2012[11]; Liang, 2019[12]). Urban road systems underwent a similar analysis, using data from national economic agencies and the Asian Infrastructure Investment Bank.

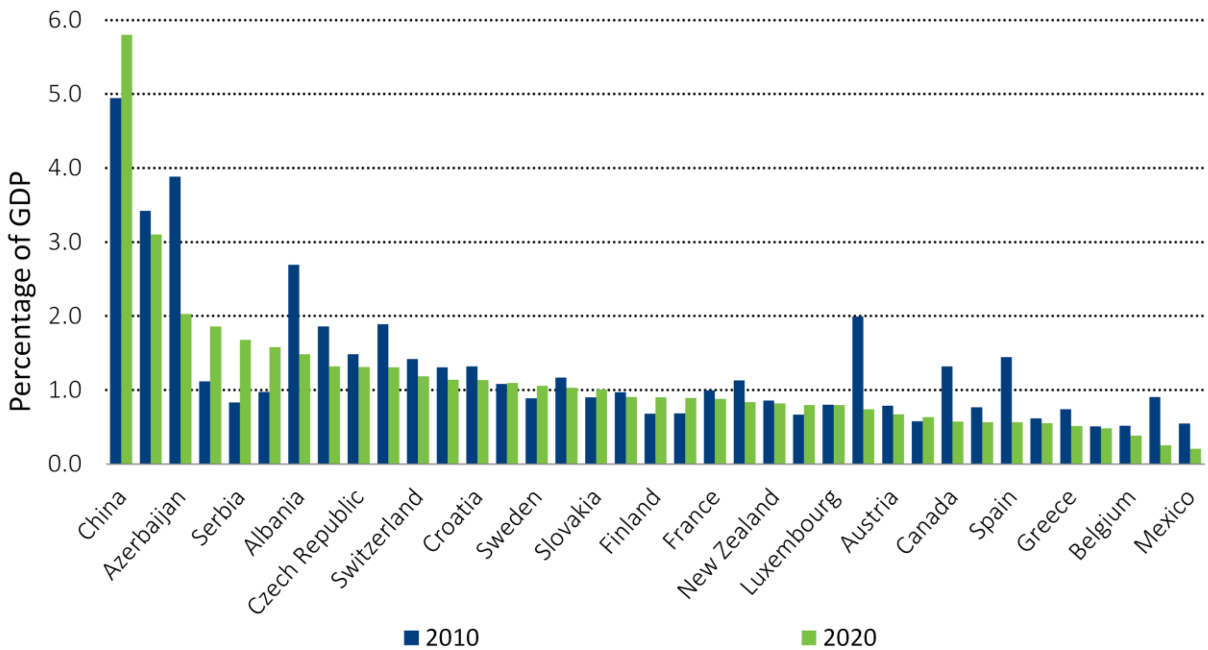
The UK government and the European Cycling Federation collect data on the respective costs of cycleway scheme types, which form the basis of calculations of cycleway-related infrastructure (Taylor and Hiblin, 2017[13]; ECF, 2021[14]). Tax rates related to car circulation and acquisition come from reported values published by the International Council on Clean Transportation (Chen, Yang and Wappelhorst, 2022[15]), the OECD and academic studies (OECD, n.d.[16]; Zahedi and Cremades, 2012[17]; PwC, 2019[18]).

The overall availability of data varied, with specific categories of infrastructure seeing a wide value spread and others remaining reasonably consistent. A proxy based on region was applied to account for countries with data gaps after calculating investment costs for economically and geographically similar states. Ranges of values depended on the level of existing infrastructure, the size of current and potential investments, demographic and geographic composition, and economic development. Limited data is currently available for certain types of investment (e.g. pipelines and waterways).

Generally speaking, developed countries spend less on infrastructure, given their well-established networks, although this can mean they are underspending (OECD/ITF, 2013[19]). An assessment of global transport infrastructure investment needs by Oxford Economics (2017[20]) estimated that transport (road, rail, airports and ports) would require approximately 1.9% of global GDP between 2016 and 2040. The figure is lower in developed economies than in emerging economies. However, the gap between current spending levels and future needs in Europe and the United States, for example, still amounts to 0.3% and 0.6% of gross domestic product (GDP), respectively (Oxford Economics, 2017[20]).

Low-income countries start from a lower level of infrastructure stock and a lower overall available budget, meaning essential infrastructure investment would typically be expected to consume a higher proportion of available funds. Even so, some estimates put the current rate of spending – particularly on roads – below the level needed (Foster, Rana and Gorgulu, 2022[4]). Rozenberg and Fay (2018[3]) estimate that the annual infrastructure investment needs for low- and middle-income countries would fall into the range of 0.9-3.3% of GDP between 2015 and 2030, depending on the modes chosen for investment. The Inter-American Development Bank estimates that the Latin America and the Caribbean (LAC) region needs to spend 1.4% of GDP through to 2030 on capital investments in roads, public transport and airports (Brichetti et al., 2021[21]).

Figure 6.1. Investment in inland transport infrastructure, 2010 and 2020



Source: ITF (2022[22]).

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According to the World Bank, more than 80% of infrastructure investment in emerging economies comes from the public sector, either directly from the government or via specially established public-sector bodies (World Bank, 2017[23]). This is a trend mirrored in the provision of climate finance. The OECD reports that 82% of the financing mobilised as part of the pledge to raise USD 100 billion per year for decarbonisation in emerging economies comes from public sources, including multilateral development banks (OECD, 2022[24]). The private sector is more likely to be involved in upper-middle-income regions and is almost invisible in Africa (OECD, 2018[5]).

The split between public and private is also visible across transport modes. Private investment making up the majority of development investments in roads airports and ports in emerging economies. Meanwhile, long-distance rail projects have tended to attract funding from the multilateral development banks, or state enterprises. For example, Chinese state-owned enterprises have provided funding in Africa as part of the Belt and Road initiative. Helping to create a more “enabling environment” for private investment in transport in emerging economies has been identified as one of the ways development partners can help these regions, in addition to actions the governments themselves need to take (OECD, 2018[5]). However, given the lifespan of most infrastructure, private investment in infrastructure must be well-managed to avoid governments finding themselves locked into unfavourable arrangements (ITF, 2018[25]). How this can best be achieved in the context of emerging economies is an area for further investigation.

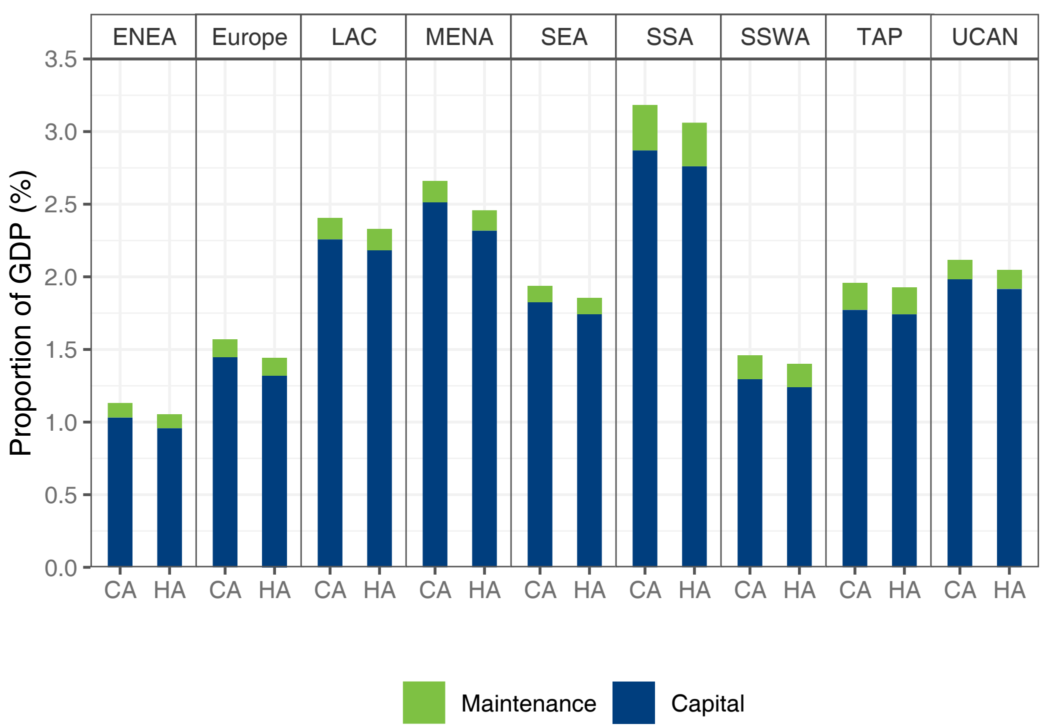
Investment needs for core infrastructure are lower under the High Ambition scenario

At a global level, the investment needed for core infrastructure is 5.2% less under the High Ambition scenario than under the Current Ambition scenario. This reduction is mainly due to an overall decrease in the amount needed for investments in road infrastructure capacity. While the investment needs of other transport modes increase under the High Ambition scenario, even cumulatively, they do not reach this scale of spending.

This underlines the importance of adopting demand-management and mode-shift measures (see Chapter 3) in conjunction with technology and energy transition measures (see Chapter 4). This combination of measures reduces vehicle-kilometres and associated road-capacity needs for private motorised vehicles, and accelerates the move towards higher-occupancy modes and shorter urban trip distances.

Figure 6.2 provides a regional breakdown of operational and capital investments in transport infrastructure. The shares of GDP represent the average infrastructure spend across the whole of the period 2019-50. However, in most regions, costs are concentrated in the 2020s, when a higher share of GDP is needed under both policy scenarios. On average, most regions' investment requirements under the High Ambition scenario will be about 0.1% of GDP lower than under the Current Ambition scenario. The exceptions are the Middle East and North Africa (MENA) region, where the expected reduction would be around 0.2% of GDP, and the Transition economies and other Asia Pacific (TAP) countries, where the reduction would be close to zero as a share of GDP.

Figure 6.2. Average core infrastructure investment under the Current Ambition and High Ambition scenarios as a proportion of gross domestic product, over the period 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.
Source: GDP data based on the OECD ENV Linkages model, http://www.oecd.org/environment/indicators-modelling-outlooks/modelling.htm.

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The estimates presented here consider the projected changes in new infrastructure and assets required to service the projected demand by mode under the two policy scenarios. It also accounts for the estimated maintenance costs of existing and new core infrastructure. In this Outlook, heavy infrastructure includes active travel infrastructure, airports, buses, bus rapid transit (BRT), intercity rail, light rail and metro (urban rail), ports, roads and waterways.

