Global Roadmap of Action Toward Sustainable Mobility

PAPER 6 | Green Mobility

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GLOBAL ROADMAP OF ACTION

Toward Sustainable Mobility

GREEN MOBILITY

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LIST OF ACRONYMS

ACI	Airports Council International
ASEAN	Association of Southeast Asian Nations
ASI	Avoid-Shift-Improve
ATAG	Air Transport Action Group
BD2S	Beyond 2 Degree Scenario
BECCS	Bio-Energy with CO2 Capture and Storage
BEV	Battery Electric Vehicle
BMZ	German Federal Ministry for Economic Cooperation and Development
CAAF	Conference on Aviation Alternative Fuels
CAEP	Committee on Aviation Environmental Protection
CCAC	Climate and Clean Air Coalition
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DALY	Disability-Adjusted Life Year
dB	Decibel
DNL	Day Night average sound Level
EEDI	Energy Efficiency Design Index
EST	Environmentally Sustainable Transport
EU	European Union
EV	Electric Vehicle
EVI	Electric Vehicles Initiative
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMR	Global Mobility Report
GRA	Global Roadmap of Action
Gt	Giga Ton
GTF	Global Tracking Framework
HDVs	Heavy Duty Vehicles

HEV	Hybrid Electric Vehicle
ICAO	International Civil Aviation Organization
ICE	Internal Combustion Engine
IEA	International Energy Agency
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ISDB	Islamic Development Bank
IT	Information Technology
ITDP	Institute for Transportation and Development Policy
ITF	International Transport Forum
ITS	Intelligent Transport Systems
Kt	Kilotons
kWh	Kilowatt hour
LAQ	Local Air Quality
LC2RTI	Low Carbon Road and Road Transport Initiative
Lden	Day Evening Night sound level
LDVs	Light Duty Vehicles
LEZ	Low Emission Zones
MaaS	Mobility as a Service
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
MRV	Measurement, Reporting and Verification
Mt	Million Tons
NDC	Nationally Determined Contributions
NEVs	New Energy Vehicles
NOx	Nitrogen Oxide
OECD	Organization for Economic Cooperation and Development
OPS	Ozone Depleting Substances
PA	Paris Agreement
PHEV	Plug-in Hybrid Vehicle
PKM	Passenger-Kilometer
PM	Particulate Matter
PPMC	Paris Process on Mobility and Climate
R&D	Research and Development
REN21	Renewable Energy Policy Network for the 21st Century
SARPs	Standards and Recommended Practices

SDGs	Sustainable Development Goals
SEEMP	Ship Energy Efficiency Management Plan
SGLF	Sustainable Gas Liquid Fuels
SLoCaT	Partnership on Sustainable, Low Carbon Transport
SOX	Surphur Oxide
SuM4All	Sustainable Mobility for All
TDM	Transportation Demand Management
TKM	Tonne-Kilometer
TUMI	Transformative Urban Mobility Initiative
UEMI	Urban Electric Mobility Initiative
ug/cu.m	microgram per cubic meter
UIC	International Union of Railways
UITP	International Association of Public Transport
UN	United Nations
UN	United Nations
UNCRD	United Nations Center for Regional Development
UNCTAD	United Nations Confernce on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
VP	Vice President
WB	World Bank
WHO	World Health Organization
WLTP	Worldwide Harmonized Light Vehicle Test Procedure
WRI	World Resources Institute
ZEV	Zero Emission Vehicle

FOREWORD

Sustainable Mobility for All (SuM4All) is an umbrella platform that brings together 55 public and private organizations and companies with a shared ambition to transform the future of mobility. Its unique value lies in bringing key influential actors to work together. It serves as the principal platform for international cooperation on sustainable mobility, a center of excellence, and a repository of policy, knowledge and resource on sustainable mobility. Its mission is to play a leading role in the ongoing transformation of the global mobility system, and support countries in their transition towards sustainable mobility.

Established in 2017, SuM4All's first task at hand was to find common ground on what countries wanted to achieve. We all agreed that transport was a key contributor to economic development and core to people's quality of life. We also agreed that the transport that we have is not the transport that we want—congestion in cities, segregation among rural and urban communities, carbon emissions, air and noise pollution, and traffic mishaps that are symptomatic of a systemic problem with mobility. We set our ambition high for the mobility of the future: we need an equitable, efficient, safe and green mobility.

The consensus on what sustainable mobility meant set us on our next task to establish the imperative for action. The Global Mobility Report 2017 benchmarked countries' performances on mobility relative to four policy goals. The findings of that report were alarming: not a single country in the world—developed or developing—has achieved sustainable mobility.

With evidence at hand, SuM4All embarked on a major drive in 2018 to develop a comprehensive policy framework to assist decision makers in cities and countries as well as practitioners at development banks to identify gaps, necessary steps, and appropriate instruments to attain the Sustainable Development Goals, and improve the sustainability of their transport sector.

We are pleased to share the outcomes of these efforts that embody the collective knowledge of all its members and more than 180 experts, and feedback from more than 50 public decision makers and 25 large private corporations. The Global Roadmap of Action builds on six policy papers, including this Green Mobility paper, whose content is made accessible and usable to all in a web-based tool for decision making.

Sustainable Mobility for All Steering Committee
(On behalf of our 55 Member organizations)
July 2019, Washington, D.C.

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EXECUTIVE SUMMARY

The green mobility policy goal aims to "reduce the environmental impact of mobility in terms of greenhouse gas (GHG) emissions, air pollution, and noise."

Global GHG emissions from the transport sector need to be reduced from 8 billion tons of Carbon Dioxide (CO_2) to contribute effectively to keeping temperature increase within acceptable limits. The indicative target is a reduction to 2 to 4 billion tons by 2050, with net–zero emissions in the decades thereafter. This implies emissions of less than 0.5 tons on average per capita. Many countries are below this level, yet their emissions are rising rapidly because of increased motorization. Meanwhile, countries with high per capita emissions of 1 to 5 tons, require rapid decarbonization as a necessity.

The transport sector, in particular because of diesel vehicles and ships, is also a key contributor to ambient air pollution. Air pollution annually causes 4.2 million deaths globally. Only a few countries and large cities meet the WHO's mean guideline value of 10 microgram PM2.5/m3. Against this backdrop, it is proposed that by 2020, each country and each large or medium-sized city develop clean air plans with the objective of reaching 50 percent reduction of premature deaths from surface transport sources by 2030, compared to 2010 levels.

Though a lack of globally comparable data envelops noise pollution, transport-related sources have been identified as serious health threats, particularly in cities. The priority is to "substantially reduce global human mortality and burden of disease from transport-related noise levels". It is thus proposed that, by 2030, the number of urban dwellers exposed to excessive noise levels be reduced by 50 percent compared to 2015 levels.

Priority areas are highlighted based on an avoid–shift–improve framework to address these environmental impacts from transport. The avoid-and-shift measures, in particular, are often employed for other sustainability reasons than the environment. Reducing the GHG and air pollution could be considered co-benefits of sustainable transport actions. However, it is the "improve" policy measures that are driven by air quality, energy and climate concerns that provide relatively few co-benefits for the other policy goals.

The nationally determined contributions under the Paris Agreement provide a framework for national and local actions for low-carbon transport, however these do not go far enough to decarbonize the sector. Priority policy measures are organized by passenger and freight, with both sub sectors crucial in addressing environmental issues:

Passenger	Freight
Promote active mobility modes: walking and cycling	Factor in energy and environmental concerns for better-informed shipping decisions
Push and pull approach to support modal shift in cities	Encourage efficient supply chains and circular economy
Promote electric two-wheelers	Favor modal shift toward more rail and waterways
Apply standards and incentives for clean buses	Develop and promote clean, low-carbon fuels
Craft policy packages for cleaner and more efficient cars	Foster R&D strategies for electric vehicles and alternative fuels

Passenger	Freight
Phase out fossil fuel subsidies and reflect external costs in fuel prices	
Design policies supporting the transition to electric vehicles	
Take advantage of digital tools and new mobility models	
Address the noise issue	
More sustainable aviation	
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Improved data, and measurement, reporting and verification (MRV) are critical, and will support the transport policy making process. Institutional development is important as well; stakeholders of transport and stakeholders of environment, energy and industry need to work together and coordinate to design integrated Green Mobility strategies.

A long-term transition to green mobility additionally requires significant changes in the energy system. Key issues include decarbonization of electricity and hydrogen supply, investments in grids, battery life-cycle management and sustainable bio-or synthetic fuels.

Building upon the existing frameworks developed by the ICAO and the IMO, further policy measures such as advanced R&D on cleaner aircraft and alternative fuels launched at country level, particularly in connection with other transport modes, can be developed.

Climate change strategies for transport should also include adaptation, as climate change poses major threats to transport infrastructure because of the increased risk of disasters. The case in favor of a more resilient transport system seems clear, especially since transport can also help alleviate the impact of economic and safety-related consequences of extreme weather events. It rests with major adaptation strategies on international regional and local levels to make a resilient transport system possible. Nonetheless, such developments remain rare and only a limited number of countries have so far developed full-fledged national adaptation plans. Consequently, adaptation efforts should be strengthened and broadened, in combination with mitigation measures.

Increasing investment attractiveness in low-carbon technologies and crafting supporting economic instruments will be paramount to succeed in accelerating the transformation of the sector. Studies show that the cost of action is less than the cost of inaction because of substantial savings to infrastructure, fuel and vehicle expenditures.

Therefore, resistive trends to change, arising from vested interests in solutions proposed, must be condemned.

INTRODUCTION

Who would deny the immense social and economic benefits of a mobile society? The freedom to move is one of the most essential human rights. Achieving the Sustainable Development Goals (SDGs) will require both effective means of transport for goods and the ability for people to access services and opportunities. Therefore, in many countries a sizable effort to develop mobility is necessary.

At the same time, who would deny that the human and environmental impacts of mobility rank high in terms of risk on a global scale?

While cars, motorcycles, trucks, buses, trains, aircraft, and ships have all made tangible technical progress in terms of safety, efficiency, and emissions, it is undeniable that this incremental progress has not been enough to outrun the growth of traffic or to lower transport externalities to an acceptable level.

The world is currently off track in its ambition– stated by 196 governments in the 2015 Paris Agreement–to drastically reduce GHG emissions; and emissions from transport grow the fastest (IPCC 2018), representing the one sector that might jeopardize the success of the Paris Climate Agreement.

In most big cities, recommended WHO limits related to air pollutants and noise are often significantly exceeded, even in the most technologically advanced countries. Air pollution is estimated to kill three million people each year, and to harm many more (WHO 2018a), making it the biggest current environmental health risk. The transport sector is the biggest global contributor to particulate matter (PM) 2.5 urban air pollution (Karagulian et al. 2015), with a disproportionate contribution by the road sector.

Evidence from a few countries suggests that traffic noise has the second biggest environmental impact on health (WHO 2011). Also, the absence of physical activity for many people, because of systematically choosing motorized means of movement, is creating a very critical health situation (WHO 2018b).

Addressing the downside of a booming mobility trend will require profound changes in travelling and shipping patterns and in the technologies used. Solutions do exist. Procrastination in launching them would only add to the criticality of the situation. However, as shown in this report, embracing the necessary changes without delay will generate positive externalities–not only socially and environmentally, but also economically.

1. THE GOAL OF GREEN MOBILITY

As part of the SuM4All Global Roadmap of Action, and following the Global Mobility Report of 2017, this Green Mobility report aims to specifically address greenhouse gas emissions, air pollution, and noise from the transport sector.

Green mobility solutions cannot be implemented at any cost: solutions need to be pragmatic and balanced between the benefits provided and the economic costs of achieving them. This is especially relevant in countries that face multiple development challenges amidst severe constraints (including fiscal, institutional, economic, conflict-related, and others)

Incremental progress achieved in all transport modes has shown its limits, and the time has come for more advanced, comprehensive strategies. There is no path by which the triple win of long-term economic prosperity, social, and environmental sustainability can be achieved that does not involve significant changes to the mobility infrastructure and services that currently dominate global trends. Further, transport infrastructure is generally long-lived and develops over long periods—often centuries—so that its consequences are very difficult to alter.

Mobility is also inextricably linked to land use and the spatial configurations of cities, regions, and entire countries; mobility shapes the physical world that people live in, which in turn affects the emissions intensity of human deeds and their physical activity. Finally, mobility (or lack thereof) either constrains or enables different types of economic activity, which in turn greatly impact growth, prosperity, and the distribution of both.

Therefore, reshaping and enhancing mobility with these realities in mind can be a powerful lever for development, better shared prosperity, and sound lifestyles, while achieving the objective of environmental sustainability.

Moved by such convictions, civil society around the world is now asking for drastic improvements, implying fundamental changes in technology,[1] behavior, and lifestyles to reconcile economic, social, and environmental health. Positive initiatives were developed in the past two decades to try to respond to such emerging aspirations, but rarely at the required scale.

A few front-running cities around the world have taken proactive steps to ensure healthier lifestyles and a decrease in GHG emissions. Some companies are also striving to develop alternatives to existing mobility solutions. But the involvement of governments is now greatly needed to enable and boost transformations that market mechanisms have, so far, failed to secure.

A groundbreaking step toward such a better way forward would be the determined and rapid implementation of the Paris Agreement on Climate Change: ratified in 2016, it sets an overall long-term direction for a thorough transformation, aiming at net zero emissions in the second half of the century. The 'well-below 2 degree' and '1.5 degree' targets imply a global obligation for all economic sectors– including transport as one of the main emitters—to collectively decarbonize within the next 30–50 years.[2] To be perceived as desirable by all, and fully successful, the decarbonization process of all sectors, including transport, should also support other major transformations of more rapidly visible impact: improve air quality, help reshape access, foster health, and increase social and regional or territorial equity.

This integrated vision to transform the transport sector to achieve a range of objectives is well-aligned with the Sustainable Development Goals and the international policy frameworks for international aviation and maritime transport (such as the CORSIA agreement[3]), and other frameworks for action at the global and regional level (See Section 3).

To fulfill the aforementioned Green Mobility goal, this report suggests focusing on 3 specific sub-goals:

- **Sub-goal 1 (climate change mitigation)**, aims to "reduce GHG emissions from the whole transport sector as consistent with the worldwide objective of limiting global average temperature increase to well below 2 degrees Celsius above pre-industrial levels, and aiming for 1.5 degrees by the end of the century." Achieving this ambition requires action from each and every transport subsector, with some modes already having set their own targets, and an effort to integrate and coordinate such actions with one another to push the ambitions:
  - **Domestic transport[4] and international surface transport:** in 2015, they represented 82 percent of total GHG emissions (ITF 2017), approximately 90 percent of which comes from the road sector. By 2050, road transport emissions may rise by more than half. The Paris Climate Agreement sets out to reverse this trend. Although the Paris agreement sets neither sectoral nor quantitative targets for GHG emissions, it commits all sectors of the economy, including transport, to collectively decarbonize (net zero emissions) as soon as possible in the second half of the century.
  - **International aviation:** currently, international aviation accounts for 6 percent of transport GHG emissions,[5] and projections on passenger air traffic suggest a potential doubling to quadrupling of air transport activities, with a strong rise in total emissions by 2050. The 2010 General Assembly of the International Civil Aviation Organization (ICAO) sets the collective global aspirational goals for the sector at two per cent annual fuel efficiency improvements, and carbon neutral growth from 2020. Prior to this, the aviation industry, through the Air Transport Action Group (ATAG), set itself three climate goals, including a long-term goal to cut net CO_2 emissions from all commercial aviation by 50 percent below 2005 levels by 2050. This is not an ICAO goal.
  - **International maritime transport:** The IMO estimates that shipping carbon dioxide emissions (at 11 percent of current transport emissions) may increase by 50–250 percent by 2050,[6] unless additional action is taken to address those emissions. IMO's initial strategy on the reduction of GHG emissions from ships, adopted in April 2018, identifies levels of ambition as follows: at least 40 percent carbon intensity reduction by 2030, pursuing efforts toward 70 percent by 2050, compared to 2008. It also aims to reduce by at least 50 percent the total annual GHG emissions, compared with 2008 levels, and to pursue efforts toward phasing reductions "as soon as possible in this century." This is seen as a point on the pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals.

Recent international literature suggests that realizing the deep decarbonization required to achieve the Paris Agreement (PA) objectives implies an indicative target for emissions in the transport sector of 2–4 $GtCO_2$ emissions by 2050,[7] down from approximately 8 Gt today, and net-zero emissions[8] in the beginning of the second half of the century. This requires the peaking of emissions by the mid-2020s, or latest by 2030.

Achieving the Paris Agreement temperature goal, as agreed by all Parties, can only be doable if global emissions are reduced. Therefore, all sectors and all national emission sources should contribute to achieving the temperature goal. However, the mitigation mechanisms of the PA, particularly the Nationally Determined Contributions (NDCs) for each of its Parties, affect only domestic emissions. The emission mitigation ambitions of the Paris Agreement are complemented by the reductions achieved by other emissions sources outside the Agreement, such as international aviation and international maritime transport, through ICAO[9] and the International Maritime Organization (IMO).

- **Sub-goal 2 (air pollution)** aims to "substantially reduce premature deaths and illnesses from air pollution from local transport."[10]
  - **Domestic transport and international surface transport:** regional sectoral regulations have progressively improved emissions of ICE vehicles. But urban pollution remains high, with traffic being the highest emitting sector
  - **International aviation:** ICAO has developed measures aimed at limiting or reducing the impact of aircraft engine emissions on local air quality. Engine emissions are regulated in the

Chicago Convention, Annex 16, Environmental Protection, Volume II, including gaseous exhaust emissions from jet engines, such as nitrogen oxides (NOx) and particulate matter (PM).

- **International maritime:** IMO regulations to address air pollutants from international shipping, particularly sulphur oxide (SOx) and nitrogen oxide (NOx), are included in MARPOL Annex VI. There is a global limit on sulphur content in fuel oil, currently 3.5 percent (m/m) which will be lowered in January 2020 to 0.5 percent, while in IMO designated Emission Control Areas the limit is 0.1 percent[11] (See Annex II for further information).

Broadly, we suggest that by 2020, each country and each large and medium-sized city will have developed clean air plans with the objective of reaching **50 percent reduction of premature deaths from transport-related local emissions by 2030, compared with 2010 levels.**

- **Sub-goal 3 (noise)** aims to "substantially reduce global human mortality and burden of disease from local transport-related noise levels."
  - **International aviation:** ICAO has set out to control aircraft noise since the 1970s by setting noise limits for aircraft in the form of ICAO SARPs, contained in Annex 16 on Environmental Protection, Volume I. As a result, it is expected that more than one million people could be removed from "Day Night average sound Level (DNL) of 55 dB affected areas" between 2020 and 2036.

In addition to international aviation efforts, we suggest that by 2020, each country and city has developed traffic noise reduction plans and raised awareness by the population of the health benefits from noise abatement, with the objective that **the number of urban dwellers exposed to excessive noise levels be reduced by 50 percent by 2030 compared to 2015 levels.**

When considering such objectives, road transport environmental and health impacts are by far the greatest within today's transport sector, and therefore require focused attention and specific efforts. But the real transformation of mobility will only come from smartly orchestrated progress through all sectors, decisively going beyond the commitments made so far, and promoting solutions that maximize synergies.

To address the environmental impacts of transport, in this paper, we use the Avoid-Shift-Improve approach (Dalkmann & Brannigan 2007). This policy framework for environmentally sustainable transport emphasizes the need to: (i) avoid the necessity of travel if possible, or shorten trips—for example through land-use planning, pricing, and telecommuting; (ii) shift to more sustainable modes of transport such as cycling, public transport, or rail freight (as long as a comprehensive analysis of options for providing a proper lifecycle and a land use impact assessment are carried out); and (iii) improve the sustainability of transport modes by increasing energy efficiency, reducing air pollution and noise, and reducing the carbon-intensity of the fuels used.

Governments which, in many countries, have large stakes in energy supply, vehicle industry, infrastructure, and mass transit, are invited to make courageous and coherent decisions, throughout the entire scope of their responsibilities, to accelerate toward pollution-free, resilient mobility ecosystems. They are also invited to consider that domestic transport might become the proving ground for innovative low- or zero-carbon technologies before they break through in international transport.

Also, governments and city administrations should carefully review and ambitiously improve their institutional frameworks for mobility planning and implementation.

Decision makers must bear in mind that the achievement of the Green Mobility goals and targets will require ensuring that envisaged solutions will not contradict, locally and globally, other environmental objectives such as clean water and soil, biodiversity, and habitat conservation;[12] systematic life-cycle analyses are thus required.

The success of such an endeavor does not only depend on actions proposed in this paper, as actions from the other GRA policy papers are also needed. Table 1.1 below gives an overview of how the three Green Mobility Objectives covered in this paper depend also on successful implementation of Access, Efficiency, Safety, and Gender action plans. For example, air pollution

management critically depends on an efficient urban public transport system, covered by the Urban Access paper.

In addition, Green Mobility actions contribute to other Sustainable Mobility objectives (see Chapter 4 and the Global Roadmap of Action report)

Table 1.1: Indicative relevance of actions towards other GRA goals for Green Mobility Targets

	Efficiency	Urban Access	Rural Access	Safety	Gender
Climate change mitigation					
Air pollution					
Noise					

Note: Darker shaded cells indicate higher relevance of the actions proposed in the respective papers to the green mobility goals.

ENDNOTES

1 Current technological innovations in autonomous vehicles, new power trains, shared mobility and digital tools can change mobility systems radically

2 The original Paris Agreement text states the need to "achieve a balance between anthropogenic emissions by sources and removal by sinks of greenhouse gases in the second half of this century" in order to achieve the well-below 2 degrees temperature goal. Aiming for 1.5°C corresponds to a much shorter timeframe, namely within the next 30 to 50 years (see IPCC, 2018).

3 Carbon Offsetting and Reduction Scheme for International Aviation: https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx. See Annex I for more information

4 This includes road, rail, inland waterways, coastal shipping and domestic aviation

5 International aviation contributes 1.3% of anthropogenic CO2 emissions (ICAO 2018), which corresponds to 6% of emissions from the transport sector (approximately 0.5Gt out of a total of 8Gt for the transport sector)

6 Third IMO GHG Study 2014, International Maritime Organization

7 The broad consensus in the climate change mitigation literature is that for a 1.5 degree scenario, there should be 'carbon-neutrality' around 2050 or shortly after as confirmed by the 2018 IPCC report. Noting that allocating emission budgets to sectors is ultimately a subjective exercise, Gota et al. (2019) use the following approach for arriving at a transport sector target. Residual emissions for all sectors is estimated to be 10 Gt in 2050 (which need to be compensated by negative emissions technologies), based on a set of modeling studies. The transport sector is assumed to have a 22% share in emissions in 2050 versus 14% today (based on existing climate modeling), therefore transport emission should be approximately 2 Gt in 2050 for a 1.5 degrees scenario. In the Beyond 2 Degree Scenario of the IEA (2017a), transport emissions are 3 Gt. For a 2-degree scenario there is more flexibility, but carbon neutrality should be achieved between 2060 and 2080. For transport 6 Gt is suggested for a 2 degree scenario in the IPCC (2014) Fifth Assessment Report, however this assumes much stronger reductions in other sectors such as energy.

