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Evaluating 15 years of transport and environmental policy integration

TERM 2015: Transport indicators tracking progress towards environmental targets in Europe

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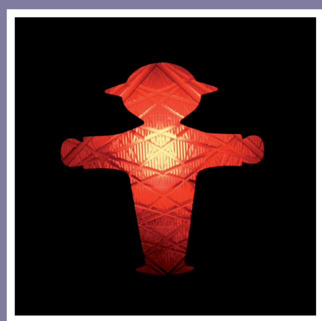

European Environment Agency

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European Environment Agency

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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Executive summary

The Transport and Environment Reporting Mechanism (TERM) report has been monitoring progress in integrating environmental objectives into transport since 2000. TERM 2015 is launched at the end of the year in which the European Environment Agency (EEA) launched its report *European environment: State and outlook 2015* (SOER 2015) (EEA, 2015a).

SOER 2015 analyses the state of, trends in and prospects for Europe's environment in the context of the European Union's (EU's) Seventh Environment Action Programme (7EAP) and its 2050 vision of a Europe 'Living well, within the limits of our planet' (EU, 2013a). The headline messages in SOER 2015 include the following:

- policies are working, however, the level of ambition of existing environmental policy may be inadequate to achieve Europe's long-term environmental goals;
- 'Living well, within the limits of our planet' requires fundamental transitions in the systems of production and consumption that are the root cause of environmental and climate pressures;
- such transitions require profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking;
- achieving this level of commitment could put Europe at the frontier of science and technology, but it calls for a greater sense of urgency and bold actions.

These messages are also directly applicable to Europe's transport sector, both with their clear reference to the challenges ahead if Europe is to meet the objectives of the 7EAP and also the longer term ambition of developing a low-carbon economy. These messages create a context for this year's TERM 2015 report and the planned forward-looking TERM 2016 publication.

Fifteen years after the publication of the first TERM report, TERM 2015 takes a retrospective look at the transport sector, highlighting the past key developments in Europe's overall policy framework for reducing the environmental impacts of transport. This year's report summarises key environmental trends and looks at the factors behind them, with a view to identifying what has improved and what has hampered the environmental performance of the transport sector.

The changing European transport policy framework

Europe's policy framework for reducing the environmental impacts associated with transport activities has evolved substantially since the early 1990s. The introduction of a number of EU policy instruments addressing specific environmental areas, such as air pollution and climate change and, to a lesser extent, noise and biodiversity, have played an important role in reducing the environmental impacts caused by transport. More recently, steps have been taken towards greater integration and policy coherence between climate, energy and transport policies. The importance of defining targets against which progress can be measured has increasingly been recognised, as well as the need for proper monitoring of policy implementation and *ex post* effectiveness.

TERM 2015 describes several of the 'primary' policies introduced in the transport sector that have included increasingly stringent technical standards, for example limits for the exhaust emissions of air pollutants and for the average CO_2 emission standards for new passenger cars and vans and noise standards for various types of engine and equipment. The future role of additional policies promoting more environmentally friendly transport modes, such as the EU Railway Packages and the revised TEN-T (Trans-European Transport Network) guidelines for transport infrastructure, is also presented.

The roadmap to a single European transport area — Towards a competitive and resource efficient transport system (EC, 2011a) (referred to as the 2011 Transport White Paper) sets out 40 initiatives needed to help Europe develop a competitive transport system, reducing Europe's dependence on imported oil and reducing carbon emissions from transport by 60% by 2050 while supporting growth and employment.

Included in the core of the 2011 Transport White Paper were the principles of 'user pays' and 'polluter pays'. Consistent with this is the use of market-based instruments, which are increasingly being chosen as policy options to help mitigate transport's environmental impacts. The road user charges, which are allowed for by the Eurovignette Directive (Directive 2011/76/EU amending Directive 1999/62/EC) in order to address environmental externalities associated with the use of heavy-duty vehicles (HDVs), is one such example of a policy instrument consistent with 'user-pays' principles. In 2015, 27 of the EEA's 33 member countries had some type of road charging for HDVs in place. The incorporation of aviation into the EU Emissions Trading System (ETS) for greenhouse gases (GHGs) is another such example of market-based instruments described in this report.

Finally, the use of subsidies remains widespread in the EU, including in the transport sector. While certain public subsidies are generally beneficial in terms of their overall impacts on the environment, such as those supporting the provision of public transport infrastructure, others are less so. Some subsidies have had the inadvertent side-effect of inducing behaviour that is effectively harmful to the environment. Case studies presented in this year's report highlight such examples, including the preferential tax treatment of company cars and commuting expenses that lead to greater distances being driven than might otherwise have been the case, the tax exemptions on fuels for international transport by plane or ship, vehicle tax exemptions and the differential tax treatment of diesel and gasoline.

Past environmental trends and progress towards transport policy goals

In recent decades, progress has been made in improving many aspects of environmental quality in the EU, as assessed in SOER 2015. However, achieving the EU 2050 vision of 'Living well within the limits of the planet' remains challenging. Considering the mid-term outlook, environmental trends in Europe either show a mixed picture or are deteriorating (EEA, 2015a). Transport conforms to this broader perspective. While the information included in this report highlights the progress that has been made in certain areas, key challenges remain.

Over the past 15 years, the annual TERM reports have documented the progress being made to reduce environmental impacts associated with the transport sector, as well as tracking the distance from target of specific policy objectives and goals. However, progress in meeting the transport goals set for EU Member States cannot yet be fully monitored, owing to lack of data and the often complicated nature of the evaluations required.

In relation to environmental pressures from transport, SOER 2015 is clear:

> *The economic recession led to reduced pollutant emissions by lowering transport demand. Transport is still responsible for 25% of EU GHG emissions, and contributes significantly to air pollution, noise and habitat fragmentation.*

Table ES.1 summarises information presented in TERM 2015, highlighting past progress and outlining the extent to which the EU is on track to reach selected policy goals for which monitoring is performed ([1]). For each goal, a base year and corresponding value are determined, which serve as a starting point for a target trajectory. For transport GHG emissions, the 2011 Transport White Paper (EC, 2011a) defined the preferred policy option to reach the objective. This forms the basis of the trajectory for the reductions in transport GHG emissions. For the other objectives, the trend towards the target is assumed to be linear, starting from the base year.

Transport greenhouse gas emissions — to be reduced by 20% from 2008 levels by 2030, and by at least 60% from 1990 levels by 2050

Despite existing policies addressing GHG emissions, the transport sector is the only main European economic sector in which GHG emissions have increased since 1990 — all other sectors have achieved reductions in emissions. Transport emissions accounted for almost one-quarter of the EU's total GHG emissions in 2013 (one-fifth excluding international aviation and maritime emissions), with passenger cars contributing almost 45% and HDVs a further 20% of the transport sector's emissions.

([1]) The methodology underlying the table is described in the TERM 2012 report (EEA, 2012). For a more detailed presentation of the comparison between the observed evolutions and the target path, refer to Annex 3.

Table ES.1 Transport — overview of past progress and policy goals in the EU-28, 2015

	Source	Target	Unit	Where we were		Where we want to be		Where we are (current trends vs. target paths)											Latest observed annual trend
				Base year		Target		2000	2010		2011		2012		2013		2014		
				Year	Value	Year	Value	Observed	Target path	Observed	Target path	Observed	Target path	Observed	Target path	Observed	Target path	Observed	
Key target	European Commission's 2011 Transport White Paper (EC, 2011a)	Transport GHG (including international aviation, excluding international maritime shipping) ([a])	Mt CO_2	1990	855	2030 2050	921 (+8%) 335 (– 60%)	1 036	1 112	1 072	1 114	1 065	1 116	1 027	1 118	1 022	1 120	*1 025*	*0.3%*
Key target	European Commission's 2011 Transport White Paper (EC, 2011a)	EU CO_2 emissions of maritime bunker fuels ([a])	Mt CO_2	2005	162.5	2050	97.5 (– 40%)	133	155	157	154	161	152	148	151	140	149	n.a.	– 5.4%
Indicative goals	Passenger car CO_2 EC regulation 443/2009 (EU, 2009a)	Target average type-approval emissions for new passenger cars ([b])	g CO_2/km	2010	140	2015 2021	130 95	172	140	140	138	136	136	132	134	127	132	123	– 2.6%
Indicative goals	Van CO_2 EC regulation 510/2011 EU, 2011a)	Target average type-approval emissions for new passenger vans ([b])	g CO_2/km	2012	180	2017 2020	175 147						180	180	179	173	178	169	– 2.4%
Indicative goals	Impact assessment accompanying the 2011 Transport White Paper (EC, 2011b)	Reduction of transport oil consumption	million TJ	2008	17.1	2050	5.1 (– 70%)	15.7	16.5	16.2	16.3	16.1	16.0	15.4	15.7	15.2	15.4	*15.4*	*1.1%*
Indicative goals	Renewable Energy Directive 2009/28/EC (EU, 2009b)	10% share of renewable energy in the transport sector final energy consumption for each Member State (here EU-28 as a proxy) ([c])	%	2010	4.81%	2020	10.0%		4.8%	4.8%	5.3%	3.4%	5.8%	5.1%	6.4%	5.4%	6.9%	*5.6%*	*3.7%*

Notes: Numbers in italics are preliminary data.

([a]) EU CO_2 emissions of maritime bunker fuels data for 2011 is in yellow indicating data inconsistencies in that specific year.

([b]) The EU-28 excluded Croatia until 2013. EU-28 from 2014 onwards.

([c]) In the case of the Renewable Energy Directive target, Eurostat published for the first time (2011 data) the proportion of biofuels used in transport energy that meet the sustainability criteria of the Directive. The increase observed between 2011 and 2012 is explained by the fact that in previous years these new sustainability criteria were not fully applied. The system for certifying sustainable biofuels is increasingly operational across all Member States.

The TERM 2015 report highlights that since 1990:

- emissions of GHGs from the transport sector have increased by almost 20%;
- international transport emissions (aviation and shipping combined) have doubled their share of total GHG emissions, reaching 6% of total EU emissions in 2013;
- international aviation emissions in the EU have almost doubled;
- international maritime emissions in the EU have increased by 28%;
- road transport emissions have increased by almost 17%;
- rail transport (– 49%) and inland navigation (– 35%) are the only two modes of transport for which GHG emissions have decreased.

Compared with the target path to meet the 2050 goal (see Annex 3), the trend in GHG emissions is presently on track. However, to reach the mid-term indicative goal of 2030, a further reduction of 10% needs to be achieved. The 2050 target requires a reduction of two-thirds compared with current levels. While emissions are clearly linked to economic activity and transport demand, various other factors have also contributed to the changes in GHG emissions seen in recent years, including:

- efficiency improvements as a result of legislation;
- changes in consumer behaviour and preferences.

Maritime bunker greenhouse gas emissions — to be reduced by at least 40% ([2]) from 2005 levels by 2050

CO_2 emissions from maritime bunker fuels sold in the EU increased by 33% between 2000 and 2007 and decreased by 23% between 2007 and 2013, following the global economic recession. Compared with 2005 levels, which form the basis for the 2050 target, the 2013 emissions were lower than the derived target path. It is important that the lower emissions since 2007, mainly a result of reduced speed or 'slow steaming' of the majority of the fleet, are sustained with higher economic growth rates and consequently an anticipated increase in the demand for freight. The future system for monitoring, reporting and verification of CO_2 emissions from maritime transport (established by Regulation (EU) 2015/757) is expected to deliver more reliable data on maritime GHG emissions from 2018.

Average CO_2 emission targets for passenger cars and vans

Since monitoring started under current legislation in 2010, emissions of CO_2 from newly registered vehicles have fallen by 12%. The 2015 target, of 130 g CO_2/km, was met 2 years before the deadline. In 2014, the majority of the car and light commercial vehicles (van) manufacturers met their CO_2 emission targets set for that year ([3]) (EEA, 2015b). In the period up to 2014, emissions from vans fell by 6%, which is better than implied by the target path. Both regulations ((EC) No 443/2009 (EU, 2009a) for passenger cars and (EU) No 510/2011 (EU, 2011a) for vans) are considered effective instruments that have reduced vehicle CO_2 emissions. However, for cars, emissions still need to fall by an additional 23% in order to meet the 2021 target of 95 g CO_2/km (see Chapter 5). Moreover, the figures reported under the legislation are based on measurements made under a standardised test cycle. In recent years a growing discrepancy has been observed between the official and real-world emissions. While a new testing procedure has been developed so that the official results may in the future better represent actual vehicle performance, the date for introducing this new procedure in the EU has not yet been agreed.

Transport oil consumption (including maritime bunkers) — to be reduced by 70% by 2050 from 2008 levels

Transport remains very much dependent on oil. Oil-derived fuels account for around 94% of final energy demand by transport. Road transport is responsible for the largest amount of transport energy consumption, accounting for almost three-quarters of total demand in the EU-28 in 2014. The fraction of road transport fuel that is diesel has continued to increase, and in 2014 it amounted to just over 70%, compared with 52% in 2000, which reflects the increasing dieselisation of Europe's vehicle fleet since that time.

The evolution of transport oil consumption since 2008 is generally in line with the target path towards the 2050 goal, but the additional efforts remain very challenging, as transport oil consumption needs to

([2]) By 50%, if feasible.

([3]) This report uses the latest official CO_2 data submitted by Member States and vehicle manufacturers. Volkswagen Group has publicly confirmed that the CO_2 emission values it has published for some models are incorrect. The company is presently reviewing which models are specifically affected. Therefore it is not possible at this stage to assess the extent to which incorrect data from vehicle manufacturers may alter the analysis and conclusions in TERM 2015.

be reduced further by two-thirds. The majority of the projected reduction in oil consumption is a direct consequence of the EU's commitment to reducing CO_2 emissions.

Renewable energy — all EU Member States to achieve 10% of all transport energy from renewable energy by 2020 for all transport options

In order for EU Member States to meet this target, it is expected that biofuels will play a major role. Only those biofuels complying with the sustainability criteria under the Renewable Energy Directive (i.e. Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC) (EU, 2009b) can be considered. Information for these fuels has been reported only from 2011. According to preliminary EEA estimates (EEA, 2015c), the proportion of renewable energy was 5.6% in 2014, with biodiesel being the most widely used type of renewable energy, followed at a distance by bioethanol. Based on the official 2013 data, half of the EU Member States are on track towards the 2020 goal. However, in the other countries much still needs to be done. For the EU-28 overall, the observed evolution lies well below the target path from the base year to 2020. Formally, the 10% target of the Renewable Energy Directive apply to the year 2020 but not for the years beyond. It is unclear at this stage how this will affect the uptake of biofuel in future. It is likely that, without additional policies, the uptake of biofuel will decrease beyond 2020.

Air pollution

TERM 2015 highlights that emissions of three important air pollutants — sulphur oxides (SO_X), nitrogen oxides (NO_X) and particulate matter (PM) — from transport activities decreased in the period 2000 to 2013 in the EU. With the exception of international aviation, all modes of transport contributed to the decrease. The introduction of fuel quality standards limiting sulphur in fuels, together with the Euro vehicle emission standards for cars and HDVs and coupled with the gradual renewal of Europe's vehicle fleet, have played a key role in reducing emissions of these three pollutants from vehicles. Progress is not all positive, however; despite some reductions, international maritime transport — shipping — remains by far the largest emitter of SO_X from transport in the EU.

Emissions of lead and carbon monoxide (CO), historically emitted in large amounts from the road transport sector, have also decreased significantly, according to the analysis presented. With the introduction of lead-free fuels across Europe, emissions from vehicles have today dropped to almost zero. For CO, as for NO_X and PM, the introduction of the Euro emission standards and the corresponding use of catalytic converters reduced total CO emissions from transport by over 70% between 2000 and 2013.

Despite these advances, achieving levels of good air quality in Europe is still a challenge, especially in urban areas with high volumes of traffic. For example, the annual EU limit value for NO_2, one of the main air quality pollutants of concern and typically associated with vehicle emissions, was widely exceeded across Europe in 2013, with 93% of all exceedances occurring at road-side monitoring locations. As noted for CO_2, there are also significant differences currently observed between official and real-world vehicle emissions of NO_X.

Noise

Noise pollution has long been recognised as negatively affecting quality of life and well-being. Over past decades it has, in addition, increasingly been recognised as an important public health issue. Road traffic is by far the dominant source of environmental noise in Europe, with an estimated 125 million people potentially exposed to noise levels greater than 55 dB L_{den} (average day, evening and night noise levels) in 2012. No significant change in exposure levels appears on the basis of earlier reported data for 2007, but information reported by countries under the EU Environmental Noise Directive (END) (EU, 2002) is incomplete. Noise from trains and aircraft has a much lower impact in terms of overall population exposure to noise, but nevertheless remains the cause of many localised issues.

Biodiversity

Transport can cause important negative impacts on ecosystems and biodiversity in different ways. The design and use of road, rail and waterborne transport infrastructure alters the quality and connectivity of habitats and can create physical barriers to the movement of plants and animals between habitat areas. Species can be injured or killed by vehicles, become isolated by habitat fragmentation, or exhibit behavioural changes that put their survival at risk, such as feeding on or near roads or changes in migratory behaviour (Bennett et al., 2011; CEEweb, 2011). The development and use of transport infrastructure can also increase pollution levels in surrounding habitats and serve as a vector for the spread of non-native and invasive species (von der Lippe and Kowarik, 2008). A number of policies have been introduced establishing procedures and obligations to minimise such consequences. However, several gaps remain concerning their implementation in practical terms.

Looking to the future

In relation to the challenges ahead in terms of transport, SOER 2015 is clear:

> *While progress has been made in meeting certain policy objectives, including efficiency and short-term GHG-reduction targets, major challenges remain toward meeting longer-term objectives. The European Commission's target of a 60% reduction in GHG emissions by 2050 will require significant additional measures.*

The EU has set itself ambitious future targets for the long-term decarbonisation of its economy. However, according to the European Commission's own projections, the 2011 Transport White Paper's decarbonisation targets will not be met unless further ambitious measures are put in place.

1 Introduction

The Transport and Environment Reporting Mechanism (TERM) report has been monitoring progress in integrating environmental objectives in transport since 2000, and since that year it has been providing information to European Environment Agency (EEA) member countries, the European Union (EU) and the public. The TERM reporting mechanism includes indicators used for tracking the environmental performance of the transport sector and measuring progress in meeting key transport-related policy targets.

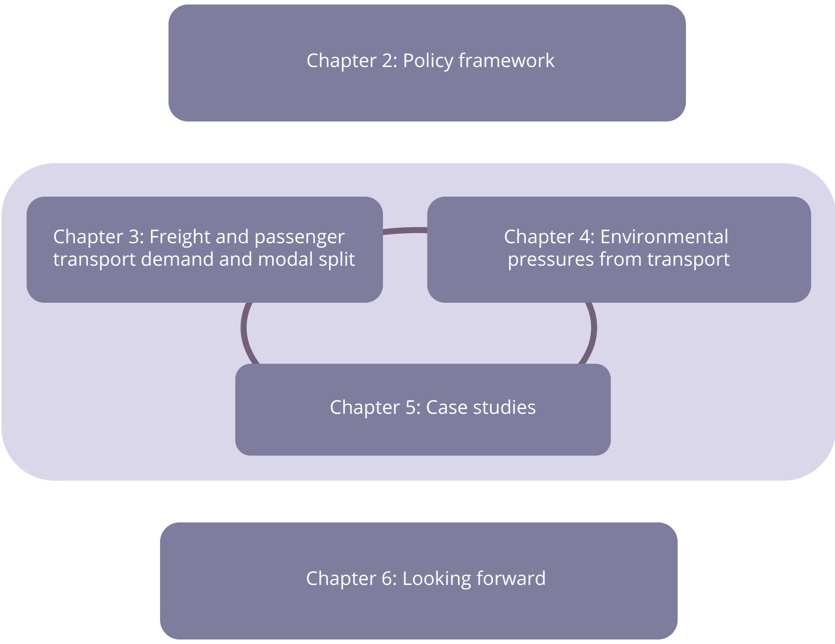
The TERM 2015 report provides a retrospective perspective on the environmental performance of transport since 2000. It provides an overview of:

- how the environmental performance of transport has changed;
- some of the key underlying factors contributing to this change;
- the factors that have hampered additional improvements.

This report is structured as shown in Figure 1.1 and detailed below.

- Chapter 2 presents a descriptive overview of Europe's transport policy framework. It provides a description of the general policy context as, for example, provided by the 2011 Transport White Paper (EC, 2011a) and highlights other cross-cutting policy initiatives designed to mitigate the environmental impacts of the transport sector, as well as highlighting specific policies and regulations that have established technical standards relevant for the sector, for example emission limits and standards.
- Chapter 3 contains an indicator-based assessment of general freight and passenger demand, and modal split trends, as important factors affecting the environmental performance of transport. It describes the changes since 2000 in freight and passenger demand, the energy system and environmental transport technologies. An analysis of the intensity of freight and passenger transport in the economy is presented (expressed as passenger-kilometres (pkm) or tonne-kilometres (tkm) per unit of gross domestic product (GDP)). Information on the transport modal splits is another indicator analysed in the chapter: under EU policy, it is expected that the environmental performance of the transport sector will improve by reducing the share of road and air transport modes.
- Chapter 4 provides a review of the evolution of the past emission trends of greenhouse gases (GHGs), air pollutants and noise pollution, accompanied by a detailed decomposition analysis of the explanatory factors underpinning the observed trends in GHG and air pollutant emissions. The impacts of transport upon biodiversity are also described. At the end of Chapters 3 and 4, the reader will have a better insight into the following questions:
  - To what extent is the environmental performance of transport explained by underpinning explanatory factors?
  - To what extent have EU policies and regulations helped in reducing the impacts from transport on health and the environment?
- Chapter 5 examines three case studies in more detail:
  - regulations that have generally successfully restricted CO_2 emissions from passenger cars and light-duty vehicles (LDVs, i.e. vans);
  - the 'Eurovignette' Directive — a market-based instrument that established road user charging for heavy-duty vehicles (HDVs) to better reflect the environmental external costs of transport;
  - environmentally harmful subsidies — examples of subsidies that have reduced or limited the scope of past environmental progress in the transport sector.
- Finally, Chapter 6 presents a short forward-looking perspective.

Figure 1.1 Guide to the TERM 2015 report



1.1 Scope of this report

The report covers all 33 EEA member countries, wherever information is available.

The different country groupings are also described (see Box 1.1). For some indicators, EU-28 data have been prioritised, as policy targets and goals are specifically developed for these countries, but a brief assessment based on the available EEA data has been included as far as possible.

When Croatia joined the EU in July 2013, it also became the 33rd member country of the EEA. Where it has not been possible to include data from Croatia in this year's TERM report, this has been indicated. Data for the EU-28 excluding Croatia are referred to as EU-27 data.

Where appropriate, the EU-13 (Member States joining the EU after 2003) and the EU-15 (EU Member States prior to 2003) are compared; occasionally, information from particular countries or a particular grouping of countries is provided to illustrate particular issues.

Data for most indicators have been available since 1990. However, some member countries have provided information covering only recent years, and changes in statistical series may render comparisons irrelevant. This has been taken into account when selecting the time series for analysis.

Box 1.1 Country groupings

Throughout the report, abbreviations are used to refer to specific country groupings. The following definitions are used:

- EU-13: Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia;
- EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom;
- EU-28: EU-15 and EU-13;
- EU-27: EU-28 excluding Croatia;
- EEA-33: EEA member countries (EU-28, Iceland, Liechtenstein, Norway, Switzerland and Turkey).

2 Europe's evolving transport and environment policy framework

Key messages

- Europe's general policy framework for reducing the environmental impacts of transport has evolved substantially since the early 1990s.
- A number of specific EU policy instruments have been introduced, addressing specific environmental areas such as air pollution, climate change, and to a lesser extent noise and biodiversity.
- To date, many of these policies have consisted mainly of technical standards. However, an increased use of market based legislative tools is also evident. Other policies, promoting more environmental friendly transport modes (e.g. Railway Packages, the revised TEN-T guidelines), have also played a role.
- Steps have also been taken towards the greater integration of climate, energy and transport policies.
- The importance of monitoring and the definition of targets against which progress can be measured has increasingly been recognised, as well as the role of proper ex post evaluation of policies.

2.1 General policy development

The 2001 White Paper, *European transport policy for 2010: Time to decide* (EC, 2001), introduced the concept of the need to integrate transport policy with environmental considerations, emphasising the need for transport growth to be managed in a more sustainable way by encouraging a more balanced use of all transport modes. One of the main messages of the 2001 White Paper was that, in addition to facilitating the growing demand for transport, a modern transport system must be sustainable from economic, social and environmental viewpoints. Although it stressed the need to control the growth in air transport and promote the use of non-road transport modes, no specific overall environmental targets were included at the time. Only the need for these to be developed and quantified in the future was highlighted.

The integration of environmental considerations within the transport sector was significantly extended with the publication in 2011 of the Transport White Paper, *Roadmap to a single European transport area — Towards a competitive and resource efficient transport system* (EC, 2011a). Along with the Roadmap for moving to a competitive low carbon economy in 2050 (EC, 2011c) and the *Energy roadmap 2050* (EC, 2011d), it was developed in line with the objective of reducing Europe's total GHG emissions by 80 to 95% by 2050 compared with 1990 levels. The 2011 Transport White Paper focused strongly on the oil dependence of the transport sector and its contribution to GHG emissions and included quantitative targets requiring the transport sector to achieve an overall reduction in GHG emissions of 60% by 2050. Annex 2 presents a detailed overview of the environmental targets and goals currently in place for the transport sector.

It has also become clear that regular monitoring of legislative policy measures is required to assess policy effectiveness. The introduction in 2000 of the TERM indicators and reports is just one example of monitoring Europe's progress in integrating transport and environmental considerations. *Ex post* policy evaluations also became more common. For example, the *ex post* evaluation of the 1999 Eurovignette Directive (EU, 2011b) found great disparities in national road charging policies, hindering the functioning of the Internal Market, and slowing the potential for integrated network-wide electronic tolling (EC, 2013a). The 2011 Transport White Paper itself was accompanied by an impact assessment, which concluded that the EU had not to date succeeded in containing the growth in the economic, environmental and social costs of mobility while simultaneously ensuring that current and future generations have access to safe, secure, reliable and affordable mobility resources to meet their own needs and aspirations (EC, 2011b).

2.2 Cross-cutting and specific transport policies

As an important economic sector, road transport falls under a number of cross-cutting pieces of European legislation that aim to reduce environmental impacts from across all economic sectors. The following are examples of such legislation.

- The National Emission Ceilings Directive (2001/81/EC) (EU, 2001) under which EU Member States were required to meet individual emission limits, or 'ceilings', by 2010 and thereafter for four important air pollutants, SO_2, nitrogen oxides (NO_X), NH_3 and non-methane volatile organic compounds (NMVOCs). The need to achieve emission reductions in the transport sector has been key to a number of countries meeting their ceilings.

- The 2009 Climate and Energy Package was introduced with the aim of reducing EU GHG emissions to 20% below 1990 levels by 2020. For sectors including transport but not aviation and international shipping, which are not covered by the EU Emissions Trading System (EU ETS) (EU, 2004), a reduction of around 10% is required compared to 2005. These non-trading sectors are separately covered by the EU Effort Sharing Decision (ESD) (EU, 2009d). For both the National Emission Ceilings Directive and ESD, EU Member States have the flexibility to define and implement their own policies and measures for lowering the GHG emissions of the transport sector.

- The EU 2030 Climate and Energy Framework (EC, 2014a) is a further example of cross-sectoral policy. It stresses the need for a gradual transformation of the entire transport system in order to reach the 2030 targets set. For the aviation and maritime sectors, the need for international action is put forward, as well as a strategy to address maritime emissions within European emission reduction strategies.

Specific 'primary' transport policies and measures designed to mitigate the sector's environmental and health impacts can be classified according to the general 'avoid, shift and improve' typology (EEA, 2010).

- 'Avoid' policies address transport energy use and environmental impact by reducing the number and/or length of trips. Avoid measures can be economic (fuel and vehicle taxes, road use and parking charges) or regulatory (vehicle access restrictions) in nature. But policy instruments can also focus on planning (high-density land use), information (promotion of alternatives to travel) and technology (promoting tele-conferencing and remote working) (EEA, 2010).

