2.3

Low Carbon Transport Pathways

Key findings

2020 emission reduction targets

- While the majority of Annex I countries (industrialised countries and economies in transition) under the Kyoto Protocol have met their 2020 targets for reducing greenhouse gas emissions, the world is not on track to meet the overall Paris Agreement target for 2030.
- Transport is the only sector where emission levels rose in Annex I countries between 1990 and 2020, increasing 19%.
- Had the transport sector contributed proportionally to the agreed 2020 targets of the Kyoto Protocol 2020, transport CO_2 emissions would have been reduced by at least an additional 7%.
- Vehicle electrification and transport renewable energy targets for 2020 set in early 2010 have largely not been met.

2050 transport emission pathways

- To keep the rise in global temperature below 2 degrees Celsius (°C), annual transport emissions must be reduced to 6.5 gigatonnes of CO_2 or less by 2050; and to keep the rise below 1.5 °C, emissions must be reduced to roughly 3 gigatonnes of CO_2 or less. This would mean slashing per capita transport CO_2 emissions from 0.88 tonnes in 2019 to 0.2 tonnes in 2050.
- To achieve the 1.5 °C scenario with ambitious low carbon transport measures, emissions must start to decline now. To achieve a 2 °C scenario, the mitigation can be delayed until 2030, but emissions must plateau at around 2020 levels.
- Studies indicate that high-income countries were nearing their peak in transport CO_2 emissions by 2020.
- The majority of projected growth in transport emissions is in road transport (both passenger and freight) in middle-income countries, as well as in international aviation and shipping.

- Despite progress in reducing the energy intensity of transport, the sector is expected to have the highest carbon intensity among all sectors in 2040 due to its high dependency on fossil fuels.
- An analysis of transport emission pathways based on national studies shows that despite recent efficiency gains, the sector is not on track to meet 2050 emission reduction targets. In the most recent (2019) analysis, under the average business-as-usual pathway, global transport CO_2 emissions could increase from 8 gigatonnes in 2019 to 14.5 gigatonnes in 2050.
- Low carbon transport measures are becoming increasingly efficient and lead to a more positive trend than previously projected. Whereas previously (in 2017) the emission gap was estimated to reach 16 gigatonnes of CO_2 by 2050, new estimates (based on studies up to 2019) show a gap of around 12 gigatonnes.
- A balanced and inter-modal application of Avoid, Shift and Improve measures is capable of yielding an estimated reduction in transport emissions of 2.39 gigatonnes of CO_2-equivalent by 2030 and 5.74 gigatonnes of CO_2-equivalent by 2050.
- An analysis of personal consumption options has identified low carbon transport choices as the most effective area for reducing emissions, well above shifts in food, housing and other sectors.

Impacts of the COVID-19 pandemic

- As the pandemic subsides, transport emissions are likely to return to previous growth trends. In projections for 2030, climate models estimate that, compared to global temperatures if countries were to adhere to their emission pledges, the halt in transport during COVID-19 would have made only a -0.01 °C difference.
- Emission growth in international shipping has been slowed by the pandemic and is not projected to return to pre-COVID-19 levels until 2030.
- Growth in international aviation emissions was previously projected to be 230% to 310% between 2015 and 2050, and the pandemic has had a minimal impact on these projections (as of mid-2020, they were revised to 220% to 290% growth).
- Many COVID-19 recovery packages and bailout programmes have invested more heavily in fossil fuel-related companies than in clean energy, a trend that is likely to drive transport emission curves upward.

Overview

The transport sector's share of energy-related greenhouse gas emissions is on a trajectory to grow in both absolute and percentage terms. Overall, the Intergovernmental Panel on Climate Change has identified transport as one of the most difficult sectors to fully decarbonise.[1] The COVID-19 pandemic is perceived to have effects on the future pathways of transport CO_2 emissions, but the long-term impact will likely depend on the recovery measures implemented (*see Box 1*).[2]

The International Energy Agency (IEA) projects in its sustainable development scenario that transport will be the second highest emitter of CO_2 in the energy end-use sector (after industry) by 2032, and the highest emitter in 2070, due to lingering fossil fuel use in aviation, road freight and maritime shipping.[3] Similar results from the International Renewable Energy Agency project that the transport sector's share of global emissions will equal that of industry by 2030, and then overtake industry to become the largest emitter of CO_2 in end-use sectors in the period from 2030-2040.[4]