"Decide and provide": A new approach to infrastructure planning and investment

A series of ITF reports over the past several years has recommended that governments adopt a "decide and provide" approach to infrastructure provision (ITF, 2021[26]; ITF, 2023[27]). This approach involves planning for desired future sustainable transport systems, rather than providing infrastructure in response to existing or projected demand (Lyons et al., n.d.[28]). Continuing to build infrastructure based on projections of growth in existing demand patterns (the "predict and provide" approach) will only perpetuate the problems car-led planning has engendered. These include environmental costs as well as negative impacts on accessibility and equity.

Decision makers can also come under pressure to make decisions on transport infrastructure based on short-term gains or political cycles. This pressure can result in disjointed choices that impact transport systems for decades (Rosenberg and Fay, 2018[3]). Aside from the environmental benefits, the "decide and provide" approach, guided by a vision of the outcome rather than following forecasts based on current transport patterns, can support effective decision making, even in times of uncertainty (ITF, 2021[26]; ITF, 2023[27]).

Evaluating the Current and High Ambition scenarios on the same cost basis suggests there is only a small difference between the total cost of the two. However, this finding assumes that governments begin implementing the measures included in the High Ambition scenario (see Chapter 2) in the 2020s. In other words, transport planners must decide now on the sustainable transport systems they want in the future. They then need to make strategically aligned investment decisions about the modes for which they need to build infrastructure.

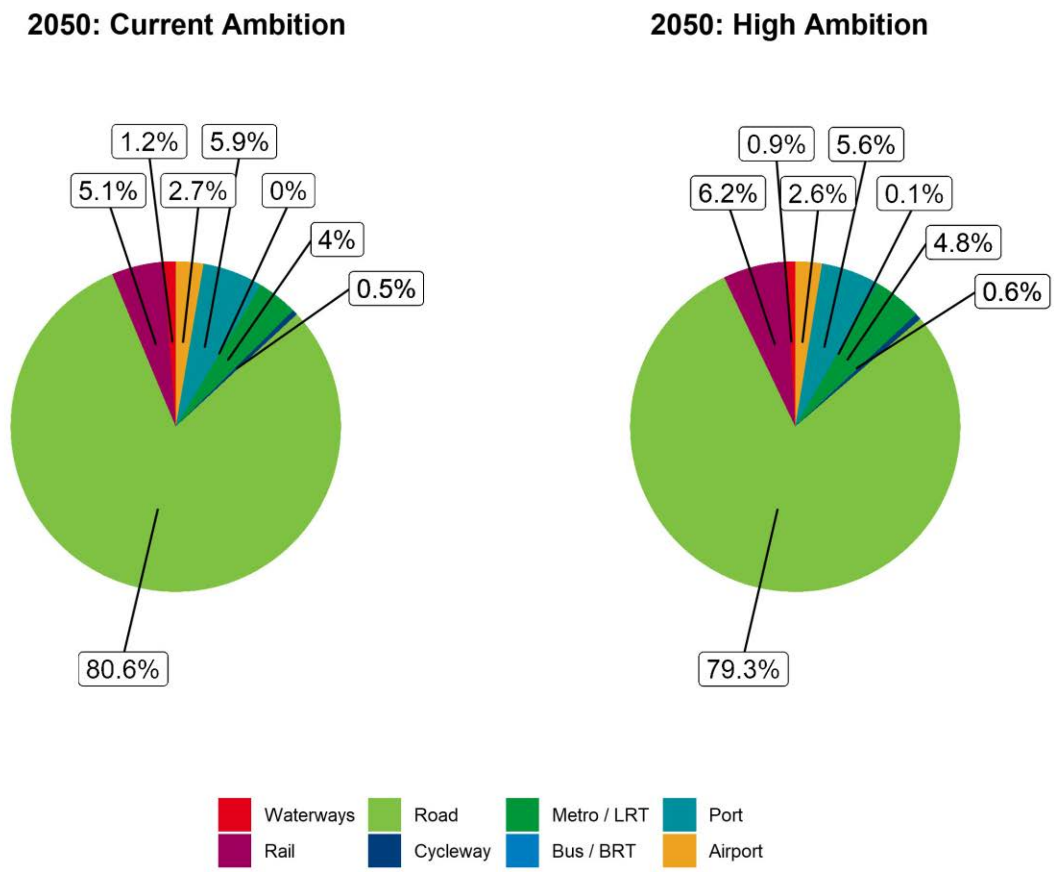
O'Broin and Guivarch (2017[29]) found that restricting the development of capacity for carbon-intensive modes resulted in a greater reduction in emissions than allowing the development to go ahead but introducing measures such as carbon pricing. Restricting development also had a less detrimental impact on GDP and would avoid the carbon dioxide (CO_2) emissions inherent in constructing excess capacity (O'Broin and Guivarch, 2017[29]).

Infrastructure investment profiles: Where will the money go?

Globally, road investment represents the largest proportion, by far, of infrastructure investment in the Current Ambition scenario (see Figure 6.3), and this will also be true under the High Ambition scenario. The combined maintenance and global capital investments in road infrastructure still exceed USD 60 trillion over the next three decades, even under the High Ambition scenario. Rail will attract the second-largest share of investment under both the Current and High Ambition scenarios.

Given the long planning timelines required for infrastructure and its expected life span, the infrastructure investment decisions made today will influence the options available in the future, potentially locking-in private car use (Fisch-Romito and Guivarch, 2019[30]), especially if short-term decisions are made in the face of growing demand. It is important to reflect here that the changes in investment refer only to the investment required to serve the projected demand for the different modes under the two policy pathways. These numbers would not reflect a decision to build or maintain a railway line, road or other link to improve connectivity (rather than satisfy demand).

Figure 6.3. Investment anticipated by 2050 under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. BRT: bus rapid transit. LRT: Light rail transit.

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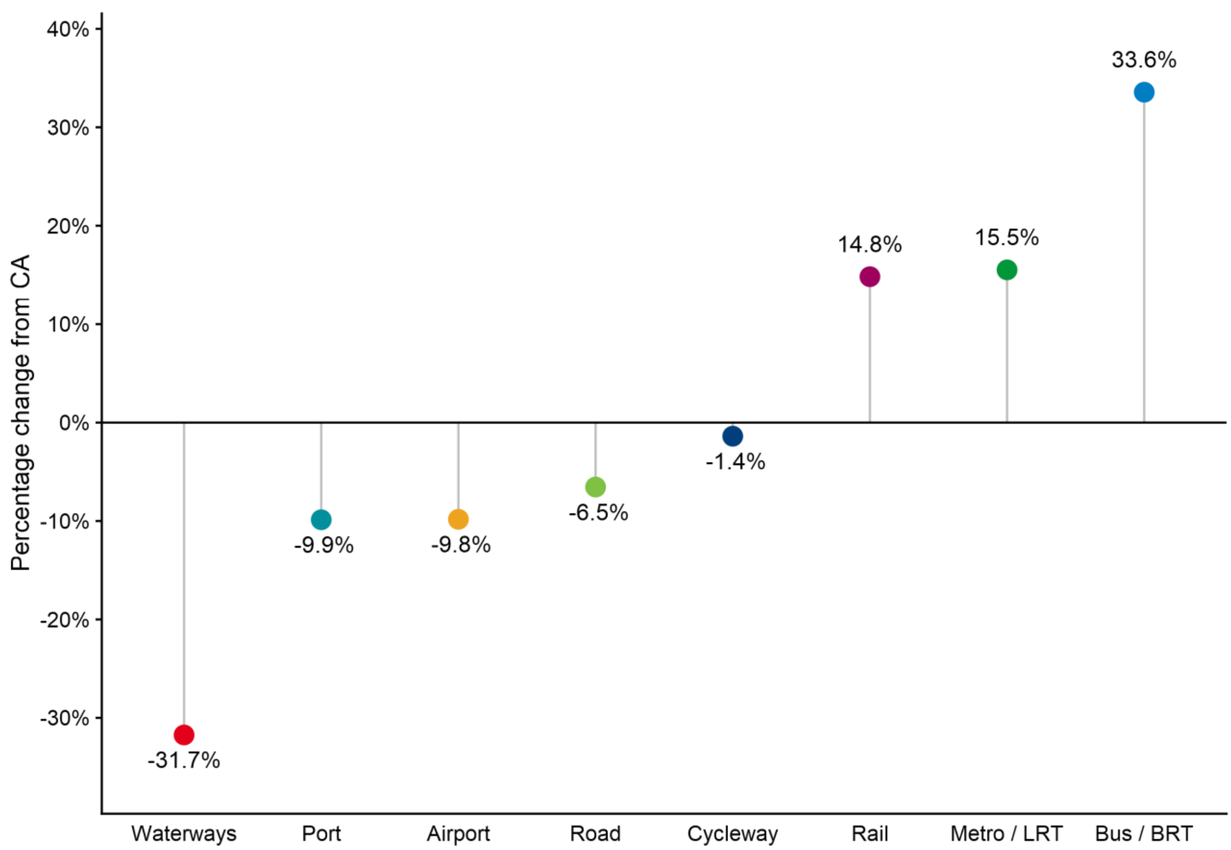
A "decide and provide" approach would base long-term transport strategies on a vision of the future transport system rather than reacting to demand projections. It would support infrastructure investment decision making by providing foresight on how future mode shares and demand could evolve under a High Ambition scenario. New investments may need to move away from traditional modal hierarchies and historical transport planning priorities in different regions. Long-term strategies based on this approach can help ensure all investments contribute towards the same goals and support effective investment decisions.

Over time, the changes in passenger and freight demand seen under the High Ambition scenario for different modes suggest there could be a corresponding change in the investment required (see Figure 6.4). For example, road investment would be 6.5% less under the High Ambition scenario as a proportion of the spending required under the Current Ambition scenario. This equates to more than USD 4 trillion in avoided investment between 2020 and 2050 due to lower demand for road modes under the High Ambition scenario.

This reduction comes from a combination of sources. For freight transport, higher-capacity vehicles, high costs and a change in commodity types (particularly the reduction in fossil fuels) result in lower tonne-kilometres under the High Ambition scenario in 2050, and fewer road-based vehicle-kilometres. For passengers, the reduction comes from reduced demand, and the shift to higher-occupancy vehicles and modes. This is particularly the case for buses and rail-based modes, and an increase in active modes. BRT investment is classed as a separate type of infrastructure to road infrastructure in this chapter. However, urban roads will also need investment as part of supporting buses and shared-vehicle fleets.

This Outlook assumes priority measures for buses are operational investments, while road investments cover the associated capital costs. Investment in public or mass-transit modes is greater. Bus lanes and BRT lines, urban rail – including metro and light rapid transit (LRT) – and intercity rail all see higher investments under the High Ambition scenario due to greater expected demand. Buses and BRT see the greatest change, with expected investment being 33.6% (USD 10.4 billion) higher over the three decades to 2050. For rail, expected investments total more than USD 1 trillion across all rail types. Both urban and non-urban rail-based modes see increased investments of around 15.5% and 14.8%, respectively.

