THE ROAD FORWARD:
COST-EFFECTIVE POLICY MEASURES TO DECREASE EMISSIONS FROM PASSENGER LAND TRANSPORT

WITH

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IN ASSOCIATION WITH

SUSTASIS FOUNDATION

ISBN: 978-9403651255 (Paperback Edition)
ISBN: 978-9403651248 (Hardcover Edition)

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PREFACE

This book is a resource for that perennial challenge of all urban policy: implementation. The policies in this case are those aimed at reducing passenger transport emissions on land, and especially (but not exclusively) in urban areas.

The reduction of transport emissions has become a key priority for many cities and towns, particularly as we seek effective action to mitigate the disastrous effects of global climate change. Transport emissions reductions are also essential to improve air and water quality, to promote human health and well-being, to support urban liveability and quality of life, and even to enhance economic performance and competitiveness.

The reality is that high levels of transport emissions impose increasingly high and unbearable costs on governments and citizens. What once seemed a reasonable trade-off for economic development is now looking more like a "road to disaster," economically as well as in other important ways. So-called externality costs, once ignored as hidden subsidies, are increasingly manifesting as heavy transaction costs, affecting cities' and citizens' bottom lines. We can't grow on like this.

It is true that many of the available methods to reduce emissions are capital-intensive and costly (e.g., new generation technologies, mass fleet electrification, etc.). However, in many cities and countries, expensive technical solutions are not yet feasible - at least not in the near future. It is therefore imperative to find and share locally affordable technical and non-technical solutions to curb pollutant emissions from road transport.

Luckily, there are many such solutions available, as this book explores. They occur at a range of scales and costs, and also at a range of implementation scales of time. In many cases, changes made carefully now can pave the way for more dramatic changes later. Relatively modest alterations can help to "future-proof" the transport system for later improvements, like set-aside areas for future pathways, transport stations and vehicle rights of way.

The more expensive technical solutions are often not even the best options for the global environment, and other options – including land use changes,

behavioural changes, and attractive non-motorised and public alternatives to private transport – are often better solutions, at least in the short term.

This is particularly true because only part of the emissions from transport comes from the vehicles themselves – the so-called "tailpipe emissions." We must also consider the embodied energy and emissions of vehicle manufacturing, as well as the embodied and operating energy of transport infrastructure – the streets, bridges, rail lines, signals, and other elements of the system. The fuel extraction, refining and delivery system is another important source of emissions generated for transport end use. For electric vehicles, we must consider the power source and its emissions, as well as the infrastructure for its delivery, and transmission losses and other impacts that contribute to emissions.

Often less well understood are the behavioural patterns of consumption that drive emissions, not only from the vehicles themselves, but also from the relatively high-emissions "choice architecture" of car-dependent places. Research shows that higher emissions from automobiles is closely associated with higher emissions from those who live car-dependent "drive-through" lifestyles. It seems that consumption and emissions drive more consumption and emissions, in a positive feedback loop.

The reduction of transport emissions is a particularly urgent topic in a time of historically unprecedented rapid urbanisation. Increased economic activity and welfare in many developing countries and emergent economies is lifting millions out of poverty and expanding well-being, but also giving rise to increased demand for transportation, and with it, increased level of emissions and resource depletion. There is an urgent need, then, to identify and share effective low-emissions alternatives.

This book is one resource in addressing that need. It is written for political leaders, decision-makers, practitioners, and other stakeholders in the transport sector, as well as for those responsible for land-use and community planning. It provides them with required information and analysis necessary to make decisions on sustainable and cost-effective transport and land-use solutions to reduce emissions. It is not meant to be an exhaustive compendium of solutions – many more will be needed in the years ahead – but rather, a useful contribution toward significant progress on the path ahead.

The book is organized into eight primary chapters. After discussing transport emissions trends and their impacts, we examine a number of low-cost technical options. We then examine demand-side reductions, including pricing signals and other feedback measures. The next section considers land use planning and allocation – a slower form of change, but a more powerful one over time. The optimum allocation of paths and rights of way is discussed in

detail. We conclude with financing and business models, certainly critical implementation topics.

The final chapter provides additional links and references, and further reading and resources.

As the title indicates, we are speaking only of land-based passenger transport, meaning that freight is excluded, as are air and sea passenger lines. Private automobiles and light trucks are included, as are taxis, buses, subway and passenger rail, ride share and TNCs, motorcycles, scooters, bicycles, and of course, pedestrians – those creatures who must begin and end every trip, even if only to a garage or car park. One cannot reduce emissions much from bicycles, of course; however, one *can* reduce emissions a great deal indeed, by shifting modes from private automobiles to bicycles, or to rail and bus. One can also reduce emissions by increasing the number of passengers per trip in private automobiles and decreasing the number of trips.