2020 emission reduction targets

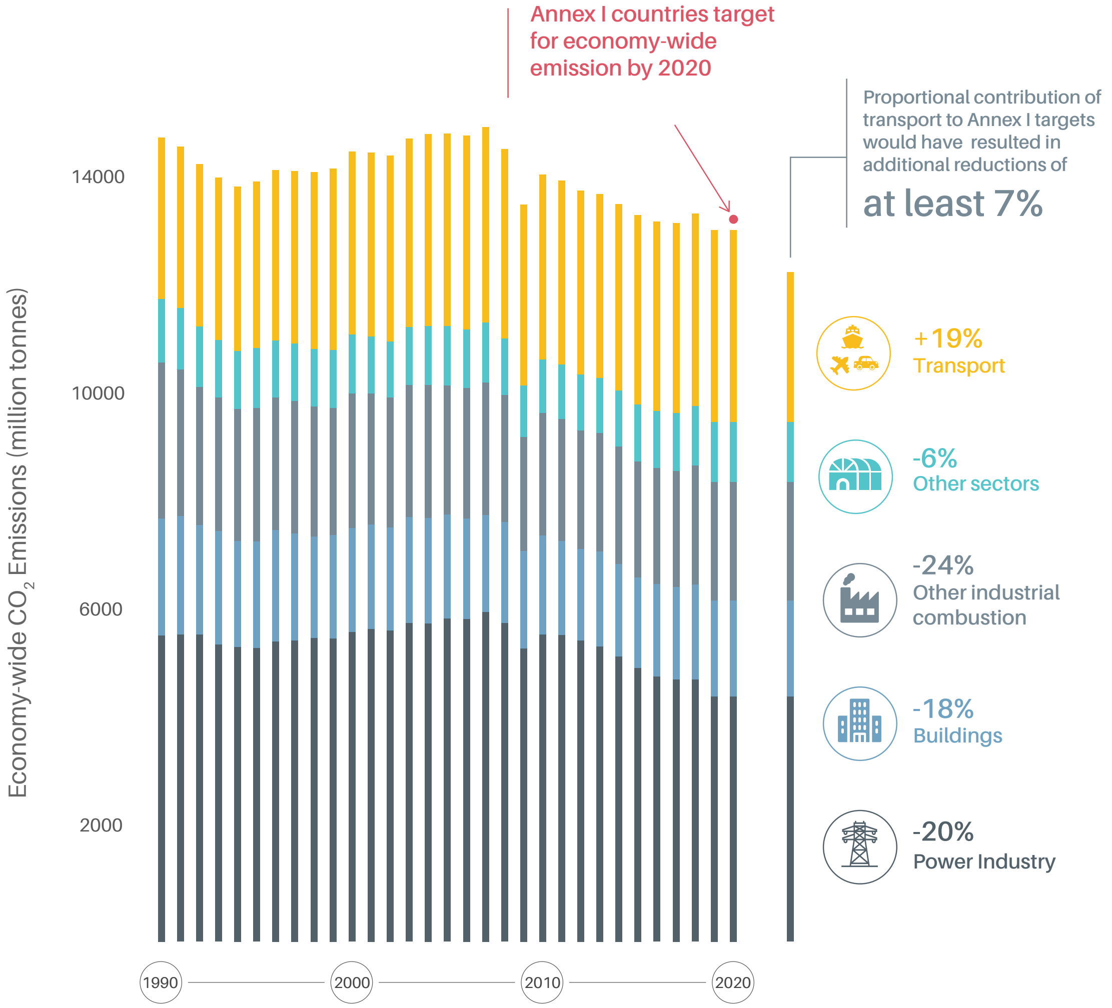
As an outcome of the 1997 Kyoto Protocol and subsequent international climate negotiations, the so-called Annex I countries (industrialised countries and economies in transition) agreed to economy-wide CO_2 emission reduction targets for 2020. These targets called for reductions in the range of 5% to 20% below 1990 levels.[5] Based on the latest robust data on CO_2 emissions available (for 2019[i]), these countries were able to meet their aggregated 2020 targets, with 22 out of the 38 Annex I countries actively contributing to this goal.[6]

While the majority of Annex I countries under the Kyoto Protocol have met their 2020 targets for reducing greenhouse gas emissions, the world is not on track to meet the overall Paris Agreement target for 2030.[7] Current emission trends will result in a global temperature increase of around 2.5 °C to 3.5 °C by 2100.[8] A major push to stem the impacts of climate change can be realised if countries set and seek to achieve targets for net zero emissions. As of April 2021, 127 countries representing 63% of global emissions had announced net zero targets.[9] If all these announcements are fully achieved, the temperature increase could be limited to 2.1 °C by 2100.[10]

Transport is the only sector where emission levels rose in Annex I countries between 1990 and 2020, increasing 19% (*see Figure 1*).[11] Although some gains in the sector were made in the areas of energy efficiency and fuel economy, improvements in standards were undercut by skewed emission testing (for example, the Volkswagen "Dieselgate" scandal) and by the shift from smaller cars to larger sport utility vehicles (SUVs). According to the IEA, this shift to SUVs outweighed almost all fuel economy progress during 2010-2018.[12] SUVs were responsible for the second largest increase in energy demand since 2010, even more so than heavy industry.[13]

i It is difficult to estimate 2020 levels due to uncertainties caused by COVID-19.

Figure 1. CO_2 emissions in Annex I countries by sector, 1990-2020



Source: See endnote 9 for this section.

In addition, freight activity increased strongly in Annex I countries, as did freight transport emissions; prior to 2016, the majority of new trucks sold were in countries that lacked both fuel economy and CO_2 emission standards for trucks and commercial vehicles.[14]

Had the transport sector contributed proportionally to the agreed 2020 targets of the Kyoto Protocol 2020, transport CO_2 emissions would have been reduced by at least an additional 7%.[15] To speed emission reductions, accelerated action and structural change in the transport sector is required in the coming years. Given current trends, the European Union (EU) is unlikely to meet its original 2030 target for reducing transport emissions (which includes a 37.5% reduction in CO_2 per kilometre for passenger cars, from 2021 levels) – much less its newer, economy-wide target (a 55% reduction).[16]

Vehicle electrification and transport renewable energy targets for 2020 set in early 2010 have largely not been met.[17] For example, Ontario, **Canada**, targeted sales of 18,000 electric vehicles in 2020, yet as of 2019 only 8,025 had been sold in the province, well off the target (2020 data were not yet available).[18] The **EU** targeted a 10% renewable share in transport energy consumption by 2020, but had achieved only a 7.6% share by 2017 and 8.1% by 2018.[19]

2050 transport emission pathways

Low carbon pathways

To keep the rise in global temperature below 2 degrees Celsius (°C), annual transport emissions must be reduced to 6.5 gigatonnes of CO_2 or less by 2050; and to keep the rise below 1.5 °C, emissions must be reduced to roughly 3 gigatonnes of CO_2 or less (*see Figure 2*).[20] **This would mean slashing per capita transport CO_2 emissions from 0.88 tonnes in 2019 to 0.2 tonnes in 2050.**[21]