- 'Shift' policies enable and encourage movement from road travel to more energy-efficient and environmentally friendly modes of transport. The attractiveness of non-road modes can be promoted through, for example, pricing or improving the market conditions for non-road modes.

- 'Improve' policies reduce the energy consumption and environmental impact of all travel modes through the introduction of environmentally friendly fuels and vehicles.

In practice, the distinction between these three categories is not always clear-cut. For instance, some pricing instruments can affect not just total travel demand and modal choice but also vehicle choice, and thus also the energy consumption and the emissions of the vehicles. Table 2.1 shows a selected list of significant EU legislation and policy instruments relevant to the transport sector.

As an example of 'avoid' policies, the Eurovignette Directive (EU, 2011b), which lays down the rules under which EU Member States can charge for the use of road infrastructure, could in principle have an impact on the freight transport and the proportion of road freight, depending on the structure and the level of the charges (see Chapter 5). Similarly, the EU Cabotage Regulation aims to reduce empty running in road freight transport. They, however, also be considered as an 'improve' policy because of the potential gain in logistic efficiency.

Among the policies designed to encourage modal shift were the Marco Polo programmes. These provided financial support to projects aiming to transfer cargo from road to alternative modes. Other policies to induce modal shift were found in the three Railway Packages and the recast of the Interoperability Directive. Their collective aim was to encourage development of the internal market in rail transport by opening it up to regulated competition and eliminating operational barriers. Finally, there have been initiatives to promote inland navigation through the so-called NAIADES I and II packages. These include measures that lower the regulatory burdens on the sector.

'Improvement' policies have played an important role in the EU for reducing the environmental impacts caused by transport (see Chapter 4). Up until now these have consisted mainly of technical standards. However, use of market-based instruments as a legislative tool is

Table 2.1 Selected European Union legislation and polices relevant to the transport sector

Measure	Reference
Air pollutant emission standards for cars, light duty vehicles and heavy-duty vehicles	Directive 70/220/EEC and amendments — and regulations since Euro 5
Air pollutant emission standards for non-road mobile machinery including railways and inland waterways	Directive 97/68/EC and five amending directives
Airport Charges Directive	Directive 2009/12/EC
Cabotage: rules for access to the international road haulage market	Regulation (EC) No 1072/2009
Car Labelling Directive	1999/94/EC
Clean and Energy Efficient Road Vehicles Directive	Directive 2009/33/EC
Clean Power for Transport Directive	Directive 2014/94/EU
CO_2 emission targets for new cars and vans	Regulation (EC) No 443/2009, Regulation (EU) No 510/2011
Eliminating administrative and technical barriers via Railway Packages (2001, 2004, 2007), the Interoperability Directive, NAIADES I and II for quality inland water transport, Blue Belt	
Environmental Noise Directive	Directive 2002/49/EC
EU Emissions Trading System — partial inclusion of aviation	2008/101/EC amending Directive 2003/87/EC
Eurovignette Directive — road user charging for heavy duty vehicles	Directive 1999/62/EC and subsequent changes (2006/38/EC and 2011/76/EU)
Financial support to non-road modes via European Structural and Investment Funds, Connecting Europe Facility, loans and guarantees from European Investment Bank, TEN-T, Marco Polo I (2003–2006) and Marco Polo II (2007–2013), Motorways of the Sea (via TEN-T and Marco Polo)	
Fuel Quality Directive	Directive 98/70/EC amended by 2009/30/EC
Noise emission standards for road traffic, aircraft and railways; noise charges for railways	Various regulations
Renewable Energy Directive	Directive 2009/28/EC
Sulphur limits for marine fuels	Directives 1999/32/EC, 2005/33/EC, 2012/33/EU
Sustainable Urban Mobility Plans	

increasing, for instance in the Eurovignette Directive, the inclusion of air transport in ETS (see Box 2.1) or the Airport Charges Directive.

Over time, 'improvement' policies including technical standards designed to reduce emissions from the transport sector have typically been progressively tightened. This has been the case for, for example, the emission limits for air pollutants via the introduction of successive generations of 'Euro' exhaust standards for passenger cars, vans and HDVs, as well as the introduction of CO_2 emission limits for cars and vans following a less successful voluntary agreement with industry to reduce CO_2 emissions. Although vehicle emission standards have been effective in reducing exhaust emissions from road vehicles, as measured in official laboratory-based tests, reductions in emissions in the real-world have not always been as significant (Chapter 5).

Another example of 'improvement' policies is the EU's Fuel Quality Directive (EU, 2009c), which requires a reduction of the GHG intensity of the fuels used in vehicles of 6% by 2020. It also regulates the sustainability of biofuels. It has previously led to significant reductions in the sulphur content of fuels for road transport and non-road mobile machinery. For marine fuels separate directives apply. The Renewable Energy Directive (EU, 2009b) sets a binding target of 20% final energy consumption from renewable sources by 2020. To achieve this, EU Member States have committed to national renewables targets ranging from 10% (Malta) to 49% (Sweden). They are also each required to have at least 10% of their transport fuels come from renewable sources by 2020. Recently, the European Commission has proposed amendments to the Renewable Energy Directive and the Fuel Quality Directive, which aim to address the risk of indirect land use change (EC, 2012a).

Box 2.1 Aviation and the EU Emissions Trading System

Under current trends and adopted policies the European Commission expects air transport to grow faster than any other passenger transport mode, increasing by 133% by 2050 compared with 2010 (EC, 2013b). In its 'regulated-growth' scenario for 2050 — which it deems most likely — (Eurocontrol, 2013) projects the number of flights to more than double compared with 2012.

At present the inclusion of aviation in the EU ETS (EU, 2008) (Directive 2008/101/EC) is a key EU policy aimed at reducing emissions by aviation. Since 2012 all flights from, to and within the European Economic Area (EU-28 plus Iceland, Norway and Liechtenstein) were to be included in the ETS. The legislation applies to both European and non-European operators. Airlines receive tradable allowances covering a certain level of CO_2 emissions from their flights each year. They are obliged to purchase additional allowances to cover all annual emissions. The EU Member States are responsible for the implementation and enforcement of the EU ETS.

However, in order to allow time for negotiations on a global market-based measure applying to aviation emissions, the system was first suspended in 2012 for flights from and to the European Economic Area. This was followed by an extension of reduced scope measures to the period 2013–2016 (Regulation (EU) No 421/2014). Under the amendment only emissions from flights within the European Economic Area fall under the EU ETS. In addition, exemptions for operators with low emissions have been introduced.

The amendment is designed to give the International Civil Aviation Organisation (ICAO) time to produce a global market-based measure for aviation. The ICAO's triennial assembly in 2016 should agree on a global market-based measure, to be implemented from 2020. Based on the outcome of the assembly, the Commission may propose policies for 2017 onwards that it deems appropriate considering the international developments. The EU initiative has opened international discussion and may lead to a global response to the problem of CO_2 emissions from aviation.

In the meantime the ETS itself is being reformed in order to increase market stability. This is necessary because in recent years the functioning of the system has been challenged by a growing surplus of allowances, mainly because of the economic crisis.

Transport is the main source of environmental noise. Many noise policies therefore understandably address the mitigation of specific impacts of noise from transport. In the 7EAP, the EU committed to significantly decreasing noise pollution by 2020, moving closer to levels recommended by the World Health Organization (WHO). It was noted that this would require, in particular, the implementation of an updated EU noise policy, aligned with the latest scientific knowledge, and measures to reduce noise at source, including improvements in city design.

The Environmental Noise Directive (2002/49/EC; EU, 2002) is the main EU legislation to address the assessment and management of environmental noise. It requires EU Member States to conduct a process of noise mapping and preparing action plans for noise management for all major roads, railways, airports and large agglomerations in 5-year cycles. The Directive neither sets limit values nor prescribes measures to be included in the action plans. Its primary strategy for effecting improvement in noise pollution is therefore to require public authorities in Member States to collect information on noise, share that information with the public and engage in a discussion with the public on whether or not and how to act on that information. Numerous legislative instruments address noise at source. From the 1970s onwards, European legislation established harmonised maximum noise limits for motor vehicles and household equipment, such as appliances, outdoor tools and other noise-generating products. Others address noise from specific sectors, such as aviation, by establishing procedures for the introduction of noise-related operating restrictions.

In the areas of habitat fragmentation and biodiversity protection, important policy instruments include the EU's Environmental Impact Assessment Directive, Strategic Environmental Assessment Directive, Natura 2000 and the EU 'Nature' Directives — the Birds Directive and the Habitats Directive — as well as the Water Framework Directive. These are described further, together with examples of their application to transport-related issues, in Chapter 4.

3 Freight and passenger transport demand and modal split

Key messages

- Freight transport grew considerably in the EU-28 between 2000 and 2008. A sharp fall in freight demand occurred in the years immediately following the economic crisis and, following a limited recovery, freight volumes have since remained largely stable. In 2013, total freight transport was 7.3% higher than in 2000.
- Passenger transport increased until 2008, but it has remained broadly stable following the economic recession. In 2013 the number of passenger-kilometres was 8.4% higher than in 2000.
- Despite certain EU policies designed to encourage greater use of environmentally friendly transport modes, no substantial overall changes in modal shares have been observed.
- Car transport remains the dominant mode of passenger transport, although the average distance travelled by car per inhabitant has fallen since 2009, owing to both economic and changing socio-demographic factors. Air transport is the fastest growing mode of passenger transport. It has now surpassed its pre-recession levels of demand.
- Between 2000 and 2013 the proportion of diesel in energy consumed by road transport increased substantially. Over the last years, because of their generally lower contribution to CO_2 emissions, many European governments have chosen to provide financial incentives to directly or indirectly encourage the uptake of diesel engines. The number of electric vehicles (EVs) has grown but is only a minimal proportion (0.07%) of total passenger car fleet numbers.
- The proportion of renewable energy used by the transport sector is growing but remains small.

This chapter explores the different underpinning factors driving changes in the environmental performance of transport in the EU-28. It reviews trends in freight and passenger transport demand in Europe, with a focus on the different transport modes — road, rail, air and sea. Transport demand and the modes and type of energy (fuels) used to meet this demand, as well as technological developments, all determine the environmental impacts of the transport sector.

3.1 Freight transport demand

Total land freight transport within the EU-28 (road, rail and inland waterways) increased steadily, together with economic growth and expansion in the EU throughout the 1990s and the early 2000s, growing by 22.4% up to 2007. In the period 2000–2007 the average annual real growth rate of GDP was 2.3% in the EU-28, with higher growth in the EU-13 than in the EU-15. This took place in the context of continued globalisation, with rising trade volumes both within the EU and with trade partners outside of the EU (EEA, 2015a). A sharp fall in freight demand occurred in the years immediately following the economic crisis, and since then freight volumes have recovered slightly but have not yet reached pre-recession levels.

An important determinant of emissions is the modal composition of freight transport, because inland freight transport, rail and inland waterways have substantially lower CO_2 emissions per tonne-kilometre than road (see Annex 1, TERM 27). The specific emissions per tonne-kilometre of air pollutants are lowest for rail compared with road and inland waterways (see Annex 1, TERM 28) ([4]). The shift to more

([4]) As was discussed in the TERM 2014 report (EEA, 2014a), the average specific emission rates hide several important sources of variation in each mode and have to be interpreted with caution.

energy-efficient modes for freight transport was put forward in the 2011 Transport White Paper as one of the 10 goals to achieve the 60% reduction in GHGs.

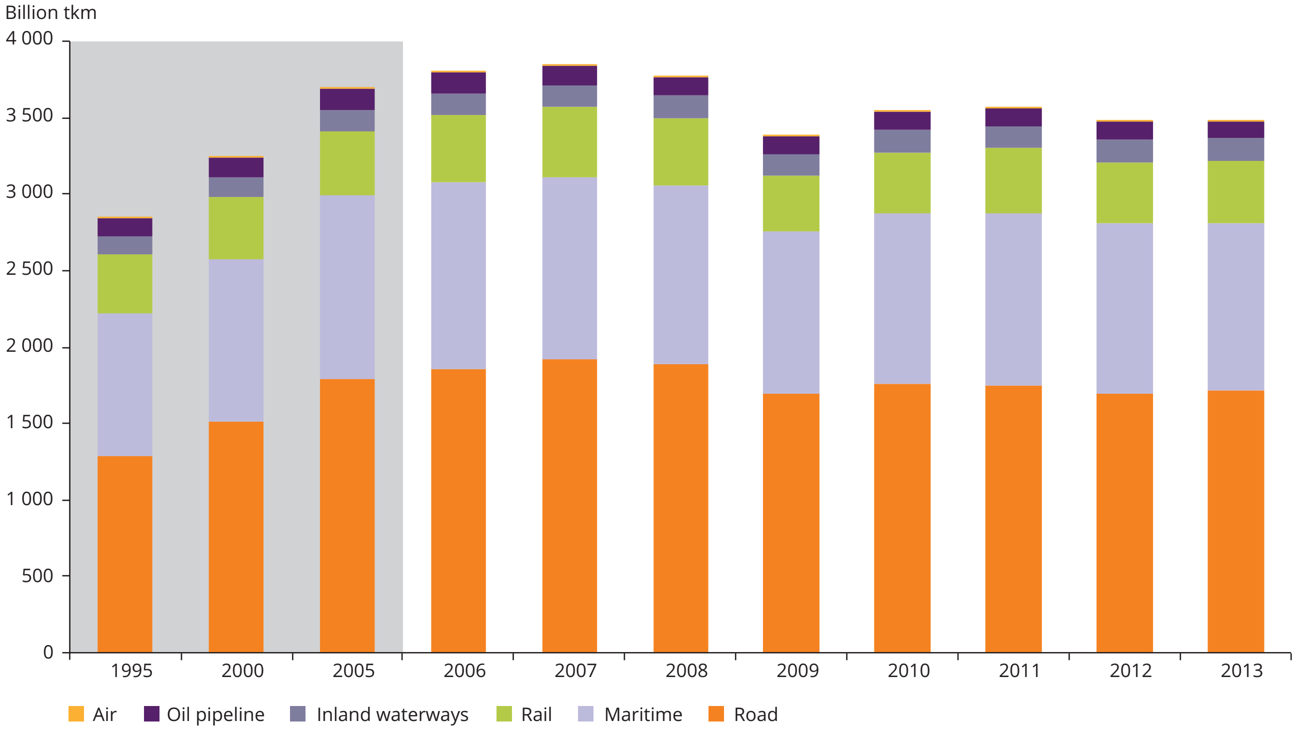
Figure 3.1 shows the trend in freight transport volumes, by mode, since 1990. In 2013, the majority of EU freight was transported by road (49%) and sea (22%). Over time there have been no substantial changes in the modal contributions — away from road transport towards more environmentally friendly modes — in the EU-28. In contrast, freight tonne-kilometres transported by road increased by 14% between 2000 and 2013, accounting for the majority of the increase since 2000. The contribution of air transport within the EU remained very small throughout the whole period (0.1%).

The changes in freight transport volume (tkm) across the different modes since 2000 are as follows:

- road 14%
- maritime 2%
- rail 0.5%
- inland waterways 14%
- pipelines – 12%
- aviation 0.1%.

If the evolution of the intensity of freight transport in the EU-28 economy (tkm per unit of GDP in constant prices of 2010) is considered with the year 2000 as a benchmark (Figure 3.2), freight intensity was lower from 2001 to 2003, but subsequently increased from 2004 to 2008. Since 2009, the intensity of freight transport in the economy has been around 5% lower than in 2000. This lower intensity coincides with the period of lower or negative economic growth in Europe following the economic recession.

Figure 3.1 Freight transport volume (tkm) and modal split in the EU-28



Note: Figures in tonne-kilometres for air and maritime freight transport are available only as an EU-28 aggregate. Air and maritime tonne-kilometres are provisional estimates for domestic and intra-EU-28 transport. Figures for road, inland waterways and rail are available separately for all EU-28 Member States. The sources used by (EC, 2015a) include national statistics, estimates, the International Transport Forum and Eurostat.

Figure 3.2 Inland freight transport volumes (tkm) and GDP at constant prices in the EU-28

Note: Inland freight transport includes road, rail and inland navigation.

Source: Calculations based on EC, 2015a and the Annual macro-economic database (AMECO, http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm).

Box 3.1 Developing the European railway market

The development of a more competitive European railway market has significant potential to limit the environmental impacts of transport. National monopolies and a lack of interoperability between countries are just two of the reasons that explain the slow progress in developing an improved European railway market (Dehousse and Marsicola, 2015). Past EU action has focused on improving the competitiveness and interoperability of the sector, as well as supporting infrastructure development. The first major EU railway directive dates from 1991, and the First Railway Package from 2001. Since then subsequent Railway Packages (II and III) have been issued, as well as a recast of the First Railway Package in 2012.

Despite such policies encouraging the further development of the railway sector, the modal share of passenger rail transport in inland transport:

- has not changed significantly since 2000 in the EU-28;
- fell from 12.9% in 2000 to 8.8% in 2013 in the EU-13.

For freight transport, the modal proportion of rail has fallen by around 1% in the EU-28 since 2000.

The further development of a more competitive European railway market faces several challenges. While rail transport has lower externalities than car and air transport, this is not yet fully reflected in the relative prices across these three transport modes (Dehousse and Marsicola, 2015). The European Commission has also pointed out that new operators on the international rail passenger market still often face significant barriers. As a result, there are few examples of new international passenger services exist (EC, 2013c).

In 2013, the European Commission proposed a Fourth Railway Package covering the issues of rail governance, market openings for domestic passenger rail transport, competitive tendering for Public Service Obligations contracts and a changing role for the European Railway Agency (EC, 2013c). Discussions concerning the proposal are ongoing.

3.2 Passenger transport demand

Passenger transport demand in the EEA-33, measured in passenger-kilometres, experienced a sustained period of robust growth until 2005 for all modes. Following its peak in 2009 (9% higher than in 2000) (Figure 3.3), it has remained broadly stable, with only a slight overall reduction being seen as a result of the economic recession from 2008 onward. In 2013, total passenger demand was 8.4% higher than in 2000, and has now almost reached the same levels as the 2009 peak being just 0.5% lower than that year.

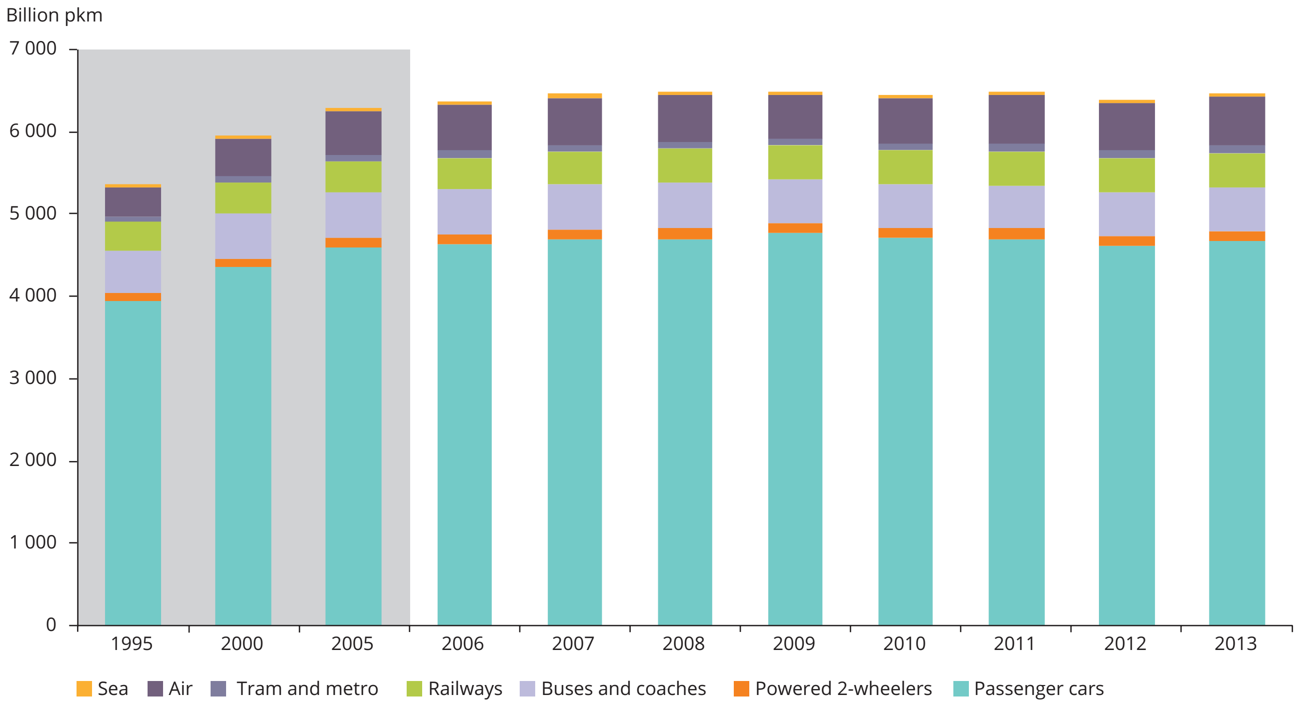
The changes in passenger transport volume (pkm) across the different modes since 2000 are as follows:

- passenger cars 7%
- powered two-wheelers 16%
- buses and coaches – 4%
- railways 14%
- trams and metro 22%
- aviation 27%
- sea – 7%.

In absolute terms, passenger cars account for most of the overall increase in passenger transport volumes seen since 2000, followed by aviation and railways. Since 2000, the EU population has grown by 3.7% ([5]), less than the 8.4% growth seen in passenger transport. Figure 3.4 shows how annual passenger car passenger-kilometres per capita has changed with time. There clearly are very different trends for the EU-15 and EU-13 groups of Member States, with average passenger-kilometres for EU-15 Member States having fallen slightly between 2000 and 2013 while growing significantly in the EU-13 Member States. Car mobility peaked in the EU-15 in 2004 and most EU-15 Member States reached peak car travel values sometime between 1999 (Denmark) and 2007 (Sweden), before the economic downturn.

The decreasing average distance travelled by car per inhabitant in the EU-15 may be related to various

Figure 3.3 Passenger transport volume (pkm) and modal split in the EU-28



Note: Figures on passenger-kilometres travelled by air are available only as an EU-28 aggregate. Air passenger-kilometres are a provisional estimate for domestic and intra-EU-28 flights. Figures for car, bus and rail are available, separately, for all EU-28 Member States. The sources used by (EC, 2015a) include national statistics, estimates, the International Transport Forum and Eurostat.

([5]) In the period between 2000 and 2013 the evolution of population was different across the EU–28 Member States. It fell in nine Member States belonging to the EU–13 and in Germany. In the other 18 Member States it increased.

factors. A literature review for the United Kingdom (Rohr and Fox, 2014) points to:

- changes in economic determinants (such as fuel price increases and income changes);
- fewer younger people driving;
- urbanisation;
- increasing car travel by women (who drive less far on average than men);
- changes in population demographics, with more elderly drivers;
- changes due to immigration.

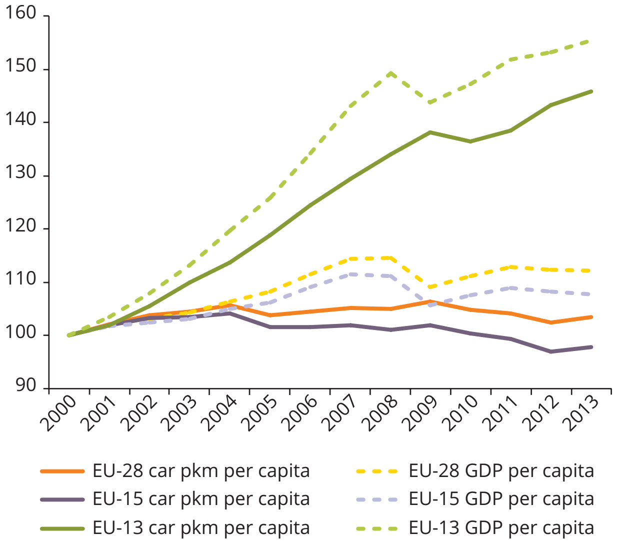
However, there is still uncertainty about the size of some of these factors and their underlying drivers. For Sweden, changes in GDP per capita and fuel prices explain most (80%) of the changes in vehicle-kilometres (vkm) travelled (Bastian and Börjesson, 2015). At municipality level, changes in car mobility vary depending on public transport supply, population density, the proportion of foreign-born residents (who tend to drive less) and average income levels.

In contrast, in most EU-13 Member States, per capita car travel keeps growing, as in some non-EU countries such as Turkey, which experienced strong growth of around 25% between 2009 and 2013.

Considering only inland passenger-kilometres, that is, road, rail and bus transport, average annual growth rates have been much higher for the EU-13 than for the EU-15. For 2000–2013 the inland passenger-kilometre intensity (defined as motorised inland pkm per unit of GDP in real terms) reduced, that is, improved, in both groups of countries (Figure 3.5). An exception was the year 2009, when GDP dropped significantly as a result of the economic recession. As discussed in the TERM 2014 report (EEA, 2014a), passenger transport reacts less noticeably and more slowly to changes in GDP than freight transport.

Figure 3.4 Evolution of annual car passenger transport volume (pkm) per capita and GDP per capita at constant prices

Index compared to 2000

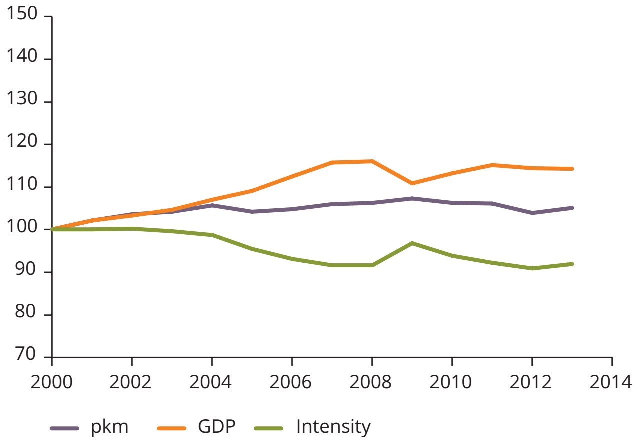


Source: Calculations based on (EC, 2015a) and the Annual macro-economic database (AMECO, http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm).

Figure 3.5 Inland passenger transport volumes (pkm) and GDP in constant prices, EU-15 and EU-13

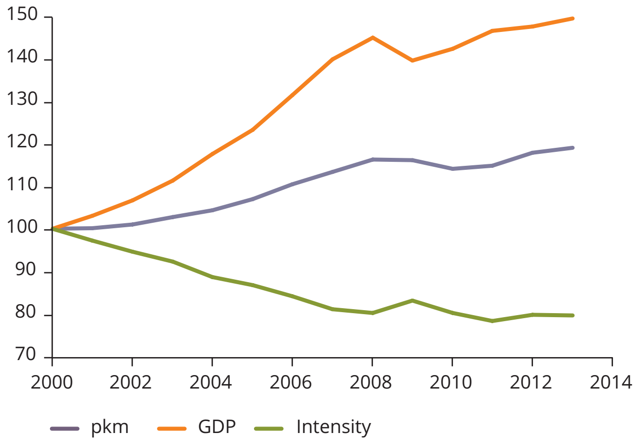
EU-15

Index compared to 2000



EU-13

Index compared to 2000



Source: Calculations based on (EC, 2015a) and the Annual macro-economic database (AMECO, http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm).

There are a number of underlying factors behind the trends illustrated.

- Each EU-28 inhabitant on average travelled approximately 12 850 km in 2013, across all modes. This is 5% higher than in 2000 but remains slightly less than the peak in 2007 and 2008 of around 13 000 km.

- 72% of passenger-kilometres were travelled by car in 2013. In the EU-15, the average distance travelled by car was 10 220 km, significantly higher than the EU-13 average of 5 750 km. A substantial increase in average distance travelled by car per capita has been observed in the EU-13 since 2000, but in the EU-15, following an increase up to 2004, it has since decreased.

- The proportion of total distance travelled by car in the EU-13 has increased significantly since 2000. In 2013, 77% of passenger-kilometres used car transport, compared with 65% in 2000. There is, however, considerable variation across the individual EU-13 Member States, with, for instance, car travel contributing 66% of total distance travelled in the Czech Republic, compared with 91% in Lithuania.

- Owing to the rise in car travel, transport by bus, coach and rail fell in the EU-13, and more so after 2008, while tram and metro travel increased less than car travel. In these countries, on average 30% less rail passenger-kilometres were travelled in 2013 compared with 2000 and 21% less passenger-kilometres by bus and coach.