Figure 6.4. Difference in infrastructure investments under the High Ambition compared to the Current Ambition scenario



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. BRT: bus rapid transit. LRT: Light rail transit.

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Box 6.2. Decarbonisation and climate change risks to port infrastructure

The scale of ambition for decarbonisation is a crucial piece of information for long-term port infrastructure planning for three reasons. First, the degree of decarbonisation determines the amount and composition of future maritime trade flows. As such, it influences decisions about where new port infrastructure is needed and the type of terminals required. Second, decarbonisation, and its subsequent implications for the severity of climate change, affect the physical climate risks faced by ports.

These risks are relevant to existing infrastructure and any new infrastructure required to cope with future demand. Third, the decarbonisation of maritime transport will determine infrastructure planning, particularly fuel bunkering facilities and charging infrastructure.

In 2022, researchers from the ITF and the University of Oxford explored the first two links between decarbonisation and port infrastructure planning as part of a joint study. They constructed 14 trade scenarios and fed them into a port planning and cost model to determine the terminal area and investments needed to meet the demand for trade in 2050. They also modelled physical climate risks to port infrastructure under three decarbonisation scenarios.

The results from the study indicate that strong decarbonisation leads to considerable benefits for society. More sustainability-focused scenarios lower the need for future trade, reducing the potential investment gap, particularly in developing economies. For example, under the most sustainable scenarios, investments would only be 40% of what would be required under less sustainable scenarios.

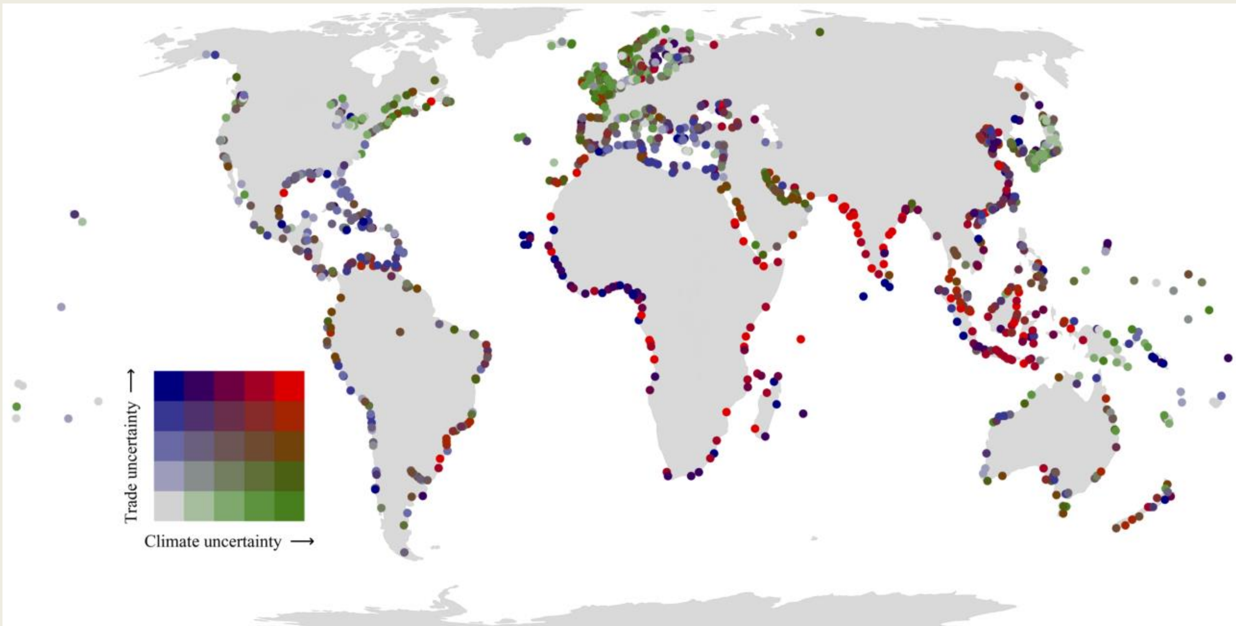
In addition, stronger decarbonisation moderates any increases in physical climate risks. In a decarbonisation scenario that assumes ~2 degrees Celsius (°C) warming by 2100, future climate risk increases by 74%. Meanwhile, under a scenario assuming ~5°C warming by 2100, this risk increases by 118%. If the demand for future trade is considered (implying that more new infrastructure would potentially be at-risk), the gap widens further. More sustainable scenarios entail a risk increase of 155-190%, while under unsustainable scenarios, the equivalent risk increase would be 270-470%.

As such, the degree of decarbonisation results in uncertainties about the long-term planning of future port expansions. Uncertainty regarding the trade scenario means that new terminals experience over- or under-capacity, while uncertainty in terms of climate change scenario means that terminals are over- or under-designed. Figure 6.5 shows the relative degree of trade and climate uncertainty faced.

Some ports (e.g. in Japan, North America and Western Europe) face planning uncertainties because they are sensitive to the future climate change scenario. Others (including ports in Chile, the Gulf of Mexico and the Mediterranean Sea) are more sensitive to the future trade scenario. In some areas (particularly parts of India, Southeast Asia and Sub-Saharan Africa), these two planning uncertainties come together, posing financial risks to new investments.

The results show that infrastructure planners need to account for decarbonisation uncertainties in long-term infrastructure planning. Plans need to be flexible to allow for a change of course if future scenarios change. But they must also be robust to ensure planning decisions perform well under multiple scenarios. For example, the Port of Rotterdam adapts its Maasvlakte 2 project Master Plan yearly based on new information. It can also transform terminals designed for containers to handle other cargo types.

Figure 6.5. Relative climate and trade uncertainties for ports worldwide in 2050 relative to 2015



Note: Based on data for 1 380 ports and 14 combined trade and climate-change scenarios. Uncertainty refers to the differences between the maximum and minimum future scenario relative to the present-day values. Trade uncertainty reflects changes in port throughput, while climate uncertainty reflects changes in physical climate risks.
Source: Verschuur et al (forthcoming[31]).

The reduction in spending for cycleways under the High Ambition scenario seems counterintuitive. However, it reflects the assumption of increasingly dense cities and a corresponding reduction of urban sprawl. This reduction in urban footprints means that while more people will cycle under the High Ambition scenario, urban trip distances and infrastructure kilometres required will both decrease. Maintenance costs for wear and tear due to cycling passenger-kilometres under this scenario would also be lower than for other modes, given that bicycles are much lighter than other vehicle types.

The investment required for airports under the High Ambition scenario declines by 9.8% compared to the Current Ambition scenario. This reduction is due to drops in both passenger and freight transport demand. The decrease in air freight reflects an increase in carbon pricing under the High Ambition scenario. It also results from changes in the types of commodities transported and greater trade regionalisation, which supports land-based modes.

These projections only reflect the investment needed to meet demand. They do not include investment in airports to support transitions to alternative fuels or reduce emissions caused by airport activity. However, the projections suggest that some costs could be offset against the costs of further expansion and corresponding maintenance if planned over the long term.

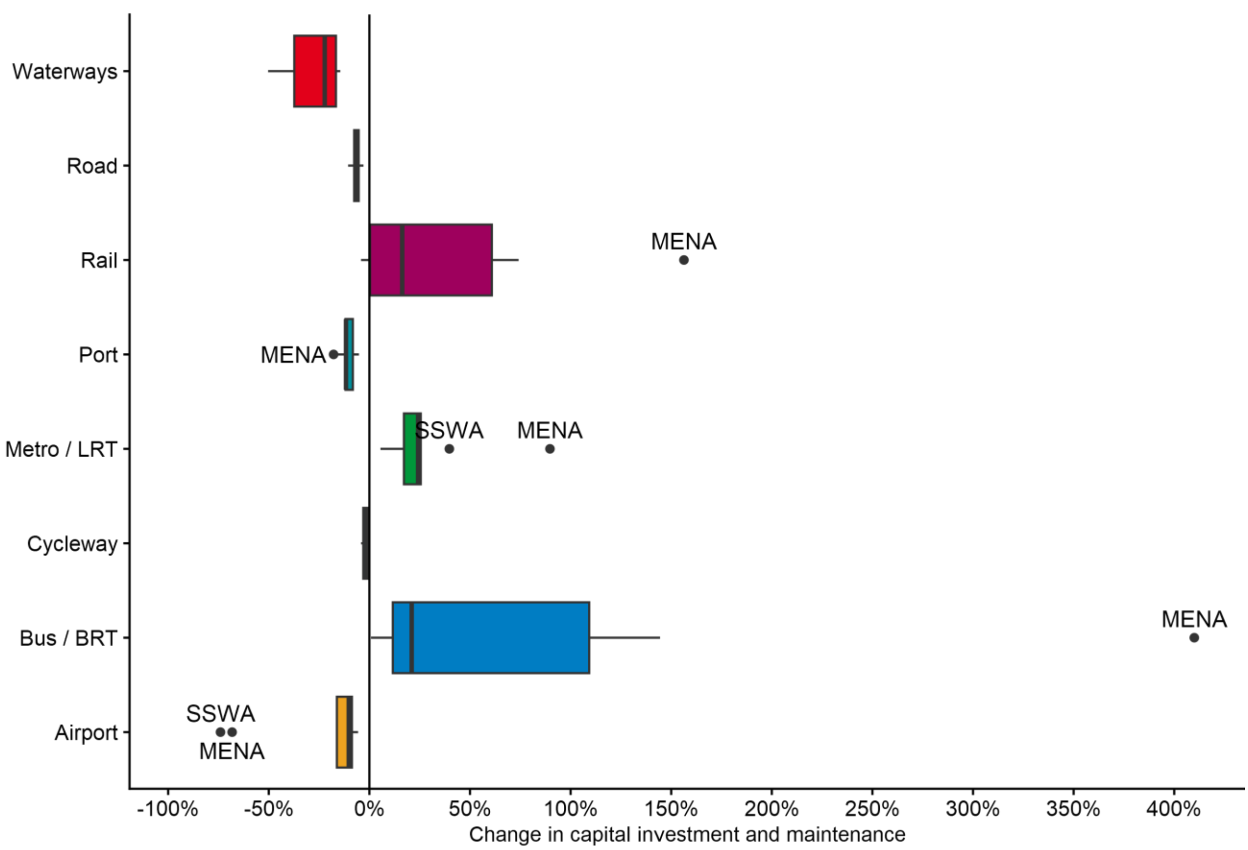
Investment in ports drops by 9.9% under the High Ambition scenario. This reduction stems from efficiency improvements, including greater asset sharing and corresponding reductions in vehicle movements. It also reflects changes in trade volumes for certain commodities. Transport activity associated with fossil fuel extraction and distribution reduces, in line with a reduction in demand for these fuels. Similar to airports, however, this reduction in investment does not include new infrastructure for alternative fuels or investment in port upgrades and digitalisation.