To achieve the needed emission reductions for the more ambitious 1.5 °C goal, the transport sector needs to contribute rapid and significant additional emission reductions, as compared to the 2 °C pathway.[22] Analysis shows that the sector could reach emissions levels of 4.7 gigatonnes of CO_2 equivalent by 2050 through steps such as modal shifts, improved vehicle electrification, the avoidance or reduction of motorised travel, and shortened travel distances.[23]

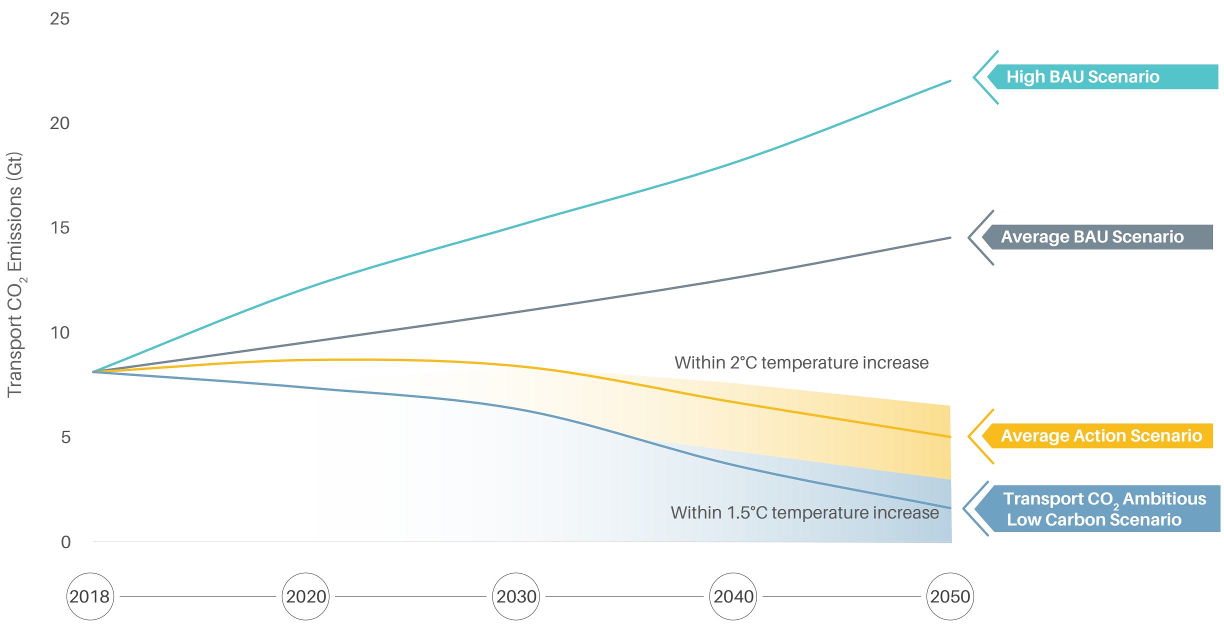
The analysis of mitigation studies on low carbon transport shows that the projections are within the Paris Agreement targets of 2 °C and 1.5 °C.[24] However, **to achieve the 1.5 °C scenario with ambitious low carbon transport measures, emissions must start to decline now.**[25] **To achieve a 2 °C scenario, the mitigation can be delayed until 2030, but emissions must plateau at around 2020 levels.**[26]

Studies indicate that high-income countries were nearing their peak in transport CO_2 emissions by 2020.[27] As of 2019, around 46% of all countries had conducted assessments of low carbon transport pathways to 2050, up from 42% of countries in 2017.[28] Among low-income countries, however, 94% still did not have transport projections for 2050.[29]

The majority of projected growth in transport emissions is in road transport (both passenger and freight) in middle-income countries, as well as in international aviation and shipping.[30] Under the average business-as-usual pathway, the share of emissions from international aviation and shipping could nearly double from 14% in 2000 to 29% in 2050.[31]

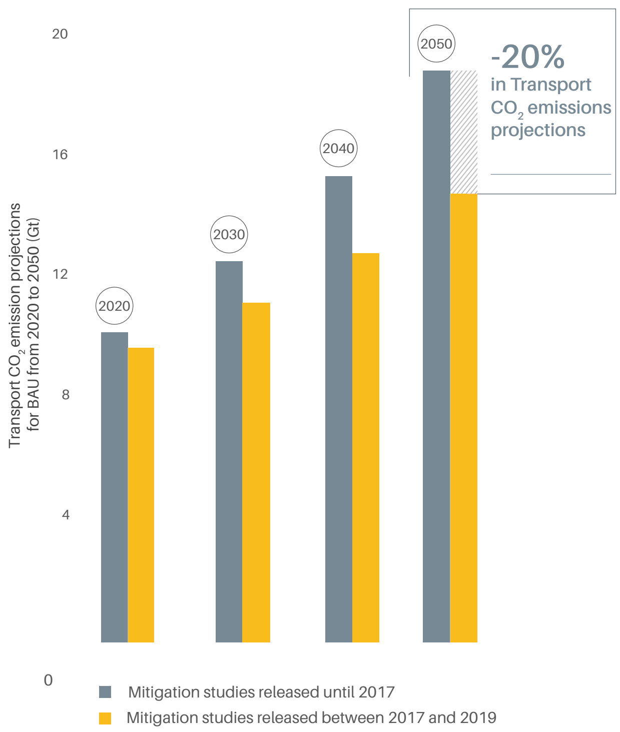
Despite progress in reducing the energy intensity of transport, the sector is expected to have the highest carbon intensity among all sectors in 2040 due to its high dependency on fossil fuels.[32] In the coming decades, transport activity is expected to grow steadily, driven mainly by freight transport and aviation, if no countermeasures are taken.[33] According to projections, the global vehicle fleet will reach between 2 billion and 3 billion vehicles by 2050, more than double the current road vehicle fleet of over 1 billion vehicles; freight activity will increase 225%, and non-urban passenger travel will grow similarly.[34]

Figure 2. Transport emission pathways for the business-as-usual, 2 °C and 1.5 °C scenarios, 2018-2050



Source: See endnote 20 for this section.