- No major changes between transport modes were observed for the EU-15 as a whole, although relatively small changes have occurred in a number of Member States.

- Car ownership rates are increasing, and significantly so in the EU-13. Ownership rates remain higher in the EU-15, with 512 cars per 1 000 inhabitants in 2013 — a 10% increase compared with 2000. In the EU-13, car ownership rates have increased by almost 70% since 2000, reaching 408 cars per 1 000 inhabitants in 2013.

Since 2008 rail passenger numbers have dropped significantly in many countries owing to the economic crisis, a growing share of private car transport or both. The drop in rail traffic has been particularly high in many eastern European Member States, as well as in certain western countries such as Italy and Portugal. In contrast, the demand for rail travel continued to grow between 2008 and 2013 in a few EU-15 and other European countries, in some cases by amounts approaching 10% or more. These include Austria, Denmark, Germany, Luxembourg, the Netherlands and the United Kingdom. Trends in passenger demand for high-speed rail are difficult to assess, as traffic growth trends have been, not surprisingly, greatly influenced by the opening of new services over the past decades. Nevertheless, it seems that its contribution to total rail passenger traffic is increasing in certain countries such as Italy, while in others it peaked in 2010 (France and Spain) or earlier (Belgium, Portugal and Sweden).

Air transport, including only intra-EU trips in the EU-28, has varied substantially since 2000. While it grew rapidly between 2000 and 2007, air transport traffic was particularly badly affected by the economic crisis — in 2009 it decreased by 6.9%. Whereas traditional airlines were particularly hard hit by the recession, low-cost airlines have grown every year since 2008. Their growth has helped drive overall growth in the aviation sector since 2009, with air passenger-kilometres travelled increasing and reaching its highest level in 2013.

There are no comprehensive EU-wide data on cycling and other forms of non-motorised passenger transport. Various efforts have been made to improve the rates of non-motorised transport in the EU (Box 3.2), and estimates of the varying importance of cycling across EU Member States are available (EC, 2014b). On average 8% of respondents to the Eurobarometer survey mention cycling as the most important mode of travel on a typical day. This ranges from cycling rates of 1% or less in Cyprus, Malta, and Portugal to 36% in the Netherlands. In the latter, the distance travelled by bicycle increased by 14% between 2000 and 2012, with most of this growth occurring as a result of increased popularity and the availability of electric bicycles (KiM, 2013).

Box 3.2 Urban transport

In the 1990s the European Commission 'Citizens' Network' initiative put forward the first set of policy proposals in the area of urban mobility, with a focus on best practices. Examples of integrated urban mobility plans, and the inspiration for later initiatives, were the *Plans de Déplacements Urbains*, compulsory in France since 1996 for all municipalities with more than 100 000 inhabitants, or the Local Transport Plans, compulsory in the United Kingdom since the Transport Act of 2000. The 2007 Green Paper on Urban Mobility, *Towards a new culture for urban mobility*, (EC, 2007) laid the foundations for a new European agenda for a sustainable mobility policy, inviting stakeholders to present their ideas on the type of EU support required and the way in which it should be provided. This resulted in the launch of the 2009 Action Plan on Urban Mobility setting out a coherent framework for 20 EU initiatives for urban mobility. In the subsequent Urban Mobility Package of 2013 (EC, 2013d), the Commission addressed three initiatives included in the 2011 Transport White Paper (EC, 2011a):

- the establishment of procedures and financial support mechanisms for the preparation of Sustainable Urban Mobility Plans;
- the development of a package for urban road user charging and access restriction schemes;
- the formulation of best practice guidelines for monitoring and managing urban freight flows.

Common standards and specifications for joint procurement are also addressed in order to avoid too much fragmentation and to develop a European market for innovation in urban mobility.

The importance of action on urban mobility was stressed in the 2013 Eurobarometer survey on urban mobility (EC, 2013e). A majority of EU citizens were concerned with air pollution and noise pollution within cities. Other problems such as congestion, high travel costs and accidents were also raised as important issues. However, Europeans were still over twice as likely to use a car every day as to travel by public transport or bicycle.

3.3 Energy use in the transport sector

The amount and types of energy used by the various transport modes directly determine the magnitude of GHG and air pollutant emissions. Annual transport energy consumption grew significantly between 1990 and 2007 (Figure 3.6). However the impacts of the economic recession caused a subsequent decline in transport demand and hence energy consumption- between 2007 and 2013, energy demand decreased by 10.5%. Overall, between 1990 and 2013, there was a net growth of EU-28 transport energy consumption of 22.3%. Factors contributing to changes in energy consumption over the past decades include high oil prices in the past, the economic recession, higher efficiency of vehicles and slower growth in mobility, as well as other specific causes such as slower speed in maritime transport.

The proportion of diesel in the total consumption of petroleum products by road transport has increased substantially, comprising:

- 52% of road transport fuels sold in 2000;
- 71% of road transport fuels sold in 2013.

This increase reflects to a large degree the increasing 'dieselisation' of Europe's vehicle fleet since that time. Diesel fuel consumption is significant in most EU-28 Member States (> 60% of total fuel sales) with the exception of Cyprus, Greece and Malta. A more detailed summary of the changes in the past use of diesel for road transport is given in Chapter 5.

While the proportion of renewable energy used in transport has similarly increased over time, in absolute terms it remains small, reaching just 5.6% in 2014 according to preliminary EEA estimates (EEA, 2015c). In 2013, the latest year for which data for individual countries are available, the proportion in the individual EU Member States ranged from 16.7% in Sweden and 9.9% in Finland to less than 0.5% in Estonia and Spain. Several reasons lie behind the slow uptake of renewable fuels across the EU, including:

- market uncertainty caused by delays in finalising the legislation limiting the risks of GHG emissions due to indirect land use change ([6]);

([6]) It is estimated, not considering emissions from indirect land use change, that the mitigation costs of biodiesel would be in the range of EUR 100 to EUR 330 per avoided tonne of CO_2; for bioethanol fuels from sugars and straw, costs would range between EUR 100 and EUR 200 per tonne of avoided CO_2 (EP, 2015).

Figure 3.6 Transport energy consumption in the EU-28

Note: Estimates for the year 2014 are based on the Eurostat indicator nrg_102m, using the categories 'gross inland deliveries observed' and 'international maritime bunkers' for a limited range of fuels. These include gasoline, road diesel, aviation kerosene and fuel oil. The proportionate change observed for these fuels between 2013 and 2014 is then used to estimate 2014 consumption figures for all oil-based road petrol and diesel, rail diesel, aviation kerosene and shipping fuels. Electricity, natural gas and biofuels are estimated by extrapolating the consumption trends of the previous years.

Source: EEA, indicator TERM 01 (see Annex 1).

- relatively high abatement costs related to biofuels (7);
- slow progress in the deployment of second-generation biofuels (EEA, 2015d).

3.4 Efficiency improvements and technology development

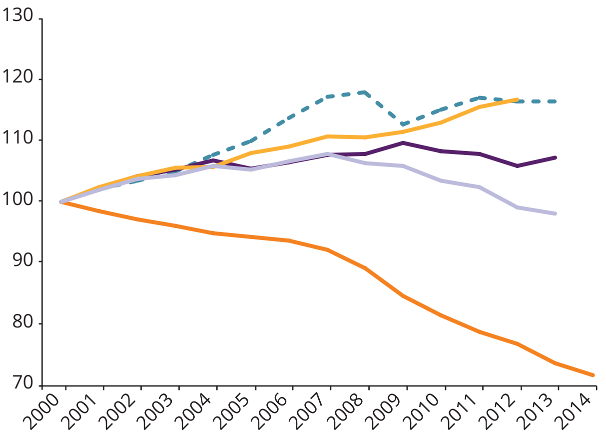
In addition to the demand for transport and the energy consumed, improved efficiencies and technological factors have also greatly affected the environmental performance of transport. However, improvements in energy efficiency alone are often insufficient to reduce environmental pressures, and the introduction of progressively stricter technical requirements in the EU has helped to drive technology development.

Furthermore, improvements in efficiency tend to make products or services cheaper, which can in itself lead to increased consumption, that is, a 'rebound effect'.

The rebound effect is apparent in the different transport modes. For instance, although the fuel efficiency and emission characteristics of passenger cars improved steadily in the period 1990 to 2009, rapid growth in car ownership and in distances travelled offset any potential improvements in terms of environmental impacts. This has been obvious since the year 2000 (Figure 3.7), noticeably that, while average CO_2 emissions from new passenger cars has been continually decreasing since the year 2000, overall fuel consumption has not decreased at the same pace because of the ever-increasing number of cars and the distances they travel.

(7) A 2015 agreement (EU, 2015a; EU, 2015b) sets a maximum limit of 7% of the total energy consumed in transport in 2020 that must be derived from biofuels produced from crops grown on agricultural land primarily for energy purposes (and which could be used for other purposes). Some 18 months after the entry into force of the directive, each Member State is to set a national target for advanced biofuels (e.g. made from waste or algae).

Figure 3.7 Fuel efficiency and fuel consumption of passenger cars (EU-28)



Source: Calculations based on (EC, 2015a), Eurostat (road_eqs_carmot), the annual macro-economic database (AMECO, http://ec.europa.eu/economy_ finance/db_indicators/ameco/index_en.htm) and the annual EU GHG inventory (EEA, 2015e).

For HDVs, efficiency and technical improvements have also reduced emissions. The latest estimate ([8]) shows a 6% reduction in CO_2 emissions per tonne-kilometre, thanks to technical improvements in light- and heavy-duty trucks, mainly thanks to improved engine efficiencies, increased load factors and reduced levels of empty running (EC, 2014c).

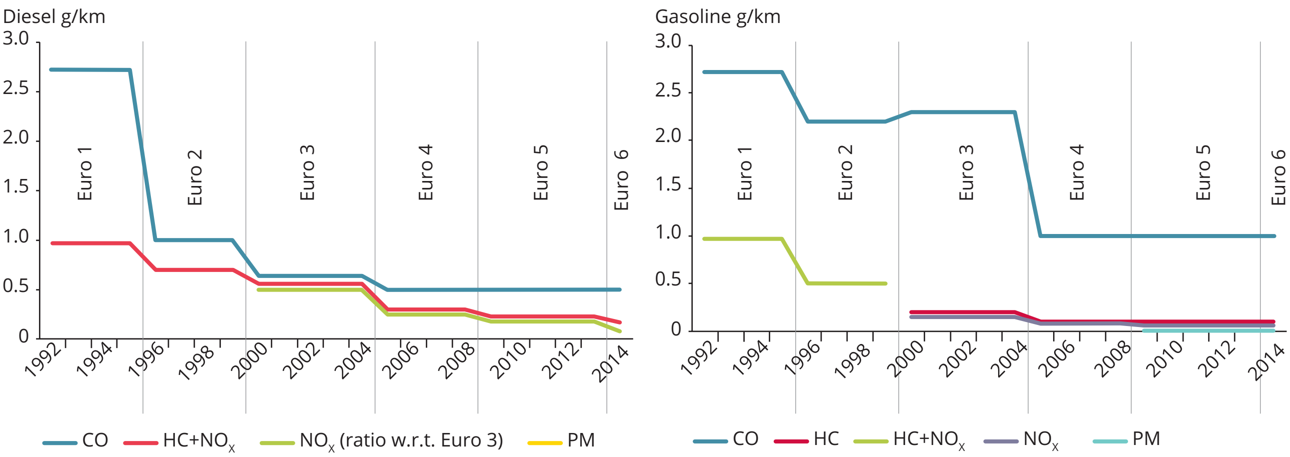
Specific CO_2 emissions from rail passenger transport (CO_2 emissions per pkm or tkm) have also fallen by some 42%, mainly thanks to the wider electrification of the railway system, a development that has also helped to reduce its direct emissions of air pollutants.

For air passenger transport, specific CO_2 emissions fell by 5% (CO_2/pkm), due to improvements in aircraft technology combined with increased load factors.

For maritime transport, specific CO_2 emissions fell by 27% from 2000 to 2014 because of increased load factors and slow steaming (Sims et al., 2014).

Technological development, specifically the development of the 'Euro' emission standards, has been important in reducing emissions of air pollutants from passenger cars, LDVs and HDVs. Over time the standards have been progressively tightened, therefore necessitating improvements in exhaust control technologies. For example, the introduction of the Euro V standard for HDVs effectively implied the mandatory use of selective catalytic reduction technology. Figure 3.8 gives an overview of the respective petrol and diesel emission limits imposed by the Euro standards for passenger cars. Importantly, and as noted previously, although vehicle

Figure 3.8 The evolution of the emission limits for gasoline and diesel passenger cars — Euro 1 to Euro 6 standards



Note: The dates refer to the year of application for the new type approvals. Application to the first registration of existing, previously type-approved, vehicle models is 1 year later, unless otherwise specified in the legislation.

Source: Euro standard regulations (EU, 1998; EU, 2007).

([8]) TERM 27 indicator. The figures have been estimated with an average number of passengers and an average load factor per vehicle. Further details on uncertainty and methodology are available (http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-5).

emission standards have been effective in reducing exhaust emissions from road vehicles, as measured in official laboratory-based tests, real-world reductions in emissions have not always been as significant. In the context of CO_2 emissions, this issue is discussed in more detail in Chapter 5.

The development of cleaner, technologically advanced vehicles is anticipated as being necessary if Europe is to meet its long-term GHG reduction targets for transport. Cleaner vehicles, for example hybrid vehicles and EVs, also deliver various environmental co-benefits in terms of reduced GHG and air pollutant emissions and noise. The number of new alternatively fuelled cars in the fleet is still very small (< 1%), but nevertheless it has increased rapidly in the last few years (see Box 3.3), influenced by a combination of economic incentives, improved cost-effectiveness compared with conventional fuels, and various regulatory developments such as the setting of CO_2 emission targets for new passenger cars (EU, 2009a) and vans (EU, 2011a) (see Chapter 5). However, some transport modes (i.e. maritime and aviation in particular) face substantial time lags before the introduction of new technologies delivers any significant changes in environmental performance (see Box 3.4).

Box 3.3 Evolving registrations of electric vehicles

The number of electric cars in Europe is increasing, due to various factors including financial incentives, increased public acceptability and market availability. The cars may be 'pure' battery EVs (BEVs), plug-in hybrid EVs (PHEVs) or EVs with range extender engines.

Sales of BEVs increased by 57% in 2014 compared with 2013, continuing a trend that has been increasing since 2008. Sales were greatest in France (10 730 BEVs sold), followed by Germany (8 572 sales). A large number of EU Member States (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Romania, Spain, Sweden and the United Kingdom) offer financial incentives such as tax reductions and exemptions for electrically chargeable vehicles. Other measures include, for example, allowing EVs to use bus lanes. Nevertheless, EVs continue to constitute only a very small fraction of new registrations in the EU-28 (0.3%) compared with, for instance, liquefied petroleum gas (1.1%).

Outside the EU, Norway is the leading market for EVs in terms of market share among EEA member countries. Of the new cars sold in Norway during the first half of 2014, almost 14% were electric (including PHEVs and BEVs). The Norwegian EV policy has gradually taken shape over the past 10–15 years and forms part of the so-called 'Climate Agreement' (*Klima-forliket*). It is based on laws and regulations set by the Norwegian Ministry of Finance and Ministry of Transport and Communications, as well as on policies implemented by some of the main cities. The incentives consist first of tax incentives: exemption from value added tax and other taxes on car sales, lower annual motor vehicle tax and a 50% lower company car tax. Drivers of EVs also enjoy other benefits in the form of free parking in public parking places, free use of most toll roads and several ferry connections and free battery charging at a growing number of public charging stations (Holtsmark and Skonhoft, 2014). The incentives were to be kept in place until the target of 50 000 EVs was reached. In April 2015 this was achieved, almost 3 years earlier than expected. There is, however, a political agreement that all of the incentives will be retained until the end of 2017.

Box 3.4 Limiting the environmental impacts of aviation

The environmental impacts of European aviation have increased over the past 25 years following the growth in air traffic — CO_2 and NO_X emissions almost doubled between 1990 and 2014. GHG, air pollutant and noise emissions from aviation can be reduced by a combination of operational, technological and economic measures.

However, Europe's aircraft fleet is slowly ageing. Owing to the generally long lifetime of aircraft, there can be a substantial time lag before new technologies deliver any significant changes in environmental performance. Without taking into account growth of the fleet, changes in schedule or technological developments, the gradual replacement at retirement of the existing fleet by the current best-available emission technology will take a long time to realise reductions in emissions: at a global level emissions would be reduced by 3.2% by 2020, by 5.9% by 2030 and by only 9.1% by 2050, compared with 2009. If, in contrast, the present-day lowest emission aircraft could replace the existing fleet, a 10% reduction in CO_2 emissions could be realised immediately (Dray, 2014).

As aviation grows, albeit at a slower rate than in the past, its environmental impact is expected to increase over the next 20 years. Improvements in engine technology, air traffic management and other operational procedures will help to limit the environmental impacts of the aviation sector in the future. However, substantial increases in future emissions are still expected as a result of growth in the sector, and technological improvements will only partly offset these increases (Eurocontrol, 2013).

4 Environmental pressures from transport

Key messages

- The transport sector affects the environment in different ways — it leads to emissions of GHGs and air pollutants, it is the main source of environmental noise and it leads to habitat fragmentation, which has a negative effect on biodiversity.
- The transport sector is the only main European economic sector for which GHG emissions have increased since 1990 — all other sectors have reduced their emissions. Transport emissions increased by 19.4% over the period.
- Accounting for almost one-quarter of the EU's total GHG emissions in 2013 (one-fifth excluding international aviation and maritime emissions), passenger cars contribute almost 45% and HDVs a further 20% of the transport sector's emissions.
- According to preliminary estimates, emissions from transport rose slightly in 2014, the first increase since 2007.
- Transport emissions of three important air pollutants SO_X, NO_X and PM decreased in the period 2000 to 2013 in the EU. With the exception of international aviation, all transport modes contributed to the decline. The introduction of the Euro emission standards for cars, LDVs and HDVs, together with the gradual renewal of the fleet, has played a key role in reducing NO_X and PM emissions. The introduction of EU fuel quality limits restricting the sulphur contents in fuels has significantly decreased SO_X emissions.
- Road traffic noise, both within and outside urban areas, is still the most important source of environmental noise in the EU. Around 125 million people were potentially exposed to noise levels exceeding 55 dB L_{den} in 2012.
- Transport has a negative impact on ecosystems and biodiversity. Important legislation has been developed in the EU, establishing procedures and obligations aiming to minimise such consequences. However, there are still several gaps regarding their implementation in practice.

This chapter assesses the most important transport-related environmental pressures across the EU-28 since 2000, including:

- GHG emissions
- air pollutants (focusing on emissions of NO_X, particulate matter, and SO_X)
- noise pollution
- biodiversity pressures.

In order to gain a better understanding of the contribution of various factors to the trends in emissions of air pollutants and GHGs in the past, decomposition analyses for the passenger and HDV transport sectors have also been carried out. These assessments provide information on the relative importance of selected explanatory factors that have influenced trends in the emissions of the pollutants since 2000 (see Box 4.1 and Annex 5 for further details).

4.1 Greenhouse gas emissions

4.1.1 Trends in greenhouse gas emissions

From 1990 to 2013, GHG emissions decreased in all the main sectors of the EU economy except transport (Figure 4.1). Transport emissions increased by 19.4% over the period (by 13.0% excluding emissions from international aviation). GHG emissions have steadily decreased since 2007, although, according to preliminary EEA estimates for the year 2014, total emissions from transport rose slightly in 2014, the first increase in 7 years (EEA, 2015d). In 2013, the transport sector contributed almost one-quarter (24.4%) of total EU GHG emissions (19.8% excluding international aviation and maritime).

Since 2000, GHG emissions from the different transport modes have shown the following trends.

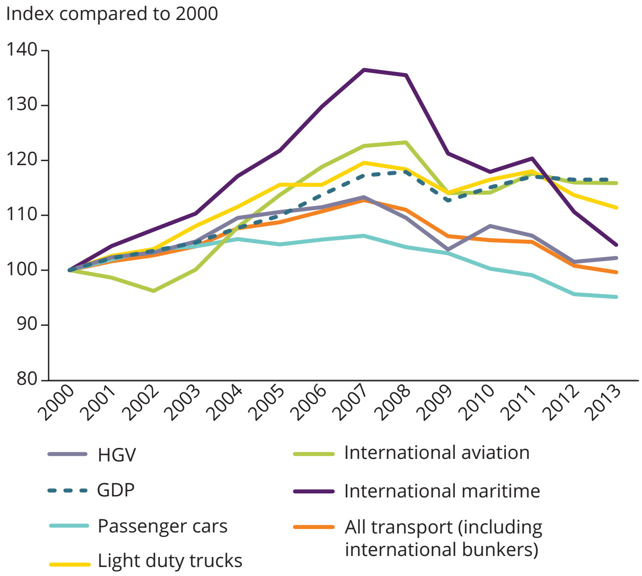
- Trends in HDV and passenger car emissions are slightly different, the former being more in line with trends in GDP. However, passenger car GHG emissions have remained more stable since the year 2000, increasing slightly until reaching a peak in 2007, and then decreasing steadily to reach 4.9% below 2000 levels in 2013.

- International aviation emissions increased strongly, by 22.6%, between 2000 and 2007, and then they fell by 5.5%. Emissions were 16% higher in 2013 than in 2000.

- International maritime bunker sale emissions increased by 36.5% from 2000 until 2007 and then decreased by 23.3% between 2007 and 2013. Compared with 2000, emissions were 4.6% higher in 2013.

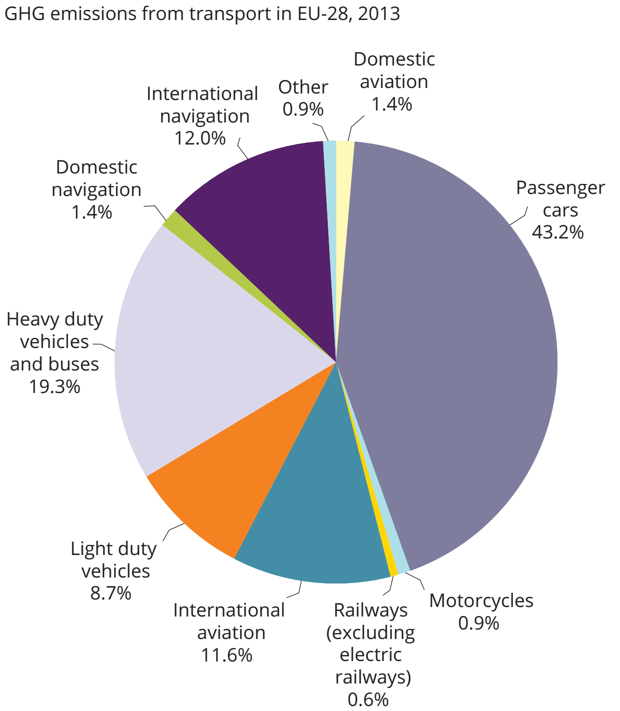
The contribution of the different modes of transport to 2013 GHG emissions is shown in Figure 4.2. Road transport was responsible for almost 73% of all GHG transport emissions (including bunkers) in 2013. Passenger cars accounted for 60% of all road transport emissions and HDVs for 27%. Emissions from light duty trucks ([9]) comprise 8.7% of total transport GHGs (and 12% of all road transport GHG emissions).

Figure 4.1 EU transport GHG emissions by mode between 2000 and 2013 compared with GDP



Note: Calculations based on (EC, 2015a) the annual macro-economic database (AMECO, http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm) and the annual EU GHG inventory (EEA, 2015e). CO_2 emissions from buses have been subtracted from CO_2 emissions from HDVs and buses, reported in GHG inventories, using data from the EC4MACS (European Consortium for Modelling Air Pollution and Climate Strategies) project (http://www.ec4macs.eu).

Figure 4.2 Contributions of the different modes of transport to EU transport GHG emissions in 2013



Source: Based on data from EEA (2015e).

([9]) 'Light duty trucks' is a UNFCCC/IPCC category that covers the emissions from vehicles in the registering country primarily for transportation of light-weight cargo or which are equipped with special features such as four-wheel drive for off-road operation. The gross vehicle weight normally ranges up to 3500-3900 kg. IPCC definitions can be found here: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

4.1.2 *Exploring the reasons for changes in CO_2 gas emissions — passenger cars*

While transport demand and related CO_2 emissions are clearly linked to economic activity, various other factors have also contributed to the overall reductions in CO_2 emissions seen since 2007, including:

- efficiency improvements due to the ongoing effects of legislation;
- changes in consumer behaviour and preferences;
- developments in the levels of service and logistics for freight.

In order to gain a better understanding of the relative contributions of different explanatory factors to the trends in CO_2emissions, a decomposition analysis was undertaken for the road transport sector based on the reported CO_2emissions from passenger cars and HDVs (EEA, 2015e) (see Box 4.1).

The selected explanatory factors used for the CO_2 decomposition analysis were:

- passenger or *freight transport demand (passenger kilometre or tonne-kilometre):*
  Passenger or freight transport activity is expressed as the product of the distance a vehicle travels multiplied by the number of occupants (passengers) or goods (tonnes) travelling that distance (EC, 2015a). Data is available for all inland transport modes (i.e. public road transport, private cars and rail for passenger transport, and LDVs, rail and IWW for freight transport). It does not include aviation or inland navigation for passenger transport. Modelled data for LDVs (in tkm, derived from the EC4MACS model) were included in the freight analysis as a competing mode;
- *proportion of passenger car transport/HGV in total passenger/freight transport:*
  This factor represents the changes in modal split over the years considered, i.e. the proportion of private cars in total passenger transport and HGVs in total freight transport (inland modes, see above) (from EC, 2015a);
- *improvements in energy efficiency:*
  The total fuel consumption from private cars per pkm and from HGVs per tkm respectively. Both CO_2 emissions and energy consumption from buses and coaches have been subtracted from CO_2 emissions from the combined category 'HDVs and buses', reported in GHG inventories (EEA, 2015e), using the EC4MACS model;
- *development of transport biofuels:*
  Fossil fuel consumption (i.e. all fuels but biofuels) from passenger cars or HGVs in total fuel consumption (EEA, 2015e). For the purposes of this decomposition, biofuels are assumed to be emission neutral;
- *carbon intensity of fossil fuels:*
  Carbon intensity is defined as the amount of CO_2 emitted per unit of fossil fuel consumed by private cars or HGVs.

Emissions from motorcycles and sources not related to fuel combustion were not considered. Also not included were indirect and upstream emissions associated with fuel production. Further details on the methodology used are given in Annex 5.

Box 4.1 What is a decomposition analysis?

Decomposition analysis is a technique often used to illustrate the contributions that different selected explanatory factors have made on emissions of air pollutants and GHGs over time.

An equation linking the observed emissions to the selected factors is first specified. These factors are typically chosen as those likely to have had a significant impact on emissions over the period considered, and for which data is available. The decomposition analysis assumes each of the different explanatory factors is independent, i.e. no interaction or synergy between different factors is assumed. It is also important that the number of factors is limited (usually 4 to 6), as the change in emissions is effectively 'decomposed' and distributed according to which is most important in terms of its impacts on emissions across the time period chosen. Selecting many factors can therefore convolute the final result. The results are also clearly dependent upon the various explanatory factors originally chosen. Therefore results should not be considered as an exhaustive assessment of the contributory factors responsible for past changes in emissions.

The charts presenting the decomposition analysis results in this report show the relative contributions made by each factor to changes in emissions over time i.e. being responsible for either increasing or decreasing emissions, compared to the year 2000. Together, the sum of the different factors in each year is the same as the change in observed emissions. Further details on the methodology used are provided in Annex 5.