The emissions from passenger transport are complex, depending on the fuels used and other factors. They carry a range of impacts including damage to human health, ecological damage, and of course, contribution to global climate change. The latter comes from so-called greenhouse gases, of which carbon dioxide (CO_2) is the most prevalent, but by no means the only greenhouse gas emitted by transport sources. Roughly speaking, CO_2 is about eighty percent of all greenhouse gases. It is common in the research literature to combine all greenhouse gases into a "CO_2 equivalent," abbreviated as CO_2e. Herein we will either refer to measurements of CO_2e, or to CO_2 alone, with the understanding that another twenty percent or so of other greenhouse gases should be added to convert CO_2 to CO_2e.

When referring to greenhouse gas measurements specifically, we will generally adhere to research by the United Nations' Intergovernmental Panel on Climate Change (IPCC), peer-reviewed research vetted by them, or inventories measured according to their protocols. One must be very careful, however, to compare apples to apples, and this can be difficult. Inventories reflect different points of time, different definitions of sectors, different national and continental borders, and different kinds of measurements, such as per capita versus aggregate, and sector-based (measured where the activity occurs) versus consumption-based (measured where the consumption occurs that drives the activity). What is important is that all these measurements are aggregated in a consistent way, and in the case of transport, in a way that accurately reflects individual behaviours and consumption patterns. These are, after all, the ultimate drivers of emissions and their impacts.

Finally, the book is aimed at helping to expand the range of solutions to the problem of transport emissions, and to provide more modest-cost alternatives at the local level. It is not looking for "silver bullets" that may never come,

but rather, for "silver buckshot" – for multiple tools and strategies available now, that can not only reduce emissions, but improve quality of life for the residents of cities and towns. It aims to assist in the evolution of a new generation of transport and of its surrounding land use, that is safer, cleaner, more walkable, more transport-supportive, and offering a greater variety of choices in mobility. That, to us, is the road forward.

- The Editors


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1. INTRODUCTION

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1.1 ROAD TRANSPORT EMISSIONS TRENDS

Increased economic activity in both developed as well as developing countries along with globalisation is leading to higher income levels and thereby to changes in lifestyle, new patterns of mobility and comfort. This is in turn leading to increased car ownership, kilometres driven, increased levels of fossil fuel combustion and thereby, to increased levels of both local and global emissions. According to the 2021 World Energy Outlook (WEO), the transport sector has had the fastest growth in CO_2 emissions of any sector during the last years. In the WEO report it is mentioned also that transport emissions are nearly 2.5 Gt higher in the announced pledges scenario (APS) compared to the net zero emissions by 2050 scenarios (NZE), with road transport standing for around three quarters of the gap between the APS and the NZE scenarios [1].

Figure 1.1 shows the development of fuel consumption for both gasoline and diesel during the last decade. The steadily increasing trend in fuel consumption from 2010 to 2019 is disrupted in 2020, which is most likely the result of the pandemic that started in the beginning of 2020 and continued through 2021, though it showed signs of waning with the development and deployment of vaccines during 2021. The trend shown in Figure 1.1 corresponds to gasoline and diesel consumption for land transport including freight transport and passenger transport (both public and private). Therefore, the decrease in fuel consumption from land transport observed in 2020 does not necessarily mean that the consumption of gasoline and diesel for private car passenger transport decreased too. On the contrary, there are all the reasons to believe it may have even increased because of the recommendations given by the health authorities in many countries not to use public transport to avoid the spreading of the virus. In a similar way, the pandemic had also a significant impact on economic activity, which led to a decreased demand for freight transport and hence to a decreased demand for fuel, especially diesel.

It makes sense to believe that the increase in private car driving may persist or even increase in the coming years. The rationale behind this is that in the same way it takes some time for people to adapt to new habits; it takes also some time for them to leave the newly adopted habits; particularly if these new habits are associated with increased flexibility and comfort. It is therefore

believed that in most of the countries wherein owners of private cars that were not using their cars before the pandemic (yet started to drive their cars following the recommendations of health authorities) will continue to use their private cars even after the ongoing pandemic is over-- and for some time to come. Although there are yet no data available to support this assumption, it makes sense to believe this could be the case.