The decline in fossil fuel demand volumes also reduces tonne-kilometres carried by river, which has a corresponding impact on the investment required to serve demand on waterways. A critical cost omitted in these estimates is adaptation of infrastructure for climate resilience. Box 6.2 presents an overview of work on this topic for ports.

Priority modes for investment vary by region

While the overall investment envelopes for the Current Ambition and High Ambition scenarios are similar, (see Figure 6.6), investments in the various transport modes change considerably between scenarios and among regions. For passenger transport, these changes often reflect a new approach to transport planning – namely, removing private cars from the top of the hierarchy. However, road building still attracts the highest investment in all regions under both the Current Ambition and High Ambition scenarios.

Figure 6.6. Regional changes in capital investment and maintenance costs under the High Ambition scenario as a proportion of the Current Ambition scenario



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand. BRT: bus rapid transit. LRT: Light rail transit. Boxplots are a way to show a five-number summary in a chart. The box shows the middle of data (i.e. the interquartile range). The ends of the box show the limits of the first (25%) and third (75%) quartiles. The median is shown by the vertical line in the box. Outliers are defined as any value beyond 1.5 times the interquartile range (the size of the box) and are drawn as points and labelled.

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For freight, connectivity continues to be essential for economic growth; reductions in investment for the relevant modes reflect a combination of a changing commodities mix and mode shift. In developed economies, the changes in priority will be about getting people to change their mode choices. Meanwhile, in regions with quickly developing urban areas and populations, the strategy should be to pre-empt car dependence in the first place by planning for sustainable transport by default.

In all regions, investment in urban public transport is expected to be higher under the High Ambition scenario than the Current Ambition scenario (see Figure 6.7). The most dramatic changes in several regions come from bus or BRT investment. Investment in buses and BRT would more than double in the United States, Canada, Australia and New Zealand (UCAN) and TAP countries, nearly double in Sub-Saharan Africa (SSA), and grow by over 400% in MENA.

Metro and LRT investment also grows considerably under the High Ambition scenario. In Latin America and the Caribbean (LAC), Southeast Asia (SEA), and SSA, metro and LRT grows by 17.2%, 22.1% and 24.7%, respectively. In South and Southwest Asia (SSWA), investment in urban rail would be 39.7% higher under the High Ambition scenario. In MENA, urban rail investment grows by 89.8% under the High Ambition scenario compared to the Current Ambition scenario. In East and Northeast Asia (ENEA), metro and LRT, and bus and BRT are the only categories with higher investment under the High Ambition scenario.

The high growth in investment in urban public transport, particularly in MENA and SSA, reflects the sustainable urban mobility policies in the High Ambition scenario that can contribute to sustainable and liveable cities (see Chapter 5). Such investment will be important as the region's populations urbanise to avoid urban sprawl and car dependency (Stucki, 2015[32]; ICA et al., 2016[33]). In SEA, the investment would also be expected to support more sustainable urban population growth.

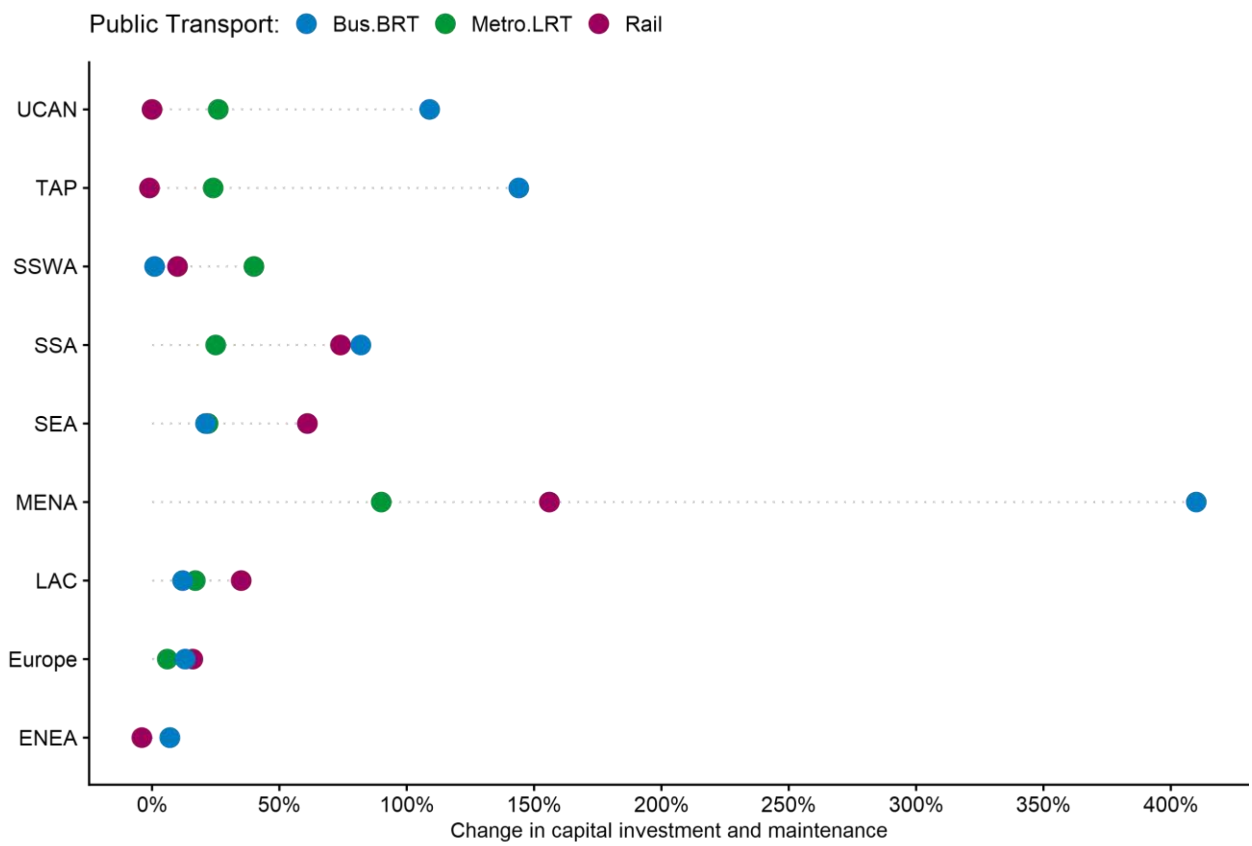
Cities in these regions already suffer from some of the worst levels of congestion in the world (ITF, 2022[34]; ITF, 2022[35]). Investment in urban public transport under the High Ambition scenario would support accessibility for existing populations and the development of sustainable travel habits as urban populations grow (ITF, 2022[35]; ITF, 2022[34]).

In LAC, while existing access to public transport is of reasonable quality, the attractiveness of those services in some cities could be hindered by poor "frequency, safety and reliability" (Brichetti et al., 2021[21]). Investment is also needed to improve public transport travel times, which are slower for comparable trips in LAC than in developed economies. Investment in transport infrastructure in LAC is also crucial to achieving the SDGs, particularly SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable cities and communities) (Brichetti et al., 2021[21]).

In UCAN, investment in BRT grows by 109% under the High Ambition scenario, reflecting the increased demand for bus-based modes. However, it also reflects a greater investment in infrastructure – in other words, investment in dedicated bus lanes and BRT services in addition to the investment in bus services that run in normal traffic. Such investments are needed to ensure that bus-based modes are reliable and attractive alternatives to private cars.

These modes offer greater flexibility than rail for sprawling, lower-density cities. Investment in sprawling cities is more focussed on providing sustainable alternatives to the private car that can be retrofitted to developed, lower-density cities where a metro would be unfeasible. Increased investment in metro also shows the need to support sustainable travel with appealing, high-frequency options where the population density can sustain them.

Figure 6.7. Change in investment needs for public transport modes by region under the High Ambition scenario compared to the Current Ambition scenario



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. BRT: bus rapid transit. LRT: Light rail transit. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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Road construction outside of cities receives the highest tranche of funding in every region. However, in LAC, SSWA and TAP countries, non-urban rail accounts for the second-largest levels of investment after roads under the Current Ambition scenario. Under the High Ambition scenario, this investment grows further in LAC and SSWA, while in TAP countries, it drops slightly. Rail also becomes the second largest capital investment in SSA. In LAC and SSWA, investment in rail grows by 35% and 10%, respectively. In SSA, inter-urban rail investment is 74% higher under the High Ambition scenario than under the Current Ambition scenario, while urban rail investment in MENA grows by over 156%.

In emerging regions, improving connectivity is an economic imperative, and investment in infrastructure networks is a priority (OECD, 2018[5]). In addition to urban public transport, road and rail connectivity investment will be needed to decarbonise transport activity (Rosenberg and Fay, 2018[3]). The lack of quality transport infrastructure in Africa is a barrier to industrialisation and potential competitiveness (ADB, 2018[36]).

The United Nations Economic and Social Commission for Asia and the Pacific has identified the region's transport system as integral to its development (ESCAP, n.d.[37]), highlighting investment in road, rail and, for freight, dry ports for transhipment. Asian sub-regions will benefit from planned investments in the Trans-Asia Highway and in Rail Networks, which will increase the number of links and the quality of existing links (ESCAP, 2021[38]). Cross-border facilitation and bilateral and multilateral trade agreements are crucial to improving connectivity in Asia. They also provide a means to support measures that mitigate increases in freight movements, such as vehicle fuel efficiency standards (ITF, 2022[35]; ITF, 2022[34]; ITF, 2022[39]).

High-speed passenger rail is also of interest in Europe. The European Commission (EC), in its Sustainable and Smart Mobility Strategy, includes targets for high-speed rail use to double by 2030 and triple by 2035 (EC, 2020[40]). Recent research commissioned by Europe Rail has examined the possibility of developing a master plan for high-speed rail "connecting all EU capitals and major cities" (Ernst and Young, 2023[41]).

The research estimates that the network would require approximately EUR 550 billion. This amount is roughly the same as the non-urban rail investment in Europe under the Outlook's High Ambition scenario (although the latter includes all rail investment, not just passenger rail). It also estimates a net social benefit of around EUR 750 billion, representing a positive return on investment (Ernst and Young, 2023[41]). The EC's Sustainable and Smart Mobility Strategy also aims to double rail freight by 2035 (EC, 2020[40]).

Electric vehicle chargers: Essential new networks for decarbonisation

In a departure from historical network investments, electric vehicle (EV) chargers consume a significant proportion of infrastructure investment in the two scenarios explored in this edition of the Outlook. This is because under both scenarios EVs will play a fundamental role in reducing emissions due to road transport. Investments in EV charging networks represent approximately 9.8% and 19% of total infrastructure investments under the Current Ambition scenario and the High Ambition scenario, respectively.