Figure 3. Comparison of business-as-usual projections for transport emissions, 2017 and 2019 studies



Source: See endnote 35 for this section.

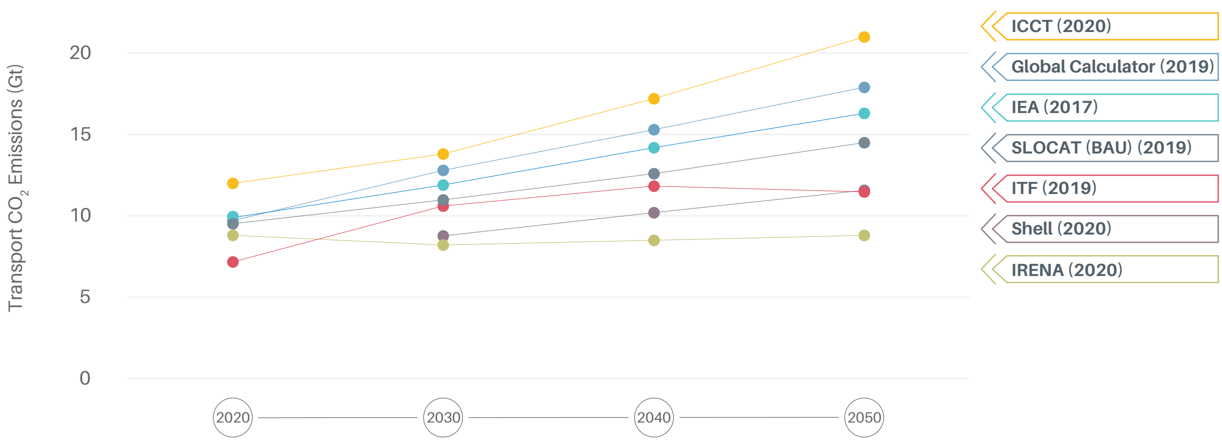
Business-as-usual emission projections

An analysis of transport emission pathways based on national studies shows that despite recent efficiency gains, the sector is not on track to meet 2050 emission reduction targets. In the most recent (2019) analysis, under the average business-as-usual pathway, global transport CO_2 emissions could increase from 8 gigatonnes in 2019 to 14.5 gigatonnes in 2050 (*see Figure 3*).[35] This suggests an improvement from the previous (2017) analysis, which showed CO_2 emissions rising to 18.5 gigatonnes in 2050 – highlighting that existing policies are now assumed to be more efficient than was previously estimated.[36] The updated analysis results in a 22% reduction in average business-as-usual emissions for 2050 compared to the earlier study.[37]

Low carbon transport measures are becoming increasingly efficient and lead to a more positive trend than previously projected. Whereas previously (in 2017) the emission gap was estimated to reach 16 gigatonnes of CO_2, new estimates (based on studies up to 2019) show a gap of around 12 gigatonnes. The improvements for business-as-usual result in a smaller emission gap between the business-as-usual pathways and the low carbon pathways – suggesting that current transport policies are seen as being more effective than previously projected.[38]

Other recent business-as-usual projections based on top-down analysis of global data show a similar outlook (*see Figure 4*).[39] Decarbonisation in line with the targets of the Paris Agreement is seen as especially challenging for freight and long-distance transport (air and shipping).[40] The projections reinforce the need to implement every possible measure to divert from the business-as-usual pathway.[41]

Figure 4. Projections for business-as-usual transport CO_2 emissions, 2020-2050



Source: See endnote 39 for this section.