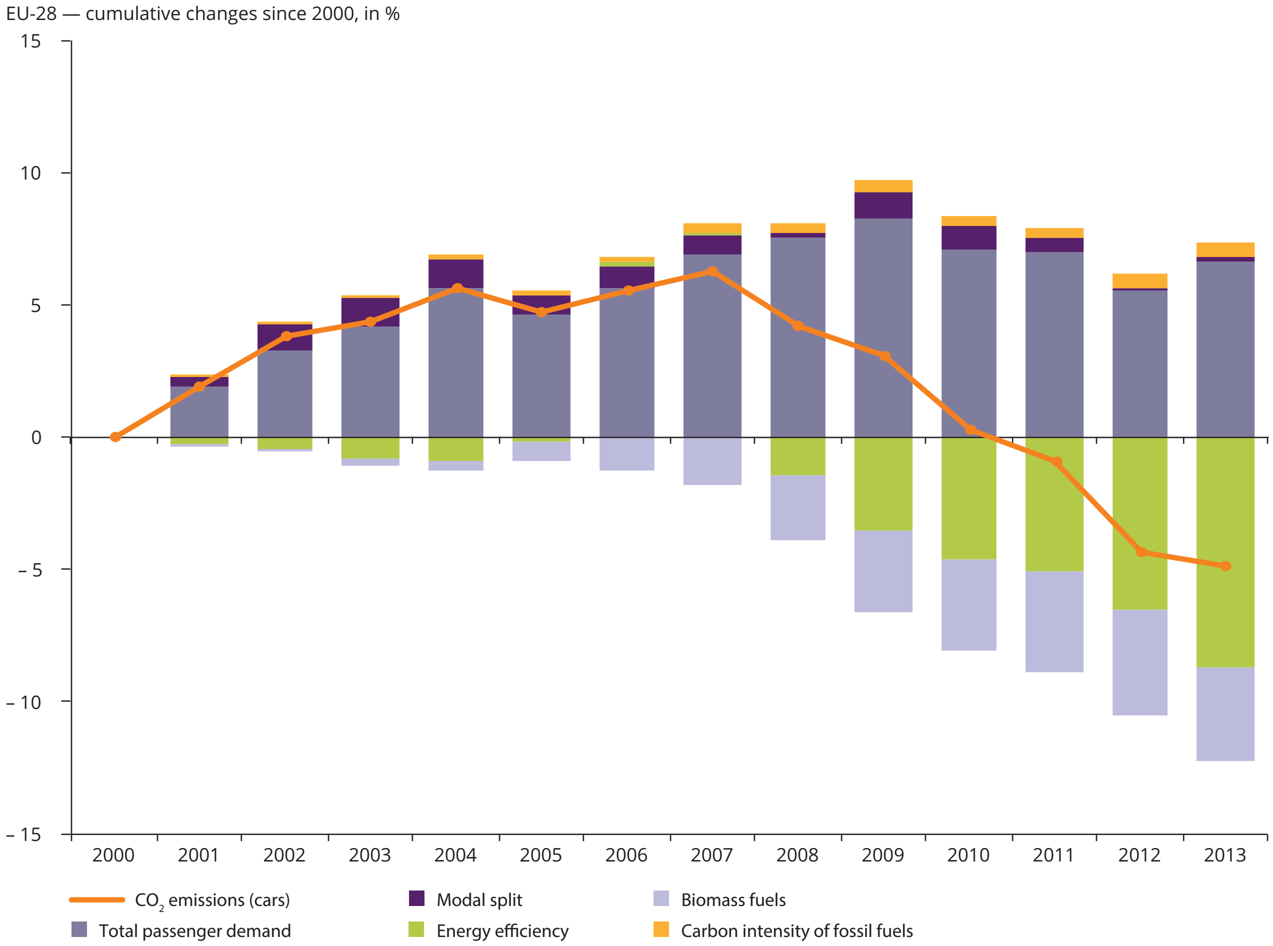
The results of the decomposition analysis for passenger car CO_2 emissions are shown in Figure 4.3. The assessment shows emissions:

- peaking in 2007 at 6.3% above 2000 levels;
- decreasing to the 2013 value, 5% below 2000 levels.

It is clear that the improvements in passenger car energy efficiency have been the main factor contributing to the reduction in CO_2 emissions since 2000, and especially since the year 2008, despite changes in demand during these years. Improvements in vehicle efficiencies have increased significantly since around 2007, the time point around which the 2009 CO_2 Regulation for cars was being developed (see Chapter 5). Although there was a voluntary agreement with vehicle manufacturers in place prior to the regulation, there appeared to be little reduction in emissions arising from improvements in vehicle efficiency during that time. It is also noteworthy that the average car sold in 2014 was approximately 25% more efficient than the average car sold in 2000 and, given that the average age of a passenger car in Europe is in the range 7.5 (indicator TERM 33, see Annex 1) to 9.6 years (ACEA, 2015), , the effects should have materialised in the last years.

Another important component of the improvement in energy efficiency is the increased proportion of diesel cars and diesel fuel consumed in Europe. The amount of diesel as a proportion of the total consumption of petroleum products by cars increased by 79% from 2000 to 2013, whereas gasoline use by passenger cars decreased by 40% in the same period.

Figure 4.3 Decomposition analysis of CO_2 emissions for passenger cars (EU-28 — cumulative changes since 2000)



Note: The graph shows the estimated contributions of the various factors that have affected CO_2 emissions from passenger cars. This approach is often used to portray the primary forces driving emissions. The explanatory factors should neither be seen as fundamental factors in themselves nor should they be seen as independent of each other.

However, the increased proportion of diesel over gasoline in passenger cars has a two-fold effect in the analysis:

- it contributes to lower CO_2 emissions through improvements in efficiency — diesel cars need less energy to drive 1 km;
- diesel's carbon content per unit of energy is higher (which pushes emissions up, as it emits more CO_2 per unit of energy).

Overall, the increased proportion of diesel over gasoline has had a positive effect on the total amount of CO_2 emissions; however, this is not the case for other pollutants, namely NO_X. The development of transport biofuels has also been evident in recent years, particularly since 2005 when the use of biofuels started to increase significantly, tripling between 2005 and 2013, and thereby contributing to decreasing emissions of CO_2 by passenger cars ([10]).

4.1.3 *Exploring the reasons for changes in CO_2 emissions — heavy-goods vehicles*

For the decomposition analysis of GHG emissions from heavy goods vehicle (HGVs), the EC4MACS model (http://www.ec4macs.eu/) was used to separate the emissions of HGVs and 'buses and coaches', as in the officially reported statistics, CO_2 emissions from these two vehicle types are combined in the heavy-duty vehicle (HDVs) category. The analysis is therefore focussed on HGVs CO_2 emissions derived from EU transport activity from national and international haulage vehicles registered in the EU-28, with generally more than 3.5-tonne load capacity.

The decomposition analysis for GHG emissions from HGVs for the period 2000–2013 (Figure 4.4) shows the demand for HGV transport and the CO_2 emissions:

- peaking in 2007 at 13.3% above 2000 levels;
- decreasing by 3.3% in 2008 and by a further 5.3% in 2009, following the impact of the economic recession.

Total HGV freight volumes in 2013 were below their 2004 levels but still 14% higher than in 2000. HGV freight's contribution to land freight transport, which also includes LDV, rail and inland waterways, also increased, reaching 66.4% compared with 64.2% in 2000. This greater contribution, albeit slight, is one of the factors contributing to increased HGV emissions.

The improvement in energy efficiency is the main factor that has contributed to HGV CO_2 emissions being only slightly above 2000 levels, despite the increase in freight movements. The improvements in energy efficiency may be the result of a mixture of factors. The most important is most likely improvements in engines, with additional contributions from the use of lighter materials, developments in vehicle aerodynamics, correct tyre use and potentially more efficient driving styles. A recent study for a manufacturers' association (Breemersch and Akkermans, 2014) also indicated a clear trend of reduced fuel consumption per tonne-kilometre between 2005 and 2010, but that trend appeared more ambiguous between 2010 and 2014. These data are in line with data extracted from the EC4MACS model (TERM 27 ([11])), showing that the energy efficiency of HGVs improved slightly over these years (by 8.4% from 2000 to 2013).

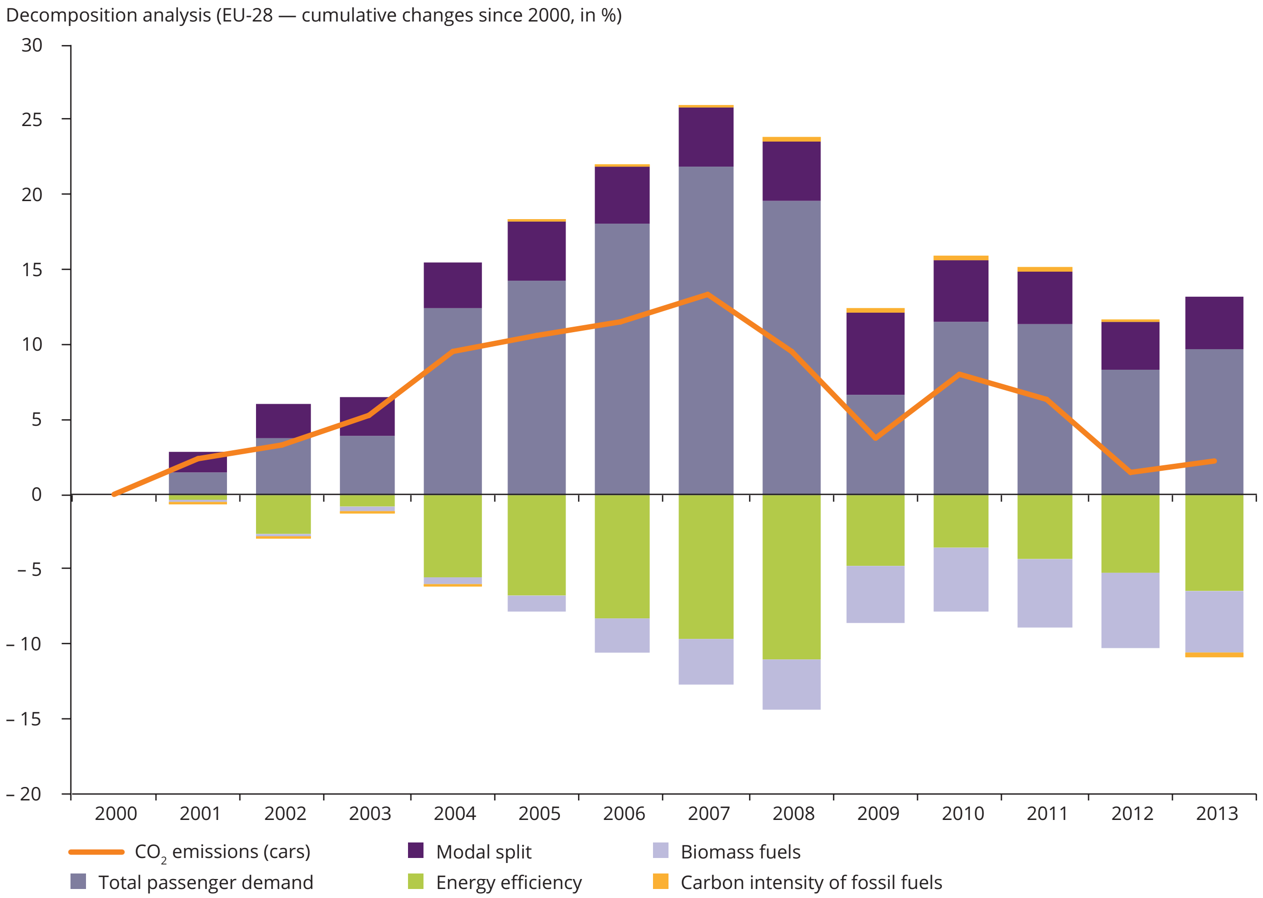
Increasing load factors in road freight transport may also have delivered improvements in energy efficiency. Owing to the lack of data available on load factors, the level of empty running is generally used as an alternative indicator. Although levels of empty running have decreased slightly over recent years, calculations based on Eurostat data for 2013 show that almost one-quarter (21.4%) of all HGV vehicle-kilometres in the EU involved an empty vehicle. There is therefore significant potential for improving load factors in long-distance freight transport through a wider uptake of innovative business models in logistics. Improvements in the operation of freight transport are also currently held back by regulatory restrictions, such as the rules on cabotage (Regulation (EC) No 1072/2009), which may limit the extent to which hauliers can increase their efficiency (EC, 2014c).

In terms of the other explanatory factors assessed, the apparent small contribution of carbon intensity factor to an increase or decrease in CO_2 emissions is probably due to slight fluctuations in the carbon content (i.e. CO_2 per unit of energy) of diesel over the period 2000–2013, which should be considered insignificant on account of the range of uncertainty.

([10]) The use of biofuels does not take impacts on the life cycle into account (i.e. GHG emissions due to indirect land-use change).

([11]) TERM 27 indicator. The figures have been estimated with an average number of passengers and an average load factor per vehicle. Details on uncertainty and methodology are available (http://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-5).

Figure 4.4 Decomposition analysis of CO_2 emissions by HGVs (EU-28 — cumulative changes since 2000)



Note: The graph shows the estimated contributions of the various factors that have affected CO_2 emissions from HGVs. This approach is often used to portray the primary forces driving emissions. The explanatory factors should neither be seen as fundamental factors in themselves nor should they be seen as independent of each other.

The increased use of biofuels may also have contributed to the lower HGV CO_2 emissions (the biomass fuels effect). According to preliminary data, the use of biofuels by HGVs increased seven-fold between 2000 and 2013. Such fuels have the advantage that they can use the fuelling infrastructure already in place, and it has been estimated that the use of the most common biofuel in Europe, FAME/FAEE (fatty acid methyl/ethyl esters), produced mainly from rapeseed oil and soya oil, decreased tailpipe CO_2 emissions by 2.5% between 2005 and 2014 at an average inclusion rate of 7% (Breemersch and Akkermans, 2014). While the reduction in tailpipe GHG emissions is apparent, there are concerns regarding the use of crop-based fuels, which may have a larger net environmental impact than conventional fuels. In 2014, the EU agreed a 7% cap on the use of biofuels from food crops in transport. Second-generation biofuels produced from non-food materials are seen as a solution to many of the sustainability issues posed by crop-based biofuels. However, to avoid making poorly judged investments, a pre-assessment of their environmental impact will be essential (EP, 2015).

Reducing future emissions from HDVs will be important if the EU is to meet its targets for reducing transport GHG emissions. While no concrete action has yet been taken to set regulatory standards for CO_2 emissions from HDVs in Europe, other countries, such as Canada, China, Japan and the United States, have already introduced legislation. As the *European Strategy for reducing heavy-duty vehicles' fuel consumption and CO_2 emissions* (EC, 2014d) acknowledged, the introduction of limits can affect the relative competitiveness of HDV manufacturing in these regions, as well as that of the businesses that rely on HDV transport. Nevertheless, mandatory performance targets for CO_2 emissions per tonne-kilometre have proven to be effective. Between 2002, the year when HDV fuel efficiency standards were implemented in Japan, and 2009, HDV fuel efficiency in that country improved by almost 7% (Breemersch and Akkermans, 2014).

4.2 Air pollution

Despite considerable improvements in past decades, air pollution is still responsible for more than 400 000 premature deaths in Europe each year. It also continues to damage vegetation and ecosystems. Transport contributes significantly to the emissions of many air pollutants and the resulting poor air quality, particularly in urban areas with high traffic volumes (TERM 04 (EEA, 2015f)). For example, road traffic emissions are an important source of nitrogen dioxide (NO_2). The EU annual air quality limit value for NO_2 was widely exceeded across Europe in 2013, with 93% of all exceedances occurring close to roads. Nineteen Member States recorded exceedances of the limit value at one or more monitoring stations (EEA, 2015f).

This section focuses on three important transport-related air pollutants, namely NO_X, PM and SO_X. It presents and explores the underlying factors responsible for the changes in emissions of these pollutants over time.

4.2.1 Air pollutant emission trends

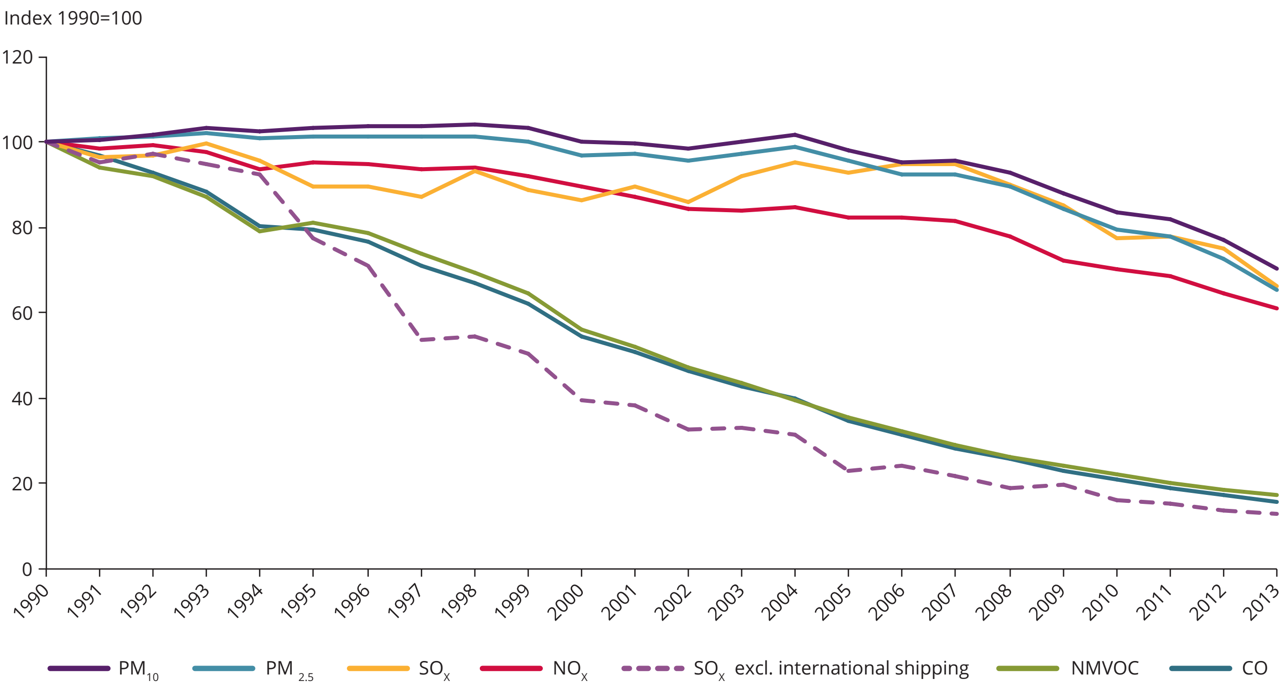
Significant progress has been made since 1990 in reducing the emissions of many air pollutants from the transport sector in Europe. The relative changes in emissions of pollutants from the EU-28 transport sector are shown in Figure 4.5. All transport modes have decreased their emissions, except for international aviation and shipping, for which emissions of each pollutant have increased since 1990.

Between 1990 and 2013, transport emissions of the main pollutants decreased as follows:

- NO_X 35%
- PM_{10} 27%
- SO_X 36%
- CO 82%
- NMVOCs 83%.

There are a combination of reasons for the observed reductions in emissions. An assessment of the reasons for these changes is presented in the following sections for NO_X, PM_{10} (particulate matter with a diameter of 10 μm or less) and SO_X. The reductions in both CO and NMVOCs since 1990 are mostly due to the introduction of the Euro emission standards and specifically the resulting implementation of catalytic converter technologies across the passenger vehicle and HDV fleets. Road

Figure 4.5 Emissions of air pollutants from the transport sector in the EU-28



Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

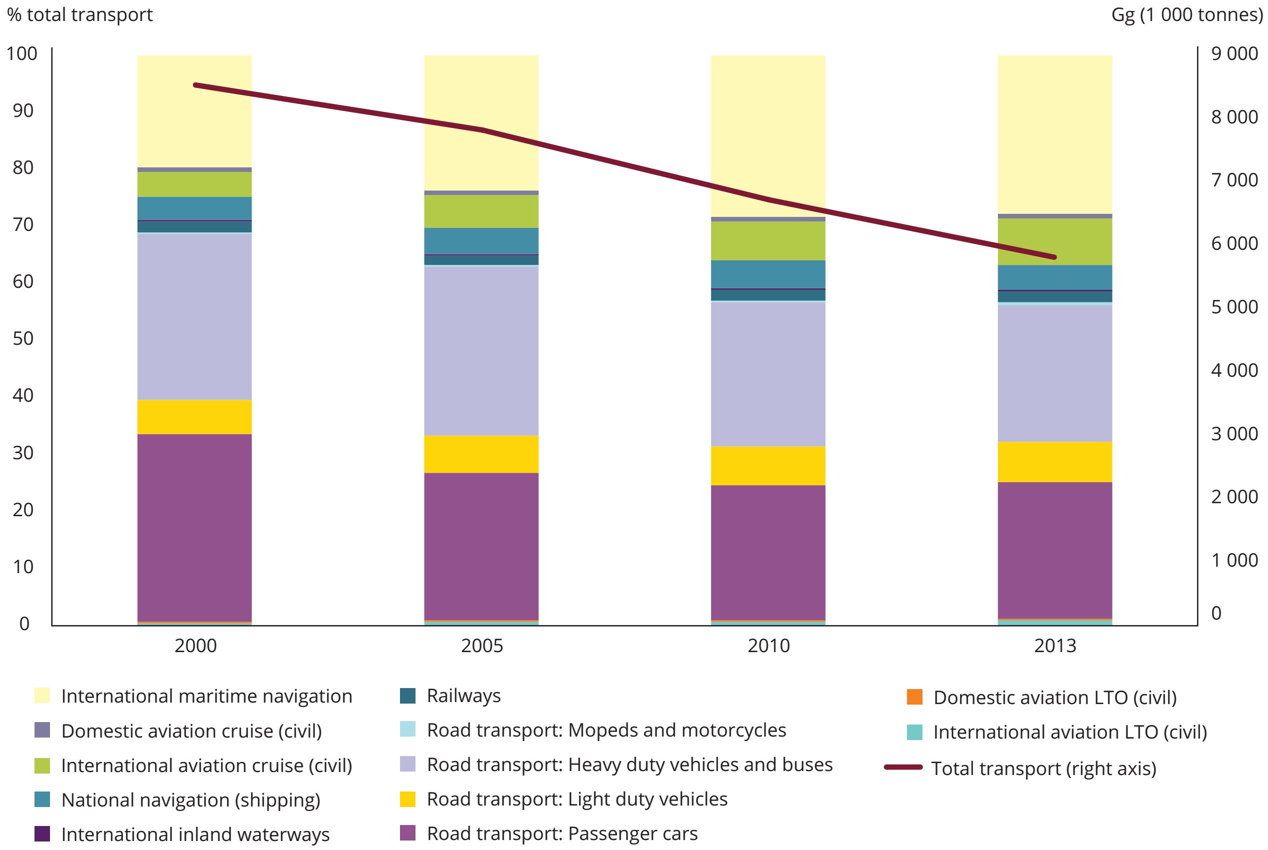
transport is the dominant source of CO from the transport sector, accounting for greater than 90% of transport emissions. In the case of NMVOCs, the development of canisters on gasoline cars to control evaporative emissions has also been an important contributory factor in terms of decreasing emissions, as has limits on the maximum volatility of the petrol sold in EU Member States, as specified in fuel quality directives. The reductions in NMVOC emissions have also been enhanced by the switch from petrol to diesel cars in some EU Member States.

4.2.2 *Emissions of NO_X and PM_{10}*

Emissions of NO_X and PM_{10} have declined for all transport modes in the EU-28 since the year 2000, with the exception of international aviation (Figures 4.6 and 4.7). Overall transport NO_X emissions (Box 4.2) have declined by 32% since the year 2000, mainly due to technical improvements in the road transport sector. International maritime transport emissions increased during the first half of the period but returned to almost 2000 levels thereafter. Only emissions from international aviation increased by almost 25%, but they are still relatively small compared with the other transport modes. The electrification of the railway network, along with enhanced energy efficiency, was the main contributor towards reductions in emissions from rail transport. The situation is similar for primary PM_{10} emissions. Total transport PM_{10} emissions have declined by 30% since 2000 with the greatest absolute and relative reductions coming from road transport (57% reduction in exhaust PM_{10} emissions).

Both NO_X and PM_{10} emissions depend primarily on the combustion technology and to a lesser extent on the fuels used. The introduction of the Euro exhaust standards has reduced emissions from new vehicles but, owing to the lifetime of the existing vehicle stock, the benefits will be realised only over a longer period of time. For certain pollutants, including NO_X, there is a significant and growing discrepancy between official emission measurements that assess compliance with the Euro standards and real-world

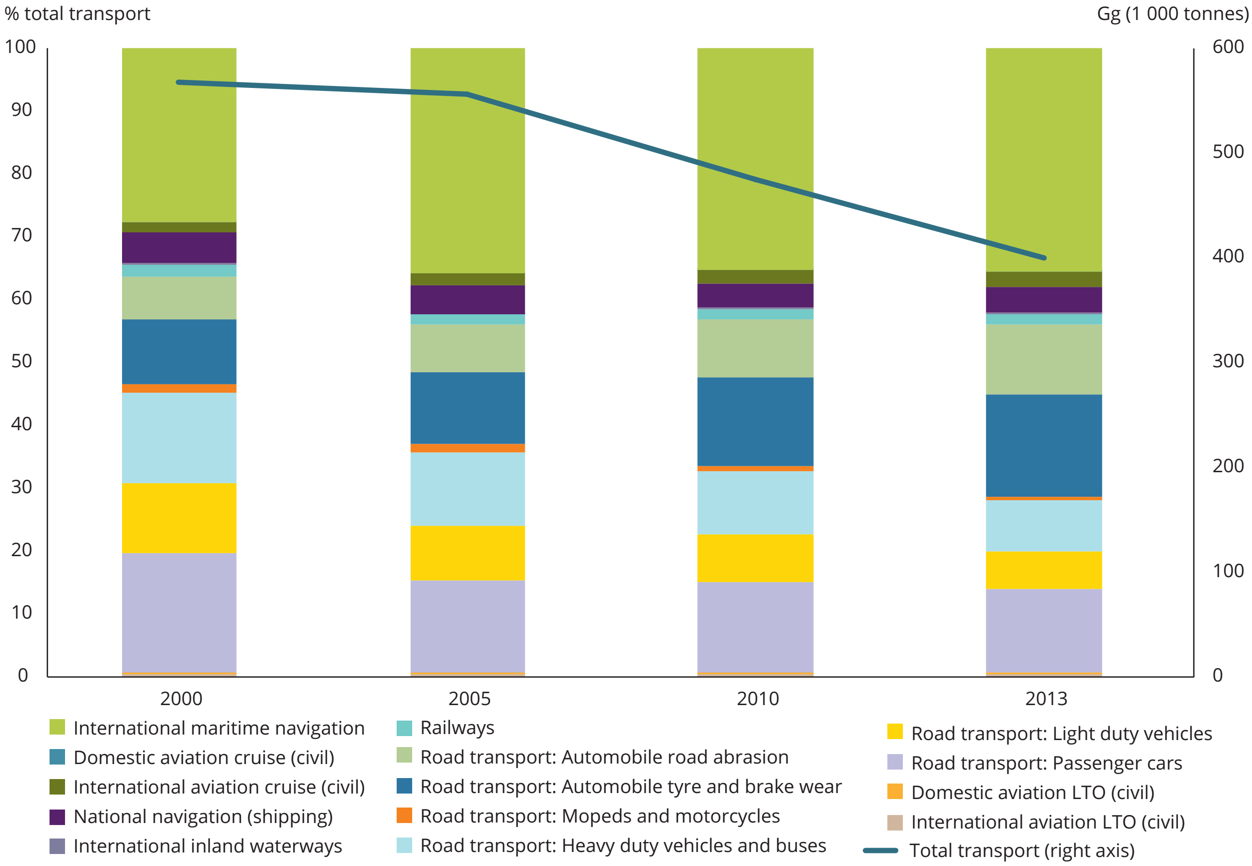
Figure 4.6 NO_X emissions from the transport sector in the EU-28



Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

vehicle performance (Box 4.3). This gap has increased over past years. For NO_X, the latest Euro 6 diesel vehicles can emit up to seven times more in real-world conditions than in official tests. The reasons for this discrepancy include the outdated measurement used to test vehicles, the optimisation of permitted flexibilities by manufacturers during vehicle testing, and changes in drivers' behaviour under real driving conditions. A detailed discussion of these issues is available elsewhere (EEA, 2015g).