8 This can be achieved by offsetting residual emissions through negative emissions technologies such as bio-energy with CO2 capture and storage (BECCS), afforestation and reforestation, biochar, enhanced rock weathering, direct air capture, ocean fertilization, and soil carbon sequestration (Fuss et al., 2018)

9 ICAO data and trends on international aviation and CO2 emissions, Local Air Quality and Noise are contained in Figure 9/ Annex I

10 Transport is a key contributor to urban air pollution, but its share varies strongly across cities and data are often not available. In addition, the difference between on-road and test cycle emissions (both air pollution and GHG) should be considered. Black carbon reduction contributes significant to climate change objectives as well (ICCT, 2018).

11 http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx

12 See, for example, this European assessment: https://www.eea.europa.eu/data-and-maps/indicators/mobility-and-urbanisation-pressure-on-ecosystems/assessment

2. THE STATE OF PLAY

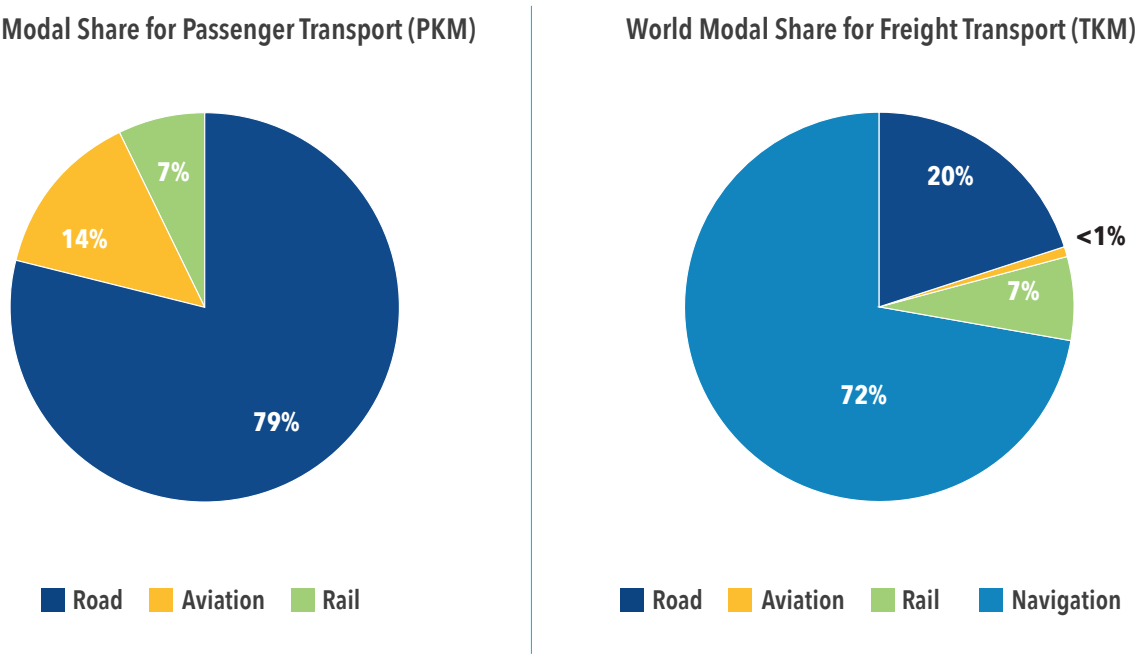
Road transport represents the largest modal share of the world's passenger transport at 79 percent of the demand, followed by aviation at 14 percent and rail at 7 percent. Maritime transport represents a tiny share of passenger transport. However, maritime transport moves 72 percent of the world's freight, with roads carrying 20 percent and rail moving 7 percent (Figure 2.1).

Using indicators and country data from the GMR and other international sources, this chapter (i) pinpoints critical issues regarding the three Green Mobility objectives, and (ii) visually shows the wide disparity in performance across countries of the world, especially for GHG emissions and air pollution.

2.1. GHG emissions and climate change mitigation

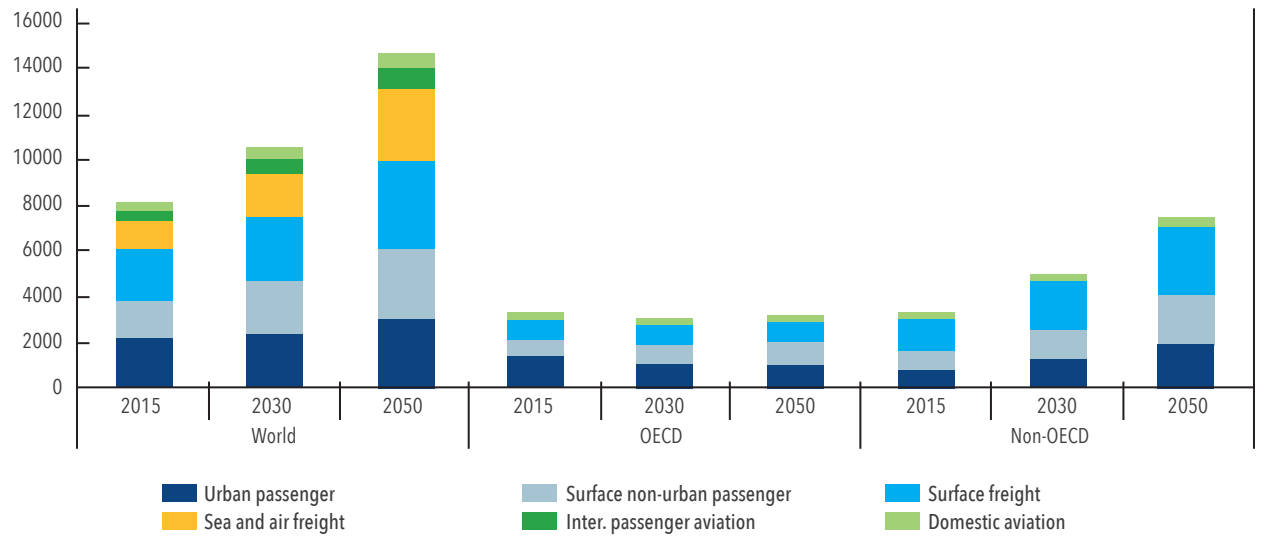
Transport emissions were 23 percent of global energy-related CO_2 emissions in 2015 (ITF 2017). They continue rising, especially in rapidly motorizing countries and in the freight sector (Figure 2.2).

Figure 2.1: World Transport Modal Share for Passengers and Freight, 2015



Source: Data from IEA/UIC Railway Handbook 2017.

Figure 2.2: Transport CO_2 Emissions and Emission Projections by Sub-Sector in a Baseline Scenario in Millions of Tons



Source: ITF 2017.

Note: (a) Emissions from international modes are not divided between OECDand non-OECD countries; (b) In 2015, the share of world CO_2 emissions from fuel combustion by sector is the following: 72.6 percent for roads, 4.2 percent for rail transport, 10.9 percent for aviation, 10.2 percent for navigation, and 2.1 percent for other transport. This includes indirect emissions from electricity consumption (IEA/UIC, Railway Handbook 2017).

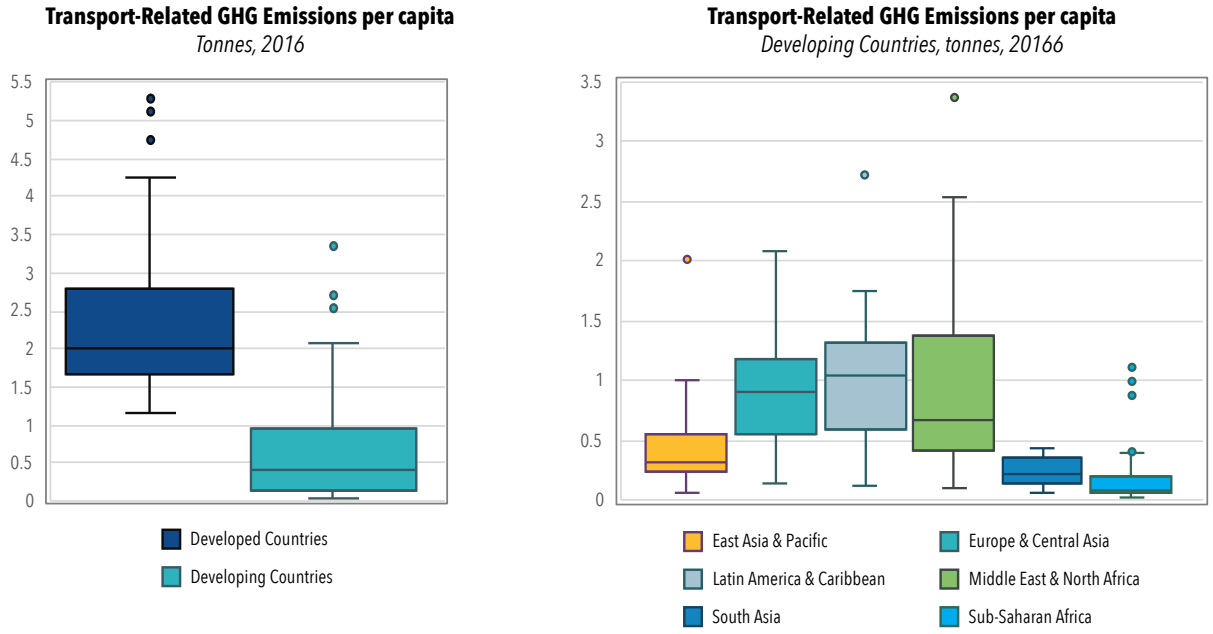
Total demand for transport in OECD countries is today comparable to non-OECD demand, yet per capita demand in the latter is much lower, even if rising rapidly. Accordingly, there is a wide disparity in per capita GHG emissions.

Figure 2.3 shows the distribution of transport related GHG emissions per capita in developed and developing countries, and in six regions of the world for developing countries only. The line in the box shows the median of the variable. The width of the box on either side of the median shows the "spread" of one quartile of the observations. The "Whiskers" show where the more spread out observations lie (two quartiles). Individual dots show observations which are outlying extreme values beyond the quartiles. For example, the median for Latin America and Caribbean is about 1.1 tonnes. The values within one quartile range from about 0.6 to 1.3 tonnes (the Box) and the broader values range from about 0.2 to 1.8 tonnes (the Whiskers). There exists an outlying extreme value at about 2.7 tonnes.

Developed countries were found to have a higher median transport-related GHG emissions per capita than developing countries. There were also clear differences between regions in the median and in the variability (spread) of the data among countries within a region. Ranked by median, the regions, from lowest to highest, would be: Sub-Saharan Africa, South Asia, East Asia & Pacific, Middle East & North Africa, Europe & Central Asia and Latin America & Caribbean.

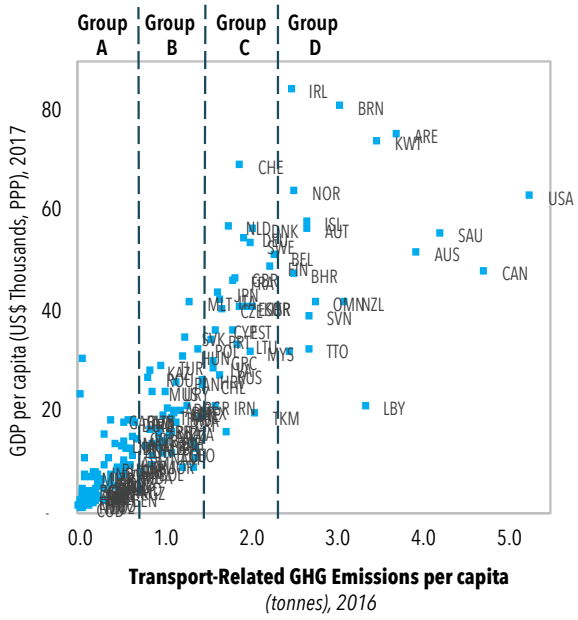
In Figure 2.4, data on transport-related GHG emissions per capita is plotted against GDP per capita and used to compare countries. The countries are assigned to four groups (A to D) based on the distance to the green mobility target for GHG emissions: 0 – 0.75t, 0.75 – 1.5t, 1.5 – 2.25t, and above 2.25t, Many countries in Group A currently have emission levels below 0.5 tons per capita, which could be compatible with a below 2-degrees scenario, however the emissions are rising rapidly. In Group D, Group C, and Group B, emission levels are far above those required, however the emission trends are often stable or slowly decreas-

Figure 2.3: Transport-related GHG emissions per capita (tonnes) by region



Source: IEA raw data analyzed by the World Bank

Figure 2.4: Scatterplot of Transport-related GHG emissions per capita (tonnes) vis-à-vis GDP per capita by country



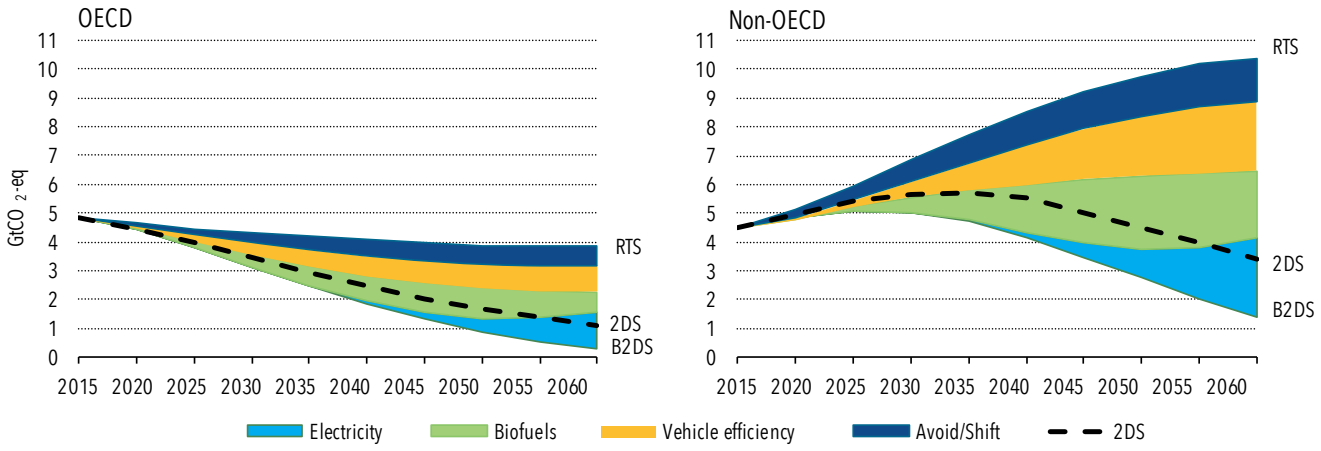
Source: IEA raw data analyzed by the World Bank

ing. This implies that ambitious mitigation action is required to be in line with the Paris Agreement targets.

Deep de-carbonization scenarios in line with the well-below-2-degree and 1.5-degree targets have been developed for the transport sector, showing that with strong action, total emissions can be limited to 2.5–3 Gt CO_2-eq in 2050 (IEA 2017a; Gota et al. 2019). This would correspond to approximately 0.3 tons per capita on average.

This is consistent with the International Energy Agency's (IEA's) Beyond-2-Degree scenario (B2DS), which reaches this level of emissions in 2055 (Figure 2.5). In order to achieve such B2DS scenario in line with the Paris Agreement, strong action is required, and includes avoiding "unnecessary" transport, shifting toward more environmentally friendly modes, and improving the general efficiency of the sector, as per the ASI framework.

Figure 2.5: Transport Sector WTW GHG Emissions in OECD and Non-OECD Countries by Scenario, 2015–2060..



Source: Below- 2- Degrees Scenario (2DS), IEA 2017a

Note: The figure shows the relative contributions of Avoid/Shift/Improve to reach a deep decarbonization scenario.

2.2. Adaptation to climate change: A critical issue

Climate change poses major threats to infrastructure investments and services by increasing disaster risks, both in terms of gravity and frequency. This includes aggravated risks of flooding, storms, and heat waves, which may impact roads, rail infrastructure, ports, and airports. It is also responsible for triggering longer-term changes, such as average temperature increase, sea level rise, changing precipitation patterns, permafrost melting, or desertification.[13]

Considering its typically long lifespan, transport infrastructure is particularly likely to be impacted in the long term: although current climate changes can be withstood, it might not be the case for more intense future weather conditions—hence leading to considerable disruptions and losses in terms of both finance and productive time. Also, weather-related damage to transport infrastructure can have strong safety implications, such as the increase in vehicle crashes from roads in worse condition.[14] Finally, transport disruptions as a result of climate change can have an important impact on economic activity of a region, area, or country, since trade and production are highly dependent on transportation to generate revenues. On the other hand, reliable access to transport can help alleviate the impact of extreme weather events, especially when it comes to disaster recovery, making resilient transport a valuable asset in adapting to climate change.[15]

The case in favor of more resilient transport is thus very clear, as it would enable accessibility and the movement of people and goods in spite of climate-triggered shocks and disruptions. However, this will only be made possible through major adaptation strategies on international, regional, and local levels. At present, a few operational stakeholders and governments have taken initial steps toward more resilient infrastructure, such as in Japan's first National Adaptation Plan,[16] or in aviation, with a number of airports encouraged by the Airports Council International (ACI).[17] However, such developments remain rare. On a larger scale, even if some international organizations, such as the Navigating a Changing Climate Action Plan (World Association for Waterborne Transport Infrastructure), are currently active in the field of climate-resilient transport, only a limited number of countries are developing full-fledged national adaptation plans. Consequently, adaptation efforts today are too weak, and should be strengthened and broadened, in combination with mitigation measures.

2.3. Health and transport-related impacts

2.3.1. Air pollution

Air pollution is a key environmental issue, with substantial health impacts globally. As shown by the World Health Organization (2018): "In 2016, 91 percent of the world population was living in places where the WHO air quality guidelines levels were not met. Ambient (outdoor) air pollution in both cities and rural areas was estimated to cause 4.2 million premature deaths worldwide in 2016."

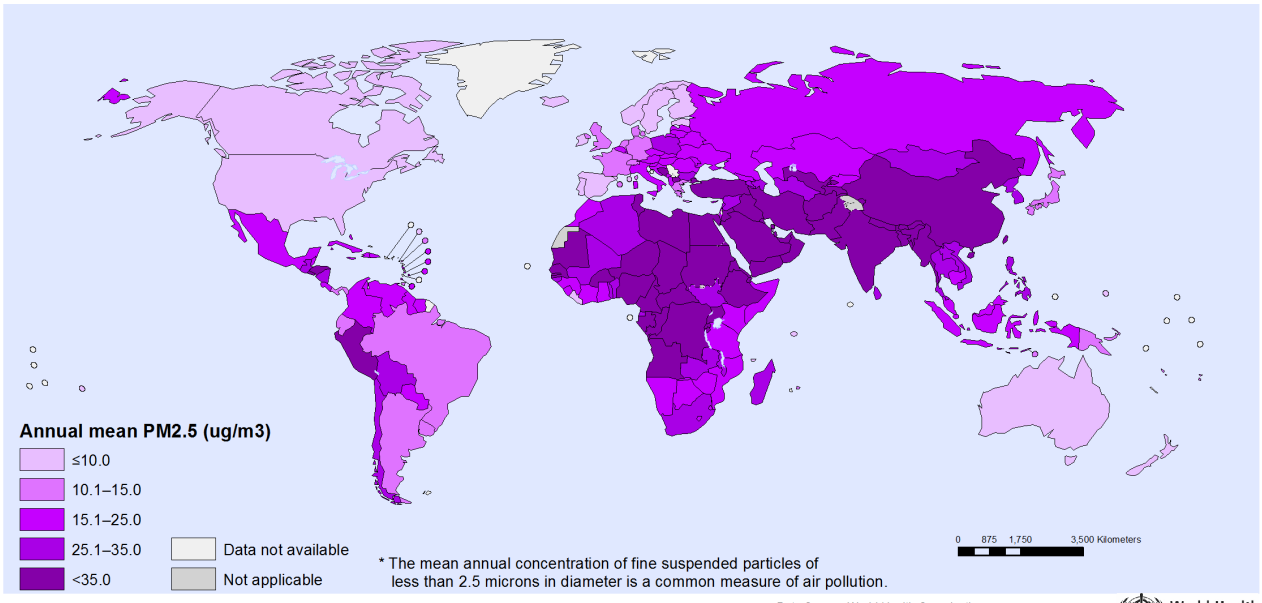
Figure 2.6 shows latest global air pollution data (from all sources). Most larger cities are experiencing substantial to severe air pollution. Although there is not a single reason that can explain the difference in air pollution levels, stringency of policies addressing various sources is key.

Transport is the largest contributing sector to urban PM2.5, with 25 percent on average, however this varies from roughly 10 to 40 percent for different world regions (Karagulian et al. 2015). The economic cost of air pollution from road transport in OECD countries is estimated at close to US$ 1 trillion per year, measured in terms of the value of lives lost and ill health (OECD 2014 in ITF 2017).

Key air pollutants include sulfur oxides (SOx), which are linked to non-desulfurized fuels, as well as Nitrogen oxides (NOx) and Particulate Matter (PM) generated by diesel engines[18]. Pollution-induced ozone is also a critical issue. Harbors are particularly exposed to SOx and black carbon.