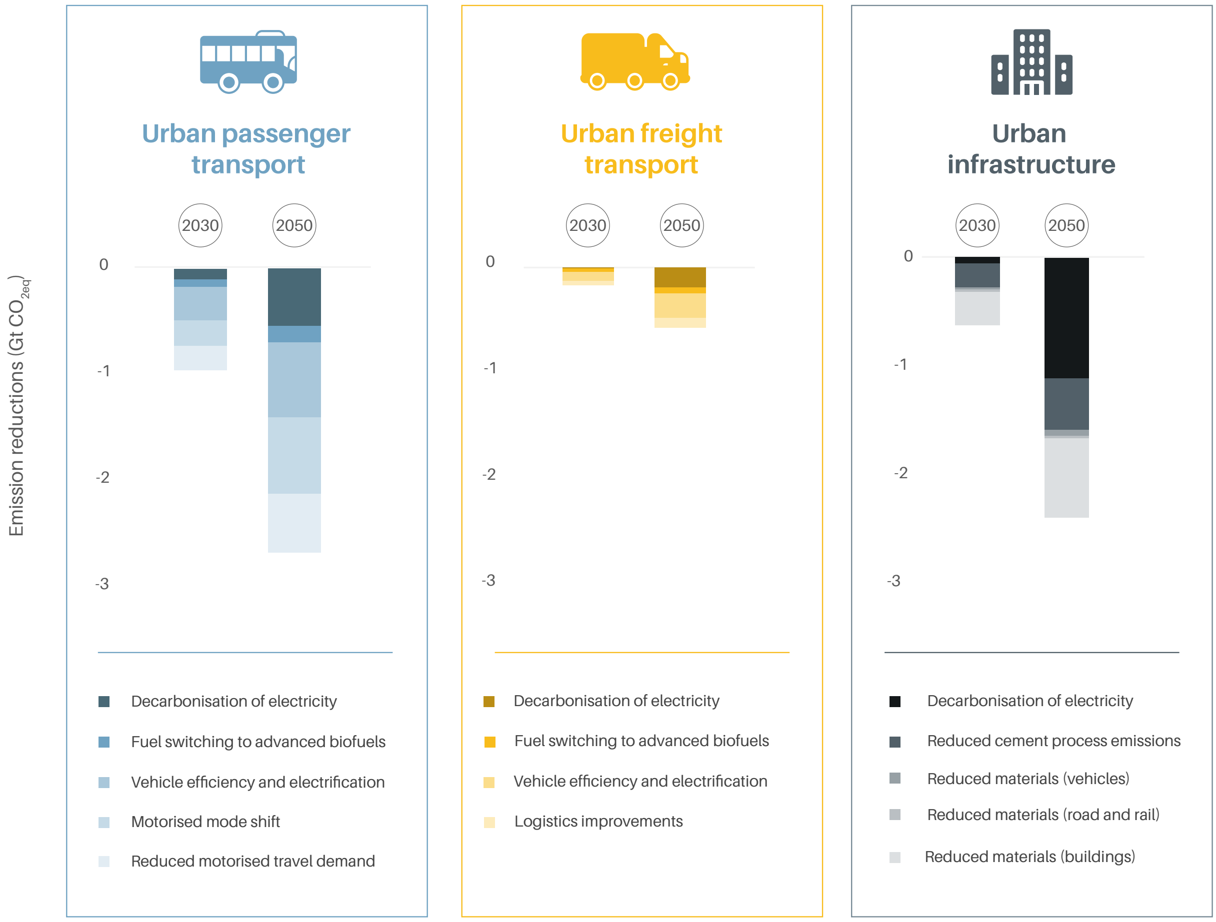
Emission trajectories and the *Avoid-Shift-Improve* framework

A balanced and inter-modal application of *Avoid*, *Shift* and *Improve* measures is capable of yielding an estimated reduction in transport emissions of 2.39 gigatonnes of CO_2-equivalent by 2030 and 5.74 gigatonnes of CO_2-equivalent by 2050 (*see Figure 5*).[42] The transformation of transport to a low carbon system can be guided by the *Avoid-Shift-Improve* framework (*see Section 1: Global Overview*). A balanced and inter-modal application of this framework that respects its inherent hierarchy (first *Avoid*/Reduce, then *Shift*, then *Improve*) can yield better mitigation results. Most of the reductions can be achieved in urban passenger transport.[43]

Achieving a 1.5 °C scenario will require a 40% reduction in transport's final energy consumption.[44] This can be achieved through better urban planning and land use, since a compact city can yield lower transport energy demand, less car dependency, higher passenger density in public transport, and more walking and cycling. Much of this relates to "Shift" measures as well as to implementing "*Avoid/Reduce*" measures, which would result in the most direct reductions in final energy consumption.

Among "*Improve*" measures, the most promising action is electric mobility, although it is unlikely that transport decarbonisation can be achieved by electrifying transport alone.[45] To achieve a 1.5 °C scenario pathway, the majority of the world's passenger and freight

Figure 5. Projected emission reductions resulting from various transport measures, 2030 and 2050



Source: See endnote 42 for this section.

vehicle fleets need to be electrified by 2050, including freight vehicles.[46] In Europe, electric cars currently contribute three times fewer CO_2 emissions than internal combustion engine cars based on life-cycle assessment.[47]

A comparison of national electric vehicle sales targets with manufacturers' plans for producing the vehicles suggests that a significant gap will remain between supply and demand through 2050 (*see Figure 6*).[48] Several national and regional entities have announced intentions to phase out sales of cars and trucks with internal combustion engines (*see Section 3.8: E-mobility*). However, this ambition cannot be supported by current levels of electric vehicle production. To help countries meet their government targets, the share of electric cars in vehicle sales needs to be around 66%.[49]

An analysis of personal consumption options has identified low carbon transport choices as the most effective area for reducing emissions, well above shifts in food, housing and other sectors (*see Figure 7*).[50] A car-free lifestyle can save on average 2.1 tonnes of CO_2-equivalent per capita a year, while the use of battery electric passenger cars can save on average 2 tonnes per capita a year, although several studies indicate even greater potential savings depending on the circumstances.[51] Meanwhile, taking fewer long-distance flights can save on average 1.8 tonnes of CO_2-equivalent per capita a year.[52]