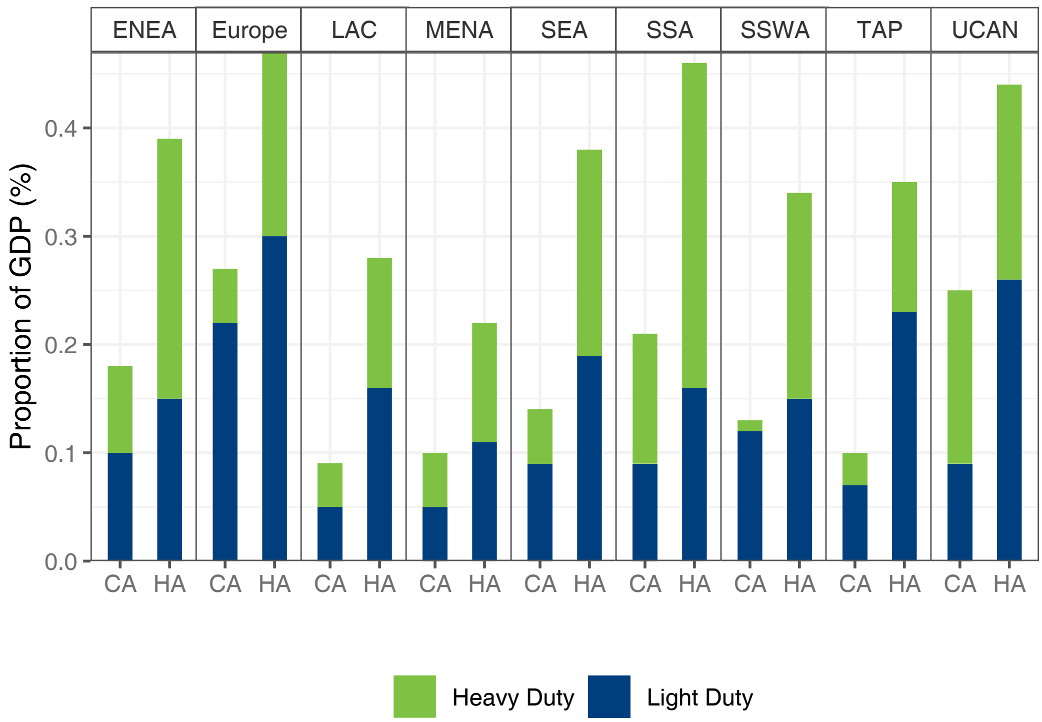
Crucially, these estimates do not account for the historical costs of building fuel stations over previous decades. Therefore, they do not include a comparison between what it cost to achieve the network of support infrastructure needed for the existing system based on internal combustion engine (ICE) vehicles and what is required to build an equivalent system for EVs.

This section is based on the assumption that the clean vehicle fleets of the future will be predominantly electric and reflects expert knowledge at the time of writing. However, even if future vehicle fleets use alternative fuels, investment in support infrastructure will still be required.

Networks for heavy duty vehicles need to be accelerated while roll-out for passenger vehicles continues

The investment needs associated with installing EV charging networks under the High Ambition scenario amount to between 0.1 than 0.3% of GDP, depending on the region, more than the investment needed under the Current Ambition scenario (see Figure 6.8). In the LAC, SEA and SSA regions, the investments needed under the High Ambition scenario are 0.3% of GDP higher than under the Current Ambition scenario.

Figure 6.8. Regional investment needs for electric vehicle chargers as a proportion of gross domestic product over the period 2019-50



Note: Figure depicts ITF modelled estimates. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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It is important to account for different power levels when estimating the infrastructure costs of EV chargers. Common household and public wall chargers use alternating current (AC) and range between 3.7 and 22 kilowatts (kW). These chargers take 4-10 hours to charge a battery-electric passenger car and 1-2 hours to charge a plug-in hybrid electric vehicle (PHEV). Increasingly, direct current (DC) fast 50-60 kW chargers are being deployed for passenger cars in public charging stations (e.g. on motorways). These enable rapid charging for battery-electric vehicles in 20 minutes to one hour (US DoT, 2022[42]).

Heavier vehicles, such as trucks, will require significantly larger batteries than passenger cars but must be recharged within similar timeframes. Therefore, heavy-duty vehicles (HDVs) will need even higher-powered chargers. For example, the EC's Alternative Fuels Infrastructure Regulation sets binding targets for HDV charging infrastructure on Europe's main road network, with minimum power requirements of 350 kW (EC, 2021[43]). Technical standards are also being developed for 1-megawatt (MW) charging systems (Charin, n.d.[44]).

Estimates of the cost of chargers vary greatly. Home and workplace chargers require less electricity grid capacity and materials and can cost as little as USD 2 000. Conversely, 50 kW DC fast chargers cost around USD 50 000 (Hecht, Figgener and Sauer, 2022[45]) and 350 kW fast chargers can cost over USD 200 000 (Basma, Saboori and Rodriguez, 2021[46]) due to more expensive equipment and higher grid connection costs. For this edition of the Outlook, the ITF's in-house models have been enhanced with specially developed modules to assess infrastructure costs. Estimates of public EV charging infrastructure costs are based on projected EV demand in different regions, the number of chargers needed to support that demand, and the power capacities of chargers.

The difference between the Current Ambition and High Ambition scenarios is especially dramatic for HDVs (including heavy-duty freight and bus fleets) in emerging economies. In these regions, zero-emission road freight would not be expected to start to pick up until towards the end of the 2040s under the Current Ambition scenario but begins to grow in the 2030s under the High Ambition scenario. In high-income regions, where the existing rate of private motorised vehicle ownership is higher and the transition to EVs is already advancing, greater investment in charging networks for passenger cars is expected.

The scale of the ambition for emerging regions should be considered in the context of the already high investment needs required for core infrastructure (see Figure 6.2) and for the delivery of the SDGs. For example, of the roughly 770 million people in the world who lack access to electricity, three-quarters live in SSA (IEA, n.d.[47]). The cost of improving the electricity grid – which the International Energy Agency has estimated will require USD 35 billion per year through to 2030 – will be in addition to the cost of installing EV chargers.

In 2018, the OECD estimated that, accounting for core infrastructure of roads, rail, airports and ports, the funding gap to deliver the SDGs by 2030 was USD 440 million. In this context, the additional scale of investment needed in the supply of EV charger infrastructure in these countries raises a note of caution regarding the timelines for achieving the High Ambition scenario. Further work is needed on the most viable models for rolling out networks of supporting infrastructure in developing contexts if the ambitious timelines are to be feasible.

Policy approaches to growing electric-vehicle charging networks vary

EV charging infrastructure roll-out is the potential weakness in ambitions to increase the number of zero-emission vehicles (ZEVs). Publicly accessible EV charging networks will be needed to encourage and support this roll-out, but a wide-spread residential and work-place network will also be crucial. Jurisdictions worldwide have taken varying policy approaches to expanding the EV charging network, often adopting a combination of policy measures. In some cases, there is direct public-sector investment in installing the charging assets to kick-start the charging network and provide confidence and leadership.

Some countries have introduced tax credits or subsidies to stimulate and support the installation of chargers by private entities and individuals, or to establish high-quality commercial charging services. Regulations have also set binding targets and establish minimum standards for the installation of EV chargers in new developments, or set out EV-readiness requirements to make future installation simpler (ITF, 2021[48]; IEA, 2022[49]). For HDVs, a greater emphasis on the roll-out of depot charging will be needed (ITF, 2022[50]).

In the United States, the federal government has set the goal of installing 500 000 publicly accessible EV chargers by 2030. The US Department of Transportation (DoT), through the Federal Highway Administration (FHWA), provides a combination of direct state funding and grants for projects to increase the EV charger network (US DoT FHWA, 2022[51]; US DoT FHWA, 2022[52]). A budget of USD 7.5 billion has been provisioned for this goal under the *Bipartisan Infrastructure Law* (US DoT FHWA, 2022[52]). However, the FHWA also encourages US states to bring private funding on board: "Many of [the DoT's] programs are oversubscribed, and EV charging infrastructure competes with many other types of eligible projects" (US DoT FHWA, 2022[51]). The US government also offers tax credit schemes to encourage private investment in charging infrastructure in "low-income and non-urban" areas (CleanEnergy.gov, 2022[53]; US DoE, n.d.[54]).

In Europe, the European Union is adopting regulations to advance the EV charging network. It is proposing binding targets on governments to extend the charging network, with the aim of reaching a goal of 3 million installed chargers by 2030 (EPRS, 2022[55]; EPRS, 2021[56]; IEA, 2022[49]). The EU is also revising its directives covering building regulations to require minimum levels of charging infrastructure in some buildings and mandate EV-readiness in others. At the EU level, EUR 1.5 billion in funding has been made available for the Trans-European Transport Network (TEN-T), although this is for both EV chargers and hydrogen refuelling. Several EU member states have also opted to supplement their networks by directly drawing on funding from the EU (IEA, 2022[49]).

The United Kingdom is deploying a combination of incentives to progress domestic and public charging infrastructure. The EV chargepoint grant provides funding for up to 75% of the cost of installing domestic EV charging infrastructure. Landlords, property owners and tenants are eligible for the grant (UK Office for Zero Emission Vehicles, n.d.[57]). Additionally, the UK government provides funding for local authorities to install street-side public EV chargers for PHEVs. In 2022, it launched an EV-charger installation pilot in nine local authorities, with over 1 000 chargers to be installed. This involved a public-private collaboration to deliver around GBP 20 million in investment, of which the government provided GBP 10 million, the private sector GBP 9 million and local public authorities GBP 1.9 million (UK Competition and Markets Authority, 2021[58]).

The People's Republic of China also combines directly funded networks with subsidies to encourage EV-charger installation. The subsidies can target the capital costs involved in installation, or at the operational costs of providing a high-quality service. As in the United States, rural networks are also of particular interest in China. It is also trialling battery-swapping programmes (IEA, 2022[49]).

Commercial providers could also potentially provide EV charging infrastructure and services if a viable business model was identified. This could be particularly relevant to oil companies beginning to move into the charging market to future-proof aspects of their business. Nevertheless, the prevalence of private EV-charging solutions is still expected to negatively impact these companies (BloombergNEF, 2022[59]).