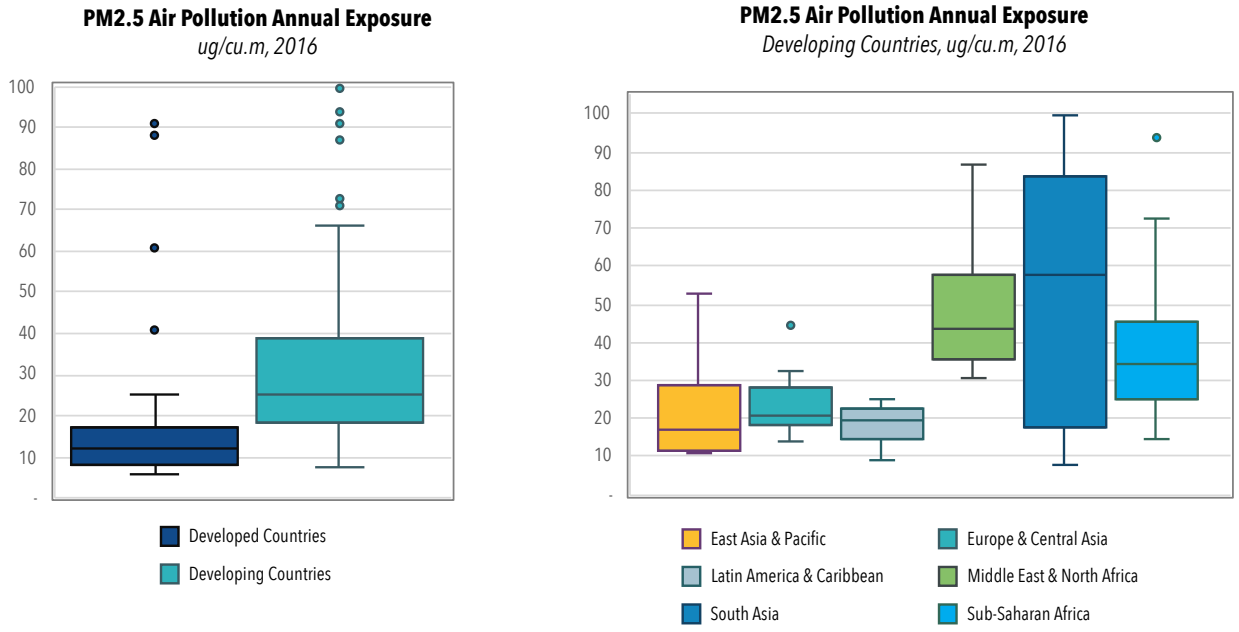
Figure 2.7 shows the distribution of PM 2.5 air pollution annual exposure in developed and developing countries, and in six regions of the world for developing countries only. The line in the box shows the median of the variable. The width of the box on either side of the median shows the "spread" of one quartile of the observations. The "Whiskers" show where the more spread out observations lie (two quartiles).

Figure 2.6: Annual Mean Concentrations of PM2.5 in Urban Areas, 2014



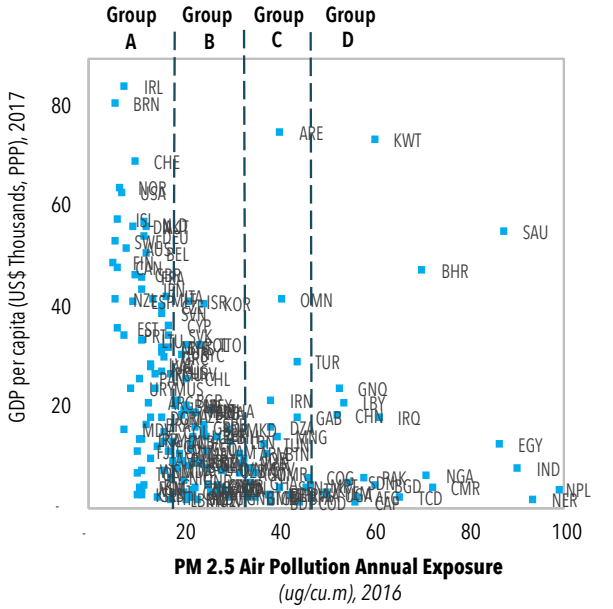
Source: WHO.

Figure 2.7: PM 2.5 Air Pollution Annual Exposure by region



Source: Global Burden of Disease 2016 raw data analyzed by the World Bank

Figure 2.8: Scatterplot of PM 2.5 Air Pollution[19] Annual Exposure vis-à-vis GDP per capita by country



Source: Global Burden of Disease Study raw data analyzed by the World Bank.

Individual dots show observations which are outlying extreme values beyond the quartiles. For example, the median for South Asia is about 58 ug/cu.m. The values within one quartile range from about 18 to 84 ug/cu.m (the Box) and the broader values range from about 8 to 100 ug/cu.m (the Whiskers).

Developed countries were found to have a lower median of PM 2.5 Air Pollution Annual Exposure than developing countries. There were also clear differences between regions in the median and in the variability (spread) of the data among countries within a region. Ranked by median, the regions, from lowest to highest, would be: East Asia & Pacific, Latin America & Caribbean, Europe & Central Asia, Sub-Saharan Africa, Middle East & North Africa and South Asia.

In Figure 2.8, data on PM 2.5 air pollution annual exposure is plotted against GDP per capita and used to compare countries. There was found to be a weak negative correlation between the variables, implying that air pollution might be a bigger burden on developing countries.

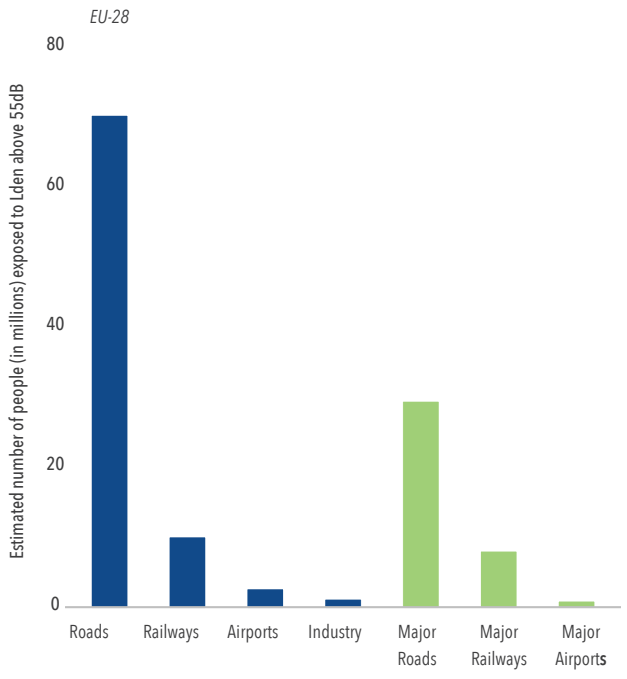
2.3.2. Noise pollution

Noise has been linked to serious health risks, including an increased likelihood of hypertension and heart disease, a deteriorated quality of life from increased stress levels, sleep disturbances, and interference with cognitive development and performance.[20] Nonetheless, despite being a global and serious problem, noise suffers from a lack of precise data in various regions, with the most accurate measurements found in studies focusing on the EU. For instance, the estimated health impact of Noise amounts to 1–2 million DALYs lost annually in this region.[21]

As far as transport is concerned, road traffic (including honking) is the key source of noise for a majority of people, even if rail and air can also be substantial sources locally.

Trucks and conventionally fueled motorized two- and three-wheelers are particularly harmful. Indeed, about 65 percent of the urban EU population is exposed to 55dB+, although this figure varies widely from country to country. Approximately 90 percent of the impact is from lorries and cars (Figure 2.9).

Figure 2.9: Estimated number of people in the EU exposed to high daily average noise levels, 2012



Source: EEA 2017.

For cars, the tire to road contact noise is the dominant source of noise pollution beginning at about 35 kph, while it is the case for trucks from 55 kph;[22] below these speeds, engine is the main source of nuisance. Driver behavior is also likely to impact the experienced noise levels, as noise increase with stop-and-go driving including sudden driving and accelerating, high driving speed, and the excessive use of horns.

Railways are a distant second most important source of environmental noise in Europe, with nearly 7 million people exposed to levels above 55 dB Lden (day-evening-night level) in 2012, considering people exposed both inside and outside urban areas.[23]

Additional factors contributing to noise impacts include the maintenance levels of both the vehicles and the road surfaces or rail tracks, and the closeness of the transport infrastructure to the receptors, including its vertical alignment.[24]

2.3.3. Active mobility and healthy lifestyles

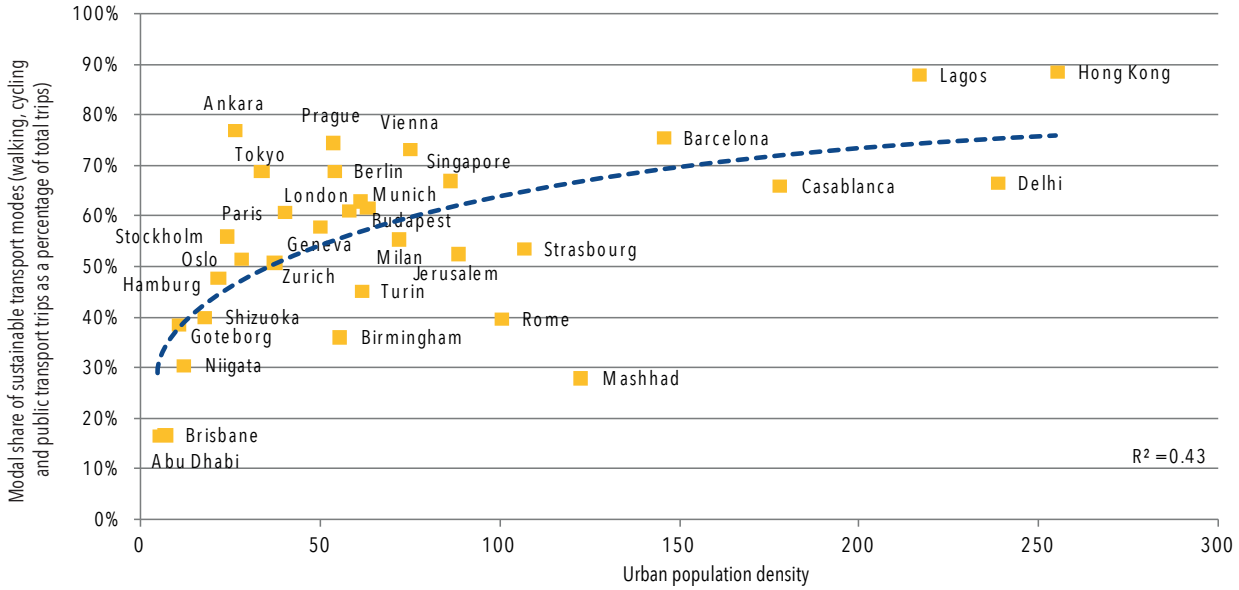
Although not specifically a target under green mobility or other SUM4All themes, the contribution of the transport sector to active and healthy lifestyles is an important aspect, implicitly considered in the GRA.

According to the most recent available data from 2010, 23 percent of adults and 81 percent of adolescents aged 11–17 years do not meet the WHO Global Recommendations on Physical Activity for Health (WHO, 2018b). Sedentary lifestyles resulting in health impacts including obesity are affecting 500 million people and are causing 3.2 million deaths (WHO in GMR).

A lack of active mobility is one of the key reasons for this.[25] Walking and cycling in safe conditions are the best ways for all generations to move around and keep good health. However, while some cities provide good infrastructure for walkers, in many cities, infrastructure conditions are such that walking is neither safe nor convenient. And for cycling, good infrastructure is the exception.

Therefore a balance has to be struck between high density habitat and "green" space allowing for walk-

Figure 2.10: Urban Density in Metropolitan Areas and Trip Modal Share of Active and Public Transport in 2012



Source: UITP: http://www.uitp.org/sites/default/files/MCD_2015_synthesis_web_0.pdf

ing and cycling. As Figure 2.10 shows, urban density generally promotes use of active modes and public transport.

This figure shows a broader point for Green Mobility: in addition to being essential in providing universal urban and rural access, public transport supports the objectives related to GHG emissions, air quality, noise, and active mobility (in the first- and last mile walking or cycling), unless provided by low-quality diesel buses or three-wheelers[26] with low occupancy rates. A high public transport modal share can be due to high quality, convenient, reliable, and frequent service (such as in Hong Kong), providing an alternative to motorized private transport; or despite low-quality (for example, in Lagos, with 'captive' users). In the latter case, keeping the current 'sustainable' modal share is key, while providing a choice of mobility options.

Taking these points into consideration, urban mobility redesign must respond to three aspirations:

- More active mobility
- More reliable, attractive, affordable mass transit
- Development of cyclable and walkable cities including access to key services through urban planning.

2.4. The case of international aviation and maritime transport–environmental trends assessment

The ICAO's Committee on Aviation Environmental Protection (CAEP) develops and regularly updates the present and future global environmental trends for international aviation, including: noise; emissions that affect local air quality (such as NOx, PM); and GHG emissions that affect the global climate. This CAEP assessment represents the basis for any decision making on matters related to international aviation and the environment at ICAO bodies.[27]

Regarding aviation noise, under an advanced aircraft technology and moderate operational improvement scenario, from 2030, aircraft noise exposure may no longer increase with an increase in traffic.

Figure 2.11 describes the ICAO CAEP CO_2 trends assessment, which reflects the contribution of the basket of mitigation measures to the reduction of in-

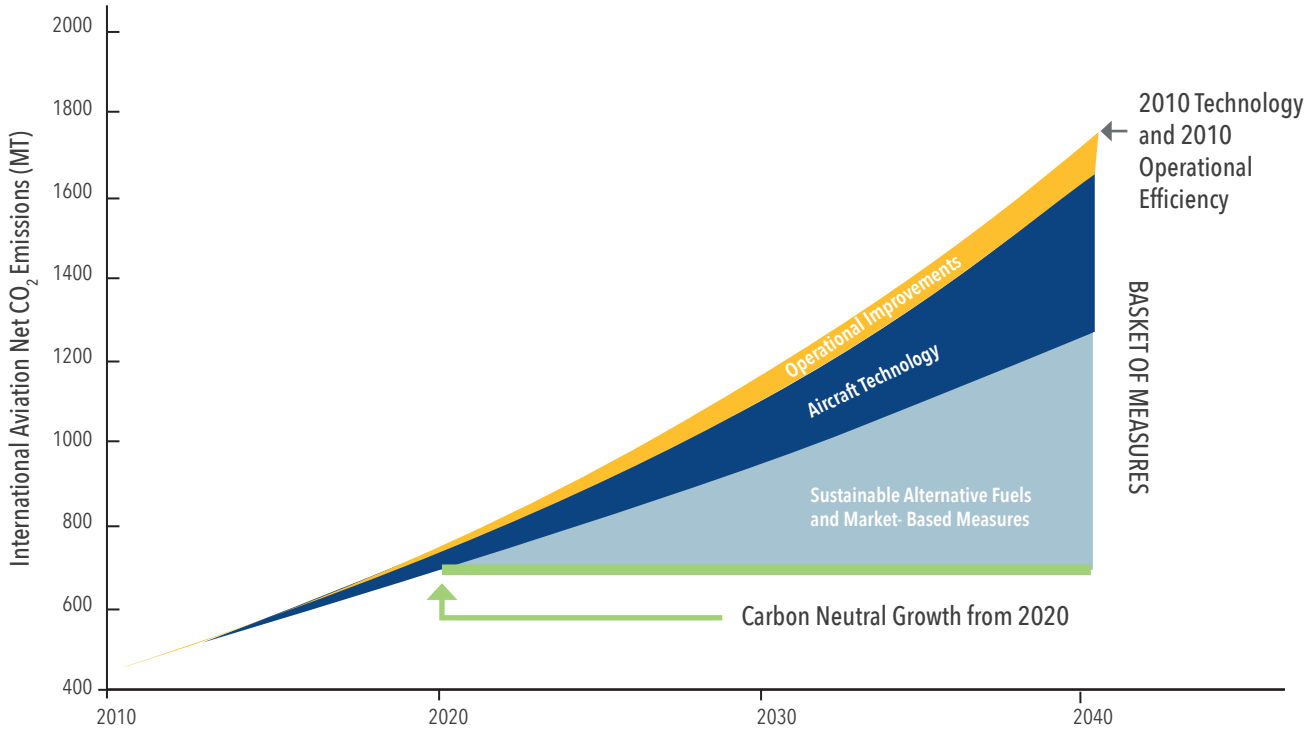
ternational aviation CO_2 emissions—including aircraft technology, operational improvements, and sustainable aviation fuels. International aviation emitted approximately 450 million tons (Mt) of CO_2 in 2010. By 2040, it is estimated that, despite an anticipated increase of 4.2 times in international air traffic, net CO_2 emissions are projected to increase by 2.8 to 3.9 times over the same period.

Emissions that affect local air quality, such as NOx or PM, are expected to increase through 2050, but at a rate slower than aviation demand: NOx emissions are estimated to increase from 0.15 million tons in 2010 to between 0.32 Mt and 0.42 Mt in 2040. PM emissions are expected to follow a similar trend, increasing from 0.9 kilotons (kt) in 2010 to about 3 kt in 2040.[28]

Concerning international maritime transport, the International Council on Clean Transportation estimates that carbon dioxide emissions from shipping currently represent around 2.6 percent of total energy-related CO_2 emissions and 11 percent of current transport CO_2 emissions, with an estimated 812 $MtCO_2$ produced in 2015 by international shipping.[29] Also, black carbon is estimated to be one of the principal contributors to the climate impact from shipping.[30] However, it is largely ignored as a climate pollutant, in spite of its short lifespan—which would result in quick improvements if addressed. Overall shipping emissions are expected to increase by 50 percent to 250 percent by 2050[31] if no mitigation actions are taken.

International shipping emissions that affect local air quality, including NOx and SOx, currently represent approximately 13 percent and 12 percent of global NOx and SOx totals respectively. Both are expected to increase, but at a much lower rate than CO_2 emissions because of the implementation of stricter regulations (MARPOL Annex VI).[32]

Figure 2.11: International Aviation CO_2 Emissions: Baseline Scenario and Contribution of Measures for Reducing Emissions



Source: ICAO.

ENDNOTES

13 World Bank (2015) Moving toward a Climate-Resilient Transport

14 World Bank (2015) Moving toward a Climate-Resilient Transport

15 PPMC Adaptation Declaration at COP22 (2016)

16 Japanese Government (2018) Climate Change Adaptation Act

17 ACI Resolution on Resilience and Adaptation to Climate Change (2018) https://aci.aero/news/2018/10/03/new-aci-policy-brief-stresses-importance-of-airport-resilience-and-encourages-airports-to-develop-climate-change-adaptation-plans/

18 The transport sector emits 53% of total NOx emissions and 11% of PM (IEA/UIC, 2019)

19 This is defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM2.5 (from all sources) by population in both urban and rural areas. WHO guidelines recommend 10 ug/m^2

20 GIZ and BMZ (2011) Noise and its Abatement. Sustainable Transport: A Sourcebook for Policy Makers in Developing Cities;

21 European Commission. (January 2015) Noise impacts on health. Sciences for Environment Policy (http://ec.europa.eu/environment/integration/research/newsalert/pdf/47si.pdf)

22 Eurocities (May 2015) Low noise road surfaces (https://workinggroupnoise.files.wordpress.com/2013/03/leaflet layout_v2_simplecover_final.pdf)

23 EEA (2014) Noise in Europe

24 Tracks or roads that are aligned vertically with the receptors result in higher noise related disruptions, as noise is then transmitted more easily. Consequently, building road or rail infrastructure slightly below ground level or elevated on a platform can help decrease noise levels.

25 It should be noted however, that lack of physical activity is due to a complex set of factors, including gender and social position differences (WHO, 2018)

26 Reducing and / or eliminating lower-performance diesel buses/three-wheelers is an important part of further enhancing the benefits of public transport. Wherever possible, this objective should be pursued in tandem with enhancements to the service quality of public transport in order to increase demand and provide safety, comfort, and equitable access to opportunity for public transport customers.

27 ICAO Present And Future Aircraft Noise And Emissions Trends, A39-WP/55: https://www.icao.int/Meetings/a39/Documents/WP/wp_055_en.pdf

28 ICAO Environmental Report (2016)

29 ICCT (2017) GHG emissions from global shipping, 2013–2015

30 ICCT (2017) GHG emissions from global shipping, 2013–2015

31 Third IMO GHG Study 2014

32 Third IMO GHG Study 2014

3. INTERNATIONAL INSTRUMENTS AND AGREEMENTS

To address the green mobility goals of mitigation, adaptation, air and noise pollution, and health, governments and non-state stakeholders have been working on the green mobility agenda since 2015, by adopting legally binding agreements or becoming involved in conventions and non-legally-binding initiatives, statements, and other commitments (WB/UNECE 2018[33]). These constitute an initial framework for action and are also an invitation to governments and stakeholders to undertake stronger efforts.

3.1. Global agreements: Paris Agreement, Sustainable Development Goals

The key elements for action contained in the Paris Agreement on Climate Change include mechanisms to support developing countries in implementing mitigation actions (Article 6[34]), and Nationally Determined Contributions (NDCs). NDCs are the climate action plans of each Party to the United Nations Framework Convention on Climate Change (UNFCCC), including both mitigation and adaptation: they are updated every 5 years with increasing ambition. Most of the current NDCs mention passenger transport as a sector expected to contribute to mitigation and focus on urban mobility. However, NDCs need to be more ambitious in order to meet the Paris Agreement objective, and freight and adaptation should be much more prominently featured.

Another global instrument is the UN 2030 Agenda for Sustainable Development, agreed upon in September 2015, which implies an ambitious rolling out of climate-resilient transport infrastructure and services. Sustainable mobility is essential to achieve 6 of the 17 Sustainable Development Goals (SDGs), including SDG 3 (health), 7 (energy), 9 (industry and infrastructure), 11 (sustainable cities), 12 (responsible consumption and production), 13 (climate action) and 14 (life below water).[35] To be more specific, green mobility is particularly relevant to the following SDG indicators:

- 7.2.1 Renewable energy share in the total final energy consumption
- 7.3.1 Energy intensity measured in terms of primary energy and GDP
- 11.6.2 Annual mean levels of fine particulate matter (for example, PM2.5 and PM10) in cities (population-weighted)
- 12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels.

3.2. Global sectoral instruments: International aviation, maritime transport and railways

Emissions from international aviation are addressed separately by ICAO and its Member States.[36] For example, following the ICAO Assembly's agreement in 2010, Member States have been voluntarily developing and submitting their State Action Plans to reduce international aviation CO_2 emissions, which are a planning and reporting tool for States to communicate information on their selected measures to reduce aviation CO_2 emissions.

To date, 107 Member States submitted and have been updating their action plans, which enable ICAO to compile progress toward meeting the global aspirational goals set by the Assembly. In the spirit of cooperation between the two international treaties, ICAO regularly provides information to the UNFCCC process on the ICAO's developments related to international aviation and climate change.[37] See Annex I for further details on the global instruments and activities under ICAO related to international aviation.

In international shipping, the International Maritime Organization (IMO) adopted in April 2018 its initial strategy on reduction of GHG emissions from ships. It identifies levels of ambition as follows: at least 40 percent carbon intensity reduction by 2030, pursuing efforts toward 70 percent by 2050, compared with 2008; and at least 50 percent total annual GHG reduction by 2050, compared with 2008 levels, while pursuing efforts toward phasing them out in line with an overall vision to phase out GHG emissions "as soon as possible in this century."[38] In 2011, IMO had already adopted a mandatory regime aimed at improving the energy efficiency of new ships (Energy Efficiency Design Index–EEDI) and existing ships (Ship Energy Efficiency Management Plan–SEEMP). In 2013, IMO also adopted regulations for data collection and reporting on fuel oil consumption to analyze ships' energy efficiency. From January 2019, "ships of 5,000 gross tonnage and above are required to collect consumption data for each type of fuel oil they use, as well as other, additional, specified data including proxies for transport work."[39] Finally, a set of short-, mid-, and long-term candidate measures is identified under IMO's initial GHG reduction strategy. With regard to mid-term measures, new or innovative emission-reduction mechanisms– possibly including market-based measures to incentivize GHG emissions reduction–have been identified. The initial IMO strategy lays the foundation for future work at IMO on the reduction of GHG emissions from ships. Regarding other air pollutants, the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI is the relevant instrument, regulating ozone depleting substances, sulphur content of bunker fuels, NOx emissions from marine diesel engines, shipboard incineration, and the energy efficiency of ships.