Figure 4.7 PM_{10} emissions from the transport sector in the EU-28



Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

Box 4.2 Nitrogen emissions from road transport

NO_X are produced when fuel is combusted in the engine in the presence of air. NO_X comprise a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is not harmful to health at the concentrations typically found in the atmosphere. However, in contrast, NO_2 is associated with a range of environmental and health problems. The proportion of harmful NO_2 in the NO_X emissions of a diesel vehicle is far higher than the proportion found in the emissions of a conventional petrol vehicle. In older diesel engines, approximately 95% of NO_X emissions were NO and only 5% were NO_2. For new diesel passenger cars, both engine size and exhaust after-treatments (e.g. catalytic converters) affect the level of NO_2 emissions: the NO_2 to NO_X ratio can vary from 12% to 70% (EEA, 2013a). Some catalytic converters may also, while significantly reducing the emissions of CO, NO_X and hydrocarbons, produce other nitrogen-containing pollutants such as NH_3 and the GHG nitrous oxide (N_2O). The road transport emissions of both these pollutants, although relatively small, have increased since 1990 as a result of the increased use of three-way catalytic converters. These release NH_3 as a by-product. However, NH_3 emissions have fallen since 2000, and are projected to fall further in the future as the second generation of catalysts — which emit lower levels of NH_3 than the first generation of catalysts — become more widely used in the vehicle fleet.

Box 4.3. Volkswagen and 'defeat devices'

In September 2015, the United States Environmental Protection Agency (USEPA) announced that it had issued a notice of violation of vehicle emission limits against Volkswagen. This occurred after the USEPA, together with the Californian Air Resources Board, had investigated a variety of four-cylinder diesel passenger cars manufactured by Volkswagen and found that the on-road performance of these vehicles emitted up to 40 times more NO_X than permitted by the US emission standards.

Volkswagen subsequently admitted to using 'defeat devices' in the USA to artificially lower NO_X emissions during testing of these diesel vehicles. The defeat devices comprise computer software that can identify when a vehicle is being tested by monitoring various parameters such as speed, engine operation, air pressure and external conditions (i.e. temperature and humidity). When the engine software recognises the vehicles is undergoing a test, engine operation and the performance of the vehicle catalyst change to ensure that the pollution standards were respected. However, once on the road, the emission control systems were reduced or switched off resulting in significantly higher emissions under 'normal' operating conditions. Volkswagen has subsequently confirmed it has also sold diesel vehicles in Europe containing the same defeat device software.

Subsequently in early November 2015, the USEPA issued a second notice of violation after discovering certain additional larger diesel vehicles manufactured by Volkswagen Group also appeared to use defeat devices. Separately, Volkswagen Group has also publicly confirmed that the fuel consumption and CO_2 emission values it has published for some models are incorrectly stated. The company is presently reviewing which models are specifically affected.

At the time of writing, several Member States have announced that they plan to independently investigate the on-road emissions of Volkswagen diesel vehicles, as well as those from other manufacturers. The new real emissions testing procedure (RDE), which will be adopted soon in the EU, will also provide a valuable check to the on-road performance of vehicles compared with laboratory testing.

4.2.3 Exploring the reasons for changes in emissions of NO_X and PM_{10}

As for GHGs, a decomposition analysis was undertaken to identify the contribution of different factors towards past changes in NO_X and PM emissions. The analysis was applied to emissions from road passenger transport and freight transport (HDVs) over the period 2000–2013. The latter also includes emissions from passenger transport by buses and coaches, as their emissions are reported along with those of HDVs. Emissions from motorcycles, LDVs and sources not related to fuel combustion, such as gasoline evaporation, tyre and brake wear or road abrasion, were also not considered.

The selected explanatory factors used for the NO_X and PM_{10} decomposition analysis were:

- *passenger or freight transport demand (passenger kilometre or tonne-kilometre):*
  Passenger or freight transport activity is expressed as the product of the distance a vehicle travels multiplied by the number of occupants (passengers) or goods (tonnes) travelling that distance (EC, 2015a). Data is available for all inland transport modes (i.e. public road transport, private cars and rail for passenger transport, and LDVs, rail and IWW for freight transport). It does not include aviation or inland navigation for passenger transport. Modelled data for LDVs (in tkm, derived from the EC4MACS model) were included in the freight analysis as a competing mode;

- *proportion of passenger car transport/HGV in total passenger/freight transport:*
  This factor represents the changes in modal split over the years considered, i.e. the proportion of private cars in total passenger transport and HGVs in total freight transport (inland modes, see above) (from EC, 2015a);

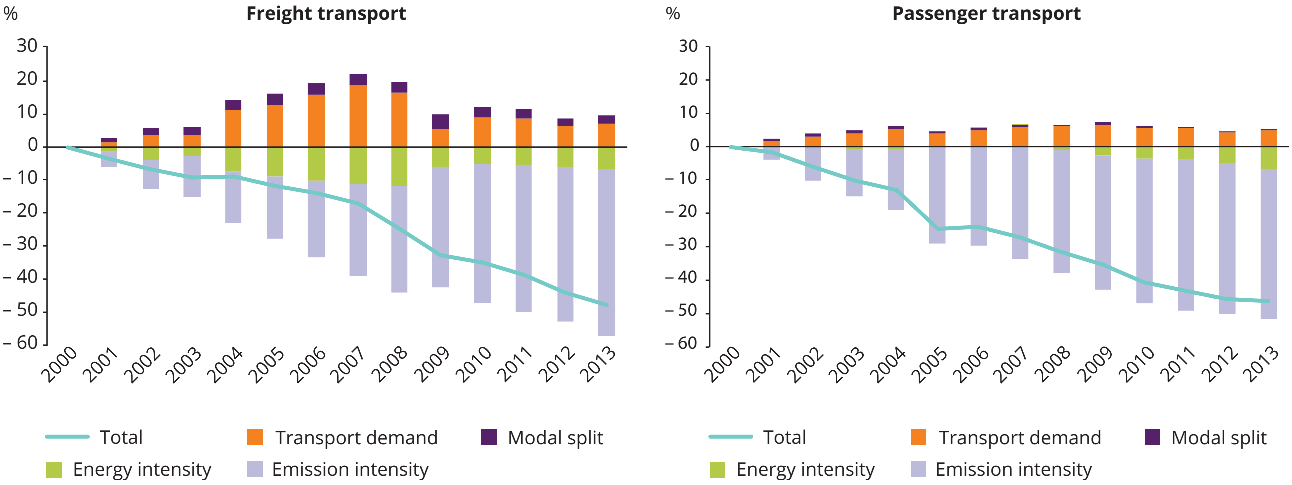
- *improvements in energy efficiency:*
  The total fuel consumption from private cars per pkm and from HGVs per tkm respectively.

- *emissions intensity of fossil fuels use:*
  Emissions of the different pollutants per unit of energy consumed by private cars or HDVs;

Further details on the factors used, data sources and the formulae applied are provided in Annex 5.

Figures 4.8 and 4.9 show the results of the decomposition analysis for both pollutants. For the EU-28, the results show the impact of EU legislation and the introduction of technical standards limiting

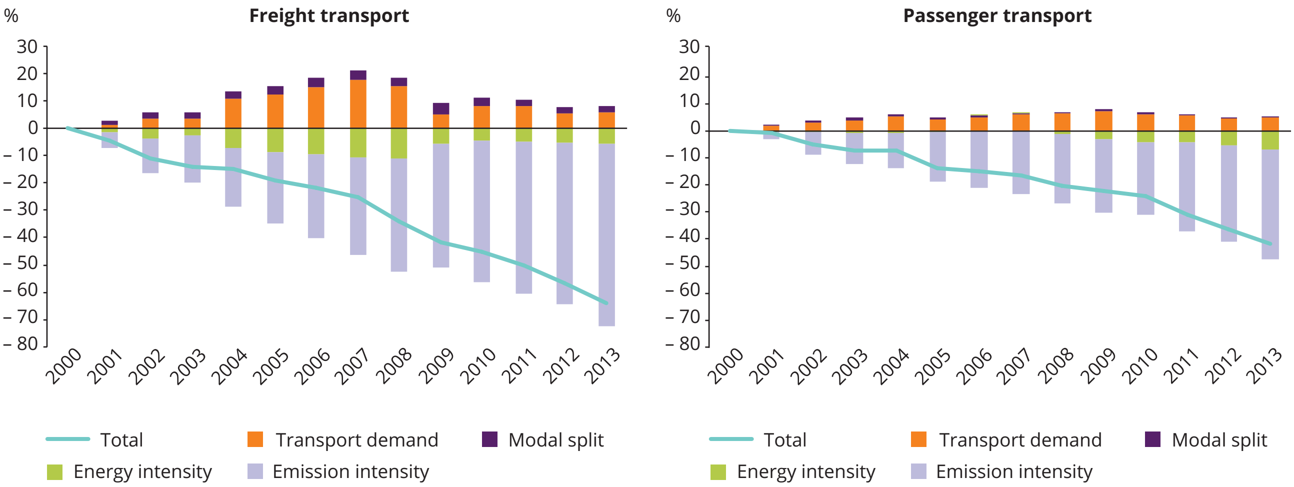
Figure 4.8 **Decomposition of NO_X emissions from road transport — freight (left) and passenger (right) transport**



Note: Changes are expressed relative to 2000 emission levels for each pollutant.

Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

Figure 4.9 **Decomposition of PM_{10} emissions road transport — freight (left) and passenger (right) transport**



Note: Changes are expressed relative to 2000 emission levels for each pollutant.

Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

the exhaust emissions included in the emissions intensity factor. The picture for NO_X and PM_{10} is very similar, in that emission standards for both private cars and HDVs have substantially helped to reduce emissions. Increased energy efficiency has also contributed to the overall reduction. The main driver contributing to the increase in emissions was a growth in the demand for transport, particularly freight transport up to 2008. Substantial investments were made in Europe's road network during that period, which generally stimulates a greater demand for road transport. For instance, the length of the motorway network in the EU-13 doubled between 2000 and 2012 (EC, 2015a).

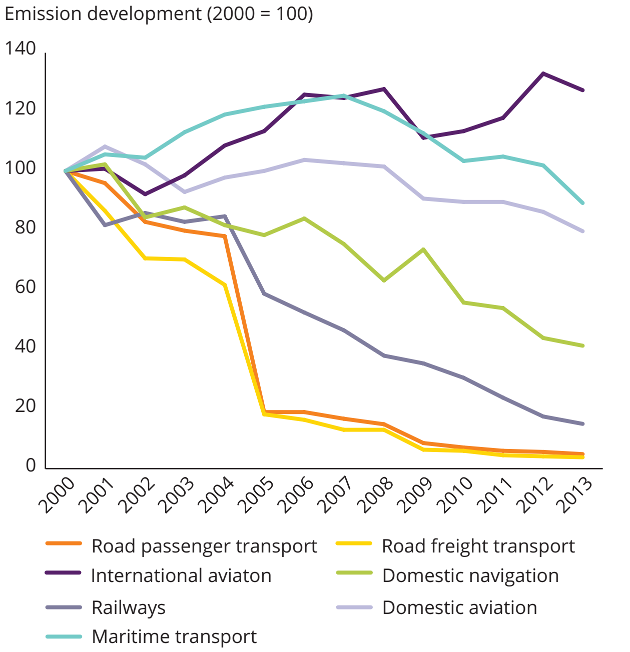
4.2.4 SO_X emissions

SO_X emissions depend mainly on the total amount of sulphur contained in combusted fuel — they are not controlled by exhaust technologies unlike NO_X and PM. Emissions of SO_X have declined since 2000 by 23%, with all transport modes reducing their emissions with the exception of international aviation, for which emissions were almost 30% above 2000 levels in 2013 (Figures 4.10 and 4.11).

Emissions from maritime transport declined after the financial crisis in line with a decreased demand for transport but were approximately 11% below 2000 levels in 2013. Despite this, the sector was responsible for over 90% of all transport-related SO_X emissions in the EU in 2013. Another 6% were attributed to domestic navigation and 3% to aviation.

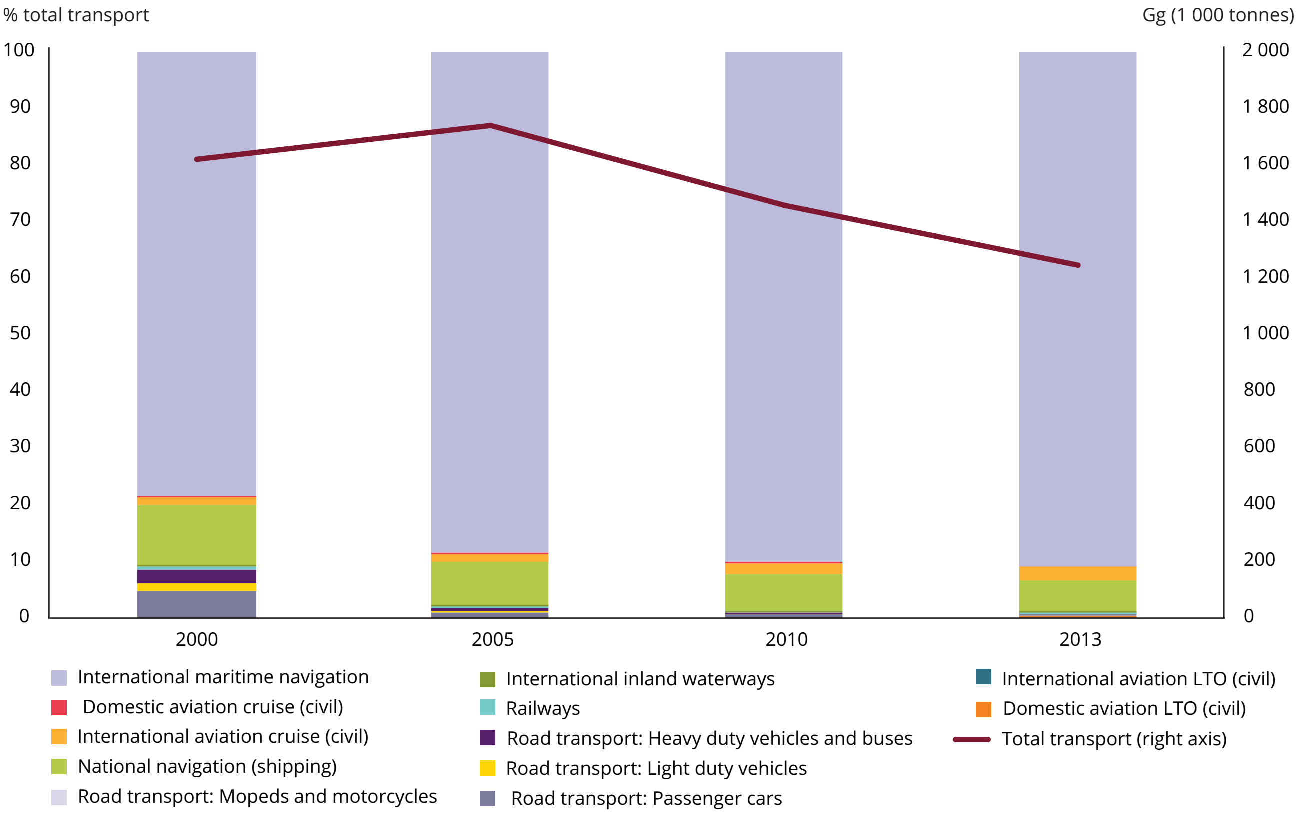
Along with a reduced demand for transport as a result of the economic recession in 2008/2009, fuel quality limits specifying the permitted levels of sulphur in fuel, which were established at EU and international levels, were the other main reason for the decreased SO_X emissions observed over time (see Box 4.4). The effect of stricter sulphur limits introduced in 2005 and again

Figure 4.10 Trend in SO_X transport emissions by mode in the EU-28



Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

Figure 4.11 Proportion of SO_X transport emissions by source in the EU-28



Source: EEA, TERM 03, based on the European Union emission inventory report 1990–2013 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).

in 2009 is clearly visible in the data for road transport, rail and domestic navigation. For international maritime transport, there was a slight decrease in the second half of the period, but the absolute sulphur content remains very high (see Box 4.4).

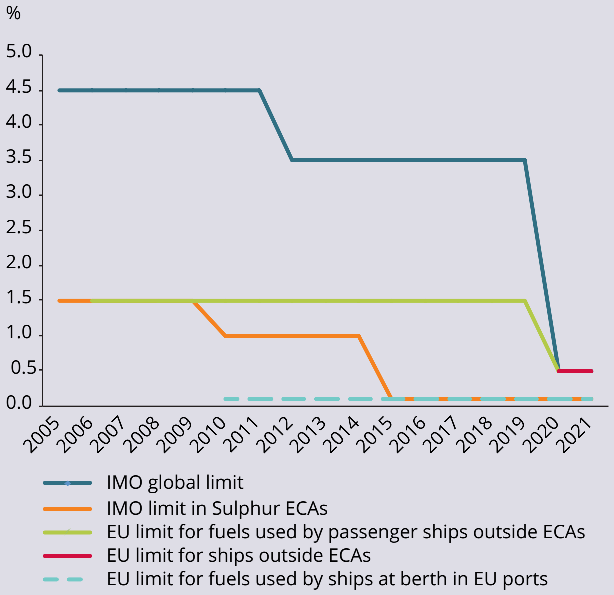
Emissions from railways and domestic navigation (inland waterways and national shipping) have also declined strongly but not in line with the introduction of the sulphur limits. This implies that EU Member States may have started to introduce low-sulphur fuels

Box 4.4 Regulating the sulphur content of fuels

The permitted levels of sulphur in fuels is subject to both international and EU regulation. At the global level, the International Maritime Organisation (IMO) is addressing air pollution through Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). Within the EU, various directives have established limit values ([12]). Figure 4.12 provides a summary of implemented and planned sulphur limits for marine fuels, set by IMO and the EU. A distinction is made between so-called emission control areas (ECAs) and other areas. In Europe, the ECAs comprised the Baltic Sea, the Channel and the North Sea.

The recently introduced IMO limits for ECAs can be met by using low-sulphur oil, gas or equipment approved by the administration (flag State) party to MARPOL Annex VI. The latest EU directive (EU, 2012)specifies that fuels with a sulphur content greater than 3.50% are not to be used in the EU, except for ships using emission abatement methods operating in closed mode. Even with these stricter limits, the maritime sulphur content is much higher than that permitted for fuels used by other transport modes. For example the 0.1% sulphur content of marine fuels applicable from January 2015 in SO_x ECAs is 100 times higher than the relevant 10 ppm sulphur limit imposed on fuels for road transport, railways and non-road mobile machinery (EU, 2009c) (Figure 4.13).

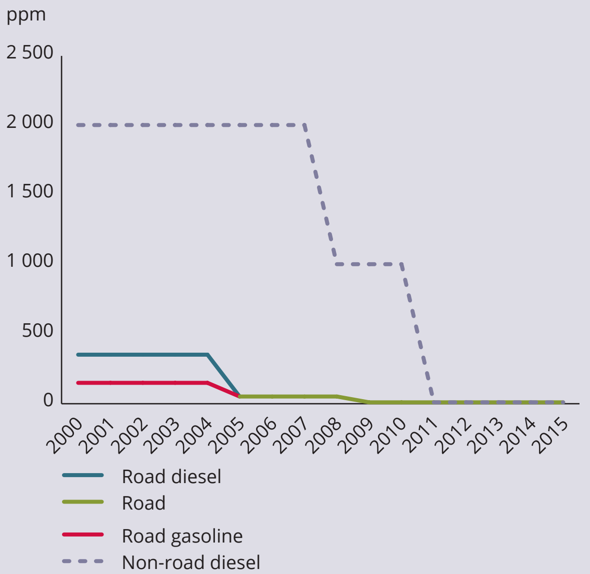
Figure 4.12 IMO and EU implemented and planned sulphur limits for marine fuels



Note: The IMO limits for 2005 started in May 2005. The IMO global limit for 2020 onwards still depends on a planned 2018 review concerning fuel availability. Depending on its outcome, the introduction date could be delayed to 2025. The EU limit for ships outside ECAs will be 0.5% irrespective of the IMO decision.

Source: EEA, 2013b; IMO, 2015.

Figure 4.13 Sulphur limit for road, rail and inland navigation



Source: EEA, 2015 based on data from (EEA, 2013b; EU, 2012; IMO, 2015; EU, 2009c) .

Jet fuel specifications limit the sulphur content to 3 000 ppm, but in practice jet fuel contains less sulphur (ICAO, 2009).

([12]) Directives 1999/32/EC, 2005/33/EC and 2012/33/EU.

before the required dates. In addition to the sulphur limits an increase in the electrification of the rail network contributed to the reductions in emissions ([13]). The maximum sulphur content of diesel for non-road mobile machinery has had to meet the same standards as that for road transport as of 2011.

4.3 Noise

Environmental noise pollution has an adverse effect on quality of life and well-being. Over past decades it has increasingly been recognised as an important public health issue. According to a WHO assessment on the burden of disease from environmental noise (WHO, 2011), at least one million healthy life-years are lost every year in western Europe owing to adverse health effects arising from exposure to noise from road traffic alone. EEA's recent report *Noise in Europe* (EEA, 2014b) estimated that one in four Europeans is potentially exposed to harmful levels of noise from road traffic. This is estimated to result in approximately 10 000 premature deaths per year, although gaps in the data reported under the EU Environmental Noise Directive (EU, 2002) mean that the true impact is likely to be much greater.

4.3.1 Population exposure to environmental noise

Road traffic noise (inside and outside urban areas) is still the most prevalent noise source according to data reported by Member States from strategic noise maps.

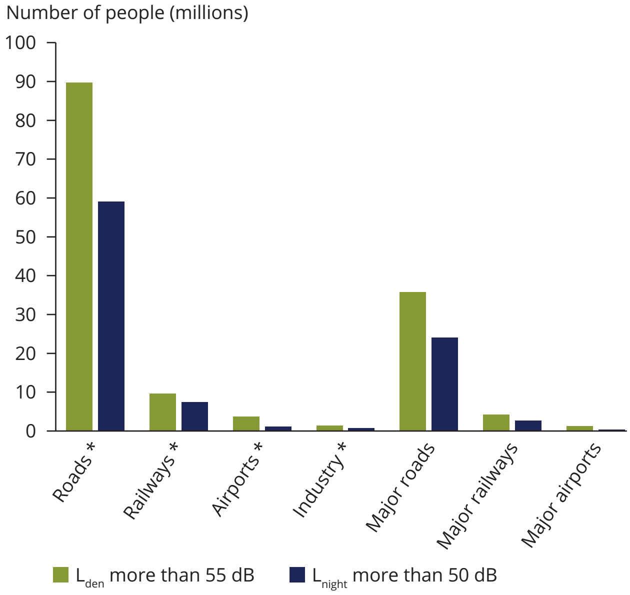
Road traffic noise contributes to the greatest level of exposure within the European population, with at least 125 million people being potentially exposed to levels above the Environmental Noise Directive threshold of 55 dB L_{den} (Figure 4.14). In addition, many people were also potentially exposed to railway, aircraft (and industrial) noise, particularly in towns and cities. This reflects the concentration of the population in urban areas and, also, the levels of traffic in most European agglomerations. Similarly, night-time road traffic is another major source of noise exposure, with over 83 million Europeans potentially exposed to harmful levels of noise greater than 50 dB L_{night}.

Railways are the second biggest contributor to environmental noise. Differences between the extent of road traffic noise and railway noise can be explained by multiple factors, starting with the length of the road network compared with the rail network, the inclusion or not of urban trams and light railways in the noise-mapping calculation inside urban agglomerations, and the fact that the majority of major railway networks in urban areas are located underground.

Aircraft noise is very limited in space; consequently the number of people exposed is lower compared with other sources of noise. However, its impact on population can be higher than other sources — studies have shown that annoyance caused by aircraft noise is greater than that for other sources.

Comparison of available data for 2007 and 2012 shows that there has been a general increase in people exposed to all noise bands from airports, a slight increase in people exposed to noise from roads (only people exposed to lower noise bands) and a slight decrease in people exposed to noise from railways.

Figure 4.14 Number of people potentially exposed to noise in EEA member countries, 2012



Note: L_{den}: Environmental Noise Directive indicator for day, evening and night levels of noise; L_{night}: Environmental Noise Directive indicator for night levels of noise. Noise mapping and assessment methods may differ by country. Gaps in reported information have been filled with expert estimates where necessary.

Source: EEA, 2015a.

([13]) Electrification reduces direct emissions from transport because they are then reported under the public electricity energy sector. Whether total emissions decrease as a result of electrification depends on the energy mix and emission control technologies for stationary combustion installations in a country.

4.3.2 Measures to reduce noise

Over past decades, a number of approaches have been developed to mitigate noise pollution. Noise emissions can be reduced at source (e.g. via measures relating to vehicles, tyres, road surfaces and traffic management) or by reducing the exposure of people by means of anti-propagation or insulation measures (e.g. by increasing the distance between source and recipient, through better insulation of buildings and constructing noise barriers). Most EU regulations focus on mitigating at source.

Road traffic

Measures at source level are often considered the most cost-effective. For example, it has been concluded that an investment of EUR 6 billion (1 000 million) in reducing vehicle emissions would result in 31.5 million fewer people annoyed, whereas the same amount invested in noise barriers would help only 0.2 million people (Milford et al., 2013). Examples of source measures that have been taken include:

- establishing limits for the noise of vehicle engines and exhausts;
- promotion of quieter tyres;
- development of low-noise road surfaces, such as thin-layer, double-layer, porous and poro-elastic pavements, which have considerable potential to cut road noise, and are complementary to technical measures that reduce engine, exhaust and tyre noise from cars and larger vehicles.

If the desired degree of noise reduction cannot be achieved through source measures, other measures that reduce noise at the receiver's end can be necessary. These include installation of road- or railside noise barriers and insulation of dwellings. On average, noise barriers reduce noise levels by 3–6 dB(A), depending on their design and height. Roadside noise barriers are most suitable for motorways and other bypass roads that there is no need for pedestrians to cross. On busy urban streets, which are crossed by pedestrians along their entire length, noise barriers cannot be placed directly on the kerbside. They therefore often provide a solution only in non-urban areas.

Road noise can also be reduced by improved traffic control and planning, to influence the speed or flow of the traffic. Limiting traffic speed reduces its noise, especially between 50 and 80 km/hour (den Boer and Schroten, 2007), and can deliver air pollution co-benefits by reducing air pollution (EEA, 2012). Traffic management measures typically involve only limited investments and have a direct effect, because of their limited implementation time. However, care needs to be taken to avoid diverting noise problems to other areas.

A major problem concerning the effectiveness of measures is that, given the different factors that determine road traffic noise, a single measure alone is often not sufficient to reduce exposure significantly. In addition, traffic growth is considered to be the most decisive factor in the evolution of vehicle noise, also taking into account the fact that the construction of new roads can expose new areas and populations to road traffic noise (EC, 2011e).

Railways

Contrary to road traffic, for which there have been European emission standards since the early 1970s, such emissions standards for trains came into force only at the beginning of the 2000s. Moreover, EU noise emission standards apply only to rail vehicles operating in more than one Member State.

As for road traffic noise, the most cost-effective measure to reduce railway noise is tackling noise at source, in this case through the retrofitting of freight wagons, usually noisy and operating at night, with composite brake blocks. It has been estimated that full implementation of this measure would cost about EUR 5–10 billion and would reduce noise for about 100 million people, while in comparison the construction of noise barriers (without any changes in vehicle technologies) would cost around EUR 80 billion and about 180 million people would benefit from noise reduction (EP, 2012). In 2015, a new regulation, (EU) 2015/429, establishing incentives to encourage rapid retrofitting, was agreed.

Regulation (EU) 1304/2014 on the technical specification for interoperability relating to the subsystem 'rolling stock' aims to reduce the noise emitted by existing vehicles. The regulation defines limits for stationary and pass-by noise for freight wagons and locomotives, application to new rolling stock and retrofitting programmes.

Aircraft

Aircraft noise has its own specifics, and it is not comparable to the principles and problems of addressing noise from road and rail traffic. Although substantial efforts have gone into developing new quieter engine technologies, partly addressed by international regulations, the main challenge is currently increasing noise levels as a result of the growing amount of air traffic. Many mitigation measures therefore focus upon optimising flight operations and improving spatial planning of airports and their expansion.

Operational noise abatement procedures are used at all airports in different forms: noise preferential routes (whereby aircraft fly, for example, over the least populated areas), thrust management (the more thrust, the more noise is generated but the steeper the aircraft may climb) or specific measures on the ground (e.g. use of specific taxi runs or runways). The EU contributes through its Single European Sky legislation, which aims to set performance targets for air navigation service providers in the environmental field, and through its associated research programmes, SESAR and Clean Sky.