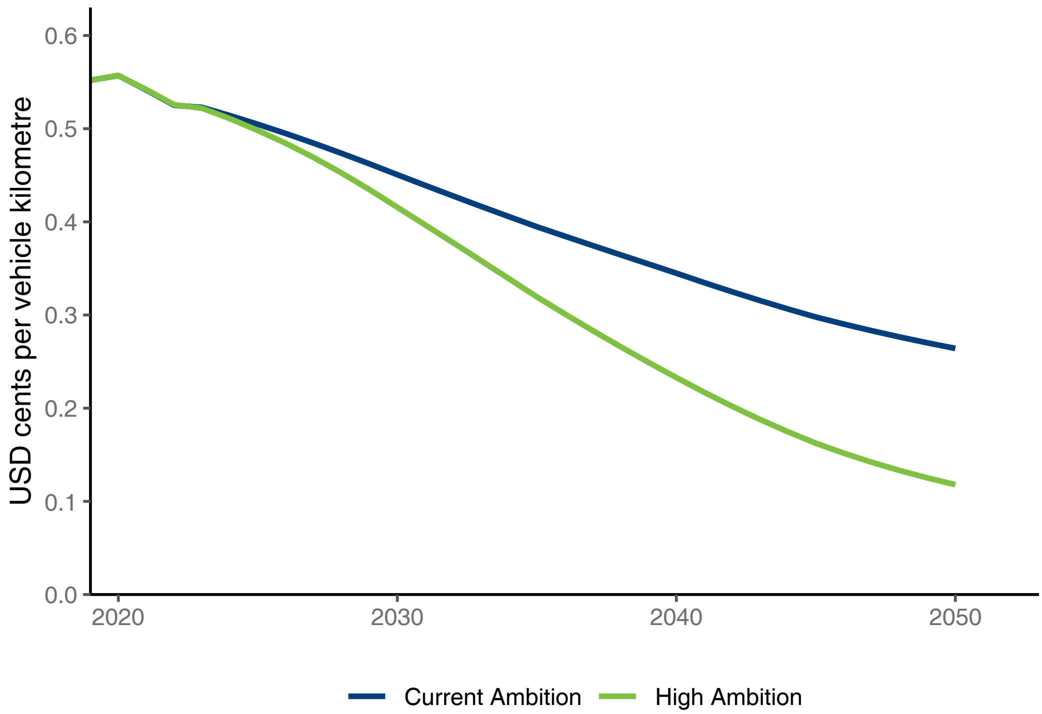
Fuel tax: Avoiding shortfalls through reform

Many countries, including the majority of OECD member countries, tax the acquisition, ownership and use of vehicles. While the scale of these taxes varies, they nevertheless represent an important revenue stream for governments. Vehicle taxation has also become a policy lever to affect change in consumer and travel behaviour (OECD, 2022[60]). An important element of this is fuel excise duties on petrol, gasoline or diesel used in ICE vehicles.

In most countries, fuel taxes account for the largest share of the revenue from road transport (ITF, 2022[61]). They can be considered reasonably equitable compared to other flat taxes, as they reflect the "user pays" principle to internalise the external costs of car use (ITF, 2018[62]). Excise duties also often incorporate environmental taxes. For example, in Austria and Colombia, the tax rate is different for fuels that include a share of drop-in biofuels (OECD, 2022[60]).

However, revenue from fuel taxes is already on a downward trend due to the growing share of EVs in vehicle fleets and improvements in fuel efficiency standards for ICE vehicles (ITF, 2022[61]). For example, the UK government estimates that its current policy pathway and tax regime are "likely to result in zero revenue for the Government from motoring taxation by 2040" (HM Treasury, 2021[63]). Using other taxes to offset these losses would likely require politically difficult rate increases. In the United Kingdom, value-added tax (VAT) would need to grow by an estimated 4% (Lord and Palmou, 2021[64]) to make up for lost revenue.

Figure 6.9. Global fuel tax revenues under the Current Ambition and High Ambition scenarios



Note: Figure depicts ITF modelled estimates based on estimates of fuel tax rates derived from OECD and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) figures. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.
Sources: OECD (2022[60]); GIZ (2021[65]); OECD (n.d.[16]).

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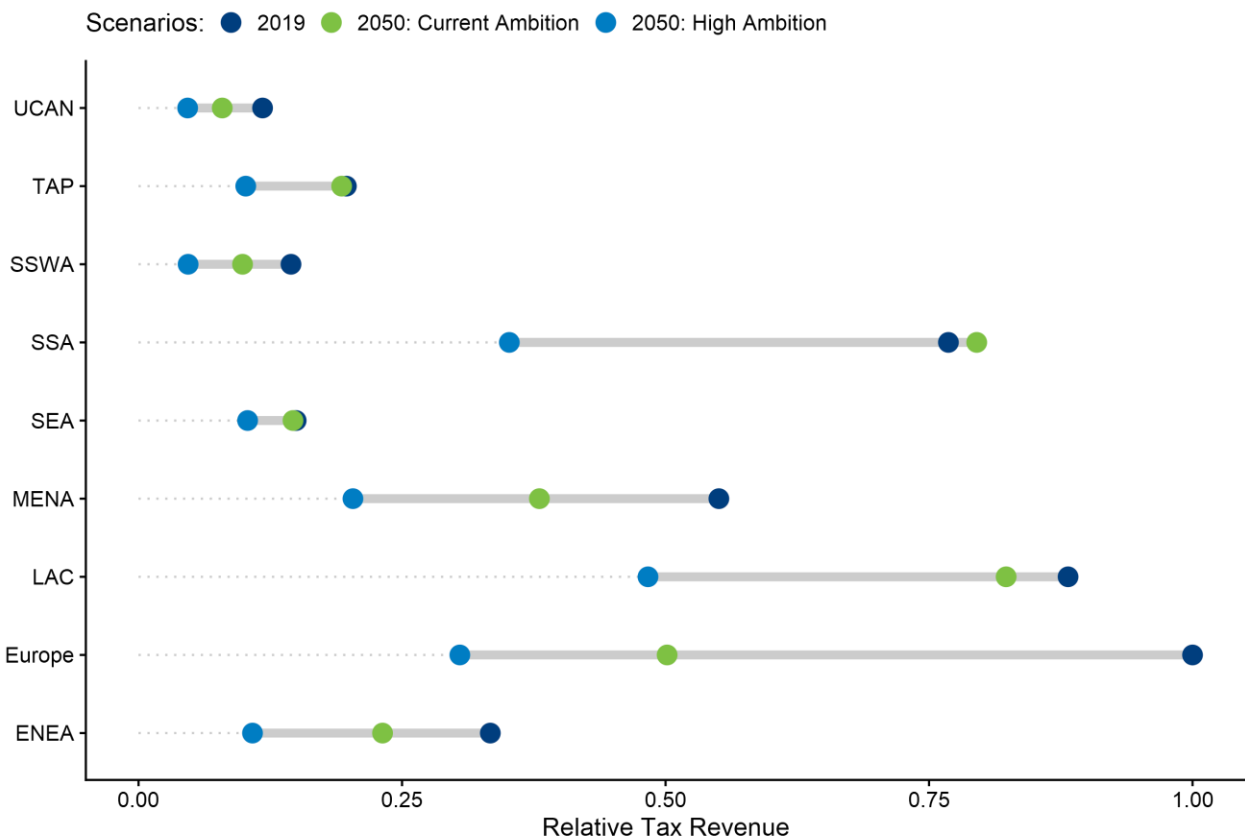
This downward trajectory for fuel tax would continue under both scenarios explored in this edition of the Outlook (see Figure 6.9). But revenue will decline faster under the High Ambition scenario, as this pathway includes more ambitious targets on new vehicle sales.

As the share of ZEVs in vehicle fleets increases, the lack of a replacement for fuel taxes raises the issue of fairness. As things stand, in the absence of a charge specifically targeted at ZEV purchasers, or some form of road-user charging, EV owners will not contribute to the costs of maintaining the infrastructure they use. Participants in a recent ITF Roundtable (ITF, 2022[61]) discussed the various policy options available to governments seeking to reform vehicle taxation. The analysis in this section explores the outputs of the Current Ambition and High Ambition scenarios in the context of these discussions.

Approaches to vehicle taxation vary significantly among regions

Figure 6.10 shows the total level of vehicle taxation (accounting for taxes on vehicle acquisition, ownership and use) in the different world regions under the Current and High Ambition scenarios. It compares vehicle taxation in these regions per vehicle-kilometre and accounts for approximate fleet sizes based on ITF estimates. Because the vehicle taxation rates in Europe are higher, the other reporting regions are shown relative to that region. For this analysis, fuel taxes were compared using the OECD's Consumption Tax Database (OECD, 2022[60]), a Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) report for the Sustainable Urban Transport Project (GIZ, 2021[65]) and the OECD's 2019 data on taxation on premium-unleaded gasoline (OECD, n.d.[16]).

Figure 6.10. Relative change in vehicle tax on private vehicles between 2019 and 2050 under the Current Ambition and High Ambition scenarios



Note: Comparison is normalised by fleet size. The fleet includes two- and three-wheelers, passenger cars, buses, LCVs, lorries and road tractors. Figure depicts ITF modelled estimates and modelled changes to the vehicle fleet from the ITF in-house models. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: the United States, Canada, Australia and New Zealand. Vehicle taxation rates in Europe are highest and so the other reporting regions are shown relative to that region.
Sources: Estimates of tax rates derived from figures in OECD (2022[60]), GIZ (2021[65]), OECD (n.d.[16]), Zahedi and Cremades (2012[17]), PWC (2019[18]) and Chen et al. (2022[15]).