As far as mitigation of emissions from domestic aviation and maritime transport are concerned, they are considered under the UNFCCC and are included in the Paris Agreement. Consequently, parties have the possibility of addressing these emissions in their NDCs, as part of their actions aiming at reducing GHG emissions from domestic sources. The aviation industry-led climate goal of reducing net CO_2 emissions by 50 percent by 2050 is for both international and domestic aviation emissions, and the industry encourages actions to reduce emissions across its operations.

The International Union of Railways (UIC) adopted the Low Carbon Rail Transport Challenge – Action Plan in 2014, at the UN Climate Summit. This non-binding action plan calls for a change in the "business as usual" pattern, and highlights the need for a more sustainable direction, shifting activity away from high-carbon modes through medium-to-long-term investments in rail and public transport. The challenge includes three sets of voluntary targets: to improve rail efficiency; to decarbonize electricity supply; and to achieve a more sustainable balance of transport modes. Signatories commit to a reduction in specific average CO_2 emissions per traffic unit from train operations of 50 percent by 2030 and 75 percent by 2050 (all relative to a 1990 baseline). In 2015, UIC also launched the Modal Shift Challenge calling for investments that encourage a shifting toward rail transport and away from more carbon-intensive transport options. The goal of this action is to achieve a 50 percent increase in the share of rail in passenger transport (in passenger-km) by 2030 compared to 2010, followed by a 100 percent increase by 2050. For land-based freight transport, the target is to achieve the same level of rail activity (in ton-km) as the road transport sector by 2030, achieving a share that is 50 percent greater than 2010 levels by 2050. One key component of the Modal Shift Challenge is the Railway Climate Responsibility Pledge (signed by more than 60 UIC members, representing the majority of global rail activity), which sets out industry actions to complement the targets set for railways worldwide (see Annex III)

3.3. Regional intergovernmental policies

On a regional level, the European Commission has issued a series of proposals about greener mobility: the "Mobility Package" is a collection of three rounds of initiatives concerning the governance of road transport in the European Union. The first wave in June 2017 (8 proposals) was complemented by the second draft in November 2017 and the third in May 2018. These proposals will further drive innovation; improve competitiveness; reduce CO_2 emissions; improve air quality and public health; and increase the safety of transport. The Commission also intends to promote seamless mobility solutions so that citizens and businesses can travel easily across Europe. Member states can now utilize these proposals to harmonize and sim-

plify their rules in terms of national mobility (for example, connected mobility - 'Europe on the Move' of May and November 2017; CO_2 standards for Heavy Duty Vehicles – the VECTO tool; infrastructure safety management and others).

The 2016–2025 ASEAN[40] Strategic Transport Action Plan[41] is noteworthy as well, as it sets out specific goals with the intention of boosting multimodal connectivity within the region. Land Transport Projects include large investments in infrastructure, and are expected to promote land transport in terms of safety and smart-connected transport services. Also, the Sustainable Transport chapter of the plan addresses green mobility topics such as fuel economy, green freight, and logistics, non-motorized transport, and sustainable transport indicators.

3.4. Other international initiatives

Regarding vehicle emission standards, the United Nations Economic and Social Commission for Europe (UNECE) administers a legally binding international agreement concerning the adoption, by 52 contracting parties, of Uniform Technical Prescriptions for Wheeled Vehicles,[42] that includes performance requirements for reduction of air pollution and pollutant emissions, fuel and energy consumption determination, CO_2 and GHG emission regulations, noise emission reduction, and recyclability of vehicles produced. UNECE also administers the European Agreement Concerning the International Carriage of Dangerous Goods by Road, adopted in 1957 and open to global accession (currently by 50 parties): it provides a labelling emergency framework in case of accidents or incidents that is essential for limiting negative environmental impact. The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways also addresses the same topic for goods carried through inland waterways. Also, the development of the Worldwide Harmonized Light Vehicle Test Procedure (WLTP) supports harmonization measures of pollutant and CO_2 emissions as well as fuel consumption values.

The Green Mobility goal is also reflected in other international non-binding instruments and commitments, which may address other global goals of sustainable mobility at the same time, such as universal access and efficiency. Thus, in the New Urban Agenda adopted in 2016, and which supports the SDGs, sustainable transport and mobility play a key role. The Agenda calls for the establishment of urban transport infrastructure funds at the national level, the development of national urban mobility plans, and the promotion of walking and cycling, public transport, and of new technology that enables shared mobility. Similarly, the 2016 Ashgabat Statement[43] addresses the transport sector, underscoring the need to curb GHG emissions across all modes of transport, including waterborne and air transport, and calling for accelerating the progress toward the implementation of the Paris Climate Agreement.

Additional UN-related initiatives include:

- The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) administers the Regional Action Programme for sustainable transport connectivity in Asia and the Pacific (2017–2021), which aims at harmonizing technical standards, minimum requirements for emission standards, and infrastructure connectivity (including a dry port agreement), ITS, and urban transport.
- Under the UNCRD Asian Environmentally Sustainable Transport (EST) Initiative,[44] national EST strategies have been developed and the regional EST Forum has been held 11 times since 2005. A key element of the initiative is the Bangkok 2020 Declaration for Sustainable Transport Goals for 2010–2020 (2010), which is an expression of intent to develop and realize integrated and sustainable transport policy options, programs, and projects to support 20 EST goals. These goals are organized according to the avoid-shift-improve framework, complemented by cross-cutting strategies.
- The UNCTAD Framework for Sustainable Freight Transport[45] provides guidance and tools that help to plan, design, implement and monitor sustainable freight transport strategies. It includes a catalogue of more than 300 measures as well as a key performance indicator list.

In addition to all these international instruments, several initiatives and commitments from organizations acting in the sustainable mobility arena support the green mobility goal. Examples of these initiatives in-

clude: (i) the MobiliseYourCity partnership and the Transformative Urban Mobility Initiative (TUMI), which both aim to accelerate the implementation of sustainable urban transport development and the mitigation of climate change; (ii) the Low Carbon Road and Road Transport Initiative (LC2RTI) and the Navigating-a-Changing-Climate Action Plan (PIANC), which aim to build strong and sustainable adaptation policies for the road network and waterborne transport infrastructure respectively; (iii) the Global Sidewalk Challenge, which aims to support and promote more walking; (iv) the Urban Electric Mobility Initiative (UEMI), which aims to increase the share of electric vehicles, among other existing global initiatives; (v) the ITF Decarbonising Transport project, which aims at providing mitigation modeling tools; (vi) and the CEM-EVI (Electric Vehicles Initiative) in which major electric vehicle market are working to achieve the collective objective of attaining 30 percent of market share of electric vehicles by 2030;[46] and (vii) the UITP Declaration on Climate Leadership, which aims to encourage a shift to low carbon public transport.

Additional noteworthy commitments from organizations include the C40 Cities Climate Leadership Group, which adopted the Clean Bus Declaration and the Fossil-Fuel-Free Streets Declaration in 2015 and 2017 respectively, pledging to only procure zero-emission buses by 2025 and to ensure that major areas of cities are zero-emission by 2030.[47] Further, the Global Fuel Economy Initiative, developed in 2015, aims at supporting the development and uptake of fuel-saving technologies, with a worldwide target of 50 percent improvement of new car fuel consumption by 2030. Similarly, the Global Green Freight Action Plan, put forth by CCAC and EPA in 2014, intends to help develop and support new green freight programs from a global perspective. Another recent commitment for consideration is the Transport Decarbonisation Alliance, initiated in December 2017 as part of the 12 Official Commitments made at the One Planet Summit in Paris. TDA gathers Countries, Cities, and Companies—an alliance of the "three Cs"—committed to accelerate transport transformation ahead of the Paris Agreement horizon. It was launched at the ITF Summit 2018 with UN Secretary General's support, and is seen as a potential major game changer. These actors are committed to scaled-up ambition for the transport sector, with concrete action by setting up Fast Track pathways to decarbonization, "3 Cs Communities of Interest," and effective advocacy by influencing political decision makers in key international fora and international political processes.

Finally, comprehensive but simple acting and tracking frameworks are a necessary step for use at different levels of government, including cities. They allow the crafting of a pathway and an actionable vision to sustainable and green mobility, to measure progress, and to understand needs for adjustments. The Global Macro Roadmap to decarbonization—which the Paris Process on Mobility and Climate (PPMC 2016) developed in the wake of COP 21, with UNFCCC endorsement—provides a phased-action process covering a 2020–2050+ timeline by recommending both short- as well as mid- to long- term transformations, with an operational focus on each segment of the transport sector, including: people and freight; road, railway, aviation, and waterborne; and urban and rural.

ENDNOTES

33 WB/UNECE (2018) A Review of International Agreements, Conventions and Other Instruments to Achieve Sustainable Mobility

34 Existing mechanisms have had limited effectives for the transport sector, while new mechanisms are being developed, which are potentially more suitable for transport (Bakker, 2018).

35 However, a recent analysis of the Voluntary National Reviews shows that countries' reporting on transport in the SDG context is limited (SLoCaT 2018).

36 The Convention on International Civil Aviation was established in 1944 to promote cooperation and "create and preserve friendship and understanding among the nations and peoples of the world." Known more commonly today as the 'Chicago Convention', this agree-

ment established the core principles permitting international transport by air, and led to the creation of the specialized agency which has overseen it ever since – the International Civil Aviation Organization (ICAO). As of November 2017, the Chicago Convention has 192 Member States. ICAO and its 192 Member States develop and maintain the internationally-harmonized environmental Standards and Recommended Practices (SARPs), as contained in Annex 16 – Environmental Protection, Volumes I, II, III and IV to the Convention on International Civil Aviation and other guidance material to address the impacts of international aviation on the environment.

37 Statements and submissions by ICAO to the UNFCCC: https://www.icao.int/environmental-protection/Pages/statements.aspx

38 IMO (April 2018) UN body adopts climate change strategy for shipping. http://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx

39 IMO (March 2018) MARPOL amendments enter into force – ship fuel oil reporting requirements, garbage classification and IOPP certificate (http://www.imo.org/en/MediaCentre/PressBriefings/Pages/04MARPOL-amendments.aspx)

40 Association of the Southeast Asian Nations

41 https://www.asean.org/storage/2016/01/11/publication/KUALA_LUMPUR_TRANSPORT_STRATEGIC_PLAN.pdf

42 Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be fitted and /or be used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted based on these Prescriptions.

43 https://sustainabledevelopment.un.org/content/documents/11987Ashgabatstatement.pdf

44 http://www.uncrd.or.jp/index.php?menu=383

45 https://sft-framework.org

46 https://www.iea.org/media/topics/transport/3030CampaignDocumentFinal.pdf

47 Other initiatives addressing green mobility include the Airport Carbon Accreditation, Below 50, Cycling Delivers on the Global Goals, EcoMobility Alliance, EV100, Global Strategy for Cleaner Fuels and Vehicles, ITS for the Climate (ITS4C) and Taxis4SmartCities

4. CATALOGUE OF MEASURES

This section includes a structured list of possible actions—based on the Avoid-Shift-Improve approach—that could be undertaken by countries or cities between now and 2030 to achieve the goal of being on track to the SDGs, and on a path to sustainable mobility by 2050+. It is divided into freight and passenger transport, because of the varied natures and drivers of these subsectors and of the policy approaches. Adaptation measures are discussed later.

The proposed "toolbox" is essentially four-fold, with four categories of measures or policy instruments: an Engineering and Technology toolbox, dealing with infrastructure and technology; a Regulatory and Institutional toolbox, dealing with regulation and institutions, including the international and regional agreements described in Section 3, and including urban and regional planning; the Economics and Finance toolbox, dealing with financial instruments, such as taxes and subsidies; and the Communications toolbox, dealing with public information and communication tools for public acceptance of measures. In practice, a combination of tools is used to reach the intended policy goals: sustainable transport policies often need to be packaged in order to be effective.

4.1. Overarching actions

Along with the specific measures in the following sections, some overarching actions are essential in creating a policy framework conducive to sustainable transport, including:

- Analysis of the impacts and externalities of the current transport system, including but not limited to the three Green Mobility objectives, as well as soil and water pollution
- Development of a long-term vision in connection with stakeholders, including NGOs, companies and professional bodies, and policy frameworks for green mobility (or sustainable mobility if all objectives are covered). This can be at the national level as well as at the local level. City commitments or targets, or legislation such as a clean air act, are often key starting points for action. Targets can be for air quality, GHG, zero-emission vehicles, modal share, and more. Long-term strategies for GHG in the transport sector can also be formulated, such as the target of minus 60 percent in 2050 compared to 1990 in the EU, or sub-sectoral targets, for example, for road freight, which could be established at the national or international level
- Financial and investment frameworks, including comprehensive project appraisal, outcome-oriented indicators, financial instruments and support, and diversified funding options including climate, and investment pipelines including sustainable funding (see also the Efficiency discussion)
- Institutional development, including synergies among the Ministries of Transport, Finance, Environment, and Economy to break down silo-thinking and planning; benchmark the current set-up against international practices
- Sufficient highly-trained government staff with a systemic intermodality mindset; Capacity building for transport and urban planners and decision makers; Development of appropriate on-the-job training schemes reflecting the technical, social, and methodological dimensions of work in the transport sector and the corresponding academic curricula
- Use public procurement instruments to support measures in Section 4.2 and 4.3, such as electrification, circular economy, environment-friendly engineering practices, adaptation, and criteria for awarding service contracts.

- Improve data collection and establish performance indicators[48], and monitoring systems (MRV)
- Voluntary National Reviews (for the SDGs) need to better reflect transport issues, including adaptation (SLoCaT 2018). The NDCs (nationally determined contributions, or climate action plans) provide a process for increasing ambition in mitigation and adaptation in transport, and cover the sector more comprehensively than is done currently

4.2. Freight and logistics: Domestic and international

4.2.1. Context and trends

Key stakeholders in the freight and logistics sector include the users (shippers and traders) and logistics service providers (carriers and logistics firms), along with government authorities, planners, infrastructure developers, operators, ship owners, and investors. Shippers select carriers predominantly based on reliability and costs, whereas environmental considerations are of a lower priority today.

This sub-section first deals with maritime transport (72.2 percent TKM of freight transport[49]), and then with surface transport, each of which have their own dynamics, yet both are key in moving toward green freight and logistics. As air cargo only represents 0.7 percent of freight transport in volume, it will not be discussed at length.

There is a strong relationship between global trade and GDP growth, although the elasticity is now lower than in the period up to 2010 (ITF 2017). International maritime transport alone covers 80 percent of volume, more than 55 percent of ton-km,[50] and over 70 percent of the value of global trade. Because of important investments in more and larger vessels in the past, there is now overcapacity, depressing freight rates.

In addition to being a source of GHG emissions[51] (Figure 2.2), maritime transport is also a substantial emitter of SOx and PM. Currently, heavy fuel oil contains maximum 3.50 percent (m/m) sulphur, while by 2020 the global limit in terms of sulphur content of any fuel oil used on board ships will be 0.50 percent. In Emission Control Areas, the limit is 0.10 percent.[52],[53] There are limited data availability and emissions inventories in the shipping sub-sector, with limited bottom-up data on energy use and externalities. However, an EU measurement, reporting, and verification regulation[54] (MRV) requires large ships with >5000 gross tonnage using EU ports from January 2018 to report their verified annual emissions of CO_2, PM, NOx, SOx and other relevant information, on a per-voyage basis. Also, IMO has been providing emission estimates for greenhouse gases from ships since 2000 to inform its Member States through three studies covering the period 2000–12. A Fourth IMO GHG Study will be initiated in spring 2019 for publication in autumn 2020. Adoption in 2013 of amendments to MARPOL Annex VI on data collection systems for fuel oil consumption of ships (see Section 3) will also improve data availability to inform future decision making.

Meanwhile, in domestic freight systems, trucks are the main mode of transport, although rail[55] is the dominant transport mode in some countries—such as Russia, Australia, Canada, an important mode in the US and China, and to a lesser extent in India and the EU (IEA/UIC 2017), for example.

Rail is an efficient and low-emitting mode if it is electrified, and particularly if based on a clean and sustainable electricity mix.

On the other hand, trucks are approximately 10 percent of the vehicle fleet, but emit close to half of transport CO_2 emissions and about two-thirds of PM emissions in the G20.[56] This share will grow in the future as countries get richer (IEA 2017b).

Inland waterways and coastal shipping are important modes in China and some OECD countries, while coastal shipping is key in regions such as Southeast Asia.

To achieve climate objectives, there is a need for deep decarbonization of all modes. For larger trucks, aircraft and ships, electrification, electrification faces higher barriers than the passenger transport sector and may not deliver all of the required GHG reductions. Therefore, alternative fuels such as sustainable biofuels, power-to-liquids/gas, hydrogen from low-carbon energy sources, and possibly methanol and ammonia, may play an important role as well (IEA, 2017b). For

rail, although it is the lowest carbon- intensive surface mode now, further electrification with the use of catenary lines or hydrogen fuel-cell trains is required as well.

Each commodity type (for example, fossil fuel, building material, food, or chemicals) has its own dynamics in its respective supply chain. Tackling transport emissions thereby touches upon wider topics and structures such as green supply chains, local production of goods, and the circular economy[57]. Decisions by producers and consumers, as well as policies, will impact on freight demand, through:

- Structural changes in the economy, such as more renewable energy,[58] reshoring of activities, circular economy[59]
- Technological changes and innovations
- Changes in lifestyles and consumer preferences that reduce the need for manufacturing and/or transport of products, such as car sharing, e-books, local food
- New business models, such as "Industry 4.0"[60]

To be more specific, technological and system innovations that may impact freight systems include:

- Internet-of-Things, or physical internet: allows more collaboration between shippers and carriers and a more efficient use of transport assets and warehouses
- Autonomous trucks (which may increase competition with rail) and delivery vehicles
- Asset sharing between companies (warehouses, IT systems, trucks)
- Last-mile delivery options, such as cargo delivery drones
- 3-D printing, which results in decentralized production and reduced freight flows

4.2.2. Measures to promote green freight and logistics

This section presents a substantial—though non-comprehensive—list of measures[61] that addresses environmental impacts from freight and logistics, based on the Avoid-Shift-Improve approach (see Chapter 1). Key categories of actions include:

4.2.3. Factor in energy and environmental concerns for better-informed shipping decisions

Shippers, who choose carriers to ship their products, need to be enabled to better factor in aspects related to environment and energy, while in general the knowledge base needs to be improved. This can be achieved through the development of green- freight labelling schemes that both shippers and carriers can join, to be rated on their environmental performance. Also, the existing national and international initiatives and regulations to improve bottom-up data, and monitoring, reporting, and verification (MRV) systems for ships and road transport need to be strengthened. To internalize external costs, market-based mechanisms such as carbon pricing, emissions trading, or a fuel levy can be used.

4.2.4. Encourage efficient supply chains and circular economy

More efficient supply chains, circular economy, and more locally produced goods, without compromising countries' development objectives through trade, can result in meeting a demand for goods with less total ton-kilometers. Policy instruments to promote this can include public procurement regulations, improved information for consumers through product labelling, national targets, and incentives for the recycling of various goods. Also, optimizing logistics to reduce empty trips, increase the load factor of vehicles, and re-time urban deliveries can be achieved through infrastructure (for example, consolidation centres), facilitation of information (such as freight exchange), pilot projects, and addressing non-tariff barriers.

4.2.5. Favor modal shift toward more rail and waterways

Transport by railways and waterways requires much less energy per ton-km than by road. Modal shift can be promoted through better infrastructure and intermodal facilities, addressing tariff and non-tariff barriers, and regulations, for example for capping the maximum load of road freight for a particular road or corridor. International redesign of the competitive

regulatory or fiscal framework between modes[62] may also be pursued.

4.2.6. Increase ship and truck energy efficiency, reduce pollution and noise

For newly sold trucks, fuel economy or CO_2 standards, together with incentives and labelling, are key measures, in addition to air pollutant emissions standards (Euro IV to VI[63]). For the existing truck fleets, national green freight programs[64] can be developed, which cover a range of instruments to promote clean and efficient technologies and tires, eco-driving[65], platooning[66], scrapping of old vehicles, speed management, and an operation and maintenance policy. Zone-specific vehicle noise standards, restricted access for trucks, low-noise road surfaces, and noise barriers are key measures to reduce phonic pollution. For new ships, IMO's regulatory energy efficiency framework (Energy-Efficiency Design Index) and operational energy efficiency measures for both new and existing ships can be further strengthened. Market-based measures can also be taken, as well as measures by ports, such as financial incentives,[67] power facilities construction, and ship-berth planning.

4.2.7. Develop and promote clean, low-carbon fuels

Key measures include 1) Low-emission zones (LEZ) to promote clean urban logistics, 2 low-sulphur diesel standards for ships and trucks, 3) incentives and standards for sustainable biofuels (bio-methane, second and third generation biofuels) as well as other sustainable gaseous or liquid synthetic fuels (power to gas, power to liquids, hydrogen, methanol). These are particularly important for trucks, ships, and aviation (IEA 2018) and 4) infrastructure, for example, electric road systems, and incentives for charging stations and hydrogen supply systems

4.2.8. Foster R&D strategies

Promising, but still immature low-emission technologies need significant research, development, and deployment support to improve technology and cover risk for early adopters. This includes electric trucks, delivery vehicles and ships, synthetic and bio fuels, hydrogen fuel cells, and advanced ITS solutions. International research programs on new sea powertrains and vessel design are also required, focusing on ammonia, methanol, fuel cells, dual fuel, electricity or hybrid, wind, and solar, for example. Autonomous and semi-autonomous logistics systems could benefit from joint research programs, while noting that potential implications for energy and emissions are ambiguous.

Table 4.1 shows the measures discussed above in the form of a 'catalogue. It also indicates whether measures have synergies or trade-offs with the five other goals in the GRA: Urban Access, Rural Access, Gender, Safety and Efficiency. Assessment is not for each policy measure or intervention individually, but for the change they are trying to achieve (such as a modal shift to rail).