4.4 Habitat fragmentation and biodiversity

The design and use of road, rail and waterborne transport infrastructure alters the quality and connectivity of habitats and can create physical barriers to the movement of plants and animals between habitat patches (Ogden, 2012; Forman and Alexander, 1998). Transport activities and infrastructure can lead to a variety of adverse impacts on biodiversity, including:

- wildlife injuries and deaths from vehicle collisions and the isolation of species populations due to habitat fragmentation (Bennett et al., 2011; CEEweb, 2011);
- increased pollution levels in surrounding habitats, in terms of both air quality and increased waste, oil spills, noise pollution, etc. from traffic (Beckmann et al., 2012; van der Ree et al., 2011);
- behavioural changes that put the survival of individuals and populations at risk, such as feeding on or near roads or changes in migratory behaviour or call patterns (van der Ree et al., 2011; Bennett et al., 2011);
- infrastructure serving as a vector for the facilitated spread of non-native and invasive species (von der Lippe and Kowarik, 2008); physical changes to watercourses designed to improve usability for transport can also endanger biodiversity dependent on the natural functions of water bodies and water cycles ([14]) (EC, 2012b);
- indirect impacts in terms of changed patterns of land use and urbanisation, with areas that are appealing for transport infrastructure often constituting valuable habitats (e.g. river valleys offer easy passageways for transport in hilly areas and contain high species richness) (Beckmann et al., 2012).

The EU has a number of biodiversity targets to be met by 2020. The European Commission recently performed a mid-term review of progress under the EU Biodiversity Strategy, in which it stated that the 2020 biodiversity targets can be achieved only if implementation and enforcement across the EU become considerably bolder and more ambitious. At the current rate of implementation, biodiversity loss and the degradation of ecosystem services are anticipated to continue throughout the EU (and globally), with significant implications for the capacity of biodiversity to meet human needs in the future (EC, 2015b).

Recognising the potentially negative impacts of the transport sector on nature and biodiversity, several EU regulations and strategies have established procedures and obligations aiming to minimise such consequences. The most relevant pieces of legislation to regulate transport infrastructure projects within this framework are summarised in the following section, acknowledging that there are strong links between each.

Trans-European Transport Network

The development and functioning of the transport infrastructure has been linked in part to the failure of the EU to meet its target to halt biodiversity loss by 2010 (Lucius et al., 2011; Szabolcs, 2015) and is seen as a barrier to achieving the goals of the EU Biodiversity Strategy to 2020 (EC, 2015b). A 2008 study led by Birdlife International highlighted the potential conflicts between the TEN-T priority projects and the EU's Natura 2000 network of protected areas in the 2007–2013 programming period. The study concluded that 379 sites protected under the EU Birds Directive (EC 2009/147/EC) and 935 under the Habitats Directive (EC 92/43/EEC) were likely to be affected by the

([14]) Activities such as canalisation and construction of navigation structures, drainage, and dredging and maintenance activities can prevent fluctuations in water level and seasonal flooding, degrade water quality, pose a barrier to migration and dispersal, and disrupt natural hydromorphological processes, sediment balances and nutrient cycles (EC, 2012b).

21 TEN-T priority projects analysed (e.g. see Box 4.5), with watercourses and maritime areas warranting particular note (Byron and Arnold, 2008).

From the beginning of 2014, the EU has had a new transport infrastructure policy in place, and, with it, biodiversity and nature considerations have been strengthened compared with the previous programme (IEEP et al., 2012). The respective regulation (EU, 2013b) stipulates that when projects are planned and implemented, 'the protection of the environment and of biodiversity, as well as the strategic requirements of inland waterways, should be taken into account' by Member States by carrying out Environmental Impact Assessments (EIAs) of projects, or other appropriate assessments under the Birds and Habitats Directives. Accordingly, funding for projects has been withheld in extreme cases where there was serious reason to distrust the quality of the EIA or Strategic Environmental Assessment (SEA) conducted (Box 4.5).

EU Nature Directives/Natura 2000

The Natura 2000 network of designated sites was established by the EU Birds and Habitats Directives (known as the Nature Directives) and strives, among other aims, to ensure that sufficient weight is given to potential impacts from the transport infrastructure on sites designated for environmental protection.

The Habitats Directive delineates the obligations regarding all potential developments taking place within Special Areas of Conservation (designated protected sites) ([15]). It also protects sites from threats that come from outside the conservation area in question; for example, if a transport infrastructure project would fall outside a designated area, the potential impacts on the site itself must still be acknowledged, avoided, remediated and/or compensated (Box 4.6).

According to the legislation, compensatory measures should only be utilised as a last resort in cases in which 'a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature' (92/43/EEC, italics added). In such cases, the plan or project may still be approved despite acting against the conservation goals of one or more Natura 2000 sites, given that the procedural safeguards outlined in the Directive are followed (EC, 2000). However, given the room for interpretation in assessing the so-called 'imperativeness and overriding public interest', the stipulations for protecting biodiversity and nature from infrastructure development and functioning have been found to be insufficient to protect the sites as intended.

Water Framework Directive

River ecosystems are of vital importance for freshwater biodiversity and the many bird and mammal species dependent thereon, as well as for the transport of goods across the European continent. The Water Framework Directive (2000/60/EC) serves in part

Box 4.5 Biodiversity proofing TEN-T transport infrastructure investments — Via Baltica (S8) Expressway in Poland

Located in north-eastern Poland along the Lithuanian border, the S8 expressway 'Bialystok' project was designed to form a continual transport network from Portugal to Finland via Poland. Although its operational programme recommended mitigation measures to minimise adverse environmental effects, the need to amend the proposed routes based on the potential harm it would cause to biodiversity was not addressed. Given this consideration, and the high biological diversity of the area, environmental non-governmental organisations (NGOs) such as WWF (World Wide Fund for Nature), Birdlife and Bankwatch closely monitored the planning of the expressway.

On the recommendation of the Bern Convention, a full SEA was carried out that considered around 40 alternatives for the 'Via Baltica' route to minimise the potential harmful effects on multiple Sites of Community Importance (under the Habitats Directive) and Special Protection Areas (under the Birds Directive). Separate EIAs were performed in parallel for the expressway, but in 'pieces' rather than for the entire project — a process severely criticised by the observing NGOs, as the results were not thought to provide a realistic picture of the alternative routes and cumulative effects of the individual road sections. A formal complaint to the European Commission in 2006 resulted in the opening of legal proceedings against eight road projects on the Via Baltica and referral to the European Court of Justice. EU funding for the Polish part of the project was eventually withdrawn after several years of legal proceedings as a result of breaching environmental legislation and failing to protect Natura 2000 sites (Hjerp et al., 2011; IEEP and Milieu, 2013).

([15]) More information is available on http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/provision_of_art6_en.pdf (EC, 2000).

Box 4.6 The contribution of Natura 2000 to conservation in transport planning: construction of the A2 highway in Poland

In cases in which conflicts between transport projects and conservation are deemed to be unavoidable, Article 6 of the Habitats Directive ensures that conservation goals are still met through the implementation of compensation measures. One such case is the A2 highway in Poland, which stretches across the centre of Poland from east to west. Two sections were added to the western part of the highway between 2002 and 2010, connecting the A2 to the German border.

In the middle of the construction period in 2004, Poland joined the EU, and EU law, including the Nature Directives, was subsequently transposed into national law, including requirements for the Natura 2000 network. Due to the timing of this legislative change, work had already been done that had a negative impact on protected species and habitats (such as removing forest for surveying).

In contrast to the pre-2004 planning process, the new legislation gave impact assessments legal weight and formalised the conflicts of interest into legal conflicts. Although it was not possible to avoid all damage to protected habitats and species from the highway construction, the damage was compensated through other measures. These included measures to improve the conservation of habitats and rare species in the neighbourhood of the highway and also the designation of a new Natura 2000 area with comparable conservation value (Wojterska et al., 2010). Before the implementation of EU conservation law, none of these compensation measures would have been required. Although compensation is generally a less favourable choice than preservation (CEEweb, 2012), the compensation required by the Habitats Directive represents an improvement compared with previous conservation regimes in many countries.

to balance these dual functions. As the directive requires developments to be consistent with other EU environmental legislation, new navigation-related plans must, for example, also follow the Habitats Directive in addition to Water Framework Directive procedures.

This Water Framework Directive allows new modifications and sustainable human development activities that may result in the deterioration of the status of the water body or prevent the achievement of good ecological status or potential or good groundwater status. However, a given set of criteria outlined in the guidance on 'Inland waterway transport and Natura 2000' (EC, 2012b) must then be met (Box 4.7).

Information on the policy effectiveness of the Water Framework Directive regarding navigation development and impacts on biodiversity is largely lacking — further research is needed in this area.

Environmental Impact Assessment and Strategic Environmental Assessment

The Environmental Impact Assessment Directive (85/337/EEC) and the Strategic Environmental Assessment Directive (2001/42/EC) are key components of decision-making over whether or not to grant approval to implement an infrastructure project or plan. EIAs outline specific environmental and social impacts of a proposed project in order to predict potential environmental impacts at an early stage in the *project* planning and design processes, while SEAs are used to assess *plans and programmes* at an earlier stage of the decision-making cycle (APFM, 2013). They both follow the precautionary principle and aim to avoid environmental damage or pollution before implementation rather than compensate for these impacts later.

An EIA is obligatory for projects listed in Annex I of the EIA Directive, which are identified as having significant effects on the environment (e.g. long-distance railway lines, airports with a basic runway length of 2 100 m or more, motorways, express roads, roads of four lanes or more (of at least 10 km), etc.) (EC, 2013f). The EIA Directive outlines the need to identify, describe and assess the direct and indirect effects of a *project* on 'fauna and flora' and include 'a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant effects' (Article 5(3)) stemming from the construction of the infrastructure, as well as its operational phase.

The SEA Directive also directly refers to biodiversity in that it 'requires an environmental report to consider any existing environmental problems, in particular, those relating to any areas of a particular environmental importance'. In many cases, the SEA is the only legally required tool that necessitates the consideration of the environment at an early stage of developing plans or programmes when alternatives are still open.

When applied as intended, both the EIA and the SEA have been shown to be effective tools to consider and minimise environmental impacts arising from infrastructure projects. However, studies assessing the effectiveness of these directives, specifically with regard to biodiversity and transport, are largely lacking. One review partly addresses this question, highlighting several shortcomings in practice specifically for EIA (EC, 2009). For example, it was found that transparency was sometimes lacking, with public or interest groups being excluded from the evaluation and decision-making processes, or if they were included it was only after key decisions were taken. The EIA Directive is also thought to be inefficient in some cases in that multiple EIAs can be carried out for a single transport infrastructure project that has been broken into multiple 'pieces' for the purpose of legal procedures. This results in short sections of projects (particularly roads) being assessed and granted permits separately, instead of evaluating the project more holistically as intended.

A review of the SEA Directive's effectiveness was conducted in Ireland (EPA Ireland, 2012). The SEA was generally found to be a useful tool and viewed positively, but as most plans had been only recently implemented at the time of publication and monitoring had not yet taken place, uncertainty remains regarding the extent to which SEA leads to positive environmental outcomes and prevents negative effects in practice. Nevertheless, several considerations were outlined to improve its potential effectiveness, including the need to:

i. strengthen the legal requirement for taking opinions from the consultation process and the Environmental Report 'into account' (emphasising that these steps are obligatory for decision-makers);

ii. carry out SEA earlier in the planning process;

iii. focus SEA scoping on well-defined critical issues rather than trying to cover too many issues;

iv. strengthen SEA governance by awarding statutory authorities a role in 'signing off' and/or following up on plans/SEAs and in ensuring that monitoring takes place.

The significant potential of transport infrastructure to negatively affect biodiversity or support for its conservation within Europe highlights the need to optimise the integration of these areas within EU policy and adopt a more cross-sectoral and interdisciplinary approach to identify and implement sustainable solutions. While the policies outlined include requirements mandating the consideration of biodiversity impacts to varying degrees, several gaps remain regarding implementation in practice. Ensuring a more holistic approach to development within and across existing policies is important. Two ways in which this may be achieved are by addressing the fragmented nature of EIAs being applied in road construction proposals and by ensuring transparency in decision-making processes, particularly regarding the provision of information to and early involvement of the public (Gasparatos and Willis, 2015).

Box 4.7 European Court of Justice decision: deepening of the Weser River for shipping

In an important decision for water transport, the European Court of Justice recently decided that the planned deepening of the Weser River in Germany, to allow more shipping traffic, did not comply with the Water Framework Directive and therefore cannot be implemented (Court of Justice of the European Union, 2015). The planned measures would have allowed ships improved access to the harbour at Bremerhaven, near the river's mouth. Friends of the Earth Germany, an environmental protection NGO, challenged the planned deepening measures, which would have created stronger tides and currents and increased the salinity of parts of the river, posing a threat to both species and human settlements in and near the Weser.

The European Court of Justice subsequently found that the decrease in water quality that would have resulted from the deepening was in violation of the Water Framework Directive requirements. According to its decision, the prohibition of water quality deterioration will have to be a mandatory part of the approval process for future water transport projects, and not a voluntary measure. Furthermore, projects that do not contribute to the improvement of water quality may not be approved by EU Member States, as they put the achievement of the Water Framework Directive at risk. The decision has a number of implications for ongoing and future water transport projects across Europe, including, for example, the planned deepening of the Elbe River in Hamburg.

5 Policies that have influenced transport's environmental impacts — three case studies

Key messages

CO_2 emissions from light duty vehicles

The efficiency of new cars has improved since 2000. The introduction of EU regulations establishing future targets for average vehicle CO_2 emissions, in 2009 for new passenger cars, and in 2011 for new vans, has significantly increased the rate of progress. A recent European Commission analysis suggests that the passenger car CO_2 regulation is likely to have successfully accounted for 65–85% of the reductions in CO_2 emissions achieved following its introduction that is, compared with relying only on voluntary agreements from industry. However, the increasing divergence between official CO_2 vehicle emissions, as measured under laboratory conditions, and real-world fuel consumption remains a major point of concern for the effectiveness of the policy in practice.

Eurovignette Directive — internalisation of external costs

Twenty-seven EEA member countries have now successfully established some type of road charging for HDVs that at least partially account for the associated environmental externalities. Over time there has been an evolution from vignette systems towards network-wide electronic tolling. The greatest environmental improvements have been achieved by the latter type of system, which typically features separate pricing classes for the cleanest technologies, sometimes combined with subsidies for the purchase of new HDVs.

Environmentally harmful subsidies

The use of direct or indirect subsidies in the transport sector is widespread across the EU. Some of these subsidies serve to encourage consumer or business behaviours that are harmful to the environment. Examples of such subsides include the typically favourable tax treatment of company cars and for subsidised commuting expenses, and the tax exemptions for fuels used in international aviation and navigation. The actual extent of the harmful environmental effects observed as a result of such subsides often depends on technical details in the schemes and how they have been implemented. Importantly, it is sometimes possible to mitigate the harmful effects of such subsidies by better integration of environmental parameters in their design.

This chapter presents three case studies focusing on specific policies that in different ways have influenced the environmental performance of transport since 2000:

i. the regulation of CO_2 emissions from LDVs — passenger cars and vans — as an example of the generally successful use of regulatory policies to improve environmental performance within the transport sector;

ii. the Eurovignette Directive, a market-based instrument establishing road-user charging for HDVs, illustrating the successful use of the 'polluter-pays' concept, consistent with the themes of the 2011 Transport White Paper;

iii. environmentally harmful subsidies, as an example of how existing tax policies have hampered the development of a more sustainable European transport system.

5.1 Monitoring CO_2 emissions from light-duty vehicles

5.1.1 Average CO_2 emission reductions from new cars since the year 2000

Car passenger transport was responsible for 43% of all transport GHG emissions in the EU (including bunkers) and 60% of road transport emissions in 2013. To reduce CO_2 emissions in the road transport sector, the EU has in the past decade adopted two

Figure 5.1 Average reduction in CO_2 emissions from new cars

Note: AFV, alternative-fuelled vehicle. AFVs include pure electric, liquefied petroleum gas, natural gas, ethanol (E85), biodiesel and plug-in hybrid vehicles (diesel–electric or petrol–electric).

Source: EEA, 2015b.

important regulations: Regulation (EC) No 443/2009 (EU, 2009a), which introduced mandatory CO_2 emission performance standards for new passenger cars, and Regulation (EU) No 510/2011 (EU, 2011a), which introduced mandatory CO_2 emission performance standards for new vans.

Both regulation set CO_2 targets for the average EU new vehicle fleet as well as for vehicle manufacturers. For passenger cars, the regulation sets a CO_2 emission target of 130 g CO_2/km to be met by 2015 being phased-in gradually from 2012. A medium-term target of 95 g CO_2/km has been set for 2021 (to be phased in from 2020). For vans, the 2011 regulation sets a CO_2 emission target of 175 g CO_2/km to be met by 2017. A medium-term target of 147 g CO_2/km has been set for 2020.

CO_2 emissions from new passenger cars in the EU fell by 28% between 2000 and 2014, from 172.1 (EU-27) to 123.4 g/km (EU-28) (Figure 5.1) (EEA, 2015b). Since monitoring started under the current legislation in 2010, average emissions have fallen by 12%.

The 2015 target for average CO_2 emissions from new passenger cars was met 2 years before the deadline. Furthermore, in 2014 the majority of the individual car and light commercial vehicle manufacturers met their CO_2 emission targets set for that year (EEA, 2015b). While the figure shows a very significant improvement for alternative-fuelled vehicles, that is, those running on electricity, compressed natural gas or liquefied petrol gas, it should be noted that these vehicles have only a small market share — 2.7% of total EU sales in 2014.

Diesel vehicles remain the most frequently bought vehicles in Europe, constituting 53% of new vehicle sales in 2014. There are significant differences in the proportion of diesel sales between countries, with Ireland (74%), Luxembourg (72%), Portugal (71%), Spain (66%), France and Greece (64%), Croatia (63%) and Belgium (62%) being those with a higher proportion of diesel vehicles in total new car sales.

However, on the basis of the official vehicle test cycle emission measurements, the efficiency gap between diesel and petrol cars has been decreasing in recent years. In 2014, the average new diesel car registered in the EU emitted 123.2 g CO_2/km, only 2.5 g CO_2/km less than the average petrol vehicle. By comparison, in 2000, the emissions difference between diesel and petrol vehicles was 17 g CO_2/km. This diminishing gap can largely be explained by the increase in the mass of diesel cars over time. The average diesel car registered in the EU is now about 310 kg heavier than the average petrol car, that is around 100 kg heavier than in 2004 (EEA, 2015b). This increased mass has largely offset the inherent greater efficiency of the diesel engine, diminishing the fuel economy benefits of diesel cars.

5.1.2 Improved average CO_2 emissions over time — policy links

The average annual improvement in energy efficiency/ CO_2 emissions of new cars has increased since 2000. It can be deduced that the introduction of the car CO_2 regulation in 2009 speeded up that process. For example, while the average annual reduction in emissions between the years 2000 and 2008 was 1.4%, the rate increased to 3.6% from 2009 to 2014.

This effect can also be seen in light commercial vehicles, where the required target for 2017 has also already been met. Around 1.4 million new vans were registered in the EU in 2014, with average emissions of 169.2 g CO_2/km, significantly below the 2017 target of 175 g CO_2/km. The average emissions in 2014, and the trend followed in terms of reductions in emissions (not shown — see EEA, 2015b) suggest that the implementation of the van CO_2 regulation has also significantly influenced manufacturers' efforts and technical developments to reduce emissions.

One way that Member States can influence the uptake of efficient vehicles is through their national taxation systems, including vehicle registration tax, circulation tax and fuel tax. Over the last years, because of their generally lower contribution to CO_2 emissions, many European governments have chosen to provide financial incentives, which have directly or indirectly encouraged the uptake of diesel engines (EEA, 2015g). For example, in almost all EU Member States gasoline excise duties are higher than those for diesel (see TERM 2 ([16])). Whether the lower diesel levy constitutes a harmful subsidy, however, also depends on the differences between other taxes that apply for diesel and gasoline cars. Obviously the lower diesel excise duty favours the use and ownership of diesel cars and creates an incentive to drive more kilometres relative to gasoline cars. Purchase and/or road taxes, however, are usually higher for diesel cars. More recently, incentives that promote the uptake of EVs have also become more common across a number of Member States.

The uptake of diesel vehicles, has not, however, necessarily been positive in terms of the subsequent impacts on air pollution. Diesel vehicles emit higher levels per kilometre than their petrol equivalents of fine PM and NO_X — both important pollutants in terms of the harm they cause to health. Many air quality problems in Europe's cities have been attributed primarily to the increase in NO_2 emitted directly into the air from new diesel vehicles (EEA, 2013a). Furthermore, there has recently been significant public attention focused on the widely publicised findings that NO_X emissions from diesel vehicles can be, on average, as much as four or five times higher under real driving conditions than the emissions measured during the formal vehicle 'test-cycle' measurements.

According to an analysis performed for the European Commission evaluating the impacts of Regulations 443/2009 and 510/2011 on CO_2 emissions from LDVs (EC, 2015c), the car CO_2 regulation is likely to have accounted for 65–85% of the observed reductions in tailpipe emissions achieved following its introduction, that is, compared with relying upon the previous voluntary agreement from industry. The same study found that there was no conclusive evidence that the CO_2 regulations themselves are primarily responsible for the increased uptake of diesel vehicles in Europe. Other factors, such as national vehicle registration taxes and consumer preferences, appear to be more important factors (EC, 2015c). This perspective is confirmed by other studies that have identified the main reasons for increasing dieselisation of the car fleet as national registration taxes (ETC/ACM, 2012) and consumer preferences (Linn, 2014). Using a registration tax to increase the sales price of a diesel car relative to its petrol counterpart by EUR 1 000, decreases the proportion of diesel cars in new car sales by 3% (ETC/ACM, 2012).

5.1.3 Encouraging uptake of alternative-fuelled vehicles

Owing to the limited number of alternative-fuelled vehicles sold each year, their present effect on the EU average CO_2 emissions of new cars is minimal.

([16]) See indicator here: http://www.eea.europa.eu/data-and-maps/indicators/fuel-prices-and-taxes/assessment-3.

However, the passenger car and vans CO_2 regulations are considered to have contributed to increasing that percentage (Box 3.3), and will probably continue to do so as an indirect effect of these policies. Although the two regulations remain technology neutral by not specifying particular technologies by which the average CO_2 levels should be reached, those technologies that significantly lower CO_2 emissions are indirectly encouraged. For instance, EVs are considered to have zero CO_2 emissions and can also benefit from so-called super-credits, meaning that they are effectively incentivised. This is in line with the EU's overall aim to achieve a low-carbon economy.

5.1.4 *Official versus real-world vehicle CO_2 emissions*

There is a significant discrepancy between official vehicle CO_2 emission measurements and vehicles' performance in the real world. A recent comparison of fuel consumption data from more than half a million private and company vehicles across Europe has shown how this discrepancy between 'type approval' CO_2 measurements, made on the basis of a standardised laboratory test, and real-world values has grown over the last 12 years (ICCT, 2014).

In particular, the gap has increased considerably since 2007, when the binding EU average CO_2 target for passenger cars was first proposed. While the average discrepancy between type approval and on-road CO_2 emissions was below 10% in 2001, by 2013 it had increased to around 30%. Moreover, while the average discrepancy between type approval and real-world CO_2 values was initially similar for diesel and petrol vehicles, since 2010 the difference between the two technologies has increased: for conventional diesel vehicles, the gap is 5% greater than for conventional petrol vehicles. Several other European studies have also demonstrated the magnitude of the gap between the current New European Driving Cycle legislative and real-world CO_2 emissions. All studies confirm this gap: the average discrepancy between type approval and on-road CO_2 emissions is in the range of 10–40%. For NO_X emissions from diesel vehicles the gap is even larger, with real-world emissions being on average up to four or five times higher than the official test measurements (ICCT, 2015).

A recent report (EEA, 2015g), explores the reasons for the existing gap between real-world and official test cycle emissions. The differences are mainly due to three factors:

i. an outdated European test procedure that does not accurately reflect on-road driving patterns and modern engine loads;

ii. flexibilities in the current procedures that allow manufacturers to optimise the testing conditions and thereby achieve lower fuel consumption and CO_2 emission values;

iii. several in-use factors that are driver dependent (e.g. driving style, use of electrical auxiliary equipment) or independent (e.g. environmental conditions).

The European Commission is currently working on introducing an updated standardised emissions test, the 'World-harmonised Light-duty Vehicle Test Procedure' (WLTP). This includes a new test cycle that is more representative of average driving behaviour, and a test procedure that limits the allowed flexibilities and loopholes compared with Europe's current testing system. It is expected that the WLTP will reflect real-world driving emissions better than the current testing methodology. It is important that the new WLTP test is implemented in a sufficiently robust way, including sufficient checks to ensure that the new test does not in future become subject to the problems experienced with the New European Driving Cycle (EC, 2015c).

5.1.5 *Improving vehicle CO_2 emissions policy — other considerations*

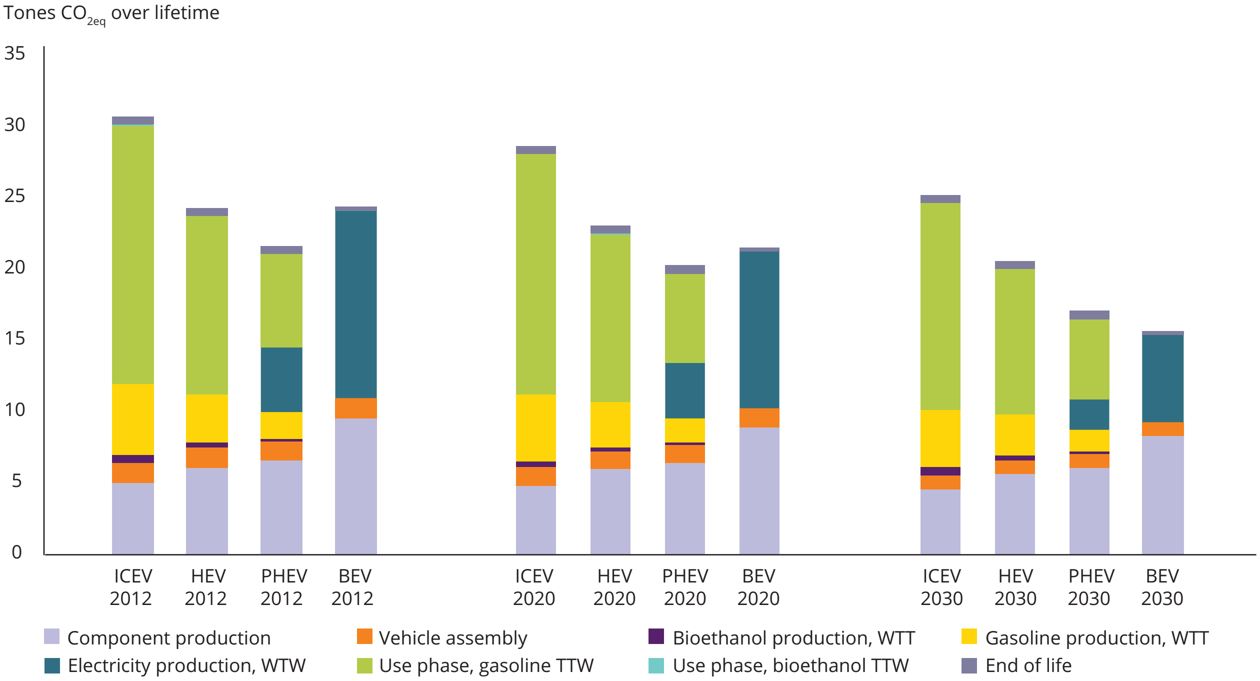
The European Commission study evaluating the effectiveness of the regulations on CO_2 emissions from LDVs (EC, 2015c) also stressed two key factors that might be addressed or improved in future EU policy proposals.

- Well-to-tank emissions, that is, emissions produced in all the combination of steps necessary to turn a resource into a fuel and bring that fuel to a vehicle. As noted above, the regulations effectively incentivise the use of vehicles that have 'zero' CO_2 emissions. However, such vehicles, for example EVs, may have higher indirect emissions associated with the production of the energy they use than internal combustion engines. These emissions are not considered within the regulations.