In the absence of appropriate incentives/disincentives, policies and regulations that can prevent the expected development described above, and at the same time speed up the deployment of cleaner and more fuel efficient vehicles, this development is likely to continue.

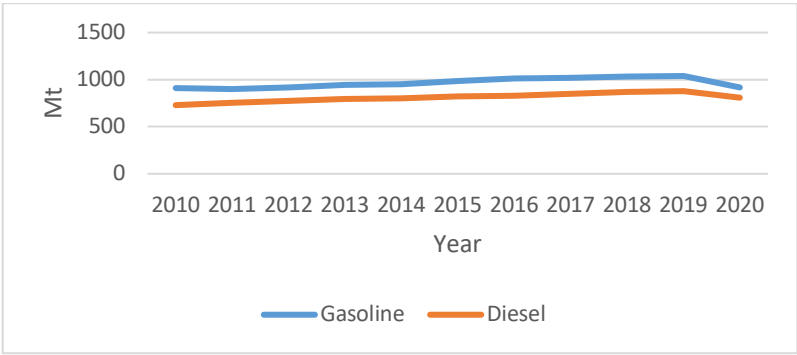

Figure 1.1 Road transport gasoline and diesel consumption (ethanol and biodiesel excluded), 2010-2020. Source: compiled by the author using data from ENERDATA.

The amount of fossil fuel consumed is directly proportional to the amount of both local and global emissions, of CO_2, this being one of the main precursors of climate change. In times of increased global temperature and the irreversible consequences it may have on our planet, these emissions are of particular concern. The direct relationship between fossil fuel consumption and CO_2 emissions is also reflected in the development of global CO_2 emissions over the same period from land transport as shown in Figure 1.2.

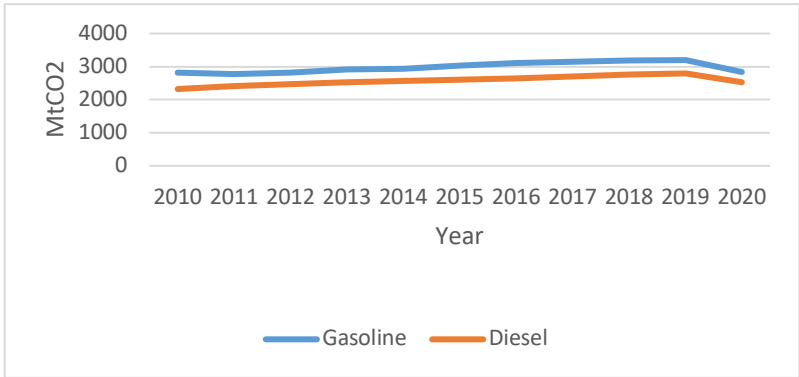

Figure 1.2 Global CO_2 emissions from land transport gasoline and diesel consumption (ethanol and biodiesel excluded), 2010-2020.Source: compiled by the author using data from ENERDATA.

Although the share of electric vehicles (EVs) in the global vehicle fleet has been steadily increasing during the last years, this is taking place mostly in high-income developed countries and not in poor developing countries. To expect EVs to be the solution to a global problem is still far from realistic for many low-income developing countries, where EVs are still not affordable. Much of the generation of electricity is also from fossil fuels, meaning that fleet electrification is far from a complete solution, even where it occurs. Therefore, more affordable technologies that can mitigate emissions are needed. In addition to this, policies and incentives leading to changed behaviour are needed. Reducing the level of emissions from land transport is not an easy task, nor there is a one size fits all solution. Nevertheless, there are a number of affordable options that could be applied to achieve this objective. These options will be presented in this chapter, and further elaborated in following chapters of this book.

The transport sector, and in particular the land transport sector, can play a crucial role in the objective of slowing down the current development due to its great emissions reduction potential, as nearly a quarter of the total emissions of CO_2 are originating from this sector (Figure 1.3). To exploit its full potential, a combination of policy measures, low-cost technical and non-technical solutions must be considered. These policy measures and solutions must take into consideration also the prevailing conditions of the particular country or city where those will be implemented. In this context, it is also very important to consider the specific social and cultural circumstances prevailing in the particular country.