Table 4.1: Green Freight and Logistics Measures

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
CROSS-CUTTING							
Factor in environmental externalities	Economics / Finance	Ensure the internalization of environmental externalities through economic incentives, such as fuel pricing			◆		
	Communications	Promote further environmental transparency and informed decisions through data collection requirements and green freight labelling					

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
AVOID							
Promote circular economy	Economic / Regulatory	Promote circular economy through target setting and financial incentives			◆		
	Communications	Promote awareness through product labelling based on embedded energy					
Reduce empty trips and promote efficient supply chains	Infrastructure / Technology	Avoid fragmented supply/production/distribution chains through logistic consolidation centers and exchange platforms		◆	◆		
	Economic / Regulatory	Optimize the load factor through financial incentives and regulations, such as cabotage rules					
SHIFT							
Urban scale	Economic / Regulatory	Promote light electric vehicles through financial incentives, pilot programs, and Low Emission Zones (LEZ)		◆	◆		
Non-urban scale	Economic / Infrastructure / Regulatory	Promote a modal shift toward rail and water through additional infrastructure, regulations for maximum total truck loads by corridor, financial incentives and addressing non-tariff barriers for cross-border traffic			◆		
IMPROVE: Cleaner and more efficient vehicles							
Road transport	Regulatory / Economic / Communications	Regulate CO_2 emissions, fuel economy, and air pollution through standards, financial instruments, and labelling			◆	◆	
	Infrastructure / Regulatory	Regulate noise pollution through noise standards, traffic management regulations, and low- noise road engineering and maintenance.					
	Economic / Regulatory	Limit the use of vehicles beyond a maximum age through financial incentives and legal action, including limitations on second-hand imports					
	Technology / Economic / Comunications	Promote cleaner and efficient technologies and practices through green truck programs, operation and maintenance policy, and investments such as platooning					
	Regulatory / Communications	Improve efficiency through speed limits and eco-driving campaigns					
Rail transport	Technology / Regulatory	Develop electrification and hydrogen fuel as alternative to diesel, fuel standards, noise standards, ITS services			◆		

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
Maritime transport	Regulatory	Develop national action plans for green and low carbon shipping					
	Infrastructure	Develop port electrification, e.g. electric charging facilities and hydrogen refueling infrastructure					
	Regulatory	Improve ship efficiency by strengthening IMO's energy-efficiency technical and operational framework and pollution standards and regulations			◆		
	Economic / Communications	Promote green shipping through port or market-based incentives, eco-rating schemes, capacity building, and technical cooperation					
IMPROVE: Clean, low-carbon fuels and electrification							
Sustainable gaseous and liquid fuels	Economic	Promote sustainable alternative fuels for trucks through financial incentives or blending mandates					
	Infrastructure / Regulatory	Develop SGLF for ships through the development of a legal framework, and production and storage facilities					
Electrification	Infrastructure / Economic / Regulatory	Promote truck electrification (hydrogen & electricity) through infrastructure development (electric road systems and hydrogen refueling infrastructure), pilot programs, incentives and LEZ			◆		
Maritime transport	Technology	Develop R&D and pilot projects for low and zero-carbon fuels and technologies (Hydrogen, ammonia, methanol), and hybrid/electric ships and alternative means of propulsion (wind, solar)					
	Economic / Regulatory	Develop regulatory framework to permit the safe use of sustainable alternative fuels, develop new design standards and fuel specifications along with financial incentives			◆		
	Economic / Communications	Assess global sustainable biofuel supply capacity					

4.3. Passenger mobility

4.3.1. Context and trends

Passenger trips are taken for a variety of purposes, with commuting/school, shopping, and leisure/social taking a one-third share each. Modal shares of private vehicles are higher than public transport at a global level, both in urban and inter-urban transport (ITF 2017). Especially in non-OECD countries there is a large variety of vehicles, including paratransit or intermediate public transport modes such as mini-buses, motorcycle taxis, and tricycles. A large share of motorized trips is shorter than 5 km –for example, 35 percent in the U.S.[68] indicating a large potential for trips by NMT.

To address the environmental impacts and lack of physical activity, transformational change in the realm of: (i) transport system and behavior (avoid and shift)[69] as well as (ii) vehicle technology and fuels (improve) are required. Policies are showing some effectiveness in decoupling GHG emissions from economic growth, yet absolute reductions require much stronger action. For air pollution, cleaner fuels and emission standards for new vehicles have shown to be an effective first step in many countries, although much remains to be done. Planned initiatives in cities are driving a further move to cleaner transportation. As for noise pollution, limited action is taking place.

For urban mobility policy in particular, congestion, air pollution, noise, and livability are key issues. High levels and growth of vehicle ownership and use exacerbate these problems. Therefore, policies to optimize motorization and transport demand are warranted, while this is less the case in non-urban contexts, especially with fewer alternatives.

Mobility systems are currently undergoing changes because of new technologies (for vehicles and communication systems), giving rise to new models such as Mobility as a Service[70], ride sharing, urban transport drones, and vehicle sharing. Some of these models increase vehicle occupancy rates, while others do not– and may in fact compete with public transport.

4.4. Measures to promote green passenger mobility

In essence, the fundamental orientations are the following:

4.4.1. Promote active mobility modes: walking and cycling

The measures are well covered in the Universal Urban Access paper, including overarching policies such as Sustainable Urban Mobility Plans and National Urban Mobility Policies or Programs. Also, action plans for active modes at both the national and local levels can be crafted. Setting targets for the trip-based modal share for urban areas – for example having sustainable modes (public + active[71] transport) higher than 80 percent in 2050[72] – could further promote walking and cycling.

It should be noted that dedicated cycle lanes may also be used by e-bikes and e-mopeds up to a certain speed, e.g. 25 km/h.

4.4.2. Push and pull approach to induce modal shift in cities

As shown in the Universal Urban Access paper, Transport Demand Management in urban areas, in combination with development and maintenance of high-quality public transport systems ('pull') are essential in promoting a modal shift to public transport. The latter includes physical integration, integrated ticketing, and integrated fares. Key TDM measures ('push') are parking management (including parking maximum standards, pricing and reducing on-street parking), traffic calming, private vehicle taxation and access restrictions. In addition, avoiding trips and reducing trip distance are promoted through land-use planning (density, mixed-use, transit-oriented development).

4.4.3. Promote electric two-wheelers

Motorcycles and mopeds play a key role in many countries[73] in providing convenient, affordable, equitable, and space-efficient accessibility, including their combination with public transport. However, they significantly contribute to air pollution and noise. Electric

two-wheelers (pedal-assisted bicycles, e-bikes, and electric motorcycles) should thus be promoted and barriers to their adoption reduced. However, there may be a lack of attention from policymakers. Policy options include vehicle classification regulations, emission standards, LEZ, financial incentives, access restrictions for—and later phasing out of—conventional motorcycles, dedicated road lanes for two-wheelers (or e-bikes and e-mopeds), speed limits on shared roads, and awareness raising (IEA 2017a; Bakker, 2019). A shift from conventional two-wheelers to cars should not be promoted in cities.

4.4.4. Apply standards and incentives for clean buses

Diesel buses may account for a significant share of urban air pollution. Key technologies enabling 'soot-free'[74] buses are available and often commercially attractive, including EURO VI diesel, hybrid, plug-in hybrid, hydrogen fuel cell and battery electric buses. Policy options include standards in bus route tender specification, incentives, public procurement for public fleets, and development of the charging infrastructure. Age limits or standards for import of second-hand buses can also be effective. Financial instruments to address lack of access to capital are also required, such as battery leasing and operating leasing.

4.4.5. Craft policy packages for cleaner and more efficient cars

To improve fuel economy and reduce CO_2 emissions from newly sold vehicles, a combination of standards, incentives, and labelling is the most effective. For air pollution, progressive vehicle standards should also be set, together with the appropriate fuel quality standards and the creation of controlled emission zones. The difference between test and real-life emissions is key, and better test procedures for type approval need to be established.[75] For the existing fleet, a set of operation and maintenance measures for management of motor vehicles[76] is essential, along with speed limits and eco-driving.

4.4.6. Phase out fossil fuel subsidies and reflect external costs in fuel prices

Fossil fuel subsidies should be reduced and phased out as soon as possible, which will be a strong incentive for energy efficiency improvement in the transport system. The revenues can be used to compensate the impact on the poor, as well as for investments in public transport. Further policies would ensure that fuel prices are raised to internalize external costs, including lifecycle GHG emissions, air pollution, and other impacts.

4.4.7. Design policies supporting the transition to electric (electricity and hydrogen) vehicles[77]

With electric vehicles (EVs) accounting for only about 0.5 percent of the global car stock in 2018, accelerating EV deployment[78] rates by ambitious policies in the near and mid-term is essential. Cities are often in the forefront of promoting EVs, primarily for air quality reasons, however national policies are essential as well. Regulatory policies to promote electric vehicles include setting sales targets (ZEV mandates) or phasing out fossil-fueled cars, progressive fuel economy standards, setting up Low-Emission Zones and public procurement standards, and enabling private investments in infrastructure. Incentives can be designed in the form of purchase subsidies, road toll rebates, or reduced parking fees. A network of charging and refueling infrastructure[79] should also be developed. As technology is developing and costs change, policies should be adaptable, yet give confidence to the private sector and vehicle buyers. (See Box 1 for lifecycle emissions considerations.)

4.4.8. Take advantage of digital tools and new mobility models

Shared, connected, and autonomous vehicles are likely to increase total vehicle-km travelled and urban sprawl, as well as reduce the relative attractiveness attractiveness of sustainable modes; therefore policies[80] are required to ensure they do not go against green goals. Their development should also be linked with low-carbon technologies, and some Mobility as a Service (MaaS) and shared mobility models may provide early opportunities for electrification of vehicle fleets. Digital applications can also promote easier access to new mobility modes, and connectivity between those modes. For technologies that are not market ready, such as autonomous vehicles or the hyperloop[81], an innovation or transition management approach in-

cluding (international) research programs may be needed.

4.4.9. Address the noise issue

The need for noise abatement for both motorcycles and cars implies the implementation of noise standards—for car engines, tires, or geographical zones—but also regulations limiting noisy driver behavior, such as honking. This could be combined with speed limits, campaigns for eco-driving, and traffic management through economic instruments, such as road charges and parking fees, to reduce motorized traffic in inner zones of the city. Finally, low-noise road engineering, better insulation standards, noise barriers, and careful land use planning could help protect homes from remaining noise disturbances.

4.5. Aviation

Aviation—domestic and international, passenger and freight: the existing framework developed by ICAO (Annex I) must be fully respected at an international level, and also provide guidance for how many actions can take place in domestic air transport. In addition, research programmes for greener air transport technology development and sustainable aviation fuel feedstock development can be developed, working with the sector and research institutions. Further support for sustainable aviation fuel production and deployment in countries can be sought, working with industry and new energy providers to identify country-specific opportunities at a national and local level, while de-risking investment in such technologies.

Based on these key categories of actions, Table 4.2 presents a substantial (though not comprehensive) list of measures that addresses environmental impacts from passenger mobility. Similar to the table for freight, it indicates whether measures have synergies or trade-offs with the five other goals in the GRA: Urban Access, Rural Access, Gender, Safety, and Efficiency. For the urban transport measures, the Urban Access paper provides a more comprehensive overview. Assessment is not for each individual policy measure or intervention, but at the level of what the measures try to achieve (such as a modal shift to rail). For example, promoting electric two-wheelers (assuming these chiefly replace or limit the growth of conventional motorcycles, and to a lesser extent cars and taxis, public transport, and bicycles): this would help urban and rural access (affordable, flexible, and fast mobility), probably help gender (increased mobility options), increase or decrease safety (depending on local conditions) and increase efficiency (taking less road space than cars per pkm). In addition, there are some important preconditions, such as whether electric two-wheelers are acceptable for all groups in society, and there is safe infrastructure; however, these conditions are not reflected in the table.

Table 4.2: Green Mobility Measures for Passenger Transport

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
AVOID/SHIFT: Urban environment							
Avoid and shorten trips	Technology / regulatory	Avoid unnecessary trips through a change in commuting habits, via the development of telecommunications and the promotion of telepresence		◆	◆	◆	
	Planning / Economic	Promote urban planning measures to reduce the need for transportation					

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
Active mobility	Infrastructure / Planning / Economic / Communications	Promote walking and cycling through better infrastructure, inclusive design, traffic management, financial incentives, and awareness campaigns		◆	◆	◆	◆
Public transport	Infrastructure / Planning / Economic / Communications	Develop bus networks through infrastructure development, improved logistics, subsidies, and improved travel information		◆	◆		
	Infrastructure / Planning / Economic / Communications	Develop urban rail through infrastructure development, intermodal integration, land value capture, and improved travel information					
Paratransit	Regulatory / Planning	Optimize informal transport in combination with all other modes		◆			
Shift away from private vehicles	Regulatory / Infrastructure / Economic	Promote the shift away from private vehicles through physical/legal restrictions and economic incentives		◆	◆		
SHIFT: Non-urban (Inter-urban and rural)							
Active mobility	Infrastructure / Planning / Economic	Promote cycling through improved infrastructure, inclusive planning, and economic incentives	◆			◆	◆
Public transport	Planning / Economic	Develop bus networks through inclusive planning and better promotion	◆	◆	◆	◆	◆
	Infrastructure / Planning / economic	Promote the shift toward rail (including high-speed) through better infrastructure, inclusive planning, and pricing measures					
Shift away from carbon-intensive modes	Planning / Economic	Decreasing private vehicles' attractiveness through planning and economic measures	◆		◆	◆	◆
Advanced technologies	Technology	Develop new technologies through R&D strategy: energy, vehicle, ITS, and intermodal transport	◆		◆	◆	
IMPROVE: Vehicle efficiency							

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
Road transportation	Economic / Regulatory / communications	Increase fuel efficiency through more stringent standards, incentives, labelling and eco-driving campaigns					
	Economic / Regulatory	Limit the use of polluting vehicles through financial incentives and maximum age regulations			◆		
	Regulatory / Economic	Limit air pollution and noise through stricter regulations and standards, LEZ, incentives and maintenance					
Rail transportation	Infrastructure	Improve efficiency by promoting electrification					
	Regulatory	Decrease noise pollution through more stringent standards			◆	◆	
Intermediate Public Transport	Technology / Regulatory / Economic	Decrease air pollution and GHG emissions through economic incentives and support to new technologies (including waterways)		◆	◆		
IMPROVE: Clean, low carbon fuels and electrification							
Electric/Hybrid buses	Infrastructure/ Economic / Regulatory	Promote bus electrification (hydrogen and electricity) through infrastructure development, regulations, including LEZ, and economic incentives			◆		
Electric 2 and 3 wheelers	Infrastructure / Regulatory / Economic	Promote electric 2- and 3- wheelers through inclusive planning and dedicated infrastructure development	◆	◆	◆	◆	◆
	Regulatory / Economic	Phase out conventional 2- and 3- wheelers through regulations, including LEZ, and incentives					
Electric cars	Infrastructure / Regulatoryl / Economic	Promote e-mobility (and hydrogen) through infrastructure development, zero-emission vehicle (ZEV) targets and mandates for manufacturers, economic incentives, preferential regulations, and public procurement			◆		
	Regulatory / Economic	Enable public and private investments in vehicle manufacturing, charging, and refueling infrastructure					
Biofuels and biogas	Economic	Develop sustainable biofuels and biogas through economic incentives and a R&D strategy			◆	◆	
Other alternatives	Economic / Technology	Develop systematic R&D strategies for promising alternatives, such as synthetic fuels or hydrogen					

Box 4.1: The Energy Transition in Transport and Long Term Sustainability of Some Solutions

Advanced biofuels are needed to ensure lifecycle Greenhouse Gas (GHG) emission savings, and to avoid competition with food production

- First generation biofuels brought limited global GHG savings. Second and third generation biofuels are expected to be an effective part of the solution (IEA 2017a), particularly for aviation and heavy road sectors
- The production and use of biomass for energy might lead to adverse environmental impacts on biodiversity, soil, water and air quality if not properly managed. Research must be intensified on most promising solutions.
- Global, realistic potential is estimated at 10-15% of current oil consumption

Methane: limited GHG savings

- Combustion of methane in internal combustion engines (ICEs) brings a substantial air pollution reduction and up to 15 percent CO2 emission decrease compared to oil-derived fuels
- However, because of methane leakages, this mitigation potential might be significantly lowered, giving methane a limited role in transport decarbonization, with the exception of a potential role for bio-methane, and generation of methane from carbon dioxide + clean hydrogen (power-to-gas)

E-mobility development must go hand in hand with power sector decarbonization, investments in (smart) grids, management of battery raw materials and waste, and clean hydrogen production

- Electric Vehicles (EVs), and to some extent fuel-cell vehicles, play a key role in all transport decarbonization scenarios and in clean air plans
- In the current situation, most EVs in most electricity grids already save GHG on a lifecycle basis compared to ICE vehicles (IEA 2017a); for two-wheelers the savings are particularly high,
- However, a 50 percent reduction of carbon intensity of the power sector by 2030 is necessary to achieve the GHG savings required for the Paris Agreement (IEA 2018)
- Strategies for investments both in smart and connected electricity grids and in the production of clean hydrogen through clean electricity (electrolysis) are required to enable large-scale electrification
- Strategies are needed for battery recycling, and to ensure that battery production does not lead to soil and water pollution

4.6. Adaptation of transport systems to climate change

When developing climate-resilient transport infrastructure, governments should ensure they have a proper strategy ready in the form of national adaptation plans[82]—with possible regional variations—to ensure climate risks are taken into account in a systematic manner (Table 4.3).

This implies that such nationally developed roadmaps should consider the main characteristics of a resilient transport network:

- Robustness: Transport infrastructure is designed, built, and maintained to withstand high-impact weather conditions and climate events
- Redundancy: Spare capacity is built into the system to absorb disruptions, and alternate options are available for transportation
- Resourcefulness: Capacity is available to mobilize needed resources and services in case of emergencies

Another facet to be taken into account is that transport resilience measures should include variations adapted to new, but also already existing transport infrastructure, especially considering their long lifespan.

Finally, one last important aspect to keep in mind when it comes to adaptation is the systematic dimension of resilience measures: the inherent uncertainty linked to climate change makes it particularly difficult –if not impossible– to have a one-time foolproof solution; hence the need to conduct systematic monitoring and constantly upgrade and adapt.

4.6.1. Existing transport infrastructure

Increasing the resilience of currently existing transport infrastructure first calls for a risk assessment, with the objective of ensuring that climate-related risks are included in national risk management and planning systems. Possible measures include a methodical inventory of transport facilities, followed by a list of possible climate hazards depending on the area: ultimately, this allows for a mapping of critical infrastructure links and a better identification of vulnerable infrastructure, such as tunnels, riversides, or seashores.

Once such a risk assessment is completed, the next step is to consider and quantify the consequences of failures and disruptions of these links, in order to prioritize which vulnerability in the transport infrastructure is considered most critical.

Next, to pick the correct and most appropriate solutions, an enumeration of possible adaptation responses and their economic assessment will help avoid strategic errors that might be prejudicial for the long-term sustainability of the project. For example, while a failure-proof infrastructure may be possible, it may not be profitable from a cost-benefit point of view and, if implemented, may have problematic financial repercussions.

Possible resilience solutions for existing transport networks comprise improved anticipation through comprehensive emergency plans that include real-time monitoring of the asset condition, and early warning systems in case of special weather events. The efficiency of such plans also highly depends on good communication and dissemination with respect to the public, to ensure citizens are aware of the different transport alternatives and are thus better prepared for special weather events. Also, coordination across all transport agencies is essential, as it allows for a more organized approach.

Furthermore, in order to build robustness, regular and thorough maintenance is fundamental to maximize adaptive capacity. Technical standards should also be regularly reviewed to ensure adaptation to changing climate conditions. Indeed, these standards act as the backbone of the "building back better principle"[83], which states that in many cases, it is more cost-effective in the long term to rebuild to a higher standard of resilience if existing transport infrastructure has been damaged.

4.6.2. New transport infrastructure

In order to increase the resilience of new transport infrastructure, it is critical to improve its robustness and adaptive capacities by integrating adaptation into the project design through regularly updated standards and regulations: this naturally includes enhanced emergency preparedness associated with real-time monitoring and maintenance, but also planning processes and evaluation techniques that recognize and accommodate climate change related risks.[84]

When designing new transport networks, it is also of primary importance to ensure redundancy in the system through the diversification of transportation modes, corridors, and fuel sources both within and between cities. This ensures that an acceptable level of service is possible a majority of the time, by offering various transport alternatives, and it is tightly linked to a push in favor of public transportation, including buses and trains. Active mobility should not be forgotten, as it can play an important role from an intermodal standpoint by connecting bicycle and walking trails with main transit routes.

Table 4.3: Measures for Adaptation in the Transport Sector

			Synergies and Trade-Offs				
Family of Actions	**Toolbox**	**Actions**	Rural	Urban	Efficiency	Safe	Gender
IMPROVE: Existing transport infrastructure resilience							
Risk and options assessment	Planning	Improve anticipation through a mapping of transport infrastructure and identification of the most vulnerable links	◆	◆	◆	◆	◆
	Planning	Conduct risk appraisal and impact quantification of failures and disruptions to determine priority actions					
	Planning	Enumerate possible response packages and decide based on economic assessment					
Increased robustness	Planning	Improve anticipation through real time monitoring, emergency plans and coordination across agencies	◆	◆	◆	◆	◆
	Engineering / Legal	Increase robustness through improved standards ("Building back better" principle) and maintenance					
IMPROVE: New transport infrastructure resilience							
Increased robustness	Engineering	Improve anticipation by integrating adaptation into transport project design	◆	◆	◆	◆	◆
	Planning / Legal	Promote adaptive management through monitoring, revised standards and rolling plans	◆	◆	◆	◆	◆
Increased redundancy	Planning / Legal / Economic	Diversify mobility options through intermodality and fuel diversification	◆	◆	◆	◆	◆

ENDNOTES

48 See e.g. https://sft-framework.org/tools/key-performance-indicators (UNCTAD) for sustainable freight indicators

49 IEA/UIC (2017) Railway Handbook

50 IMO (April 2018) Note by the International Maritime Organization to the UNFCCC Talanoa Dialogue. (https://unfccc.int/documents/66370)

51 796 million tons or 2.2 percent of global GHG emissions (IMO, 2014).

52 IMO (2018) Sulphur 2020 – Cutting sulphur oxide emissions (http://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx)

53 These sulphur content limits may increase shipping costs substantially (20-85 percent, ITF (2018a)) and could be seen as an implicit carbon price, increasing the attractiveness of more energy-efficient ships (ITF, 2018a).

54 European Commission. Reducing emissions from the shipping sector. (https://ec.europa.eu/clima/policies/transport/shipping_en)

55 International rail freight is promoted as well, yet hampered by inter-operability, flexibility and reliability issues.

56 ICCT (May 2015) Policies to reduce fuel consumption, air pollution and carbon emissions from vehicles in G20 nations (https://www.theicct.org/sites/default/files/publications/ICCT_G20-briefing-paper_Jun2015_updated.pdf).