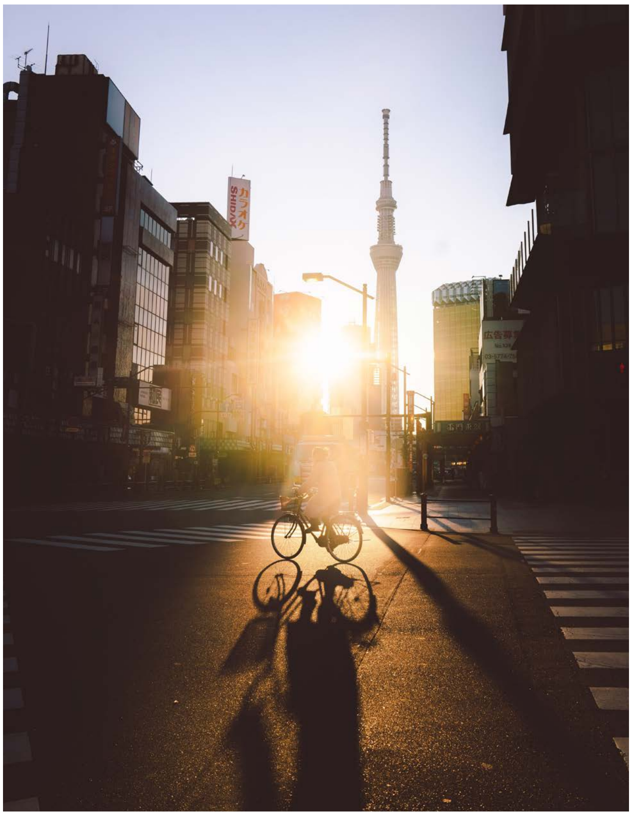
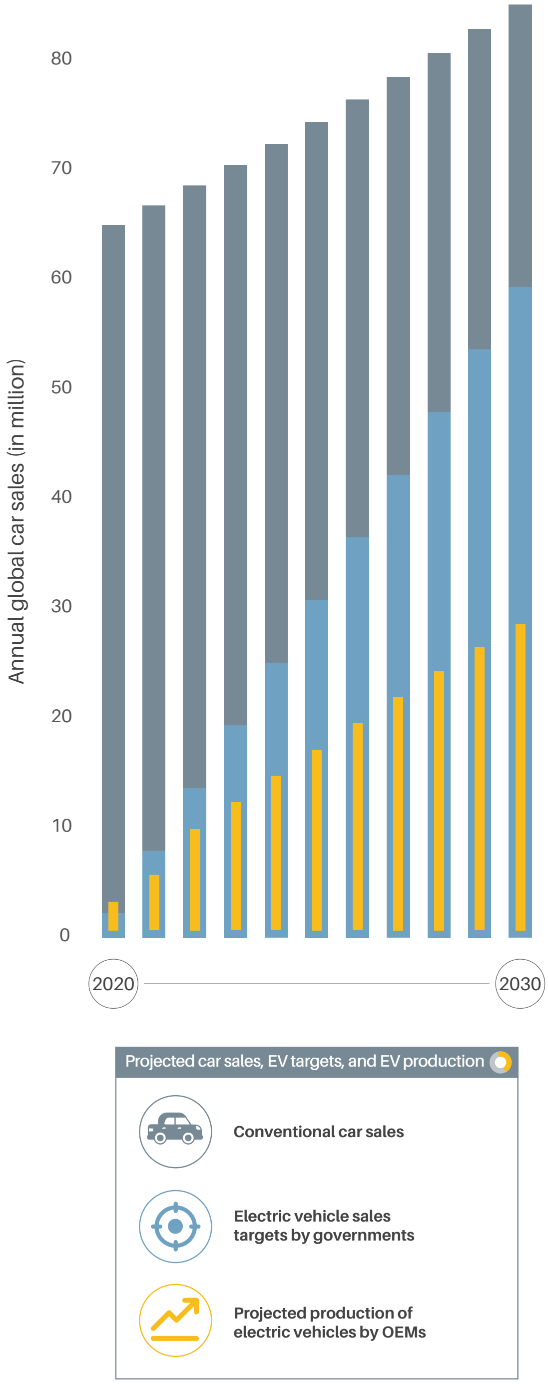
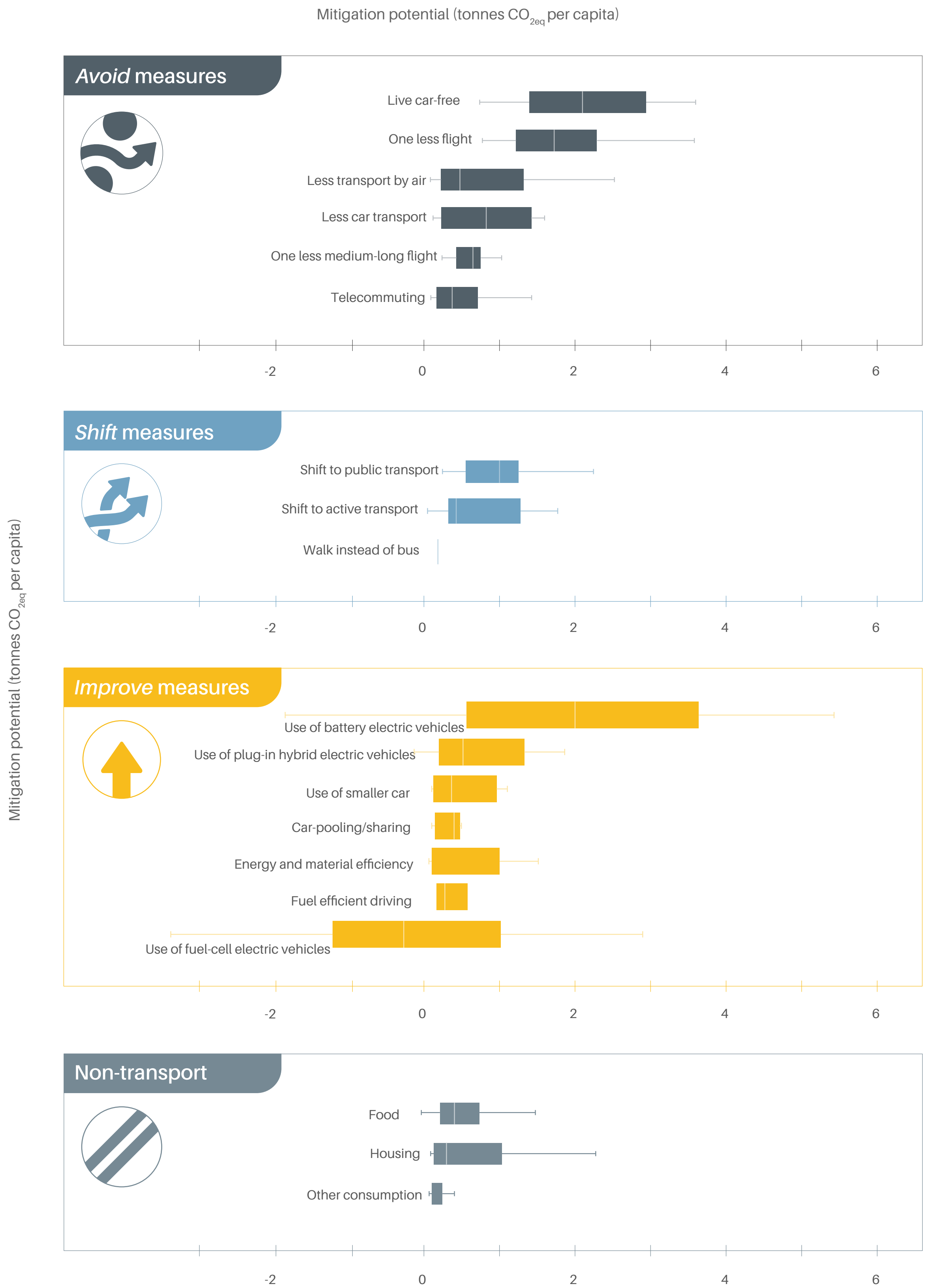