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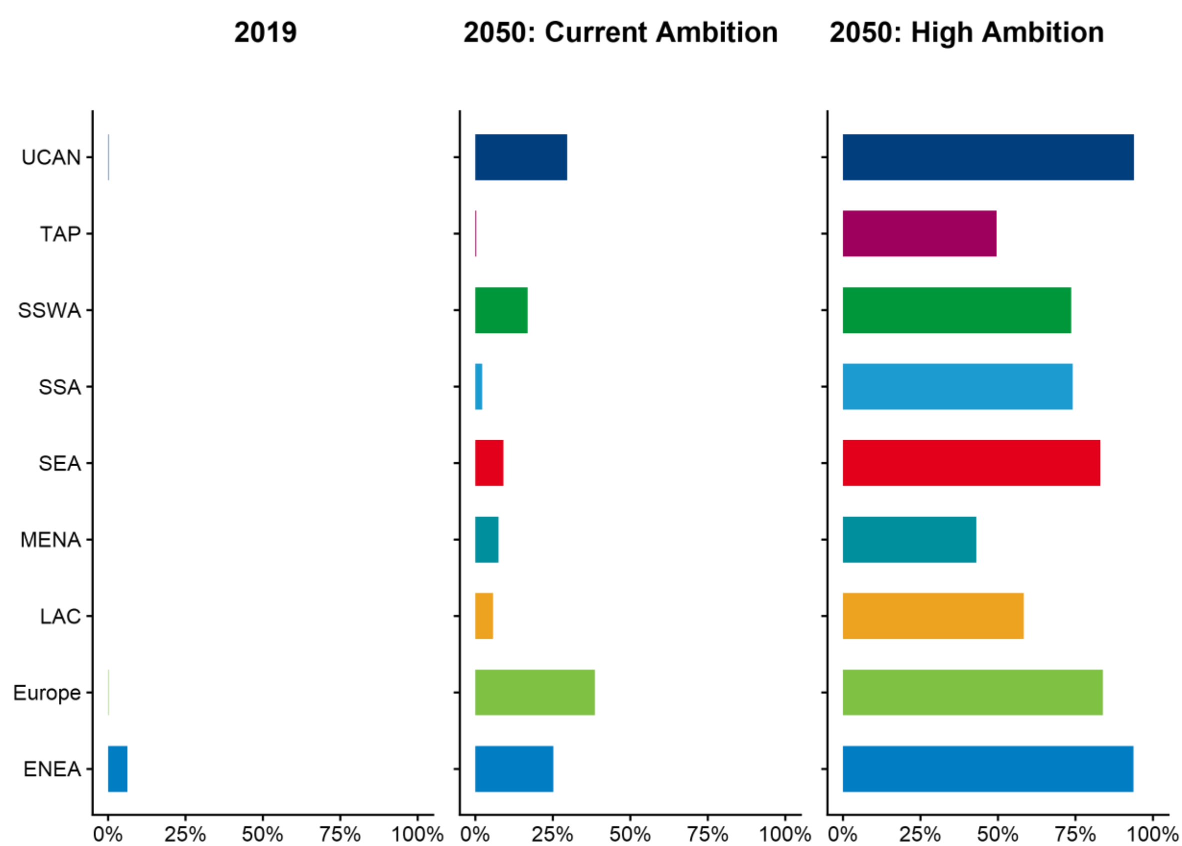
According to ITF estimates, in 2019 Europe generated the largest total tax revenue from vehicle ownership and use, standardised by fleet size (see Figure 6.10). If the tax regimes in these countries were to continue as they are now, their future tax revenue from vehicle ownership and use would nearly halve by 2050 under the Current Ambition scenario and reduce by more than two-thirds under the High Ambition scenario. These figures assume that countries in this reporting region do not apply additional charges to ZEVs at the same rates. In 2019, in all regions except ENEA, the vehicles comprising the tax bases were almost exclusively conventional ICE vehicles (see Figure 6.11).

The High Ambition scenario assumes a faster uptake rate for ZEVs than the Current Ambition scenario, which would reduce the share of ICE vehicles in the fleet to generate fuel-tax revenue. Countries in LAC and SSA received the second- and third-highest total amounts of tax revenue from vehicle use in 2019, respectively. The UCAN countries have the lowest tax rates, generating roughly 12% of the revenue per vehicle of the equivalent taxes in the Europe. It is worth noting that regional-level estimates can disguise considerable differences between countries.

For several regions, under the Current Ambition scenario, vehicle tax revenues would fall considerably by 2050. The exceptions are SEA, SSA and TAP. This result is mostly a reflection of the anticipated growth in transport demand coupled with a slower rate of decarbonisation. In contrast, under the High Ambition scenario, every region will have lower revenue from vehicle use taxes in 2050.

Vehicle tax revenues in emerging economies may also be higher than in high-income countries relative to per-capita GDP (Benitez, 2021[66]), meaning that national budgets in emerging countries are more dependent on fuel tax revenue (ITF, 2022[61]). This finding is particularly relevant in light of the accelerated rate of deployment of ZEVs (especially EVs) and greater investments in public transport under the High Ambition scenario, which will in turn contribute to reducing the tax base.

Figure 6.11. Share of zero-emission vehicles in the fleet by region



Note: Figure depicts ITF modelled estimates. The fleet includes two- and three-wheelers, passenger cars, buses, light commercial vehicles, lorries and road tractors. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport. ENEA: East and Northeast Asia. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SEA: Southeast Asia. SSA: Sub-Saharan Africa. SSWA: South and Southwest Asia. TAP: Transition economies and other Asia-Pacific countries. UCAN: United States, Canada, Australia and New Zealand.

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Governments will need to include tax reforms in their decarbonisation strategies

A strategic approach is needed to avoid the expected shortfalls in tax revenue in future years (OECD/ITF, 2019[67]). The accelerated uptake of low-emission vehicles and ZEVs under the High Ambition scenario will reduce governments' time to react to the expected changes in their tax bases. Markets in which larger, heavier vehicles (e.g. sports utility vehicles) dominate could potentially see an even more pronounced drop in tax revenue if a strategy to manage the transition is not implemented far enough in advance (ITF, 2021[48]).

In addition, in the absence of additional taxes, reducing the marginal cost of vehicle use over time could contribute to continued rises in private-car use. This would undermine the modal shift objectives central to sustainable mobility policies by making the private car more cost-competitive against mass transit and active mobility options.

Figure 6.12 shows an estimation of the change in tax revenue from vehicle ownership and use between 2019 and 2050 under the Current Ambition and High Ambition scenarios. In addition to fuel tax, the figure shows the relative changes in revenue shares due to VAT or sales tax (on all aspects of car purchase and use, which average out at a consistent share across both scenarios), specific one-off acquisition taxes (excluding VAT or sales tax), and periodic taxes (such as annual road tax or monthly motor vehicle tax).

Looking at the breakdown of tax revenue globally (see Figure 6.12), fuel taxes and periodic taxes for vehicle ownership and use account for the majority of tax revenue associated. Fuel taxes can include excise duty (i.e. a tax on the production and sale of the good) and a carbon tax element (OECD, 2022[60]; Van Dender, 2019[68]; OECD/ITF, 2019[67]). While carbon taxes directly target the CO_2 emissions of the fuel, there is evidence that governments also use excise duties as a lever for behaviour change among the populace.

In the case of fuel, excise duties can be considered "an implicit form of carbon pricing" (OECD, 2022[60]). The diminishing CO_2 emissions from road vehicles under all future policy scenarios will lead to a rapid erosion of this tax base. Fuel taxes also capture the external costs associated with CO_2 emissions. However, they are less effective at capturing other external costs (e.g. congestion), which are estimated to be higher than those of CO_2 emissions in congested urban areas (ITF, 2022[61]).

Taxing electricity at the same rates as current fuel tax is not expected to be a viable solution. Electricity is used in many sectors, meaning there would be wider impacts than just on transport, and it would also further exacerbate potential equity issues by affecting affordability for lower-income households. Additionally, as EVs are more efficient than conventional ICE vehicles, the tax revenues would still be lower than those on fossil fuels (ITF, 2021[48]).

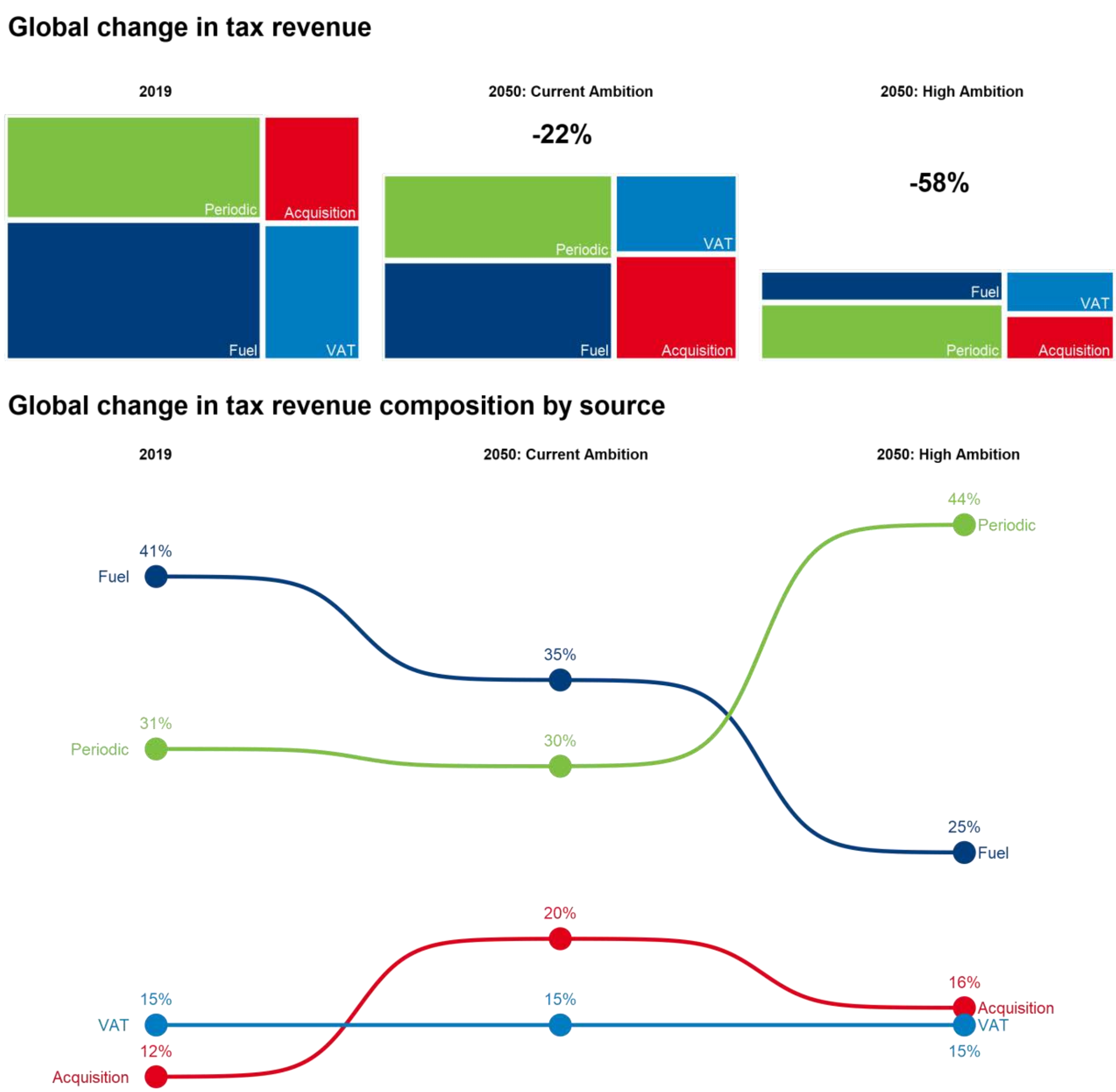
Many European and UCAN countries have also introduced acquisition or periodic tax structures designed to encourage low-emission vehicles or ZEVs by varying the tax paid based on fuel consumption or CO_2 emissions. Several explicitly offer bonuses, discounts or reduced tax rates for ZEVs or fully electric vehicles (OECD, 2022[60]). This approach to acquisition or periodic taxes is less prevalent in other regions.