57 circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life.

58 Fossil fuel accounts for 30 percent of international trade (ITF, 2018).

59 Some stakeholders for instance would appreciate the renegotiation of the EU Directive 2003/96/EC (Energy Taxation Directive)

60 Also called "Fourth Industrial Revolution", which refers to the trend towards more automation and data exchange in manufacturing. Internet-of-Things and 3D printing may be part of this trend.

61 For a more extensive catalogue of actions, see UNCTAD 2017, IEA 2017b, and IMO 2018.

62 Including the Directive 2003/96/EC (Energy Taxation Directive)

63 Euro VI is suggested by the IEA in the 'Ambitious Scenario' for all countries by 2025

64 Such programs can also be broader in scope

65 Energy-efficient driving behavior and optimal tyre pressure

66 Grouping trucks on highways to increase fuel efficiency and road capacity

67 Port-based instruments could be effective if the incentives are stronger and more widely applied (ITF, 2018b)

68 Mason et al. (2015) A global high shift scenario. ITDP / UC Davis

69 For Avoid and Shift, and sometimes Improve, there are many issues that are covered as well by (or link with) other papers (safety, rural access, urban access, gender and efficiency; see the respective papers and Table 4.2)

70 Rather than relying on privately-owned vehicles, MaaS enables travelers to use mobility service (public or private, or a combination) on a per-trip basis

71 including e-bike.

72 Cities already achieving this are e.g. Paris, Amsterdam and Hong Kong, with many others in Asia and Europe approaching such shares.

73 Motorcycles account for over a quarter of transport GHG emissions in various regions, such as Southeast Asia and China, and need to be decarbonized in 2050 for a B2DS (IEA, 2018).

74 See ICCT (2018).

75 A step in this direction is the introduction of the World Light vehicle Test Procedure: http://wltpfacts.eu/what-is-wltp-how-will-it-work/

76 Motorization management refers to systematic improvement to, or development of, eight key motor-vehicle-related systems: motor vehicle information management systems (linked to driver licensing, etc.), import certification, inspection and maintenance regimes, national protocols for visual and instrumented enforcement, mechanics' training / certification, quality assurance program for vehicle parts, quality assurance for vehicle body construction / modification, fuel quality testing protocol, end-of-life vehicles protocol, and public education, engagement / outreach on vehicle-related issues (John Rogers, personal communication).

77 For more details, see IEA's Electric Vehicle Outlook 2018.

78 Including plug-in hybrid and batter electric vehicles. The former is instrumental in the transition from ICE to electric cars.

79 Plug-in electric vehicles are likely to require one or more publicly accessible slow charger for every 15 electric cars, and one or more fast charger for every 130 electric cars (IEA, 2017).

80 Notably distance-based pricing systems and clean technology incentives.

81 Sealed tube system with reduced pressure in which pods can travel at high speed.

82 For adaptation in the transport sector, there is a strong link with the Efficiency policy paper, which also proposes preparing strategic goals and plans for the transport system with explicit references to climate resilience and infrastructure

83 Prairie Climate Centre (2017) Building a climate-resilient city: Transportation infrastructure.

84 PPMC (2017) A global macro roadmap outlining an actionable vision towards decarbonized, resilient transport.

5. COUNTRY EXPERIENCE

This section shows how countries in different categories, regions, and income groups have progressed on green mobility goals, what actions they have taken, and which actions can be considered for the future. Three countries that cover various green mobility domains have been selected, noting that other papers cover relevant developments as well, for example Colombia in the Urban Access paper. In addition, we highlight three specific policy domains in two other countries and a state. This section will not specifically include international aviation and international maritime transport, as these are under ICAO and IMO conventions. See Annex I on how certain countries can help move forward the ICAO agenda.

China

Distance to goals

China's transport-related GHG emissions are in the second lowest quartile of per capita emissions country ranking, yet are increasing rapidly. Air pollution is particularly severe in the cities (in the highest quartile) but some improvement can be noted, as the average concentration of PM10 in 338 prefecture-level and above cities decreased by 22.7 percent compared with 2013 levels. Regarding noise, the "2017 China Environmental Noise Pollution Prevention Report" stated that, in 2016 noise complaints represented 43.9 percent of total environmental complaints registered by the relevant departments–making it a prevalent issue for citizens. Regarding active mobility in cities, cycling has a significant modal share, and has been rising recently.

Actions taken

Road transport

In the recent years, China has pushed for the introduction of stringent fuel efficiency, fuel quality, and emissions standards which comply with European regulations. The latest requirements, known as China VI Standards, will come into effect in 2020 and cover both light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs).

Car restrictions have also been introduced in multiple cities in the form of vehicle quotas or number plate auctioning: such measures are only targeted at conventional vehicles, and do not affect next-generation vehicles. China additionally actively promotes the use of electric vehicles (New Energy Vehicles) through incentives and target-setting for manufacturers and buyers: the government started imposing strict sales targets for NEVs in 2019 with the implementation of the NEV mandate. It also encourages a gradual phasing out of conventional vehicles. Examples of such policies would be the ban on conventional motorcycles in multiple cities, which has resulted in a spectacular rise of e-bike use, as well as the deployment of hybrid and electric buses on a massive scale.

Public transport and active mobility

The Chinese government supports the expansion of high-quality mass transit networks within and between cities, including the development of an extensive network of high-speed rail. By the end of 2017, a total of 34 cities in China had opened urban rail transit networks. In subway and train stations, an emphasis is also put on land- value capture by introducing additional amenities to the infrastructure, such as convenience stores or restaurants.

Similarly, active mobility has been on the rise, thanks to the construction of high-quality walking and cycling infrastructure and the availability of bike-sharing facilities.

Aviation and shipping

Additional efforts have been made to develop an emission-trading scheme that would include domestic aviation. Officially launched in November 2013, the Shanghai Emissions Trading Scheme is the only carbon- trading pilot in China to have been incorporated into the aviation industry.

China has put important emphasis on green logistics, particularly when it comes to clean shipping: taking Shanghai port as an example, the harbor has benefited from government subsidies covering 70–80 percent of the costs linked to the construction of shore-based electric power supply equipment covering 26 port berths.

Actions that can be considered and potential hurdles

Potential additional measures for China's road transportation include the launch of Low Emissions Zones, a possibility that is currently under examination for the cities of Beijing, Hefei, Taiyuan and Shanghai. Increased fuel efficiency and emission standard stringency could also be envisioned, along with the introduction of noise standards, in the same line at the recent Shanghai regulations prohibiting horns within the outer ring. Further electrification should also be promoted, particularly for trucks and two-wheelers, with an emphasis put on safety and better infrastructure. Transport demand management is another prevalent issue and could be developed through speed limits, better intersection design, and stricter parking policy.

As far as shipping and aviation are concerned, while further port-based incentives could help with the development of clean energy ships, biofuels are an option to be explored for planes. In this respect, China is the fourth country worldwide with independent R&D resources for bio-aviation fuels.

Finally, adaptation planning is needed, and has to be considered for the further development of climate-resilient transport infrastructure.

Among the obstacles and hurdles that China has faced, or will have to overcome to implement a thorough transformation of transport, we can mention in particular:

- The growing demand for individual high-powered cars
- The average carbon intensity of the electricity grid (800-900 gCO2 per kWh)
- The design of major mega-poles–whose urban planning results in long distances, which fosters an extensive use of cars and insufficient mass transit solutions
- The need to deploy intelligent transport systems (ITS) more extensively.

Japan

Distance to goals

With 1.7 tons CO_2 per capita, Japan is in the second highest quartile of transport GHG emissions country rankings. However, there is a slowly decreasing trend in the past decade. PM2.5 air pollution is just above WHO recommended levels, but still in the lowest quartile. People's mobility remains heavily reliant on private cars, with a 65 percent modal share, followed by rail at 29 percent and aviation at 6 percent. A relatively high cycling modal share can also be noted in some cities, reaching 20 percent and above, despite little bike infrastructure. In freight, xtrucks represent a modal share of 51 percent, followed by coastal shipping at 44 percent.

Actions taken

Road transport

Over the last decade, Japan has gradually revised its emissions and fuel efficiency standards to include both light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs), and to comply with Euro VI stringency levels. Tokyo was also the first city in the world to introduce a Low Emission Zone (LEZ) in 2003.

Japan also puts emphasis on the fast deployment of electric vehicles (HEV/PHEV/BEV/FCEV) with a target of 50–70 percent of total car sales by 2030. This is supported by tax breaks, subsidies for both purchase and charging infrastructure construction, and priority support for selected demonstration prefectures. It also emphasizes hydrogen technology, with the development of a comprehensive roadmap and the creation of the Japan H2 Mobility platform involving automotive companies, hydrogen station owners/operators and investors. Further, Japan focuses on traffic demand management by developing intelligent transport systems (ITS) for dynamic route guidance and automatic electronic toll collection. Finally, important resources have been put into the promotion of eco-driving through the development of a National Action Plan, including the dissemination of recommendations and educational campaigns on a wide scale.

Modal shift in favor of rail and maritime transport (freight)

Japan is pushing for a modal shift in favor of rail, through financial support to the development of larger capacity railway freight cars and containers. Subsidies also help the conversion of passenger train lines for freight purposes. Further, in order to decrease overland transportation of internationally shipped cargo containers, support is provided for the development of international container and logistics terminals. The use of energy-saving vessels is also encouraged through subsidies for new technology development. Additional incentives include the Eco Rail Mark and the Eco Ship Mark, two labels that reward companies favoring rail and shipping over road transportation.

Modal shift in favor of public transportation and active mobility (passenger)

Japan promotes a modal shift toward public transportation, and particularly rail, through the development of urban railroad lines but also of the high-speed rail network. The Excellent Eco-Commuting Business Site Certification System, introduced in 2009, complements this approach by rewarding businesses that actively promote green commuting. Similarly, Japan also promotes active mobility through the development of safe- cycling route networks, and parking spots at railway and bus stations to facilitate intermodal transportation. Also, education and communication campaigns to encourage citizens to use bikes are widespread.

Adaptation

Japan promotes the development of adaptation measures through the formulation of a National Adaptation Plan that is to be translated into local roadmaps. Envisioned measures include improved robustness of rail, road, maritime, and air infrastructure along with better emergency preparedness. (These are contained in the Japanese Cabinet 2015 National Plan for Adaptation to the Impacts of Climate Change, and the Japanese Cabinet 2018 Climate Change Adaptation Act)

Actions that can be considered, and potential hurdles

After a very active phase of hybrid car development, Japan could consider the further electrification of passenger vehicles and trucks, associated with a phasing out policy of petrol and diesel cars. However, a difficulty that should be taken into account in parallel with such ambitions is the current carbon intensity of the electricity grid, following the gradual closure of nuclear plants since 2011: there is a need to further develop renewable energies where possible.

Another issue for Japan is the lack of cycling-inclusive infrastructure and policies, which could be a possible point of improvement in the future, to further develop an already significant cycling modal share.

Considering the importance of maritime freight, increasing the government support to research and pilot programs for alternative power trains and fuels could be an important measure to take on the path to transport decarbonization. In parallel, Japan could consider the deployment of port-based incentives for cleaner and electric (run by electricity or hydrogen) ships.

The Netherlands

Distance to goals

With 1.9 tons, the Netherlands is in the second highest quartile of CO_2 per capita transport emissions. A slow decline is observed in the past decade. PM2.5 pollution is above the WHO guidelines level, but in the lowest quartile. Modal share of cycling is 27 percent of trips (7 percent of person-km) country-wide, one of the highest in the world, with some cities exceeding a 50 percent share of total trips. The bicycle is used for approximately 50 percent of trips to access train stations. Noise is a significant issue, particularly for highways and national roads, as well as in cities.

Actions taken

Passenger mobility

For active mobility, cycling-inclusive planning has been practiced since the 1970s, and includes: dedicated infrastructure; integration with public–especially rail–transport; traffic and speed management; and liability laws. However, mopeds are still allowed on bike lanes, which makes cycling less convenient and safe. At the same time, car-based mobility in cities is discouraged through planning, parking management including maximum parking standards for new buildings, and low-car zones. Nevertheless, cars carry more than 70 percent of total passenger kilometers (pkm). And programs to promote modal shift, for example, through a company travel budgets and personal travel advice, have limited success. Land-use and transport planning are relatively well-integrated, and plans are aligned.

Clean vehicles

Low-emission zones (LEZ) have been in place since recent years in several cities, yet implementation is patchy and applies to a limited share of the vehicle fleet. From 2025, all new buses have to be zero-emission, and a plan to phase out fossil-fuel car sales by 2030 is under consideration. The car fleet in the Netherlands is one of the most efficient in Europe, because of financial incentives based on CO_2 emissions, additional subsidies for electric vehicles, and well-developed charging infrastructure. However the progress has slowed in recent years because of policy changes. Following EU Directives, all new vehicles comply with EURO VI emission standards.

Freight and logistics

- Trials for electric ships are ongoing
- A modal shift to rail is hardly taking place, despite investments in rail connections to Germany
- Green freight and logistics programs and measures include pilots for platooning, freight exchanges, and urban consolidation centers, and incentives for zero-emission logistics: e-bikes, small electric vehicles and e-trucks.

Noise

Detailed mappings of national roads, railways, and airports are carried out every five years, and action plans are made, focusing on improved road surfaces and noise barriers.

Adaptation

A detailed National Adaptation Strategy was developed in 2016, which maps the impacts of several dimensions of climate change on all sectors, including infrastructure, while mitigation measures are being developed. The port of Rotterdam has been integrating climate change adaptation investments in city plans and in its budget.

Actions that can be considered

- Banning mopeds from bike lanes, and phasing out petrol-powered two-wheelers in cities
- Adapt cycling strategies to cater for an increasing use of e-bikes, including in peri-urban areas
- Expansion of LEZ to more cities, with more comprehensive coverage
- Ambitious strategy to improve the national rail system, and integration with MaaS system for rural areas
- Consistent policies to move to 100 percent electric vehicle sales in 2030
- Electrification of trucks through incentives, and pilot programs with electric road systems
- Port-based incentives for cleaner and electric ships
- Research and pilots for sustainable alternative fuels used in shipping.

5.6.1. Switzerland: A successful strategy to shift from road to rail

Contrary to most surrounding countries but in close cooperation with them, Switzerland has been sustainably developing railway infrastructure and services over the past few decades—with proper funding and a stated strategy of shifting transport from road to rail—beginning with the adoption of the Alpine Initiative in 1994. The railways now transport two-thirds of transalpine freight, allowing the number of trucks to be kept under certain limits. Rail freight is made more competitive to road due to the introduction of the heavy-vehicle fee, which is also used to fund rail infrastructure maintenance[85].

For personal mobility, the Swiss have repeatedly voted in favor of extending the already comprehensive rail network even further. This success, both for freight and people, sheds light on the conditions of popular support for rail service and economic success: frequency, timeliness, reliability, safety, productivity gains, new investments, and the involvement of local authorities.

5.6.2. California: A structured ambition to promote clean electric mobility

As a national pioneer with a strict and proactive approach regarding clean vehicles, California has developed a structured strategy on the topic over the years. It began in 2002 with the landmark California Clean Cars Law—which pushed for the implementation of stringent GHG emissions standards for passenger cars—with requirements that exceeded by far the federal Clean Air Act. In 2006, it also chose to put emphasis on hydrogen mobility, with the development of the Hydrogen Highway project, consisting of the creation of a series of hydrogen stations throughout the state. Nowadays, California pursues the same strategy with its promotion of electric vehicles through the Zero Emission Vehicle Program, a regulation that requires automakers to sell a certain number of electric cars, defined as a percentage of the automaker's overall sales within the state. This program is supported by the Clean Fuels Outlet regulation, which ensures, among other measures, access to charging stations, along with green car incentives for users, and California's more recent engagement in favor of a fully decarbonized electricity mix by 2045.

5.6.3. Singapore: A comprehensive strategy in favor of an efficient and multi-modal urban transport system

Singapore is implementing a comprehensive policy package, including electronic road pricing, a vehicle quota system, investments in mass transit, and last mile connectivity. This has resulted in an increase in the modal share of public transport from 59 percent in peak hours in 2008 to 67 percent in 2017[86] and a target of 75 percent by 2030, along with car ownership of 107 vehicles per 1000 persons and transport GHG per capita of 1.4 tonnes. Starting from a low base, walking, cycling and personable mobility devices are promoted particularly as first and last mile modes, with the planned expansion of the bicycle infrastructure network to 700 km by 2030. Efficient and electric cars are promoted through a carbon emission-based vehicle scheme (feebates), fuel economy labelling, and emission standards, as well as charging infrastructure. For trucks and commercial vehicles, Euro VI air pollution standards are in place, while an Early Turnover Scheme provides incentives to scrap older vehicles. Finally, as far as ports are concerned, taking into account the need for adaptation, Singapore is building its new Tuas port terminal more than 5 meters higher than the mean sea level, with the aim of guarding against sea level rise.

ENDNOTES

85 https://www.railfreight.com/policy/2019/03/27/swiss-alps-still-see-300000-trucks-too-many/

86 https://www.mot.gov.sg/about-mot/land-transport/public-transport

6. THE CORE GLOBAL ROADMAP OF ACTION FOR GREEN MOBILITY

This section brings together the preceding chapters and proposes a focused list of Green Mobility measures by groups of countries.

Four groups of countries were broadly defined in Chapter 2. The groups are based primarily on the progress toward the Green Mobility goals, in particular climate change mitigation transport GHG emissions per capita) and PM 2.5 air pollution.

International agreements and initiatives provide an initial framework for action (Chapter 3), for both international and national policies. The Catalogue of Measures (Chapter 4) is considered to be broadly applicable in many contexts and most measures are essential in meeting the Green Mobility goals set out in Chapter 1. However, in the short to medium term, 2020–30, some measures may be more appropriate and necessary for different groups of countries, which are also shown in the country examples (Chapter 5).

This section thus aims to develop the core Global Roadmap of Actions for Green Mobility, and invites governments to consider such priorities for action.

In general, in highly motorized countries, the transport sector is a major GHG emitter in absolute and per capita terms. Air pollution is at medium levels because of policy action in various sectors, while noise affects a large share of the population, especially in urban areas. The level of active mobility varies strongly, from a very low to a medium-high modal share. Transport decarbonization is urgent, and strong action is needed to bend GHG emission trends and address air pollution. Most measures from the Catalogue are applicable, and need to be implemented in an ambitious and integrated manner.

In currently less-motorized countries, there is often a lack of mobility options, especially in rural areas (see paper on Universal Rural Access). But rapid motorization leads to urban congestion and serious health impacts from severe air pollution and noise. Slowing down the rising GHG emissions trend and stabilization in the mid-term is key. Strong air pollution measures are needed immediately, while recognizing the need for space for development. There could be scope for some measures that are appropriate for group A and B countries, such as second- hand vehicle measures, greening, reforming, and electrifying paratransit, upgrading bus transport, hybrid buses, and Euro IV standards.

In addition to these considerations, other relevant factors to consider include:

- Whether the incremental costs are acceptable
- Whether the technology or practice is socially acceptable (though policy may also address this)
- Characteristics of the transport system's infrastructure, vehicles, and practices, such as:
    - Cities' size, planning, and density[87] (for example, two- or three-wheelers could be particularly appropriate in dense cities)
    - Average vehicle age
    - Presence of coastal or inland waterways
    - Rail network density
    - Presence of a domestic vehicle industry.
- Level of technology development and presence of support systems to ensure maintenance of the low-carbon technology.

Table 6.1 shows the core Green Mobility Roadmap of Actions for the four groups of countries, while noting the following challenges: (i) the complexity of having three Green Mobility goals; (ii) the diversity in each

country's transport systems and governance structure; and (ii) the fact that many measures are applicable to multiple or all country categories. Therefore, the Roadmap is of a broad and indicative nature, and the categories should also be taken as such: a measure for high income countries could equally apply to middle-income countries (therefore, in the main GRA report each measure is assigned relevance to each country group). Its intention is to provide sets of key actions and policy recommendations that can be considered by national governments and cities, and supported by the private sector.

Table 6.1: Green Mobility Roadmap of Key Actions.