Figure 6. Projections for global electric vehicle fleet development, 2020-2030



Source: See endnote 48 for this section.

Figure 7. Estimated mitigation potential of various low carbon transport options



Source: See endnote 50 for this section.

Box 1. Impacts of the COVID-19 pandemic on transport pathways

As the COVID-19 pandemic subsides, transport emissions are likely to return to previous growth trends. In projections for 2030, climate models estimate that, compared to global temperatures if countries were to adhere to their emission pledges, the halt in transport during COVID-19 would have made only a -0.01 °C difference. The pandemic can be seen as an opportunity to transition to low carbon mobility systems and to shift to lower-emission pathways; however, initial assessments indicate that it made little difference to global temperatures and will not permanently accelerate the decarbonisation of transport. Without green investments in economic recovery packages, transport will fail to contribute proportionally to meeting the Paris Agreement targets of keeping global temperature rise well below 2 °C and below 1.5 °C.

Emission growth in international shipping has been slowed by the pandemic and is not projected to return to pre-COVID-19 levels until 2030. Shipping emissions fell an estimated 18-35% in 2020 from 2019 levels. Emission growth for 2030 is projected to range between a drop of around 13% compared to pre-COVID (2019) projections and a return to pre-COVID projections.

Growth in international aviation emissions was previously projected to be 230% to 310% between 2015 and 2050, and the pandemic has had a minimal impact on these projections. By mid-2020, the revised projections based on COVID-19 had fallen only slightly to a 220% to 290% increase by 2015-2050. The International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) had originally intended to use 2019 and 2020 as the baseline for reducing emissions, but due to the pandemic this was changed to only 2019, at least for the first three years of the scheme.

Many COVID-19 recovery packages and bailout programmes have invested more heavily in fossil fuel-related companies than in clean energy, a trend that is likely to drive transport emission curves upward. An analysis of recovery packages including from China, the EU-27, India, the Republic of Korea and the US concluded that, as of September 2020, these countries had not seized the opportunity to introduce structural changes to their economies that would induce transformational change in transport decarbonisation policies. (*See Section 4: Financing Climate Action in Transport*.)

Source: See endnote 2 for this section.

Annex: Methodological Note

Data usage

Time period for data:
The report strives to utilise the most recent publicly available data and information just prior to the time of publication (as of 31 May 2021). The figures in the report were developed between September and December 2020 using the most recent data available.

Secondary data:
SLOCAT relies on secondary data and information collected and provided by SLOCAT partners and other entities and does not make use of any internal modelling tools.

Data on sustainable mobility: A call to action

The report benefits directly from data collected by a wide range of stakeholders working in different areas of transport.

Data are important for providing a comprehensive picture of the status of sustainable, low carbon transport and are essential for both policy and investment decision making. In these times of change, it is critical to upgrade data and policy collection and interpretation capacities to better understand progress and the hurdles that must be addressed.

The data limitations mentioned below are not new. Obtaining regular, reliable and public data across regions and transport modes remains an outstanding issue. When an increasing number of stakeholders are collecting data and policy information, more and better open-access data and capacity building efforts for data interpretation are supported by many multi-stakeholder partnerships in the sustainable, low carbon movement.

If you share our passion for open-access data and knowledge towards greater impact on policy and investment decision making worldwide and/or would like to contribute data or knowledge to our collective efforts on this report, **please reach out to the research team in the SLOCAT Secretariat at tcc-gsr@slocatpartnership.org**.

Specific data used in this report

Data on emissions

The data in this edition of the report point to the direct carbon emissions from transport activity; they do not cover the indirect emissions and land-use impacts associated with certain modes of transport. The report primarily utilises CO_2 emission data compiled in the Emissions Database for Global Atmospheric Research (EDGAR) from the Joint Research Centre of the European Commission, as this represents the most recent, comprehensive dataset on transport CO_2 emissions. However, this global dataset does not convey in full detail the unique situations of individual countries.

EDGAR provides estimates for fossil CO_2 emissions from all anthropogenic activities with the exception of land use, land-use change, forestry and the large-scale burning of biomass. The main activities covered are CO_2 emissions emitted by the power sector (i.e., power and heat genertion plants), by other industrial combustion (i.e., combustion for industrial manufacturing and fuel production) and by buildings and other activities such as industrial process emissions, agricultural soils and waste. Transport activities covered within EDGAR include road transport, non-road transport, domestic aviation, and inland waterways on a country level, as well as international aviation and shipping.[1]

For the world, regions and countries, the CO_2 emission data (provided by EDGAR) span through 2019. In a few places in the report, CO_2 data for 2020 are shown to illustrate the impact of the COVID-19 pandemic; however, these data are based on a different methodology than the EDGAR dataset and should not be compared directly with the data from previous years.