Among the Asian sub-regions, emissions-based acquisition and periodic taxes are less common. ITF estimates suggest that ENEA has a stronger share of tax revenue based on periodic taxes than other regions in the long term. A 2022 study by the International Council for Clean Transportation (ICCT) found that among the countries in the ENEA region, only Japan based its acquisition or periodic taxes on CO_2 emissions or fuel consumption.

In SEA, Thailand and Singapore are the only countries to reflect environmental considerations in their acquisition and periodic taxes. However, at the time of writing, China, Japan, Korea and Singapore (as well as India in SSWA) all also offered some form of subsidy or rebate for electric or hybrid vehicles (Chen, Yang and Wappelhorst, 2022[15]), meaning the transition of the fleet would still have an impact on their tax revenue overall.

While the focus of this section is the reform of fuel tax, the results for acquisition taxes shown in Figure 6.12 also highlight the need to consider the lifespan of incentives for the purchase of ZEVs. The projections here assume that existing tax regimes carry forwards, and so existing exemptions in acquisition taxes for low- or zero-emission vehicles also carry forwards. When designing such incentives, the triggers or timing for phasing them out should also be considered.

Figure 6.12. Share of tax revenue by vehicle type and tax family in 2050



Note: Comparison is normalised by fleet size. The fleet includes two and three wheelers, passenger cars, buses, LCVs, lorries and road tractors. Figure depicts ITF modelled estimates and modelled changes to the vehicle fleet from the ITF in-house models. Current Ambition (CA) and High Ambition (HA) refer to the two main policy scenarios modelled, which represent two levels of ambition for decarbonising transport.
Sources: Estimates of tax rates derived from OECD (2022[60]), GIZ (2021[65]), OECD (n.d.[16]), Zahedi and Cremades (2012[17]), PWC (2019[18]) and Chen et al. (2022[15]).

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New taxes can address falling revenue and support climate action investments

Decisions on the future of taxation for vehicle ownership and use must consider all relevant externalities. Fuel tax has been effective for CO_2 emissions, but it is a blunt tool when seeking to account for congestion or safety risks. The EC views congestion and road crashes as the two largest external costs of private car use (EC, 2019[69]). Even as transport decarbonises, these two external costs will remain. However, they vary by time of day and location and are estimated to be higher in urban settings than rural ones (Proost, 2022[70]).

According to EC cost estimates, the externalities from EVs in uncongested rural settings are quite low relative to ICE vehicles or any car in congested conditions (EC, 2019[69]). This data suggests that undifferentiated road-user charging could be implemented in the short term so that all drivers contribute to the costs of the infrastructure. Additional pricing measures, such as congestion charges, could be implemented in congested urban settings to properly capture the external costs imposed by car use in that locality (ITF, 2022[61]). More sophisticated, differentiated road-user charges could then be introduced in the longer term. Urban pricing measures are discussed further in Chapter 3.

Of the UCAN countries, Australia, New Zealand and the United States have already taken action to move away from fuel taxes, adopting distance-based pricing at the national or subnational level. In Australia and New Zealand, distance-based pricing schemes exist based on odometer readings. The US states of Oregon, Utah and Virginia have adopted schemes that allow users to choose between an annual fee or a per-mile charge, depending on which is cheaper based on their usage level (ITF, 2022[61]). New Zealand's scheme has been in place since 1978, but in Australia and the United States, the schemes have been introduced to mitigate the impact of the changing fleet on fuel tax revenue.

However, fuel tax is not entirely obsolete: it is a largely effective and equitable means to capture the external costs of CO_2 emissions and encourage migration to cleaner vehicles. Fuel taxes should be retained as long as ICE vehicles form a significant part of the fleet, and rationalised so they fully internalise the relevant external costs of fuel use (e.g. climate costs and air pollution) for all fuel types. This also implies a relative increase in diesel taxes to account for diesel's greater air-pollution impacts (ITF, 2022[61]).

A recent ITF Roundtable on the pricing of road transport (ITF, 2022[61]) discussed introducing distance-based pricing for EVs while retaining fuel taxes for as long as ICE vehicles remain a part of the fleet. A combination of fuel taxes on ICE vehicles, distance-based road-user charges on EVs and locally adopted congestion charges should effectively capture the costs to society of road vehicle use and ensure a significant and proportionate user contribution to the costs of road infrastructure. In this way, vehicle use charges retain an element of leverage for governments to encourage mode shift and behaviour change.

The forthcoming report from the Roundtable recommends that, in the medium term, governments should develop the technical capacity to enable the adoption of differentiated pricing schemes, which can reap greater efficiency gains. In all cases, the policies must be well considered, and the reasoning behind them communicated to the general public to support political acceptability and smoother implementation. The acceptability of road pricing also needs to be considered. Such considerations may well imply congestion taxes need to be levied and spent locally, for example on improving urban public transport (ITF, 2022[61]).

As discussed in Chapter 3, the revenue generated from congestion or road pricing could be put towards improvements in public transport, so that it is attractive as an alternative to the private car. The design of any long-term road-pricing scheme must also consider the feasibility of implementation. This will include planning for the equity and affordability impacts of distance-based charges, especially in areas where the poorest communities may live on the peripheries.

Any scheme will likely require new technological solutions and administrative processes. Privacy concerns will also need to be addressed whenever the Global Positioning System (GPS) is used to estimate distance travelled. Future pricing policies should also contribute to wider policy goals, such as managing the potential for the continued risk of congestion if EVs simply replace ICE vehicles.

Policy recommendations

Adopt a vision-led "decide and provide" approach to infrastructure planning instead of a reactive "predict and provide" approach

Deciding now on the sustainable transport system of the future and investing in infrastructure accordingly can play a crucial role in decarbonising transport. If the High Ambition scenario is adopted, a "decide and provide" approach to core infrastructure will have lower investment needs than existing policy pathways. A long-term strategic vision will also encourage the integration of land-use and transport planning policies, supporting more liveable cities and greater access to – and use of – sustainable transport modes.

In the coming years, developing and growing cities will have opportunities to avoid car-dependent urban developments – if they act now to promote integrated land use and adopt a vision-led approach to their transport systems. Meanwhile, established cities in developed regions will need to prioritise sustainable modes over private motorised vehicles. The High Ambition scenario can still be delivered in these regions for lower core infrastructure costs than the Current Ambition scenario. In all regions, greater investment in public transport modes and inter-urban rail will be needed, while investment in roads will reduce, although it will still take the lion's share of investments.

This is the first time the *ITF Transport Outlook* has included costs for the infrastructure required to service the demand projections of the policy scenarios considered in the modelling exercise. While subject to limitations, as all modelling exercises are, this work demonstrates that, when assessed using the same assumptions, the two scenarios cost nearly the same in infrastructure requirements.

Infrastructure investment data remains difficult to collect at such a scale, in large part due to so many different bodies, public and commercial, being responsible for transport infrastructure projects. In most cases, no single office collates this information across all infrastructure types and governance levels. Tackling the data gap would be an important step towards developing better estimates in the future. If the data can be refined, costing exercises such as this can add important clarity to discussions of different pathways.

Account for the significant additional investment needed for electric vehicle charging infrastructure

The EV charging infrastructure needed to support the delivery of the High Ambition scenario represents a new and significant need for infrastructure investment. The investment required globally is estimated at 0.2% of global GDP per year in 2050 under the Current Ambition scenario and 0.4% under the High Ambition scenario, on average. This assumes a network comprising publicly accessible and domestic or workplace (or depot) charging. Several regions have developed policy packages to support and stimulate the installation of publicly accessible chargers while also using regulations and tax exemptions to drive domestic and workplace installations.

The extra investment needs for EV chargers in emerging regions, in particular, warrant consideration. Several already have greater investment needs for their core infrastructure than developed regions. Under the Current Ambition scenario, these regions will also experience the slowest "natural" uptake of ZEVs – meaning that the increase under the High Ambition scenario will be greater than in other regions. Crucially, emerging regions' electricity needs must be met before the EV charging network becomes relevant.

Charging networks for HDVs, in particular, will require increased planning. Currently, these networks represent the largest share of required investment under the High Ambition scenario. The development of depot-based charging infrastructure needs to be accelerated. Policy makers must now focus as diligently on planning for the transition of HGVs as they did to encourage the uptake of passenger light-duty vehicles in the past.

Reform the current method of taxing car use through fuel excise duty and introduce more distance-based pricing

Well-designed road-user pricing can help address declining fuel tax revenue and internalise the external costs of vehicle use. The climate and pollution costs of road use will decline significantly with electrification. But without significant policy change, congestion costs will continue to increase. Fuel taxes should be retained for as long as ICE vehicles form a significant part of the fleet and rationalised so that they fully internalise the relevant external fuel use costs.

Undifferentiated distance-based charges can form a useful substitute for fuel taxes in the short term. Congestion charges should also be adopted where warranted and levied locally. When road-user charges internalise all relevant external costs, they help encourage the necessary modal shifts that are an important part of transport decarbonisation. Any additional revenues can help improve public transport and develop better infrastructure for active mobility and micromobility.

Governments should work towards adopting a more sophisticated and differentiated distance-charging system in the medium term. Given the substantial efficiency and equity benefits that charging systems differentiated by time and place can achieve, governments should develop the technical capacity to adopt these systems and the legal frameworks to respond to privacy concerns. Governments should also ensure they communicate their road pricing policies effectively, to ensure public understanding and acceptance of these charges.

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Annex A. Statistical Annex

Additional statistical resources are available via OECD.Stat.

Transport performance indicators

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_INDICATORS

Short-term transport indicators

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_SHORT_TERM_INDIC

Road-injury crashes, fatalities and injuries

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_ROAD_ACCIDENTS

Passenger transport activity

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_PASSENGER_TRANSPORT

Freight transport activity

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_GOODS_TRANSPORT

Transport infrastructure investment and maintenance spending

https://stats.oecd.org/Index.aspx?DataSetCode=ITF_INV-MTN_DATA

ITF Transport Outlook 2023

The *ITF Transport Outlook 2023* examines the impacts of different policy measures on global transport demand and carbon dioxide (CO_2) emissions to 2050. The analysis covers the movement of passengers and freight across all transport modes. A particular focus is placed on transport policies that make cities more liveable. A second focus is on infrastructure investment decisions and what different policy scenarios mean for them. As a third focus, the report explores regional differences in policy impacts.

The analysis is based on two distinct scenarios for the future of transport, simulated with the ITF's in-house transport models. The Current Ambition scenario assumes policies to decarbonise transport continue along their current pathway and considers the implications for transport demand, CO_2 emissions and further aspects over the next three decades. The High Ambition scenario assumes policies focused on accelerating the decarbonisation of the transport sector and their impact.

PRINT ISBN 978-92-82-14481-7
PDF ISBN 978-92-82-16726-7

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