Country characteristics				
GHG per capita from transport				
Required mitigation ambition	Some leeway	Stabilization strategy required	Mitigation effort needed	Ambitious mitigation effort needed
Air pollution exposure				
Noise	Lack of data			
Recommended actions 2020-2030 by key category				
Factor in environmental externalities	Phase out fossil fuel subsidies	Start internalizing external costs	Comprehensive bottom-up data by freight carrier; Internalization of external costs; Green freight labelling	
Optimizing logistics	Basic, green infrastructure	Freight exchange platform	Consolidation centres	Incentive to reduce empty trips
Modal shift in freight	Develop rail and waterways; address non-tariff barriers		Multi-modal infrastructure; ensure competitive framework; ceiling on total truck load by corridor	
Road freight	Truck age limit for imports; operation and maintenance	Promote efficient technologies, practices, and standards	Fuel efficiency and air pollution standards (Euro VI); Maximum age	
Electric trucks and delivery vehicles (including two/three wheelers)	Niche applications	Niche applications in cities	Broader deployment in cities	Electric road systems; incentives
Avoid and shorten trips	Avoid urban sprawl Compact development	Integration of land-use and transport planning	Transit-oriented development; avoiding sprawl	Promote telecommuting
Active mobility	Basic infrastructure with good coverage, focusing on key nodes; TDM	Quality sidewalks; Dedicated (e)bike infrastructure; TDM	Comprehensive cycling-inclusive planning; pedestrianization	Reassign road space to non-motorized transport (NMT), comprehensive coverage; Low-Emission Zones (LEZ)
Travel demand management	Parking management; traffic calming	Parking management and pricing; traffic calming	Pricing of car purchase and use	Congestion / road pricing

Public transport improvement	Bus reform; Integration of public transit (PT) modes and NMT and paratransit	Integration of PT modes, paratransit and NMT; bus priority lanes	Integration of PT modes and NMT	Integration of PT modes and NMT; LEZ
Clean bus technology	Progressive air pollution standards (Euro IV-VI)	Air pollution standards (Euro VI) and promotion of hybrid buses	Promotion of battery electric and plug-in hybrid buses; charging infrastructure	Incentives for battery electric vehicles (BEVs); phasing out fossil-fuel buses
Two-wheelers	Air pollution standards; O&M	Air pollution and noise standards	Phase out conventional motorcycles	Phase out conventional motorcycles; LEZ
Passenger cars	Labelling and standards; O&M; import limits		Progressive fuel economy and air pollution standards	
Electric vehicles	Promote electric paratransit and decentralized electricity generation	Charging infrastructure	LEZ; charging infrastructure; incentives	Phase-out fossil-fuel cars; LEZ; charging infrastructure; incentives
Clean fuels and vehicles	Reduce sulphur content		Progressive phasing out of diesel in cities	
Advanced biofuels and sustainable synthetic fuels (e.g. for trucks, ships and aircraft)	Decentralized generation with pilot plants	Incentives for scaling up	Incentives for scaling up	Production at scale and focused R&D on new techniques; incentives
Aviation	International agreements under ICAO provide a basis for action by Member States for international aviation (See Annex I), while countries may take, as appropriate, actions for domestic aviation to promote sustainable aviation, enabled by national action plans			
Maritime	International agreements under IMO provide a global basis for action, however countries may take, as appropriate, additional actions to promote sustainable shipping –such as port-based incentives, promotion of electric ships, research, and pilots for sustainable alternative fuels, enabled by national action plans			
Institutional and capacity development	Improved institutional cooperation (transport, energy, environment, industry)	Training and capacity building on transport and GHG in key agencies	Dedicated transport training on environment in central and local government	Climate, air quality, and noise integrated in transport policymaking
Research and development	Frugal solutions; locally appropriate electric vehicles	+ Advanced solutions and circular economy	+ Integrated solutions	+ Negative GHG emissions; zero-emissions trucks, ships, and aircraft
Digitalization and shared mobility	Mobility as a Service options	Legal framework for vehicle sharing	Scaling-up	Shared, semi-autonomous, and climate-friendly
Data, indicators, and monitoring of environmental impacts	Basic transport and emissions data	Continuous improvement of data; GHG monitoring system in support of NDCs	Comprehensive monitoring of environmental impacts	Big data for transport/ energy system optimization

Adaptation	Systematic inclusion of adaptation in the form of long-term national roadmaps. Methodic risk and options assessment and prioritization of vulnerable infrastructure	Long-term adaptation planning included in national roadmaps and new infrastructure planning
	Emergency plans; early warning systems; "building back better" principle; technical standards; systematic maintenance	+ Adaptation oriented project design; Adaptation of existing infrastructure and operations where possible

Notes: GHG emissions per capita correlates positively with income, while air pollution exposure in general decreases with rising income (see Chapter 2). Recommended actions are examples of key actions, and are not specific to one country category only

ENDNOTES

87 See Urban Access paper for a more elaborate list of characteristics or enablers

7. SCALE OF THE CHALLENGE

The potential obstacles to a rapid implementation of the green objectives developed above should not be underestimated. The reason is that, despite all the negative externalities that most people suffer from in a mobility world operating under current paradigms—with growing urbanization, rapid motorization, and car-centric mobility, booming world trade, yet unchanged basic technologies, such as cars with internal combustion engines (ICE)—one cannot deny all the benefits that transport has brought to mankind as a development enabler (see papers on universal rural and urban access). Oil and ICE have enabled a significant proportion of people to enjoy more mobility than ever before in history. Therefore, setting out on a new course appears a daunting task, with risks of failure, social discontent, and economic downturns. As a result, strong action has been delayed over the past two decades, and has unsurprisingly led the world onto unsustainable paths. Governments are now expected to show the resolve to embark on a collective, new, sustainable journey, the definition of which must include cities, companies, and civil society as a whole.

7.1. Fighting resistive trends from vested interests

Of all obstacles to the transition to green mobility, the nexus between fossil fuels and mobility (at 96 percent dependence) is certainly the most critical. Geo-strategically, politically, and economically speaking, oil-producing countries might feel that they have understandable reasons not to accelerate the phasing out of such an element of wealth and power. Furthermore, several countries derive a significant part of their GDP from current (ICE centered) automotive technologies, with the production of cars, trucks, and buses now reaching more than 100 million units/year.[88] With this industry generating dozens of million jobs,[89] directly or indirectly, such countries might not be inclined to change rapidly and profoundly their business or social model. Not to mention the thousands of companies living on the distribution of fossil fuel derivatives—which generate a large share of freight demand. Further, the more than one billion car owners, who are used to the reliability, flexibility, and cost structure of the existing vehicle fleet and its supporting service industry, expect either a level of service provided by low-carbon solutions at least equal to existing ones, or significant economic incentives.

For all these reasons, fossil fuel suppliers today consider that by 2050 oil will still be the dominant fuel source for mobility and transport, with natural gas and electricity taking a growing role. Nonetheless, it must be clear for all decision makers that—as substantiated by International Panel on Climate Change (IPCC) and IEA work—such a scenario is not at all compatible with the objectives proposed in this GRA, and with the Paris Agreement in particular. In fact, the current state of scientific and technical knowledge is not sufficient to enable negative emissions[90] at a level compatible with the need to rapidly reverse the trend observed in net emissions from transport.

Therefore, courageous decisions have to be taken in a coordinated way, both in the energy (Box 1) and the mobility sectors. The role of governments, having cards to play in both sectors, will be crucial to unleash the needed transformation.

7.2. Increasing investment attractiveness in low-carbon technologies through supporting economic instruments

A second difficulty stems from the fact that there are still—and this is normal—some uncertainties about whether or not alternative solutions envisioned for the future can reliably be developed at the required

scale and in good, competitive, economic conditions. Economic instruments must therefore be designed to minimize the risk of investments in long-term low-externality solutions, for example through fiscal tools, guarantees, and amortization schemes. This priority, already brought to the forefront by business in 2015 at the Business and Climate Summit in Paris, has not yet received enough attention. But it must, because companies are the ones that—much more than states—will invest in the new solutions and services, and the level of risk they will be willing to take has its limits.

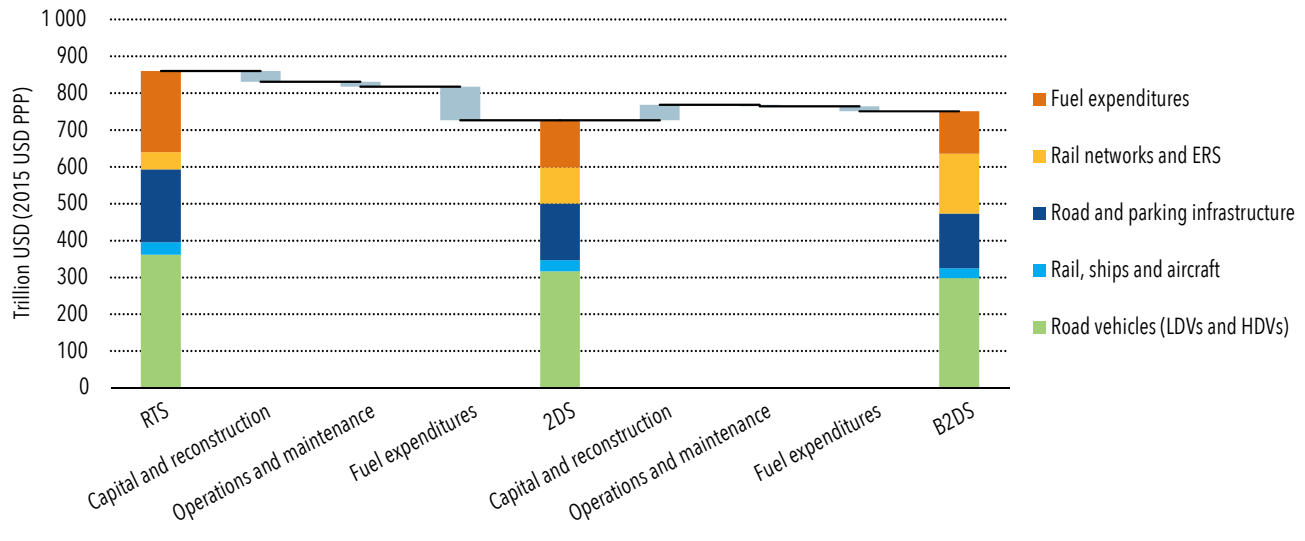
In the same manner, the cost of all key externalities must be formally introduced in the new economy: GHG emissions, pollutants, and noise must have an economic value to enable a long-term transformation of the sector. The current process to introduce CO_2 pricing in all sectors, including on mobile sources, is too slow and too limited in scope to have any substantial impact on mobility or transport redesign. In addition, given existing fuel taxation structures, the carbon price needs to be substantially higher than currently seen to begin playing a role in the transport sector.[91]

7.3. Gauging the real cost of the transformation and its benefits

Conversely, on a very positive side, decision makers must realize that the amount of investments needed to implement the transformation is certainly lower than they might fear, especially when compared to pursuing business as usual.

The International Energy Agency has shown (WEO 2014) that the extra cost of investment in green energies (as opposed to traditional solutions) would not exceed 0.5 percentage point of worldwide GDP. Figure 7.1 below is particularly important: it shows that the cost of action in decarbonizing transport up to 2060 is USD 110 trillion less than the cost of inaction, because action would lead to substantial savings in fuel and car expenditures (IEA 2017). In another example, ambitious cycling and e-biking policies (global "High Shift" cycling scenario) could save USD 0.8 trillion in 2030 and 1.1 trillion in 2050 from vehicles (purchase and operation) and infrastructure (investment and maintenance). This excludes health benefits from active mobility and reduced air pollution.

Figure 7.1: Investment Needs in the 2 Degree and Beyond 2 Degree Scenarios, 2017–2060



Source: IEA Energy Technology Perspectives 2017.

Thereby, countries having low but rapidly rising emissions have an opportunity to decouple emissions growth from economic development, and avoid the lock-in into high-carbon transport systems that many high-income countries are experiencing. Studies show that avoiding such an emissions pathway is possible (Gota et al., 2019)

7.4. Resisting the silver bullet mirage and stressing the need for a range of low-carbon solutions

To lead this transformation to full fruition, it is also essential to drop all dogmatic (simplistic) ideas; within the whole "basket of solutions" that will have to be developed, it would be presumptuous to think that we can forecast to what extent each solution, or sub-solution, will be deployed. In the case of vehicle electrification, for instance, who can predict the respective roles to be played in 2050 by batteries and hydrogen? This is why governments should refrain from pushing too-specific solutions, and focus instead on their role of establishing objectives (e.g. through NDCs), facilitating change through multi-stakeholder scenarios, and creating economic and legal instruments to foster investment in new low-externality products and services[92].

In the same vein, since mass-transit is a key element in the transformation, efforts to improve comfort, attractiveness, and safety for all, flexibility and dependability are essential. The same applies to rail activities, especially for freight, for which the expected shift of activity away from road has unfortunately failed in several countries because of a lack of flexibility and reliability. Consequently, opening this often state-owned sector to the competition and demand orientation of the private sector may help to increase the attractiveness of rail.

7.5. Embarking on a fascinating journey of collective construction

Building an enabling environment requires:

- At the intergovernmental level, a dedication to work toward a renewed international vision for the common good, which must prevail over short-term, narrowly-defined self interest
- At the country level, a necessity for national and subnational governments, together with business and representatives of civil society, to excel in defining a strategy toward an ambitious goal, and then crafting and implementing a shared roadmap.

Both must go hand in hand; it is a matter of vision and political will.

Along these lines, the transformation avenue proposed in this document is undoubtedly steep, because it requires change in most of the "fundamentals" which have, for many decades, structured our quest for a mobile and more prosperous society. But we must adhere collectively to the conviction that if we synergize our efforts along the priorities described here, we can rapidly overcome the hurdles and enjoy the shared accomplishment of building a much better future for a much wider population.

ENDNOTES

88 This figure does not include motorcycles, of which annual production is over 100 million as well.

89 https://ec.europa.eu/growth/sectors/automotive_en

90 See also footnote 8

91 For illustration, a tax of USD 1 per litre of petrol or diesel (common in many countries) would translate into CO2 price of over USD 300/t

92 As an example, the Transport Decarbonization Alliance Manifesto provides a process framework to optimize joint action between countries, cities and companies to decarbonize transport by 2050 (http://tda-mobility.org/wp-content/uploads/2018/12/EY_TDA-Manifesto.pdf)

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ANNEX I. ICAO, INTERNATIONAL CIVIL AVIATION ORGANIZATION

The Convention on International Civil Aviation[93] was established in 1944 to promote cooperation and "create and preserve friendship and understanding among the nations and peoples of the world." Known more commonly today as the 'Chicago Convention', this agreement established the core principles permitting international transport by air, and led to the creation of the specialized agency which has overseen it ever since – the International Civil Aviation Organization (ICAO). As of November 2017, the Chicago Convention has 192 Member States.

ICAO with its 192 Member States develops and maintains the internationally-harmonized environmental Standards and Recommended Practices (SARPs), as contained in Annex 16 – Environmental Protection, Volumes I, II, III and IV to the Convention on International Civil Aviation and other guidance material to address the impacts of international aviation on the environment.

For example, as aircraft noise is the significant cause of adverse community reactions related to the operation and expansion of airports, limiting or reducing the number of people affected by significant aircraft noise is one of ICAO's priorities and key environmental goal. The main overarching ICAO policy on aircraft noise is the Balanced Approach to Aircraft Noise Management[94], which contains details on all the elements that can be employed by Member States to achieve noise reductions:

- reduction of noise at source;
- land-use planning and management;
- noise abatement operational procedures; and
- operating restrictions.

An important pillar of the Balanced Approach is the reduction of noise at source. Aircraft noise has been controlled since the 1970s by the setting of noise limits for aircraft in the form of ICAO SARPs contained in Annex 16, Volume I.

With a view to achieve the global aspirational goals set by the 2010 ICAO Assembly for international aviation CO_2 emissions, ICAO has made important progress on the development and implementation of a "basket of mitigation measures". The "basket" includes advancements in aircraft technology, operational improvements, sustainable aviation fuels, and market-based measures. In 2017, ICAO adopted an aeroplane CO_2 emissions certification Standard, which will apply to new aeroplane-type designs from 2020 and to aeroplane-type designs that are already in-production in 2023. The CO_2 emissions Standard was adopted as Annex 16, Volume III. In 2016, the ICAO adopted a landmark Assembly Resolution A39-3 on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). For the implementation of CORSIA, ICAO recently adopted a new Annex 16, Volume IV in June 2018, containing requirements for Monitoring, Reporting and Verification of CO_2 emissions, to be applicable from 1 January 2019.

Since the late 1970s ICAO has also been developing measures to reduce the impact of aircraft emissions on Local Air Quality (LAQ)[95], focusing on the effects of aircraft engine emissions released below 3,000 feet (915 metres) and also emissions from airport sources, such as airport traffic, ground service equipment, and de-icing operations. One of the principal results arising from the work of ICAO is the development of the ICAO SARPs on engine emissions contained in Annex 16, Volume II, which aims to address potential adverse

effects of air pollutants on LAQ, primarily pertaining to human health and welfare, including gaseous exhaust emissions from jet engines, such as nitrogen oxides (NOx) and particulate matter (PM).

Details on GHG mitigation strategy

The ICAO basket of measures to reduce GHG emissions from international aviation includes the following:

- Use of fuel-efficient aircraft technology

The ICAO Aeroplane CO_2 Emissions Certification Standard has been developed as Annex 16, Volume III with the aim of encouraging more fuel efficient technologies into aeroplane designs. The CO_2 standard has been developed at the aeroplane level, and therefore has considered all technologies associated with the aeroplane design (e.g. propulsion, aerodynamics and structures).

- Air traffic management modernization and other operational improvements

Operational improvements that might be applied to the aviation sector, and which offer the potential to deliver fuel and CO_2 emissions reductions, are defined in the ICAO Global Air Navigation Plan endorsed by the ICAO Assembly.

- Sustainable aviation fuels

Today more than 100,000 flights are operating using aviation alternative fuels. While the technical feasibility has been well-demonstrated, ICAO is now fostering their large-scale deployment. ICAO launched and maintains the Global Framework on Aviation Alternative Fuels[96], which provides an online platform to continuously update activities and developments in the field of sustainable aviation fuels, as well as useful documentation and links, to support information sharing and dissemination for the benefit of the aviation fuels community.

In addition, the second ICAO Conference on Aviation Alternative Fuels (CAAF/2)[97] convened in 2017 adopted a Declaration, including the 2050 ICAO Vision for Sustainable Aviation Fuels as a living inspirational path toward a significant proportion of conventional aviation fuels to be substituted with sustainable aviation fuels by 2050.

- Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

CORSIA[98], the first-ever market based measure programme addressing emissions of a major industry sector at the global level, was adopted by the 39th Assembly in October 2016, through efforts by ICAO and its Member States, in cooperation with the aviation industry and other stakeholders.

To date, 72 States, representing almost 90 per cent of international flight operations have committed to participate in CO_2 offsetting under the CORSIA from its outset, contributing to the achievement of ICAO's global aspirational goal of carbon neutral growth from 2020 and complementing the other elements in ICAO basket of CO_2 mitigation measures. The CORSIA will be implemented in phases, starting with participation of the Member States in CO_2 offsetting on a voluntary basis (from 2021 through 2026) , followed by the participation of all States except the exempted ones (from 2027 through 2035).

ICAO has developed rules and guidance, including for Monitoring, Reporting and Verification of CO_2 emissions from international aviation for implementation by all Member States from 1 January 2019. ICAO is also in the process of determining eligible emissions units which airlines will purchase in order to meet their offsetting requirements under CORSIA.

The preparation and submission of State Action Plans on international CO_2 emissions to ICAO provides the opportunity for Member States to showcase the mitigation measures selected to contribute to CO_2 emissions reductions from international aviation, consistent with their national circumstances. State Action Plans also represent a meaningful data collection, monitoring and reporting mechanism that can serve as a solid basis for decision making on environmental policies and actions to be undertaken by States. At the same time, the Action Plans allow ICAO to monitor progress by States and help address specific needs through more targeted technical assistance.

To date, 107 States, representing over 90 per cent of global aviation traffic have voluntarily prepared and submitted Action Plans to ICAO, due to ICAO's capacity building programme such as holding of regional seminars, provision of tools and guidance material,

and direct contacts by the Secretariat, as well as establishment of buddy partnerships among States to help each other on the preparation and update of State Action Plans. Many States are working to update their plans with more robust quantified data on the expected emissions reductions.

While quantitatively small, air cargo is a trade facilitator that contributes to global economic development and creates millions of jobs. Air cargo transports over US $6 trillion worth of goods, accounting for approximately 35% of world trade by value.

ENDNOTES

93 https://www.icao.int/publications/pages/doc7300.aspx

94 https://www.icao.int/environmental-protection/Pages/noise.aspx

95 https://www.icao.int/environmental-protection/Pages/local-air-quality.aspx

96 ICAO Global Framework for Aviation Alternative Fuels: https://www.icao.int/environmental-protection/GFAAF/Pages/default.aspx

97 Second ICAO Conference on Aviation Alternative Fuels: https://www.icao.int/Meetings/CAAF2/Pages/default.aspx

98 Carbon Offsetting and Reduction Scheme for International Aviation: https://www.icao.int/environmental-protection/Pages/market-based-measures.aspx

ANNEX II. INTERNATIONAL MARITIME ORGANIZATION (IMO)

As a specialized agency of the United Nations, IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping. Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented.

In other words, its role is to create a level playing-field so that ship operators cannot address their financial issues by simply cutting corners and compromising on safety, security and environmental performance.

Shipping is a truly international industry, and it can only operate effectively if the regulations and standards are themselves agreed, adopted and implemented on an international basis. And IMO is the forum at which this process takes place. This role is recognized in other international instruments such as the United Nations Convention on Law of the Seas.

International shipping transports more than three fourths of global trade to peoples and communities all over the world. Shipping is the most energy efficient and cost-effective mode of international transportation for most goods.

In 1997, a new annex was added to the International Convention for the Prevention of Pollution from Ships (MARPOL). The regulations for the Prevention of Air Pollution from Ships (Annex VI) seek to minimize airborne emissions from ships (SOx, NOx, ODS, VOC shipboard incineration) and their contribution to local and global air pollution and environmental problems. Annex VI entered into force on 19 May 2005 and a revised Annex VI with significantly tightened emissions limits was adopted in October 2008 which entered into force on 1 July 2010.

In 2011, IMO adopted mandatory technical and operational energy efficiency measures which are expected to significantly reduce the amount of CO_2 emissions from international shipping. These mandatory measures (EEDI/SEEMP) entered into force on 1 January 2013. IMO has adopted guidelines aimed at supporting implementation of the mandatory measures to increase energy efficiency and reduce GHG emissions from international shipping, paving the way for the regulations on EEDI and SEEMP to be smoothly implemented by Administrations and industry.

The expected growth of world trade represents a challenge to meeting a future target for emissions required to achieve stabilization in global temperatures and so IMO has begun consideration of further technical and operational measures to enhance the energy efficiency of ships.

Amendments to MARPOL Annex VI on Data collection system for fuel oil consumption of ships entered into force on 1 March 2018. Under the amendments, ships of 5,000 gross tonnage and above are required to collect consumption data for each type of fuel oil they use, as well as other, additional, specified data including proxies for transport work. The aggregated data is reported to the flag State after the end of each calendar year and the flag State, having determined that the data has been reported in accordance with the requirements, issues a Statement of Compliance to the ship. Flag States are required to subsequently transfer this data to an IMO Ship Fuel Oil Consumption Database. IMO will be required to produce an annual report to MEPC, summarizing the data collected.

In 2012, international shipping was estimated to have contributed about 2.2% to the global emissions of carbon dioxide. Although international shipping is

the most energy efficient mode of mass transport and only a modest contributor to overall CO_2 emissions, a global approach to further improve its energy efficiency and effective emission control is needed as sea transport will continue growing apace with world trade. As already acknowledged by the Kyoto Protocol, CO_2 emissions from international shipping cannot be attributed to any particular national economy due to its global nature and complex operation. Therefore, IMO has been pursuing the limitation and reduction of greenhouse gas (GHG) emissions from international shipping, in recognition of the magnitude of the climate change challenge and the intense focus on this topic.

On 13 April 2018, MEPC 72 adopted resolution MEPC.304(72) on Initial IMO Strategy on reduction of GHG emissions from ships. The "Vision" set out in the text of this "Initial Strategy" confirms IMO's commitment to reducing GHG emissions from international shipping and, as a matter of urgency, to phasing them out as soon as possible in this century.

The Initial Strategy envisages for the first time a reduction in total GHG emissions from international shipping which, it says, should peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals.

Levels of ambition also include reviewing with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate and reduction of CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008.

The reviews of these levels of ambition should take into account updated emission estimates, emissions reduction options for international shipping, and the reports of the IPCC as relevant.

The Initial Strategy represents a framework for further action, setting out the future vision for international shipping, the levels of ambition to reduce GHG emissions and guiding principles; and includes candidate short-, mid- and long-term further measures with possible timelines and their impacts on States. The strategy also identifies barriers and supportive measures including capacity building, technical cooperation and R&D.

According to the Programme of follow-up actions of the Initial Strategy up to 2023 approved by MEPC 73 in October 2018, the consideration of concrete proposals on candidate short-term as well as candidate mid-/long-term measures should start from May 2019. Candidate short-term measures are expected to be finalized and agreed between 2018 and 2023 with a view to achieve further reduction of GHG emissions from international shipping as soon as possible.