The latest CO_2 emission data for individual transport modes are for 2018 and have been compiled only at the global level. For passenger and freight transport, the data on global CO_2 emissions are for 2017, as this is the latest year with robust data. Data on passenger activity (passenger-kilometres) and freight activity (tonne-kilometres) – provided mainly in the country fact sheets – are based on the latest available year, as indicated in the report analysis.

Information on greenhouse gas emissions – provided in CO_2 equivalent (CO_{2eq}) – include not only CO_2 but also methane, nitrous oxide, and industrial gases such as hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride.[2] These data are less up-to-date. As of 31 May 2021, data on greenhouse gas emissions were not readily available for the period 2019-2020. In some cases, additional data sources were used to provide detailed information about other climate pollutants besides CO_2.

All data on CO_2 and other greenhouse gas emissions, as well as CO_{2eq}, are provided in metric tonnes.

Data on car ownership

Information on car ownership rates is based on a global dataset from the International Organization of Motor Vehicle Manufacturers (OICA), with the latest release (as of 31 May 2021) dating from 2015.[3] Although newer information is available for some individual countries, using these data would hinder accurate global comparisons. Data on passenger and commercial vehicle sales were available only up to 2019.

Policy landscape data

The policy-related information presented in this report is not intended to be comprehensive. The data for the policy landscape indicators provided in Section 3 were gathered through desk research unless otherwise indicated. Barriers to accessing such information include language and limited availability of information through online media (e.g., websites, press releases and news articles).

Data in country fact sheets

Information in the fact sheets is based on desk research and on contributions from the national focal points. The data were collected to the best of the authors' knowledge and based on data availability, and thus may not be complete or show the most recent status. When no information was available for a given indicator, the term "Not available" is used.

Data gaps

Major data gaps exist in areas where there is no globally accepted data collection methodology. For example, the mapping of cycling and walking infrastructure is not currently done in all regions. Also, the modal share can be surveyed through different methods, leading to inconsistencies in available data. In addition, data on paratransit (informal transport), a predominant form of transport in many parts of the world, are largely lacking. This results in an incomplete picture of the impact of transport on climate change and sustainable development.

Methodological approach

Countries and regions

The report follows the M49 Standard of the United Nations Statistics Division.[4] In total, 196 countries have official United Nations membership and are also party to the United Nations Framework Convention on Climate Change. The available data have been put in a common structure for the United Nations member countries, regions and income groups to enable a consistent assessment. Income groups are based on the World Bank's classification of 2019.[5]

Economic calculations

The per capita and gross domestic product (GDP) calculations are based on the United Nations World Population Prospects 2019 and on World Bank GDP data using constant 2010 USD.[6]

Spatial and temporal scales

The geographic scale (global, national, city-level, etc.) as well as time scale (annual, monthly, daily) used in this report depends largely on the available dataset, as noted in the relevant figures and text. The detailed data forming the basis of the calculations and analysis are provided in the SLOCAT Transport Knowledge Base.[7]

Criteria for selection

The report covers policies, targets, emission reductions (achieved or envisioned) and market measures. To merit inclusion in the analysis, the policies, projects and trends must have been announced or completed between 2018 and 2020. Significant developments from January through May 2021 were included when deemed relevant, with the understanding that the next edition of the *Transport and Climate Change Global Status Report* will cover a period starting in 2021.

Pre- and post-COVID-19 pandemic trends

The year 2020 was pivotal for the world, and the COVID-19 pandemic has had substantial impacts on many of the transport trends monitored in this report. This edition attempts to differentiate between long-term trends and impacts due to the pandemic. To the extent possible, the analysis notes "pre-pandemic" (up to the end of 2019 or latest by February 2020) and "during pandemic" trends (starting in March 2020 until the end of 2020), as in some cases the pandemic led to reversals in long-term trends, at least for a specific period of time. In each section, a box describes the impacts that the pandemic has had on specific regions and sub-sectors.

Assembling the report

Global Strategy Team

This edition of the report was guided by a global strategy team consisting of 20 experts in the field who provided inputs over the span of six meetings between September 2019 and October 2020. Additionally, small group consultations were organised in February 2021, following the peer review process.

Authors and contributors

The report was collaboratively drafted by 22 authors and contributors from 16 organisations, led by the SLOCAT Secretariat. This includes additions and high-level inputs from the copy editor and from the special advisor who also co-authored the Executive Summary. Authors researched and compiled relevant facts and figures for the five sections of the report, including the Focus Features, with supporting review and inputs from several other organisations.

Peer review: A peer review process was carried out from 18 December 2020 to 20 January 2021 with 1,700 comments received from 74 reviewers. Each comment was individually reviewed by the SLOCAT Secretariat and considered in finalising the report.

National focal points: The report benefited from the contributions of voluntary national focal points, or experts from various regions and countries who have been essential to overcome language and information barriers. A public call for participation to provide information on policies and data resulted in several hundred initial registrations. Out of these registrations, 78 national focal points provided inputs through a first survey from 24 January to 3 February 2020; and through a second survey (focused on the country fact sheets) from 6 to 30 August 2020. All national focal points that contributed to the surveys are listed in the Acknowledgements.

Endnotes

2.3 Low Carbon Transport Pathways

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3.1 National Policy Frameworks for Transport and **Annex: Methodological Note**

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