- Embedded emissions, that is, emissions created during vehicle production and, to a lesser extent, disposal. The regulations may similarly inadvertently incentivise the use of vehicles that have higher GHG emissions associated with their production and disposal than more conventional vehicles.

Life cycle analyses for internal combustion engine passenger cars estimate that 60% of the total GHG emissions attributable to medium-sized gasoline passenger cars in the EU are from the combustion

Figure 5.2 Lifetime CO_2 emissions associated with production, fuel and energy use and disposal for medium-sized cars with different engine technologies



Note: Comparison of different medium-sized (gasoline) cars' life cycle CO_2-equivalent impacts over time (2012 as reference scenario). ICEV, internal combustion engine vehicle; HEV, hybrid electric vehicle; PHEV, plug-in hybrid electric vehicle; BEV, battery electric vehicle.

Source: LowCVP, 2013.

of fuels in the vehicle operation ('tank to wheel'). On the other hand, as Figure 5.2 illustrates, production of fuels and vehicles, and disposal of used vehicles, together can account for around 40% of emissions for a medium-sized gasoline car (of which around 21% is from vehicle production). This percentage is typically substantially higher in the case of EVs or plug-in hybrids, where the majority of the total production emissions are associated with the production of its battery (45% of the total in 2012) (LowCVP, 2013). Nevertheless, while significant, the total lifecycle CO_2 emissions of electric and plug-in hybrids were still estimated as being lower overall than that of an equivalent gasoline-powered vehicle. Looking to the future, pure EVs are expected to return the best life cycle CO_2-equivalent rates by 2030, mainly resulting from reductions in the carbon intensity of the future grid mixes, improved automotive technology and improvements in battery pack technology.

5.2 Internalisation of external costs — Eurovignette Directive

The 2011 White Paper on Transport (EC, 2011a) advocates that Europe's transport charges and taxes must be restructured in the direction of a wider application of the 'polluter-pays' and 'user-pays' principles, that is, 'to have user charges applied to all vehicles and on the whole network to reflect at least the maintenance cost of infrastructure, congestion, air and noise pollution', in order to align market choices with sustainability requirements.

One such early example of 'polluter-pays' charging was the EU Eurovignette Directive (1999/62/EC) as subsequently amended (2006/38/EC and 2011/76/EU), which lays down the rules under which EU Member States can charge for the use of the road infrastructure. The 1999 Directive allowed EU Member States to impose a charge on HDVs with a maximum permissible weight over 12 tonnes using motorways. The charges should be related to the costs of constructing, operating and developing the infrastructure network. While the original Directive allowed the emission class of vehicles to be taken into account only to a limited extent, its subsequent amendments introduced more possibilities to differentiate HDV tolls and vignettes in terms of the air pollution, noise and congestion costs caused by vehicle use. They also extended the framework towards vehicles with a maximum permissible weight over 3.5 tonnes. The Eurovignette Directive only covers HDVs on major roads with international and interregional traffic, where there was a need to establish a consistent charging framework in order to guarantee the smooth functioning of the internal EU market. The framework does not apply to private cars, buses or light commercial vehicles below 3.5 tonnes, or to other roads. Charging schemes can be set by individual Member States in these cases.

5.2.1 Implementation of road-pricing schemes in the EEA member countries

Different types of road-charging schemes are permitted by EU legislation. Vignettes or time-based user charges give the user the right to use the infrastructure during a given period of time. In contrast, tolls or distance-based charges depend on the distance driven. In the case of network-wide tolls they are typically levied on a whole network of charged roads, using a common electronic charging system. Tolls can, however, also be levied on motorway concessions.

In 2015, 27 EEA member countries have a system of road charging in place (Annex 4). Ten countries have a vignette system, eight countries have electronic network-wide tolls and eleven have tolls on concession motorways ([17]). Over time there has been an evolution from vignette systems towards network-wide distance-based electronic tolling. However, in some cases advanced plans to adopt electronic tolling have for various reasons had to be abandoned or postponed. This was the case in, for example, Denmark, France and the Netherlands. Belgium plans to implement a nation-wide electronic toll in 2016.

5.2.2 Environmental impacts

Based on the literature it can be expected that road user charging will have a positive impact on the environment in different ways (de Jong et al., 2010; EC, 2014e).

- They may encourage a shift towards cleaner vehicles, influencing the composition of the vehicle fleet and encouraging greater use of cleaner vehicles and less of the more polluting ones.

- By increasing the price per distance travelled, they may increase the efficiency of transport by, for example, increasing the load factor of shipments.

- By increasing the price per road tonne-kilometre they may encourage modal shift. However, in evaluating associated environmental impacts, it should be taken into account that reductions in emissions might be lower than expected, for example longer routes may be used by the alternative modes or inefficient use may be made of alternative transport modes.

- By increasing the average price of freight transport, they can reduce overall freight transport demand (e.g. by changing the logistics processes).

- When charges on some roads are higher than on others, road user charging might affect route choice (i.e. switching to routes with lower or zero road user charges), thereby worsening local air quality in such areas. Whether the final environmental impact will be positive or negative depends on where traffic is shifted to and to what extent.

Overall, it is expected that environmentally differentiated distance-based tolls will be more effective than time-based tolls with environmental differentiation, as they are more directly related to the cause of the emissions, which depend on the kilometres driven by the various types of vehicles.

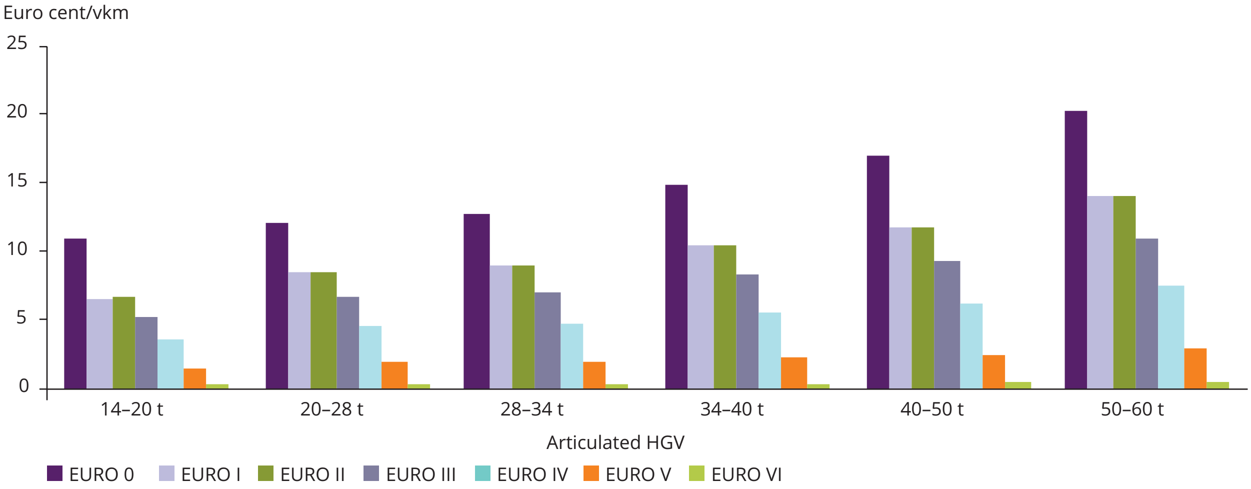
In general, however, it is not straightforward to assess the environmental impacts of road charging, as other determinants may also simultaneously change. There have been many changes over the past two decades, for example, in Europe's general economic climate, economic policies and international fuel prices. Road pricing also interacts with other policies such as the Euro regulations on HDV emission standards, country-specific taxes and subsidies regarding vehicles and fuels, and road pricing in neighbouring countries. One study of different HDV scenarios showed that increased charges would lead to lower external costs of transport through changes in trip schedules, vehicle technologies and the organisation of transport operators. If set high enough, the charges could also induce some modal shift (JRC, 2010).

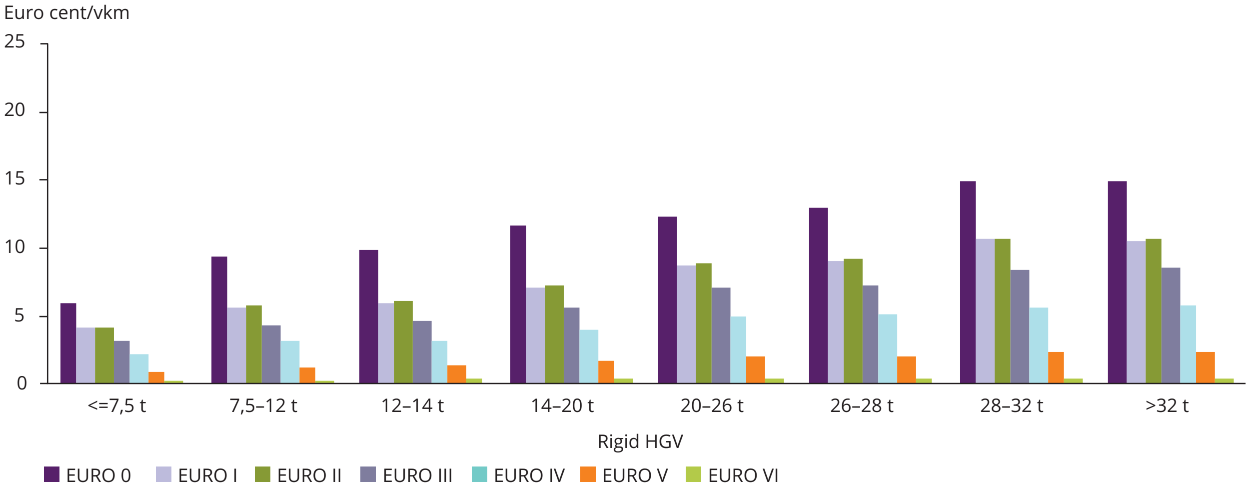
Figure 5.3 shows the air pollution costs of different types of HDVs per kilometre driven on motorways. It is clear that the most recent vehicle technologies may lead to a substantial reduction in the air pollution costs, assuming that HDVs deliver on-road emissions performance consistent with official standards.

The extent of differentiation in terms of the environmental characteristic of vehicles differs between the vignette and network-wide tolling systems (Annex 4). The latter generally include more environmental classes than the vignette systems, and often a class for the most recent technologies. For

([17]) In Poland and Portugal, network-wide electronic tolling is applied on concession motorways.

Figure 5.3 The costs of air pollution for articulated and rigid HDVs on EU motorways





Source: EC, 2014f.

vignettes, the rates for the highest and lowest categories range between 70% and 81%. For the network-wide electronic tolls this ratio ranges between 50% and 74%.

Several studies have assessed the environmental impacts of road use charging by comparing the evolution of the vehicle fleet, mileage and emissions in countries with different systems. One such comparison has been made for Sweden (using the Eurovignette system ([18])) and Germany (with environmentally differentiated distance-based tolls) (Vierth and Schleussner, 2012). Compared with the Swedish charging system, the German Maut effectively has a higher charge per kilometre and its differentiation includes more vehicle classes, including the most recent ones. The German government also subsidises the purchase of new HDVs, resulting in the German fleet having more environmentally friendly HDVs than the Swedish fleet (Vierth and Schleussner, 2012). In 2014 almost 90% of HDV traffic on tolled roads was driven by vehicles meeting the three best environmental classes (Euro V, EEV ([19]) and Euro VI) (Figure 5.4) (Bundesamt für Güterverkehr, 2014).

There are also spill-over effects between the two countries, in that hauliers have an incentive to use their cleanest trucks in countries that have tolls that are differentiated by the latest emission class and their less environmentally friendly trucks in Eurovignette countries. The difference between the two countries is

([18]) The Eurovignette system is a common system applied in Belgium (until early 2016), Denmark, Luxembourg, the Netherlands and Sweden (since 1998).

([19]) EEV is a class of enhanced environmentally friendly vehicle (as defined in Directive 2005/55/EC).

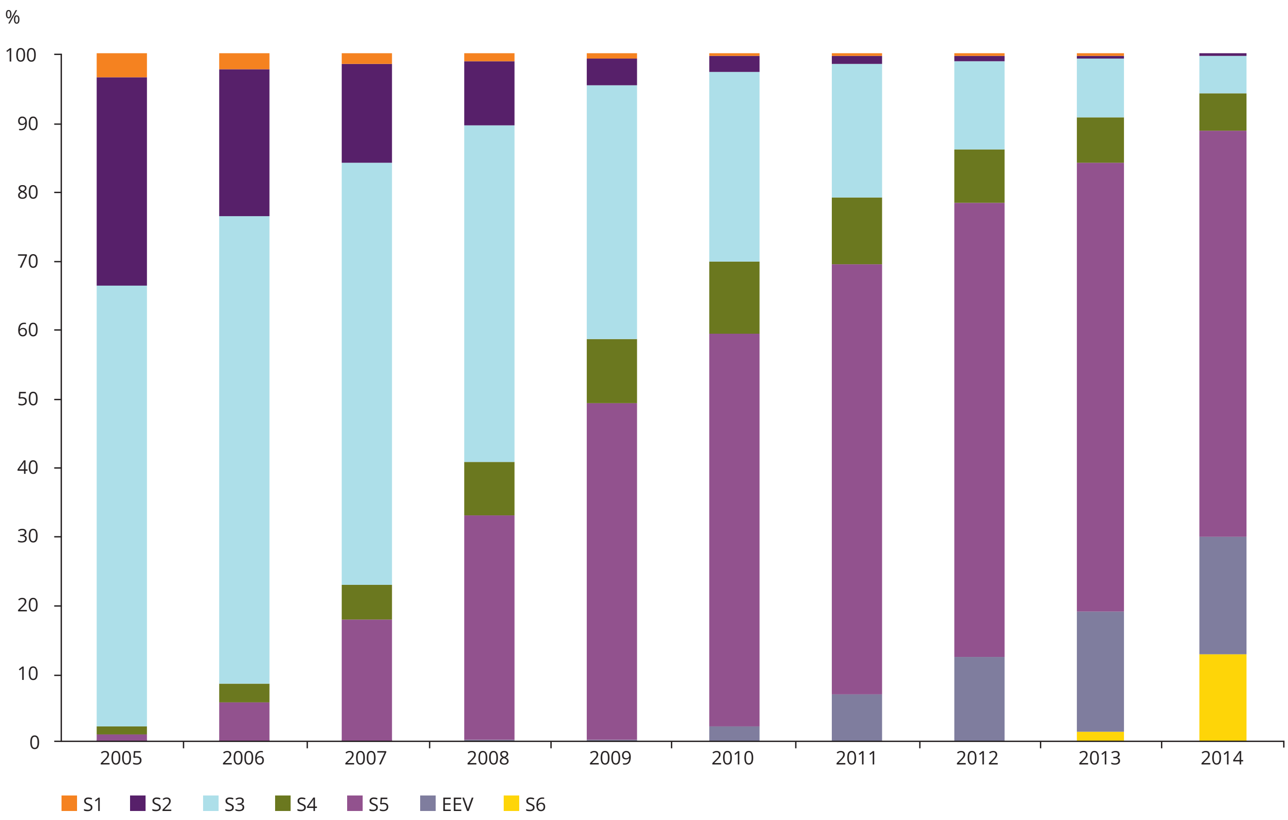
expected to increase as the tolls are updated (as done in Germany in 2015) and the Eurovignette is not.

In Austria, a country with a network-wide electronic toll system, the proportion of latest technology HDVs, EEV and Euro VI, has increased over the last few years to more than 45% of the fleet, while the proportion of Euro 0 to Euro III classes has fallen to less than 15% (ASFiNAG, 2015). Half of the truck vehicle-kilometres on the Austrian primary road network is driven by trucks equipped with the cleanest technology currently available, and the electronic toll system is considered an important driving factor behind this. Some modal shift was observed in Austria, but it was impossible to isolate the impact of road charging from that of other measures. It may also be that the charges that are currently in place are too low to generate a modal shift (JRC, 2010).

In Switzerland, the introduction of a heavy vehicle fee (HVF) has also resulted in a significant renovation of the HDV fleet (EEA, 2014a). The HVF was implemented along with an increase in HDV weight limits. Between 2001 and 2005 the number of vehicle-kilometres fell by 6.4%, while the number of freight tonne-kilometres increased by 16.4%, pointing to an increase in transport efficiency (Krebs and Balmer, 2015). After 2005, the vehicle-kilometres increased again, but the increase would have been much higher under the old regime, that is, if there had been no HVF or higher weight limits. About 30% of the reduction in vehicle-kilometres, compared with the expected situation without measures, would have been realised thanks to the HVF and the remaining 70% by the higher weight limits (Ecoplan and INFRAS, 2012). The combination of cleaner vehicles and lower vehicle-kilometres, along with an increase in rail transport, have resulted in substantially lower emissions of pollutants. When compared with a scenario without the HVF and with a lower weight limit, PM emissions decreased by 10% and NO_X emissions by 14% (Krebs and Balmer, 2015). CO_2 emissions decreased by 6%.

An *ex post* assessment of road charging systems in the EU not surprisingly concluded that the largest

Figure 5.4 Proportion of environmental classes in vkm on German tolled roads



Note: S1 to S6 and EEV refer to different pollution classes, with S1 being the most polluting and EEV and S6 being the least polluting (Toll Collect, 2015).

Source: (Bundesamt für Güterverkehr, 2014) environmental impacts were achieved by differentiated network-wide electronic tolls, with separate classes for the cleanest technologies, sometimes in combination with accompanying subsidies. The impacts of the vignettes were deemed to be smaller (EC, 2014e). The main impact of the charging regimes was the updating of the vehicle fleet, together with the more intensive use of these cleaner vehicles.

Moving from vignette systems towards environmentally differentiated network-wide tolling systems seems to be promising and feasible, as illustrated by the countries where such systems are already in use. Other potential road-charging reforms have been considered (Franckx and Mayeres, 2014).

- Firstly, the differentiation of charges to tackle other externalities such as congestion and noise is still limited.
- Secondly, the distance-based HDV charges in the EU generally apply only to part of the network — motorways and main roads. Charging could in theory be extended to other types of roads. For Austria, the potential application of the freight charge to all roads has been assessed. The impact on GDP and employment was found to be positive if a large proportion of the extra revenues was used to reduce general taxation. However, the impacts are small, even if the charge is increased, with HDV traffic and related emissions falling by only 2%. This is because only freight transport is considered (Steininger et al., 2012)
- Thirdly, the extension to other road modes might be another direction for reform. However, no EU Member States are currently planning a network-wide distance-based charge for private passenger cars.

Finally, a number of countries took measures to increase the acceptability of the system, among which were the earmarking of the revenues for specific purposes. While this is generally found to improve the public's acceptance of road pricing, it should be taken into account that such an approach is not permitted in all countries. From a strictly efficiency perspective, that is, ignoring political feasibility considerations, it may be preferable to assign the revenues to the general budget (Franckx and Mayeres, 2014).

5.3 Environmentally harmful subsidies

Subsidies or tax exemptions are considered harmful to the environment if they have an unintended negative effect on nature and/or the environment (Drissen et al., 2011). For some time now, the need to abolish environmentally harmful subsidies has been on the agenda of the Organisation for Economic Co-operation and Development (OECD) and the European Commission (Drissen et al., 2011; Valsecchi et al., 2009). The need to phase out such subsidies has been reiterated in the *EU Roadmap for a resource efficient Europe*, which includes the milestone that 'by 2020 EHS [environmentally harmful subsidies] will be phased out, with due regard to the impact on people in need' (EC, 2011f). Although the abolition of environmentally harmful subsidies would reduce environmental pressures, this has to be weighed against negative effects that may be felt elsewhere in society (Drissen et al., 2011).

Table 5.1 illustrates some examples of potentially environmentally harmful subsidies in the field of transport.

5.3.1 Examples of transport-related environmentally harmful subsidies

Subsidies for company cars

Company cars make up about 50% of European new car sales (Copenhagen Economics, 2010).In Germany, Europe's biggest market for cars, about 64% of new car sales were registered to companies in 2014 (Kraftfahrt-Bundesamt, 2015). As many of these cars will enter the second-hand market once the lease is finished, policy incentives that influence choice of company car also impact on a country's entire car stock.

Company car policies can also affect the car stock in neighbouring countries. In newer Member States, car ownership and the distances driven have been increasing. This increase has to a considerable degree been supported by the import of second-hand cars from western European countries, notably Belgium, Germany, Luxembourg and the Netherlands (Máca et al., 2013). For example, in 2008, in Bulgaria, the Czech Republic, Greece, Latvia, Poland and Slovakia, the number of imported second-hand cars exceeded the number of registrations of new cars (Mehlhart et al., 2011). In Belgium it has been estimated that the average age of a company car is 3.63 years (KPMG, 2012), while the average scrappage age in the EU is 18 years (Mehlhart et al., 2011). As a result, the car fleet in the newer Member States is considerably older than it is in western European countries. Company cars, which most likely form a considerable part of the imports, also tend to be larger and less fuel efficient than the average car.

Table 5.1 Typology of transport-related subsidies

Subsidy type	Examples in transport
On-budget or direct subsidies. Direct subsidies (e.g. direct cash transfers, low-interest loans or reduced rate loans, the government provision of goods and services and subsidies to research and development) that appear on national accounts as government expenditure	Public transport: Cash transfers to public transport operators beyond compensation for the delivery of public service requirements — whether those transfers are environmentally harmful depends on different variables such as the transport mode that is replaced by public transport
Off-budget or indirect subsidies. Tax exemptions and rebates, preferential market access, limited liabilities, accelerated depreciation allowances, and selective exemptions from government standards	Car transport: • preferential tax treatment for the in-kind benefit linked to the private use of company cars • lower taxation of diesel than gasoline All land transport: taxation of commuting expenses Maritime: tax exemptions for international transport fuels Air transport: tax exemptions for international transport fuels and air tickets
Implicit subsidies. These refer to the non-internalisation of external costs (or lack of full-cost pricing)	The absence of full-cost pricing in transport is the norm rather than the exception

Source: Based on Valsecchi et al., 2009.

The 'subsidising' of company cars arises from the tax treatment of the in-kind benefit linked to their private use. Employers typically cover the costs of purchasing or leasing the vehicle, as well as maintenance and annual registration costs, and in some cases fuel costs. If the employee may also use the vehicle for personal use, then the free availability of a company car should be considered to be an in-kind benefit (OECD, 2014).

Two methods are commonly used for estimating the in-kind benefit:

- it is assumed that the benefit is proportional to the price of the car;
- it is assumed that the benefit depends on the distance travelled.

Several countries also apply secondary conditions for the calculation of taxable benefits, including the age of the company car and its environmental impact, usually measured by CO_2 rating (OECD, 2014).

Several studies have shown that the value of the personal benefit associated with the use of a company car is usually underestimated substantially. It has been estimated that the weighted average subsidy per company car per year is EUR 1 600 (OECD, 2014), while direct revenue losses may approach 0.5% of EU GDP (EUR 54 billion) (Copenhagen Economics, 2010).

The tax benefits for company cars may have several harmful effects on the environment (Franckx and Mayeres, 2014).

- Firstly, current tax settings often provide incentives for individuals to drive greater distances in these cars.
- Secondly, some schemes implicitly provide incentives for purchasing larger, and thus less fuel efficient, cars. In some countries, this effect is partly compensated for by making the tax rate dependent on CO_2 emissions. However, in practice, this encourages the purchase of diesel cars, which are more fuel efficient but emit higher levels of certain air pollutants.
- Thirdly, tax levels provide an implicit incentive to choose a company car, leading to a larger car fleet.
- Finally, the tax benefits reduce the overall cost of the commute, which may result in longer commutes if employees decide to live further away from work.

In summary, the system of company car subsidies tends to provide little incentive for the employee to reduce the number of trips, distances driven fuel consumption or hence GHG emissions.

Various reforms of the company car taxation system have been proposed by, for example:

- moving toward tax neutrality, taxing the in-kind benefit as any other source of income;
- giving the right environmental incentives, based on the full environmental costs of the different car types.

The main obstacle to implementing the first point is that the tax treatment of company cars often allows employers to circumvent high taxes on labour (Franckx and Mayeres, 2014). A thorough reform of company car taxation is thus likely to meet opposition from vested interests, unless it would be part of a more comprehensive reform of labour taxation. Addressing the second point, one of the main issues is that environmental parameters should not just include CO_2 emissions, as is sometimes done, but also emissions of important air pollutants.

Taxation of commuting expenses

In 11 European countries, personal commuting expenses are deductible from taxable income (OECD, 2014; Potter et al., 2006). Most governments also implicitly subsidise commuting by public transport through their support for public transport fares (Borck and Wrede, 2009).

Commuting is often considered to have certain social benefits. Some argue that employees gain personal benefits from commuting because it gives them access to cheaper housing and rural amenities (Richter, 2006). Some people are constrained in where they live for family or practical reasons. Therefore, not everybody can be expected to work close to home, and subsidies can be provided to provide support for those who commute to more productive regions (Wrede, 2001; Borck and Wrede, 2009; Van Dender, 2003). In general terms, commuting subsidies can lead to less unemployment (OECD, 2014).

In practice, the environmental impacts of commuting subsidies depend on the details of their design. A general tax concession for all commuting trips promotes commuting by car and longer trips and thus urban sprawl (Potter et al., 2006; Umwelt Bundesambt, 2014). In contrast, public subsides promoting public transport can be more environmentally beneficial. When subsidies for commuting expenses are adopted to increase the mobility of the labour market, there are options to mitigate any associated potential negative environmental impacts. These include:

- ensuring that subsidies for commuting by personal car are less favourable that those given for commuting by alternative modes (public transport, car pool systems, employer-provided transport such as vans, cycling and walking);
- restricting subsidies for commuting by car if there are adequate public transport services;
- establishing distance thresholds, lower and/or upper, for commuting subsidies.

Tax exemptions for international transport fuels

Fuels used for international transport by plane or ship are typically exempted from national taxation.

For air transport, the 1944 Chicago Convention on International Civil Aviation (Article 24) established the principle that oil on board aircraft flying to, from or across the territory of another contracting State shall be exempted from any national or local duties and charges. A series of bilateral agreements have subsequently extended this exemption to 'fuel supplied in the territory of one State party to an airline of the other party'. This tax exemption for international flights provides a very significant subsidy for air travel, and it can be considered to be distorting competition between different modes of transport for certain long-distance travel, for example with long-distance rail. One study has estimated that, simply within the EU, the absence of fuel taxation on international aviation has led to a reduction in public revenues of EUR 20 billion to EUR 32 billion per year (Korteland and Faber, 2013).

Air travel is a significant and growing contributor to global GHG emissions. Within the EU, aviation has been included in the EU ETS, albeit with certain 'stop the clock' provisions (see Box 2.1). Negotiations on a global market-based measure are presently under way in the ICAO with a view to implementing a new scheme from 2020.

Although there are no treaties explicitly exempting marine fuels from taxation or duties, 'it has long been accepted in practice that ships in transit should be able to take on fuel exempt from local taxes' (Brack et al., 1999). On top of these de facto exemptions, the EU's Energy Taxation Directive explicitly exempts energy products supplied for use as fuel for the purposes of navigation within Community waters (including fishing), other than private pleasure craft, and electricity produced on board. The Directive also permits Member States to apply partial or full exemptions for energy products supplied for use as fuel for navigation on inland waterways (including fishing), other than in private pleasure craft, and electricity produced on board.

The environmental implications of the tax exemptions for marine fuels within the EU are unclear. On the one hand, the direct effect of these exemptions is to increase transport activity in the maritime and inland waterway sector. On the other, to the extent that this exemption improves the competitive position of water transport compared with road transport, it can help mitigate the environmental impacts of road transport, for example by reducing CO_2 emissions or noise nuisance from road transport. Taking into account the significant contributions of shipping to local air pollution (EEA, 2013b), and the slowly improving performance of road transport as far as local air pollutants are concerned, it is unlikely that tax exemptions for water transport are the best approach to compensate for the lack of internalisation of the external costs of road transport. However, general attempts to introduce policies that better internalise transport externalities to remove present tax distortions have largely been unsuccessful.

6 Looking to the future

Key messages

The EU has set itself ambitious future targets for the long-term decarbonisation of its economy. However, according to its own projections, the 2011 White Paper on Transport's decarbonisation targets will not be met unless more ambitious measures are implemented.