ANNEX III.
INTERNATIONAL UNION OF RAILWAYS (UIC)

ENERGY CONSUMPTION AND EMISSIONS REPORTING (ENVIRONMENT STRATEGY REPORTING SYSTEM)

European Railway operators pledged to reduce their carbon footprint through the UIC CER Commitment. Based on this commitment, UIC is gathering energy consumption and Carbon Dioxide (CO_2) and air polluting (PM and NOx) emissions data via the Environmental Strategy Reporting System in the "Energy and Environmental Database", which is fed on a yearly basis since 2005.

European Railways have set, with UIC, targets for 2030 in the fields of Climate Protection, Energy Efficiency, Exhaust Emissions and Noise & Vibration.

UIC's Sustainable Development Unit is currently working in improving data's consistency and to adapt the targets so that Worldwide companies willing to provide their data can be included in the reporting.

GREENHOUSE GAS EMISSIONS:

Target 2030

The European railways will reduce their specific average CO_2 emissions from train operation by 50% compared to base year 1990; measured per passenger-km (passenger service) and gross tonne-km (freight service).

They will reduce their total CO_2 emissions from train operation by 30% in absolute terms compared to base year 1990.

Vision 2050

The European railways will strive towards carbon-free train operation by 2050 and provide society with a climate neutral transport alternative.

ENERGY EFFICIENCY:

Target 2030

The European railways will reduce their specific final energy consumption from train operation by 30% compared to the base year 1990; measured per passenger-km (passenger service) and gross tonne-km (freight service).

Vision 2050

The European railways will strive towards halving their specific final energy consumption from train operation by 2050 compared to the base year 1990; measured per passenger-km (passenger service) and gross tonne-km (freight service).

EXHAUST EMISSIONS:

Target 2030

The European railways will reduce their total exhaust emissions of NOx and PM10 by 40% in absolute terms, even with projected traffic growth compared to the 2005 base year.

Vision 2050

The European railways will strive towards zero emission of nitrogen oxides (NOx) and particulate matter (PM10) from non-electric trains by 2050.

ANNEX IV. DRAFT LIST OF GRA POLICY MEASURES RELEVANT TO GREEN MOBILITY

The list of policy measures identified in this paper (see Chapter 4) to achieve green mobility has been consolidated and harmonized with the policy measures to achieve all other policy goals toward sustainable mobility. The Global Roadmap of Action toward Sustainable Mobility provides the consolidated list of measures.

The consolidated policy measures that have an impact on green mobility are shown in the tables below.

Table IV.1: Policy Measures with Description (by toolbox and thematic area, with an impact on green mobility)

Policy Measure	Policy Measure Description
Toolbox: Regulatory and Institutional	
Thematic Area: Plans and Strategies	
Develop an Integrated National Transport Plan	Develop and implement an integrated national transport plan to cover the four policy goals, all modes of transport, and passenger and freight traffic.
Set Targets across Policy Goals	Set clear targets to be achieved in the long term and in the interim for the four policy goals, aligned with an integrated sustainable mobility plan.
Develop Mobility Plans at the Sub-National Level	Develop a sustainable urban mobility plan and implement strategies at the sub-national level that are consistent with the integrated national sustainable transport plan.
Plan for Integrated Multimodal Transport Networks	Plan for the optimal location of transport corridors, linear facilities, and hubs from a multimodal network perspective, based on the analysis of freight origins and destinations, including a rail network development plan.
Adopt TOD Principles in Land Use Planning	Adopt integrated land use planning that supports transit-oriented development (TOD), mixed land use and compact city planning, reforming development policies and zoning codes, limiting urban expansion, and incorporating rail network development in urban planning.
Address Green and Low Carbon Shipping in Transport Plans	Ensure that the national transport plan addresses low-carbon and green shipping and describes the financial instruments to support it, including incentives and technology support programs.
Provide Policy Certainty to Businesses and Investors	Ensure a stable regulatory and policy framework, setting a timeline sustainable mobility targets, to increase the confidence for businesses and financial investors to make long-term decisions.
Thematic Area: Institutional Design, Cooperation, and Coordination	

Policy Measure	Policy Measure Description
Coordinate Planning across Government Agencies	Coordinate across agencies to ensure integrated planning and shared responsibility for results across levels of government, jurisdictions, and agencies, including but not limited to the coordination of road safety responsibilities and the coordination of response to extreme weather events.
Define Roles and Accountabilities across Agencies	Define government roles, responsibilities and accountabilities in the transport sector across the four policy goals, modes of transport, national and sub-national government levels, and passenger and freight transport.
Establish a Metropolitan Transport Governance	Establish a governance structure and an institutional framework for transport at the metropolitan level.
Thematic Area: International agreements and regulations	
Remove Non-Tariff Barriers for International Trade	Remove non-tariff barriers for cross-border traffic, including barriers for rail and waterborne transport.
Accede to and Implement International Conventions	Accede to and implement relevant international agreements and conventions that address one or more policy goals, for example, the TIR Convention, the WTO Trade Facilitation Agreement, or core road safety-related UN legal instruments.
Adopt Trucking Cabotage Rules	Adopt cabotage rules to optimize trucks' load factors, i.e., allow truck transport between two places in the same country by a transport operator from another country.
Implement ICAO's Carbon Emission Scheme	Adopt sector specific emission mitigation approaches such as the Carbon Offset and Reduction Scheme for International Aviation (CORSIA).
Implement IMO's Energy Efficiency Framework	Strengthen and implement the International Maritime Organization's energy-efficiency technical and operational framework, including ship design standards, and pollution standards and regulations
Thematic Area: Regulations for Transport Services	
Adopt a Coherent Competition Policy	Adopt a coherent competition policy for passenger and freight transport based on the principles that competitive markets are central to efficiency, and acknowledge that market failures in the transport sector require regulation.
Regulate Truck Size and Weight Limits	Adopt regulations of truck size and weight limits by transport corridor.
Regulate Freight Delivery Hours in Urban Areas	Introduce regulations about the hours and areas in which freight delivery in urban areas is allowed to reduce congestion and noise pollution, mindful of the important role of freight delivery for economic activity.
Remove Barriers to Intermodal Interoperability	Remove regulatory barriers to improve inter-operator and intermodal interoperability.
Allow and Regulate Vehicle Sharing and TNCs	Reform regulations to allow and support vehicle sharing programs (cars, bicycles, scooters), transportation networking companies (TNCs), and demand-responsive transport solutions, with a focus on last mile connectivity to high capacity modes, and support vehicle-sharing community networks such as car-sharing fleets within companies and administrations.
Review transport regulations periodically	Promote the periodic review of the regulations to allow the fast-moving mobility solutions to evolve towards a sustainable and inclusive transport system

Policy Measure	Policy Measure Description
Thematic Area: Regulations for Vehicles and Vehicle Use	
Define and Enforce Speed Limits	Define and enforce speed limits according to modal mix, road function, and protective qualities of roads.
Define Low Emission Zones in Cities	Define low emission zones (LEZ) in cities, i.e., areas where the most polluting vehicles are regulated through access restrictions, which could be based on vehicle emission standards or vehicle age, and enlarge them progressively.
Limit the Number of Parking Spaces in New Developments	Replace parking minimum requirements with caps (maximum limits) and other policies that support parking management.
Establish Electric Vehicle Manufacturing Mandates	Establish mandates for manufacturing electric vehicles and gradually increase their supply.
Limit the Number of New License Plates for Cars	Implement restrictions on vehicle ownership by limiting the number of new license plates issued.
Limit the Import of Second-Hand Vehicles	Limit the import of second-hand fossil fuel motor vehicles beyond a maximum age, including 2- and 3-wheelers.
Establish More Stringent Fuel Economy Standards	Establish stricter fuel economy standards and CO_2 emission standards for new motor vehicles, as well as stricter fuel specifications, for example, the use of low-sulphur petroleum products.
Set Fuel Quality Requirements and Blending Mandates	Determine fuel quality requirements, for example, the use of low-sulphur petroleum products, and blending mandates to support alternative fuels.
Require Periodic Vehicle Inspection	Require periodic vehicle inspections to ensure vehicles conform to regulations governing emissions and safety.
Establish Stricter Noise Pollution Standards for Vehicles	Establish stricter noise pollution standards for road transport vehicles.
Adopt Emission Standards for Aircraft	Adopt the ICAO engine emissions standards and implement the ICAO airport air quality manual to minimize the impact of aviation emissions on local air quality (LAQ).
Adopt Noise Management Approaches to Aircraft	Adopt the ICAO balanced approach to aircraft noise management to minimize the number of people affected by significant aircraft noise.
Implement Regulations to Prevent Pollution from Ships	Strengthen the design standards and regulations for the prevention of pollution from ships.
Adopt Emission Standards for Rail Transport	Adopt emission standards for diesel-powered locomotives and railcars, for example, the non-road mobile machinery by European Commission regulations.
Support Vehicle Connectivity and Smart Charging Regulations	Implement regulations supporting internationally harmonized vehicle-to-everything (V2X) technologies and smart charging solutions, both in terms of hardware and software, to facilitate the growth of e-mobility

Policy Measure	Policy Measure Description
Thematic Area: Regulations for Data Collection, Share and Use	
Develop Data Repositories and Data Collection Guidelines	Develop centralized data repositories and establish data collection guidelines at the national and metropolitan levels, and facilitate data access to different stakeholders (academics, private sector, etc.) while stablishing a legislative framework defining the context and purpose of its use.
Require Use of Data to Support Decision Making	Require using operational data to support decision making and regulatory oversight.
Thematic Area: Procurement and Contracts	
Use Public Procurement to Support the Circular Economy	Use circular economy principles in public procurement, by which public authorities purchase transport goods, services and works that contribute to closed energy and material loops, minimizing environmental impact and waste creation.
Use Public Procurement to Support Vehicle Electrification	Encourage transport electrification through the public procurement of electric vehicles, for example electric buses for public transport.
Establish Green Procurement Practices	Establish green procurement practices so that environmental criteria play a role in determining which firm gets a service contract.
Thematic Area: Capacity Building and Human Resource Development	
Identify and Empower Sustainable Mobility Champions	Identify and Empower Country Champions to Help Move Forward the Sustainable Mobility Agenda, for example, ministers and mayors.
Build Capacity Across Levels of Government	Build national and local capacity across levels of government, jurisdictions, organization, and modes, including providing training and information resources.
Provide Training for Workforce in Leadership Positions	Provide training for the current and future transport workforce in leadership positions, enabling well-trained staff to drive change toward sustainable mobility.
Facilitate Capacity Building at the International Level	Facilitate sector specific capacity building at the international level.
Create Mentoring Programs and Professional Networks	Create programs to promote role models, mentoring and networks of transport professionals, including programs targeted to women.
Toolbox: Engineering and Technology	
Thematic Area: Technical Standards	
Establish Technical Standards for Transport Infrastructure	Establish high technical standards for transport infrastructure design, for example, performing climate vulnerability screening, protecting roads against water penetration, and using local materials and resources when feasible.
Ensure Integration of Public Transport and Bicycles	Ensure physical integration between public transport and bicycles, for example, providing bicycle parking and allowing bicycles in public transport (with limitations because of vehicle size or passenger density).
Set Design Standards for Sidewalks and Bicycle Paths	Set high quality design standards for sidewalks and bicycle paths, for example, safe and convenient pedestrian crossing and adequate street lighting, ensuring accessibility to persons with disabilities and considering gender sensitive aspects (for example, dropped kerbs at crossings, size of refuge islands, and timing of traffic signals).

Policy Measure	Policy Measure Description
Set and Implement Climate Change Adaptation Standards	Set climate change adaptation and resilience standards and practices, and integrate them into project design across transport infrastructure, including roads, airports, and seaports.
Set Low-Noise Engineering and Traffic Management Practices	Set traffic management practices to reduce noise pollution, for example, speed limitations, speed humps, traffic lights coordination and roundabouts, and low-noise road engineering and maintenance practices, for example low-noise pavement and noise barriers.
Coordinate New Transport and Telecom Infrastructure	Coordinate among the different civil works necessary for new mobility infrastructure, for instance, road and telecommunication infrastructure, in order to maximize synergies and limit costs
Thematic Area: Asset Construction	
Build Complete Multimodal Networks	Build complete multimodal networks ensuring optimal network operational availability.
Build Rail and Maritime Transport Infrastructure	Build infrastructure for energy- and space-efficient modes such as rail and waterborne transport, including high-speed rail for corridors with sufficient demand.
Expand Public Transport Infrastructure	Expand the public transport network adjusted to demand requirements, with an emphasis on equitable access and considering the most appropriate modes in each context, including bus, rail, demand-responsive service, cable-propelled transport and ferry transport.
Prevent the Construction of Urban Expressways	Prevent the development of new urban expressways to avoid the segregation of neighborhoods and to avoid additional car travel.
Build Logistics Consolidation Centers	Build logistics consolidation centers and exchange platforms with a focus on multi-modal transport to avoid fragmented supply, production, and distribution chains, fostering private sector participation in investment and operations of logistics hubs.
Develop Infrastructure for Road Transport Electrification	Develop infrastructure for road transport electrification, such as charging stations, electric road systems, including electricity and hydrogen power for trucks, cars, buses, etc.
Invest in Port Electrification	Invest in infrastructure for port electrification, such as electric charging facilities in ports and hybrid and electric ships.
Invest in Railway Electrification	Invest in railway electrification, battery-hybrid trains, biogas or hydrogen-powered trains, to reduce the dependence on diesel fuel, increase energy efficiency, and reduce noise and vibrations.
Expand the Network of Bicycle Lanes	Build quality and safe infrastructure for cycling, with a focus on protected bicycle lanes.
Repurpose Road Space to Allow Access for All Modes	Repurpose existing road space with complete street designs accommodating diverse users and uses, with access for all modes, particularly pedestrians and cyclists and their access to public transport stations.
Invest in Sustainable Fuel Storage for Ships	Invest in facilities for the production and storage of sustainable alternative fuel for ships.

Policy Measure	Policy Measure Description
Modernize Railway Infrastructure	Modernize rail infrastructure by investing in lightweight rail vehicle components, electronic brakes, aerodynamic shape of rolling stock, and energy consumption metering system, with the aim of improving energy efficiency.
Thematic Area: Design and Deployment of Transport Services	
Improve the Quality and Safety of Public Transport	Improve the quality and safety standards of public and private as well as formal and informal public transport operations, such as service frequency, reliability, cleanliness, and safe driving practices, and implement bus lanes and other bus priority measures.
Provide Effective Car and Bicycle Sharing Systems	Provide effective shared car and bicycle-sharing systems as an alternative to vehicle ownership.
Support Truck Platooning Strategies	Support truck-platooning strategies based on trucks equipped with state-of-the-art driving support systems closely following each other.
Provide Eco-Driving Training for Truck Drivers	Provide eco-driving training for truck drivers, including driving practices that can reduce fuel consumption without increasing travel time.
Implement ITS Solutions for Providing Transport Information	Implement online platforms and other ITS solutions for providing information on traffic, routes, and transport mode options for both passengers and freight transport
Introduce Pedestrian and Bicycle Means of Delivery	Introduce pedestrian and bicycle-friendly means of delivery.
Adopt Best Practices for Train Driving and Timetabling	Adopt train driving and timetabling practices, such as eco-driving, automatic train operations, driver advisory systems, synchronization of acceleration and braking, and adapting train capacity to activity, to optimize energy consumption.
Implement Railway Electrical Smart Grids	Implement railway electrical smart grids, with cooperation between railway grid and electricity grid managers, for example, by coupling storage facilities with renewable energy, using or storing recovered energy from braking trains, and reducing energy losses in catenary.
Integrate New Mobility Solutions to Existing Transport	Support the complementarity of new shared solutions such as car-sharing, electric vehicles rentals and autonomous vehicles with existing public transport networks, for instance by supporting new solutions to direct traffic to public transport stations or as a replacement after operating hours.
Thematic Area: Design and Deployment of Programs	
Adopt Building Back Better Principle for Reconstruction	Adopt a building back better principle, i.e. rebuilding work after disasters and conflicts to be conducted with a decentralized participatory approach for a more cost-effective and sustainable recovery of transport systems.
Identify Risks and Vulnerabilities to Extreme Weather Events	Conduct risk appraisal and impact quantification of failures and disruptions due to extreme weather events, identifying the most vulnerable transport links.
Monitor Weather Events and Develop Warning Systems	Conduct real-time monitoring of extreme weather events, developing plans to take immediate actions to mitigate damage with early warnings.
Support Data Sharing Programs and Platforms	Establish a framework and promote data sharing programs and platforms across different sectors to exchange data relevant for transport policy, such as data collaboratives models including the public and private sector.

Policy Measure	Policy Measure Description
Provide Incentives to Increase Car Occupancy	Provide incentives to increase private vehicle occupancy, for example, high occupancy vehicle (HOV) lanes.
Provide Sustainable Alternatives for Commuting Trips	Encourage initiatives that provide sustainable mobility options for employees, such as employer-sponsored transport programs, carpooling schemes, and public transport commuter benefits.
Implement Telecommuting Policies	Implement policies that allow flexible work schedules and telecommuting, i.e., working from home schemes, to avoid non-essential trips.
Support Freight Parcel Standardization and Containerization	Support corporate initiatives to standardize freight parcels and promote containerization, facilitating intermodal integration.
Develop Vehicle Rental Platforms for Different Types of Use	Provide effective shared car and bicycle-sharing systems as an alternative to vehicle ownership. Promote the use of vehicles adapted to daily needs (i.e. small BEV for daily trips) and offer alternatives renting solutions for exceptional journeys (i.e range-extender or large BEV holidays).
Toolbox: Economics and Finance	
Thematic Area: Project or Program Cycle	
Establish Performance Monitoring and Evaluation Schemes	Establish performance and result monitoring and evaluation schemes to inform the regular adjustment for projects, policies and programs, for example, the evaluation of road safety interventions and their institutional delivery.
Conduct Impact Evaluation Studies	Conduct impact evaluation studies to improve the evidence base available to policymakers, considering the impact of transport infrastructure projects on economic growth and employment, and considering differentiated impacts on women.
Thematic Area: Allocation of Public Funds	
Implement an International Taxonomy for Green Investments	Develop an internationally recognized taxonomy for sustainable and green investments and attach fiscal and regulatory incentives (e.g. reduced solvability ratios) to these investments
Thematic Area: Fiscal and Financial Measures	
Prioritize Financial Products for Sustainable Investment	Reinforce blended finance models both for local multi-stakeholders' projects and large projects requiring the collaboration of several IFIs and private actors. Ensure their promotion towards both public and private actors including financial institutions.
Support Sustainable Mobility Impact Funds	Define regulatory frameworks to facilitate the creation of impact funds targeting sustainable mobility including small scale projects led by start-ups or NGOs. Support existing funds.
Thematic Area: Pricing for Efficiency and Inclusion	
Implement Fuel Taxes and Phase Out Fuel Subsidies	Implement and increase fuel taxes while phasing out fossil fuel subsidies to offset the social cost of greenhouse gas emissions and air pollution.
Use Congestion Charging or Pay-as-You-Drive Schemes	Use congestion charging or pay-as-you-drive schemes to charge for the congestion costs imposed by personal motorized vehicle use, with rates that increase under urban-peak conditions to reduce traffic congestions.

Policy Measure	Policy Measure Description
Implement or Increase Vehicle Registration Fees	Implement or increase vehicle registration fees to support road maintenance funding, reducing the incentives for purchasing a vehicle.
Apply Market-Based Parking Pricing	Apply market-based pricing schemes to on-street and off-street parking, such as variable pricing based on demand.
Promote Green Port Fees	Promote green port fees, charging lower fees to ships that are less polluting.
Provide Financial Incentives to Reduce Environmental Impact	Provide financial incentives, for example subsidies, tax credits, or low tax rates to reduce the environmental impact of transport, including financial incentives for cleaner vehicles, cleaner fuels, old vehicle abatements, and the circular economy.
Make Public Transport Fares Affordable for the Poor	Make public transport fares affordable for the poor using means testes approaches to ensure cost-recovering mechanisms.
Thematic Area: Innovation Policy and Enhancement	
Support Innovation through Regulatory Incentives	Develop a framework at national and sub-national level enabling public-private cooperation to design policies such as targets, regulations supporting technical and business innovation and its diffusion
Provide Financial Incentives to R&D and Innovative Products	Provide subsidies or tax credits to encourage research and development and the supply of innovative products or services.
Support R&D to Reduce Environmental Impacts	Support systematic research and development for technologies that reduce the environmental damage from transport through joint industry and government research, for example, research to optimize the life cycle of batteries for vehicle electrification, alternative fuels (sustainable biofuels, biogas, synthetic fuels, hydrogen) and intelligent transport systems (ITS).
Support R&D to optimize the life cycle of vehicle batteries	Support the research to optimize the life cycle of batteries by improving their lifespan and developing optimal cost-efficient sustainable recycling solutions
Develop a Demand-driven Research Framework	Develop a demand-driven research framework by allowing experimentations at a local level and strong connections with research centers and universities to optimize the R&D process and enable identifying missing technologies
Toolbox: Communication	
Thematic Area: Consultation and Public Engagement	
Use Participatory Planning Methods	Use participatory planning methods, including creation of a website, to help communities propose interventions.
Promote Public Discussion on New Mobility Solutions	Promote public discussion with civil society about new mobility solutions to generate new ideas, innovations and tools.
Ensure Neutrality on Technology related communication	Ensure neutrality and transparency on technology related communication, taking into account the whole life-cycle of technologies when making technology decisions, using for instance LCA (Life Cycle Analysis) methodologies.
Thematic Area: Promotion Campaigns and Public Awareness	
Implement Awareness and Behavior Change Strategies	Implement awareness and behavior change (ABC) strategies to help shift attitudes towards sustainable modes, for example, public transport, walking and cycling, complementing other engineering, legal or economic measures.

Policy Measure	Policy Measure Description
Label Products According to Environmental Performance	Label products and services according to their environmental performance, this includes adopting fuel economy labels clearly displayed on all cars and light trucks for sale, green freight labelling schemes for logistics service providers and eco-rating schemes that allow shippers to choose green freight practices, and labeling products based on their embedded energy use.
Increase Awareness about the Real Cost of Mobility	Insert the topics of sustainable mobility into formal and informal education in order to increase population's awareness of the challenges of mobility (including externalities) and raise the willingness to pay and use efficient, safe and green transport services.
Thematic Area: Knowledge Management and Dissemination of Best Practices	
Share Knowledge on Successes and Best Practices	Share successes and best practices with other agencies at the local, national and international level, based on a well-designed knowledge transfer framework.
Inform Users about New Sustainable Solutions	Promote physical and online information centers aiming to reinforce the demand for sustainable mobility products, and facilitate the understanding of new technologies.