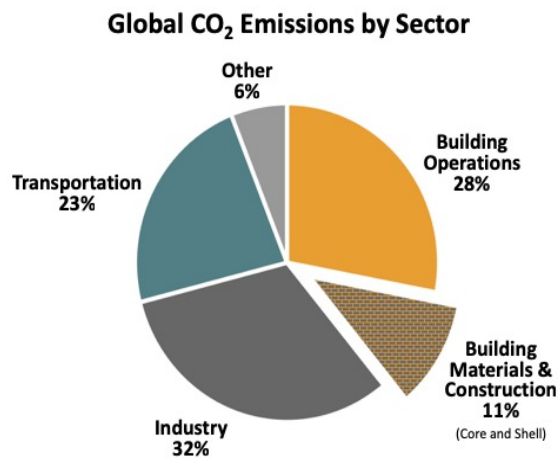

Figure 1.3 Share of CO_2 emissions by sector in 2018. Source: Global Alliance for Buildings and Construction, 2018 Global Status Report.

Of the total amount of the emissions from the transport sector as a whole, around 80% are originated by land transport alone (Figure 1.4).

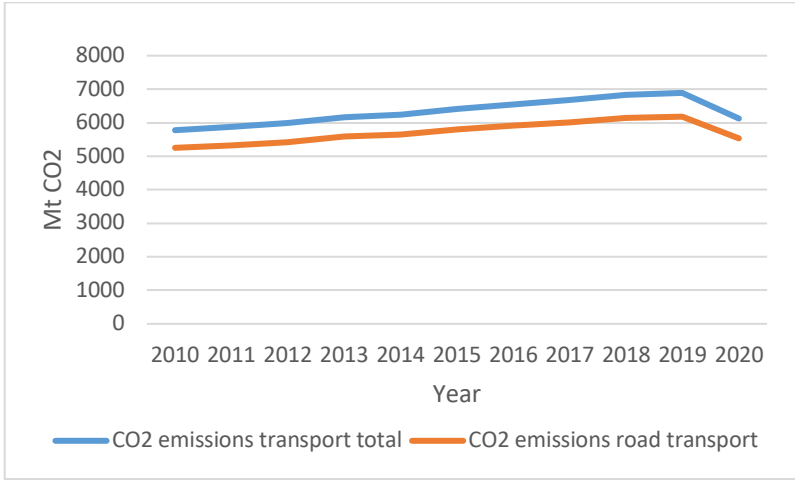

Figure 1.4 CO_2 emissions transport sector (total and land), 2010-2020. Source: compiled by the author using data from ENERDATA.

Currently, and in contrast to other sectors, which have been decreasing the levels of emissions during the last decade, with exception of 2020, emissions from land transport have been steadily increasing. For instance, the share of

land transport emissions in the EU increased from 13% in 1990 to around 20% in 2013 [2]. Global CO_2 emissions from the transport sector increased from approximately 5,300 Mt in 2010 to around 6,200 Mt in 2019, which is an increase equivalent to 17%.

1.2 WHY IT IS IMPORTANT TO REDUCE EMISSIONS FROM LAND TRANSPORT

Despite the fact that the negative impacts of air pollution on the environment (both local and global) are well known by the majority of people, and even directly perceived by many, there is still a minority of people and governments all over the world that are not fully aware of the consequences of it. Air pollution can be defined as the presence or concentration of substances in the atmosphere emanating from activities like fossil fuel combustion at levels that are harmful to human health and damaging for both the local and global environment. At the local level, these substances seriously affect human health and cause deterioration to cultural heritage by damaging, amongst others, materials, monuments and buildings. Some of the local land transport pollutants to which the mentioned impacts can be attributed to are: nitrogen oxides (NOx), sulphur oxide (SOx), particulate matter (PM), carbon oxides (CO) and volatile organic compounds (VOCs). These pollutants affect the local environment and human health in different ways with increased mortality and loss of productivity being some of the impacts. At the global level, the most known impact from the release of greenhouse gas (GHG) emissions into the atmosphere causing atmospheric pollution is climate change. Some of the impacts caused by these emissions on ecosystems and on the global climate system may be already irreversible-- and if emissions are not significantly reduced, further damages may be irreversible and of an unprecedented magnitude. One of the largest GHG contributors to climate change is CO_2. The increasing level of CO_2 emissions in the atmosphere over time is contributing to increased average temperature on our planet with consequences such as melting glaciers, increased frequency and intensity of extreme events. Some of the extreme events are storms and flooding, as recently observed in in the USA and Central America, and droughts and forest fires, as observed in recent years in Australia and the USA, in some European countries like Portugal and Spain, as well as in some Nordic countries like Sweden.