Modal shift is a central element in the EU's decarbonisation ambitions. In the case of freight, the objective is to shift 30% of road freight travelling over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050. For passenger transport, the majority of medium-distance travel will have to go by rail by 2050. The actual realisation of such a modal shift would require significant investments in infrastructure, complemented by other measures to promote more environmentally friendly transport models.

Under current trends and adopted policies, reductions in GHG emissions from transport will come mainly from fuel efficiency gains and only to a lesser extent from the use of alternative fuels.

Experience with first-generation biofuels has shown that, taking into account all indirect effects, the net environmental benefits of biofuels are subject to considerable uncertainty. Similar concerns apply to electric mobility, hydrogen and compressed natural gas, although their deployment is seen as a necessary step towards a cleaner transport sector.

Innovations such as intelligent transport systems, new business models and autonomous vehicles may increase the efficiency of the transport system. However, as improved transport efficiency can often induce additional demand, such technological developments will need to be properly priced to account for the associated environmental externalities.

6.1 Projected future transport trends within the EU

The EU has set itself ambitious targets for the decarbonisation of the transport sector. However, according to the European Commission's own projections, the 2011 Transport White Paper's decarbonisation targets will not be met unless further ambitious measures are taken. Updated scenarios included in an EU reference scenario for the development of energy systems to 2050 (EC, 2013b) include a detailed discussion of the transport sector. By 2050 (compared with 1995), passenger transport is expected to have grown by around 70% and freight transport by 100%. Other elements are listed below.

- The projected growth of passenger transport will be mainly due to elements such as ageing of the population, growing congestion, increasing fuel costs and saturation of the demand for passenger cars.
- The proportion of passenger cars in the total demand for passenger transport activity is expected to increase by 2050, while the proportions of rail and aviation will also increase.
- Aviation will significantly increase its modal contribution by 2050. Rail freight is also projected to increase its contribution by 2050, relative to 2010.
- Increases in the fuel efficiency of passenger cars and light commercial vehicles are, however, projected to counteract the environmental impacts of increased activity levels, but only up to a point: transport-related CO_2 emissions (excluding international maritime) are expected to decrease by only 8% between 2010 and 2050. In contrast, for road freight, increased emissions due to the increased rates of activity will exceed the expected improvements in fuel consumption.

- It is currently projected that diesel will become the dominant fuel used in passenger cars and continue to be the primary fuel for HDVs.
- The introduction of biofuels in road transport will be driven by the targets for renewable energy sources in the transport sector for 2020.
- The future use of EVs is anticipated to be relatively limited, even by 2050, when their proportion is not expected to exceed 8%.

A fundamental decarbonisation of the transport sector in future will require not just technological solutions but also policies that stimulate significant behavioural changes, including the correct pricing of transport externalities and planning approaches that stimulate the use of sustainable modes of transport. Taking the global perspective into account is also important when considering future trends in European transport. The expected future growth in global passenger and freight transport is expected to be mainly driven by non-OECD countries. International coordination and collaboration is therefore indispensable if long-term climate goals are to be met.

6.2 Key challenges concerning future transport trends

6.2.1 The goal on modal shift away from road transport

Modal shift away from road transport is a central element in the EU's decarbonisation ambitions. The 2011 Transport White Paper explicitly states the ambition to shift 30% of road transport of distances over 300 km to rail and inland navigation by 2030, and more than 50% by 2050. This goal will require significant investments in infrastructure, such as the completion of the TEN-T core and comprehensive network, by 2030 and 2050, respectively.

6.2.2 Reducing GHG emissions from road freight

In the EU, HDVs account for approximately 27% of CO_2 emissions by road transport (Chapter 4). The European Commission (EC, 2014g) projects that CO_2 emissions from HDVs will remain broadly constant until 2030, mainly due to an increased share of biofuels and an autonomous improvement in the efficiency of HDVs. However, this would still imply emissions 35% above their 1990 levels. Reducing expected emissions in 2030 by just 2% compared with 2010 has been estimated to require an uptake of all technologies expected to be put on the market between 2010 and 2030, regardless of the payback time of the technology (EC, 2011g).

There are specific reasons why efficiency standards for HDVs are especially challenging, including the diversity of the fleet in terms of vehicle size and configuration, as well as usage patterns, the important contribution of auxiliary equipment to total fuel consumption, and the effectiveness of regimes for assessing compliance with required performance and emissions standards (ICCT, 2012; EC, 2011g).

6.2.3 Promoting alternative fuels for transport

European Commission projections (EC, 2013b), indicate that under current trends and adopted policies, reductions in transport GHG emissions will come mainly from increases in fuel efficiency and only to a lesser extent from alternative fuels.

Technical standards can be used as instruments to promote alternative fuels and quicker uptake of new technologies for all modes if the necessary infrastructure is in place. The EU Directive on the deployment of alternative fuels infrastructure (2014/94/EU), while not setting binding targets for Member States, does indicate the minimum requirements for deployment of the infrastructure with common standards (EU, 2014). It addresses alternative fuels such as electricity, hydrogen and natural gas (pure or blended with biogas).

For biofuels, progress to date is slow. The European Commission's 2015 progress report on renewable energy suggests that the slow progress is largely due to uncertainty about policies mitigating the risk of indirect land use change, in combination with the slow deployment of conventional biofuels as well as alternative, second-generation biofuels (EC, 2015d).

6.2.4 Implementing new technologies that address transport supply and demand

Transport demand and supply technologies are today rapidly changing in ways that were not anticipated even 10 years ago. Such changes include, for example, the development of new business logistics models, the use of mobile internet applications and the development of drone technology. Each of these may significantly affect future business and personal transport patterns.

The potential role that future intelligent transport systems may have on the efficiency of road space use has long been recognised, with, for example, such systems being assigned a key role in the European Commission's Communication on Urban Mobility (EC, 2013g). New business models, facilitated by developments in mobile internet technology, are also already playing an increasingly important role in shaping transport patterns. The use of 'big data' allow for fine-tuning semi-public transport, for more flexible car-sharing systems and for peer-to-peer car sharing (Chan and Shaheen, 2012). Mobile apps that match demand and supply for taxi services, such as Hailo and Uber, are increasingly popular. The current public debate on such applications tends to focus on labour market, safety and competition issues. However, an important question is also how such technologies will impact on overall transport patterns. Such technologies can lead to improved efficiency of the transport system. Improved efficiencies in turn can induce additional demand, and it is important that expected technological developments incorporate correct pricing of transport externalities.

Remotely piloted aircraft systems, 'drones', may, for example, be used for various tasks including delivery of goods in urban areas. Although still in the experimental stage, they could assist in reducing environmental impacts associated with the current 'last mile' stage of freight delivery, which is currently a constraint on improving the overall efficiency of the freight sector. The scope and potential of such services in the urban context is, however, difficult to predict, as many issues still need to be properly addressed before drones could operate in cities, including safety, security and privacy risks.

While the outlook for all these potential innovations remains uncertain, it is clear that there is a need for a structured system allowing exchange of experience and good practice between countries and cities (EC, 2013g).

Abbreviations, acronyms and units

7EAP	Seventh Environment Action Programme
μm	Micrometre(s)
AFV	Alternative-fuelled vehicle
BEV	Battery electric vehicle
CO	Carbon monoxide
CO_2	Carbon dioxide
dB	Decibels
EC	European Commission
EC4MACS	European Consortium for Modelling Air Pollution and Climate Strategies
ECA	Emission Control Area
EEA	European Environment Agency
EEV	Enhanced environmentally friendly vehicle
EIA	Environmental Impact Assessment
END	Environmental Noise Directive
ESD	Effort Sharing Decision
ETS	Emission Trading System
EU	European Union
EV	Electric vehicle
FAME/FAEE	Fatty acid methyl/ethyl esters
g	Gram(s)
GDP	Gross domestic product
GHG	Greenhouse gas
GJ	Gigajoules (109 joules)
HDV	Heavy-duty vehicle
HEV	Hybrid electric vehicle
HGV	Heavy goods vehicle
HVF	Heavy vehicle fee
ICAO	International Civil Aviation Organisation
ICEV	Internal Combustion Engine Vehicle
ILUC	Indirect land use change

IMO	International Maritime Organisation
ITS	Intelligent Transport Systems
LDV	Light-duty vehicle
kg	Kilogram(s)
km	Kilometre(s)
L_{den}	Day- evening- and night-level indicator of noise
L_{night}	Night-level indicator of noise
MARPOL	International Convention for the Prevention of Pollution from Ships
NEC	National Emission Ceilings (Directive)
NH_3	Ammonia
NMVOC	Non-methane volatile organic compound
N_2O	Nitrous oxide
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
PHEV	Plug-in hybrid electric vehicle
pkm	Passenger-kilometre(s)
PM	Particulate matter
PM_{10}	PM with a diameter of 10 µm or less
ppm	Parts per million
SEA	Strategic Environmental Assessment
SO_X	Sulphur oxides
TEN-T	Trans-European Transport Network
TERM	Transport and Environment Reporting Mechanism
TJ	Terajoules (1012 joules)
tkm	Tonne-kilometre(s)
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
vkm	Vehicle-kilometre(s)
WFD	Water Framework Directive
WHO	World Health Organization
WLTP	Worldwide-harmonised Light-vehicle Test Procedure

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Annex 1 List of TERM transport indicators

The TERM indicators have been published annually since 2000, subject to data availability. In 2000, the indicators appeared in the annual TERM report only, but they have since been published individually on the EEA website (http://www.eea.europa.eu) with titles as listed below. When the indicator set was originally defined, it was expected that the data, despite being limited at that point, would eventually become available over time. For this reason, not all indicators have been published every year.

- TERM 01 — transport final energy consumption by fuel in the EU-28
- TERM 02 — transport emissions of greenhouse gases
- TERM 03 — transport emissions of air pollutants
- TERM 04 — exceedances of air quality objectives due to traffic
- TERM 05 — exposure to and annoyance by traffic noise
- TERM 12 — passenger transport volume and modal split
- TERM 13 — freight transport volume and modal split
- TERM 20 — real change in transport prices by mode
- TERM 21 — fuel tax rates
- TERM 27 — energy efficiency and specific CO_2 emissions
- TERM 28 — specific air pollutant emissions
- TERM 31 — proportion of renewable energy in the transport sector
- TERM 33 — average age of the vehicle fleet
- TERM 34 — proportion of vehicle fleet by alternative fuel type

Annex 2 Transport targets to 2050

Target	Target date	Source	Relevant indicator	Comments
Transport GHGs (including international aviation, excluding international maritime shipping)		Transport White Paper (EC, 2011a), 2050 Roadmap (EC, 2011c)	TERM 02	The 2050 Roadmap is the broader strategy that sets the most cost-effective ways to reduce GHG emissions based on the outcome from modelling to meet the long-term target of reducing domestic emissions by 80 to 95%. The target for the transport sector was set out in the 2011 White Paper on Transport on the basis of the 2050 Roadmap.
20% ↓ (versus 2008)	2030			
60% ↓ (versus 1990)	2050			
EU CO_2 emissions of maritime bunker fuels 40% ↓ (versus 2005)	2050	Transport White Paper (EC, 2011a)	TERM 02	
40% proportion of low-carbon sustainable fuels in aviation	2050	Transport White Paper (EC, 2011a)	TERM 31	Potentially monitored through EU ETS reporting.
Use of conventionally fuelled cars in urban transport		Transport White Paper (EC, 2011a)	TERM 34	The White Paper goal relates not to vehicle numbers but to their contribution to urban pkm.
50% ↓	2030			
100% ↓	2050			
CO_2-free city logistics in major urban centres	2030	Transport White Paper (EC, 2011a)		Not currently possible to monitor.
The majority of medium-distance passenger transport should go by rail	2050	Transport White Paper (EC, 2011a)	TERM 12a/b	Only indirectly monitored through modal shares.
Road freight over 300 km shift to rail/waterborne transport		Transport White Paper (EC, 2011a)	TERM 13a/b	Only indirectly monitored through modal contributions.
30% shift	2030			
50%+ shift	2050			
10% proportion of renewable energy in the transport sector's final energy consumption for each Member State	2020	Renewable Energy Directive 2009/28/EC (EC, 2009b)	TERM 31	
Fuel suppliers to reduce life cycle GHGs of road transport fuel 6–10% ↓ (versus 2010 fossil fuels)	2020	Fuel Quality Directive 2009/30/EC (EC, 2009a)	TERM 31	To be monitored in future indicator updates.
Target average type approval emissions for new passenger cars		Passenger Car CO_2 EC Regulation 443/2009 (EC, 2009a)	TERM 27 and TERM 34	Phased in between 2012 (65%) and 2015 (100%).
130 g CO_2/km	2012–2015			
95 g CO_2/km	2020			

Target	Target date	Source	Relevant indicator	Comments
Target average type approval emissions for new light vans		Van CO_2 EC Regulation 510/2011 (EC, 2011a)	TERM 27 and TERM 34	First data for 2012 available.
175 g CO_2/km	2014–2017			
147 g CO_2/km	2020			
70% reduction of transport oil consumption from 2008	2050	Impact assessment, Accompanying document to the White Paper (EC, 2011b)	TERM 01	This is interpreted as a 70% drop in oil consumption in the transport sector from 2008 levels, as they are the latest data available.

Annex 3 Explaining the target paths

This annex provides an overview of the method used to assess progress towards targets and assign colours to cells in Table ES.1.

Reducing transport GHG emissions

In the case of the key target, each year's data are compared with the 'trajectory' based on the 'preferred policy option' for achieving reductions, as set out in the impact assessment accompanying the 2011 Transport White Paper (EC, 2011a) in order to meet the target for reducing transport GHG emissions by 2050. Figure A3.1 compares real data and the 'target path', defined accordingly.

In Table ES.1, in the column 'Observed' under each given year, and under the title 'Where we are (current trends vs 'target path')', a green colour indicates when the latest data show a value equal or below that of the 'target path' for that year. In other words, the reduction achieved is in line with — or better than — the estimations. Because concrete 'preferred policy option' estimations are available only every 5 years (up to 2050), an interpolation of the values is still needed for the years in between, prior to the comparison.

In the final column of Table ES.1, 'latest annual trend', the colour green indicates when the latest data show improvements compared with the previous year in which data are available.

Indicative targets

In order to assign a colour to the cells in Table ES.1 for the indicative targets, a similar methodology was followed. However, as there were no official estimations on the 'target path' to be followed, this path was calculated by plotting a straight line from the base year data to the target year data, that is, assuming a linear trend towards the target. At this point, it is clear that this is a subjective assessment of progress, aiming only to give an approximate indication of whether the target will be met. Assuming a linear trend could lead to incomplete conclusions, because, for most of the targets, improvements are

Figure A3.1 Transport GHG emissions

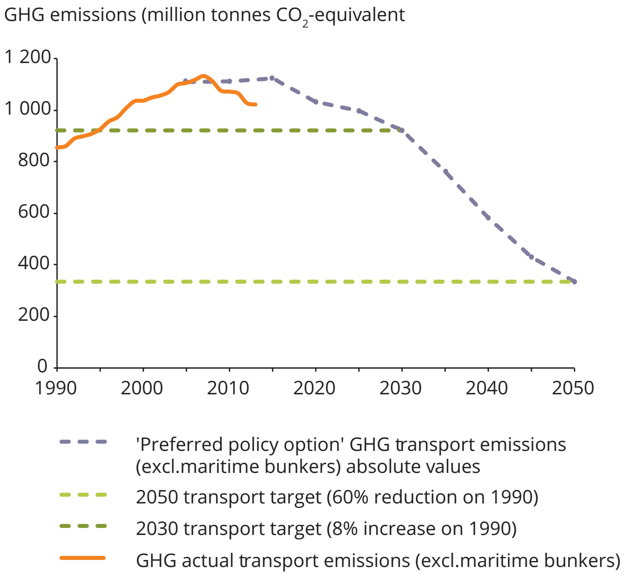
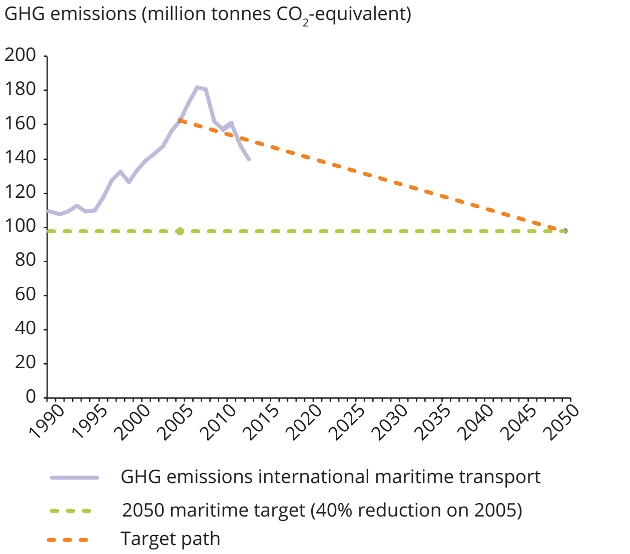
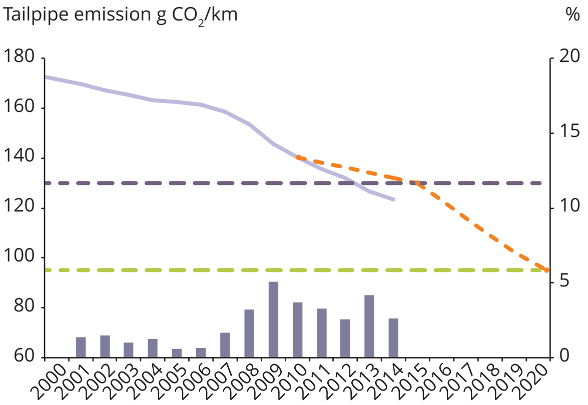


Figure A3.2 EU GHG emissions of maritime bunker fuels



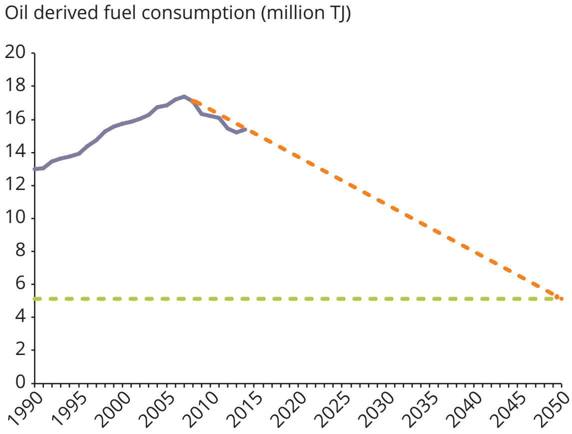
not expected in the early years. This is a consequence of fleet renewal and technology uptake, among other circumstances, including temporal breakdowns or recessions. However, these circumstances will be explained when assessing annual progress, and they can also be checked against the progression of different TERM indicators. In addition, assumed linear trends have been calculated, bearing in mind mid-term targets if available (i.e. CO_2 emissions from new passenger cars for the 2015 and 2020 targets); therefore, different speeds in meeting targets, forecast in official scenarios and documents, are taken into account.

Figure A3.3 Target average type approval CO_2 emissions for new passenger cars



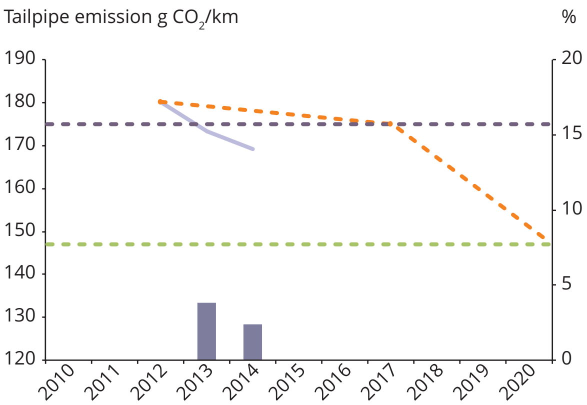
Annual reduction rate (right axis)
Average CO_2 emissions from new passenger cars
2015 target for new passenger cars (130 g CO_2/km)
2020 target for new passenger cars (95 g CO_2/km)
Target path

Figure A3.5 Reduction in transport oil consumption



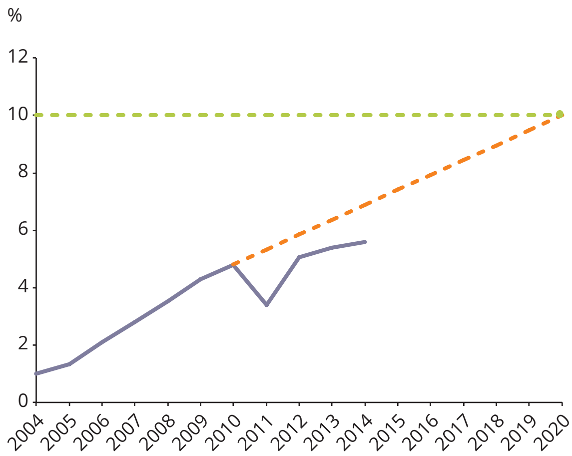
EU-28 — Oil derived fuel consumption (million TJ)
2050 oil consumption target (70% reduction on 2008)
Target path

Figure A3.4 Target average type approval CO_2 emissions for new vans



Annual reduction rate (right axis)
Average CO_2 emissions from new vans
2017 target for new vans (175 g CO_2/km
2020 target for new vans (147 g CO_2/km
Target path

Figure A3.6 Proportion of renewable energy in the transport sector



Renewables share (%) meeting RED criteria
10% share of renewable energy in the transport sector final energy consumption for each Member State (here EU-28 average as a proxy)
Target path

Annex 4 Survey of road pricing for freight transport in EEA member countries

Table A1 Road charging of HDVs in EEA member countries (June 2015)

Charging system		Member countries
Network-wide electronic tolls ([a])		Austria (since 2004), Germany (since 2005), Czech Republic (since 2007), Slovakia (since 2010), Portugal (since 2010), Poland (since 2011), Hungary (since 2013) Belgium: planned for early 2016 EEA non-EU: Switzerland (since 2001)
Concession motorways		Croatia, France, Greece, Ireland, Italy, Poland, Portugal, Slovenia, Spain EEA non-EU: Norway, Turkey
Vignettes	Eurovignette	Belgium (until early 2016), Denmark, Luxembourg, the Netherlands, Sweden (since 1998)
	National vignette	Romania (since 2002), Bulgaria (since 2004), Lithuania (since 2005), Latvia (since 2014), United Kingdom (since 2014)
No widespread charging system		Cyprus, Estonia, Finland, Malta EEA non-EU: Iceland, Liechtenstein

Note: If no introduction date is explicitly mentioned, road charging is assumed to be in place since at least 1995.

Source: (EC, 2014e), table 2.10, updated with recent information from national road-charging authorities.

([a]) Network-wide tolls are levied on a whole network of charged roads, using a common electronic charging system.

Table A2 **Differentiation of road charges in terms of Euro class (June 2015)**

	Euro 0	Euro I	Euro II	Euro III	Euro IV	Euro V	EEV	Euro VI	Ratio lowest to highest rate (%)
Vignette system									
Eurovignette countries	Group 1	Group 2	Group 3						81
Bulgaria	Group 1			Group 2					77
Latvia	Group 1			Group 2	Group 3				77
Lithuania	Group 1				Group 2				70
United Kingdom	Group 1								n.a.
Network-wide electronic toll									
Austria	Group 1				Group 2		Group 3	Group 4	74
Czech Republic	Group 1			Group 2		Group 3	Group 4		61
Germany	Group 1		Group 2 Group 3 if PM reduction	Group 3 Group 4 if PM reduction	Group 4	Group 5		Group 6	50
Hungary	Group 1		Group 2	Group 3					
Poland	Group 1			Group 2	Group 3	Group 4			51
Slovakia	Group 1			Group 2		Group 3			77
Switzerland	Group 1 Discount for Euro II if PM filter			Group 2 Discount if PM filter	Group 3			Group 4	66

Note: The ratio of the highest to lowest rate is calculated for a truck of 12 tonnes and more, for the highest number of axles; if a distinction is made in the system between road types, the rates for motorways have been used.

n.a., not applicable.

Source: Compiled from information on the websites of the road-charging authorities in each country.

Annex 5 Decomposition analysis: methodology and data

The so-called decomposition analysis is a methodology that allows identification of the contribution of different factors (drivers) towards a change in an observed indicator over time. For this report, the analysis was based on the logarithmic mean Divisia index method and it has been applied for emissions from road passenger transport and road freight transport. It is based on (Ang, 2004) and (Ang, 2005) and described there in detail. The following details the guiding formula and data sources used for the decomposition analysis in Chapter 4.

Table A5.1 Overview of the factors considered in the decomposition analysis for CO_2 emissions from passenger cars and HDVs in the EU-28

Factors	CO_2 emissions from passenger cars	CO_2 emissions from Heavy-duty vehicles
Equation	*(y) [ln]CO_2 = (× x1) [ln]PKMa + (× 2) [ln]PKMc/PKMa + (× 3) [ln]FUEL/PKMc + (× 4) [ln]FF/FUEL + (× 5) [ln]CO_2/FF*	*(y) [ln]CO_2 = (× 1) [ln]TKMa + (× 2) [ln]TKMt/TKMa + (× 3) [ln]FUEL/TKMt + (× 4) [ln]FF/FUEL + (× 5) [ln]CO_2/FF*
CO_2 emissions	(y) CO_2: carbon dioxide emissions from cars	(y) CO_2: carbon dioxide emissions from HGVs
Total passenger or freight transport demand	(× 1) PKMa: pkm by competing modes (inland modes)	(× 1) TKMa: tkm for competing modes (inland modes)
Changes in modal split	(× 2) PKMc/PKMa: pkm by cars divided by pkm by competing modes	(× 2) TKMt/TKMa: tkm by HGVs divided by tkm by competing modes
Improvements in energy efficiency	(× 3) FUEL/PKMc: total fuel consumption from cars per pkm	(× 3) FUEL/TKMt: total fuel consumption from HDVs per tkm
Development of transport biofuels	(× 4) FF/FUEL: fossil fuel consumption from cars (i.e. all fuels but biofuels) in total fuel consumption	(× 4) FF/FUEL: fossil fuel consumption from HGVs (i.e. all fuels but biofuels) in total fuel consumption
Carbon intensity of fossil fuels	(× 5) CO_2/FF: CO_2 emissions per fossil fuel consumption by cars	(× 5) CO_2/FF: CO_2 emissions per fossil fuel consumption by HGVs

Notes: The decomposition analysis shows the estimated contributions of the various factors that have affected CO_2 emissions from passenger cars and HGVs, respectively. This approach is often used to portray the primary forces driving emissions. The explanatory factors should neither be seen as fundamental factors in themselves nor should they be seen as independent of each other.

Competing modes for freight include: HGVs, LDVs (derived from the EC4MACS model), inland waterway and rail. CO_2 emissions and energy consumption from buses and coaches have been subtracted from CO_2 emissions from the category 'HDVs and buses', reported in GHG inventories, using the EC4MACS model. Competing modes for passengers include: passenger cars, motorcycles, buses and coaches, and railways and metro.

HGVs are national and international haulage vehicles registered in the EU-28 (generally more than 3.5-tonne load capacity).

The eventual use of electricity is not computed, as it is not included in any of the transport categories of the GHG inventories. The effect of the use of electricity would therefore be seen as 'improvements in vehicle energy efficiency' as any pkm or tkm covered by EVs would be made without any fuel consumption.

Data sources: emissions and fuel consumption from the annual EU GHG inventory (EEA, 2015e). Transport demand data from European Commission (EC, 2015a). Adjustments, when needed, on CO_2 from buses and LDV tkm extracted from EC4MACS (http://www.ec4macs.eu/).

Table A5.2 Overview of the factors considered in the decomposition analysis for NO_x and PM emissions from passenger cars and HDVs in the EU-28

	Driver	Road freight transport	Road passenger transport
Transport demand	Transport demand	Inland_tkm	Inland_pkm
Modal shift	Modal split Share Proportion of goods/passengers transported by one mode calculated on the basis of all cargo/passengers transported	Road_tkm/Inland_tkm	Road_pkm/Inland_pkm
Improvement	Energy efficiency Energy use per transported unit	TJ/Road_tkm	TJ/Road_pkm
	Emissions intensity Emissions of the different pollutants per unit of energy	kt/TJ	kt/TJ

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark

Tel.: +45 33 36 71 00
Web: eea.europa.eu
Enquiries: eea.europa.eu/enquiries

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