At the same time, transport, and in particular road transport, is vital for societies by providing a series of benefits. It allows the movement of people and goods, which are essential for life; it supports economic growth, which gives rise to increased employment, improved wellbeing, standards of living and comfort. However, for all these benefits not to be outweighed by the negative impacts, transport systems need to be planned in an integrated and sustainable manner, and emissions from this sector (both local and global)

significantly reduced. In 2018, motorised road transport (cars, trucks and light-duty vehicles) stood for over 80 percent of the total CO_2 emissions originating from the transport sector as a whole (Figure 1.3).

1.3 HOW IT CAN BE DONE, WITH MINIMAL COST AND MAXIMUM BENEFITS

Despite the fact that low cost measures such as regulations (mandated by law) and policies in the form of economic incentives/disincentives are sometime seen as less effective instruments to achieve emission reductions from the transport sector, experience shows, however, they can be effective and generate a number of benefits at the same time. Today there is evidence showing, for example, that the introduction of vehicle environmental standards like more fuel efficient and cleaner vehicles have resulted in reduced emissions in Europe. This thanks to the fact that most car manufacturers are complying with the imposed environmental standards and manufacturing more fuel-efficient and hence, low emission vehicles. The fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change, points out improved energy efficiency as one of the most important instruments to combat climate change. The transport sector is one of the largest energy consuming sectors and can, therefore, through improved fuel efficiency, play a significant role in reducing fuel consumption-- thereby combating climate change.

The International Council on Clean Transportation (ICCT) has been reviewing the impacts resulting from EU's fuel economy standards since 2001, and has found that, compared to the baseline scenario without mandatory CO_2 standards, CO_2 emissions have decreased on average by 18% thus reducing the total amount of annual emissions across Europe by 40 million tonnes [3]. Environmental standards, including improved fuel efficiency, constitute often a very low-cost measure for car buyers, since apparently, not much of the extra cost has been passed on to car owners.

Another low-cost policy measure that has proven to give rise to multiple benefits besides reducing emissions is Eco-driving. It has been already incorporated as an additional component in car driver courses in many countries, thus implying a marginal incremental cost. Eco-driving has been increasingly recognised as having a significant potential to reduce fuel consumption and thereby, both local and global emissions. Other benefits that can be mentioned are economic savings for car drivers (because of a more friendly driving style), and decreased level of noise pollution (due to more smooth acceleration and deceleration). Another important benefit of Eco-driving, because of a more friendly and relaxed driving style, is reduced number of accidents and hence reduced health care costs and saved lives. Eco-driving programmes have been introduced in countries outside Europe with

Japan and the USA being some of the examples. The multiple benefits have been observed when training has been given to private-car drivers as well as to bus and truck drivers. The main principles of Eco-driving will be covered more in detail in Chapter 3.

Fuel pricing policies constitute another effective policy measure. As mentioned earlier, they are an effective economic incentive/disincentive to achieve decreased fuel consumption and thereby reduced emissions. Although the impact of fuel taxes is slow, and sometimes insignificant in the short run – mainly due to the fact that car owners need some time for adaptation – the effect is more significant in the long run. A considerable number of studies on price elasticities show a positive price elasticity of between 0.5 and 1.5 [4]. For instance, estimations on fuel price elasticities for the Latin American region show a long-run price elasticity of around -0.6, which means a 10% increase in the price of fuel will give rise to a 6% decrease in the consumption of fuel [5]. Even though these elasticities were estimated more than a decade back, changes in fuel consumption due to fuel price increases are still prevailing, which can be confirmed by a number of studies undertaken later. A more extended explanation of how fuel-pricing policies work and the impact they may have in reducing private motorisation and fuel consumption is provided in Chapter 5.

There are a number of other measures that can be adopted by car drivers at a very low cost and which have significant benefits. One example is anti-idling, which has proven to have significant positive impacts by reducing both local and global emissions. There are several examples where anti-idling regulations have been introduced. The way anti-idling regulations are put in place and how they work will be further elaborated in Chapter 3. The introduction of low rolling resistance tyres (LRT) constitutes another example of low-cost measures. Other low-cost policy measures that have been implemented elsewhere are the introduction of car labelling. Massive campaigns to promote the use of bicycles including information about the multi benefits of biking is another example of a low-cost measure. These types of campaigns have been successfully implemented in a number of Latin American cities like, Bogota, Colombia; Quito, Ecuador; Santiago, Chile; Lima, Peru, and Concepción, Chile. In these cities, the implementation of massive campaigns promoting the use of the bicycle and its associated health and environmental benefits have resulted in a significant increase in the number of people starting to bike and that have started to consider the bicycle a valid and healthy mode of transportation. Below a massive campaign to promote the use of the bicycle in Concepción, Chile.