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The contribution of transport to air quality

TERM 2012: transport indicators tracking progress towards environmental targets in Europe

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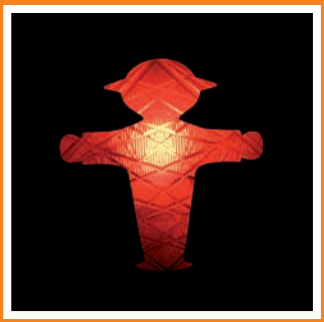

European Environment Agency

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TERM 2012: transport indicators tracking progress towards environmental targets in Europe

European Environment Agency

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The first draft of the text for chapters two to seven was completed by a team from Ricardo-AEA led by Duncan Kay and Nik Hill and comprising Charlotte Brannigan, Beth Conlan, Joanna MacCarthy, Tim Murrells, James Norman, John Norris, Yvonne Pang, and Andriana Stavrakaki.

Foreword

The European Commission's White Paper *Roadmap to a Single European Transport Area — Towards a competitive and resource efficient transport system*, published in 2011, sets out how the transport sector can contribute to meeting the European Union's targets included in the 'Europe 2020' strategy. It sent a clear signal of the role transport will have to play by setting the sector an objective of reducing its carbon dioxide (CO_2) emissions by 60 % by 2050 compared to 1990 levels. From the environmental perspective, the 60 % reduction target is expected not only to contribute to the common climate objective, but also to enhance environmental performance in other areas, such as improved resource efficiency. Clear targets allow stakeholders to keep track of the anticipated achievements.

The analytical framework of this report remains the 'Avoid, Shift, Improve' approach that the European Environment Agency (EEA) has used consistently since the TERM 2009 report (see Figure 8.2 (EEA, 2010)). This approach can be used to address pressures from transport on the environment, such as CO_2 emissions.

'Avoid, Shift, Improve' aims to reduce the environmental impact of transport by avoiding the use of transportation where possible; shifting necessary transport from more environmentally harmful to less environmentally harmful modes of transport; and improving the efficiency of all modes of transport.

The principal idea behind 'avoiding pressures' is that the optimisation of demand, as well as the shift to more environmentally friendly modes of transport, can not only be cost-effective but can also offer environmental co-benefits. For example, avoiding greenhouse gas (GHG) emissions in the transport sector by reducing transport demand has the positive side-effect of improving air quality and reducing noise levels.

Measures and activities in the 'shift' approach include the recently amended 'Eurovignette Directive' (EC, 2011g), which aims to make progress in the internalisation of external costs. Further action is anticipated to meet both the passenger- and freight-specific distance-based goals of the European Commission's White Paper relating to road, rail and waterborne modes. Such action would include further development of rail infrastructure through the trans-European transport networks (TEN-T), as well as opening the rail transport market to competition, and improving the interoperability and safety of national rail networks.

The 'improve' component focuses largely on technical solutions. While these cannot be the only answer to environmental pressures from the transport sector, they can help improve the performance of certain transport modes if efficiency gains are not outweighed by increased transport demand. For example, European Union legislation on CO_2 emission reductions from passenger cars and vans can help to promote the uptake of vehicle technologies.

In its resolution on the European Commission's Transport White Paper (EP, 2011a), the European Parliament asked the European Commission to carry out an annual assessment of progress towards the targets set out in the White Paper. The EEA's TERM fulfils the environmental part of the European Parliament's request.

Report summary

This TERM 2012 report includes the first assessment of progress towards targets set out in key transport and environment-related policy and legislation, including the 2011 White Paper.

The principal finding of this report is that Europe is making tentative progress in reducing the impacts from transport. This progress is evident in two main developments.

Firstly, Europe now has specific quantitative targets for reducing impacts from transport. These targets were mostly agreed in 2011 and include a target to cut greenhouse gas emissions from transport by 60 % by 2050 compared to 1990 levels. The establishment of agreed targets is in itself a step in the right direction towards reducing the impacts of transport.

Secondly, some of the recent data have shown reductions in emissions from transport and improvements in efficiency.

However, there are several important caveats to this broadly positive picture as **Chapter 2** makes clear. One caveat is that for a number of the targets, the methodology for measuring progress has not been finalised, or the data-sets are not yet fully complete. Providing the knowledge base to make assessments of this nature has been one of the main objectives of TERM ever since the first report was published in 2000. Future TERM reports will continue to be updated with new data and refined methodologies. This will help improve the way we monitor progress towards targets, and strengthen the quality of our findings.

A second caveat is that for many targets, the base year against which current data are compared is still relatively recent. It is difficult to read any meaningful trend into a data set of only a few years. For example, greenhouse gas (GHG) emissions from transport (including aviation but excluding international maritime) are falling, as are emissions from international maritime transport. However, many of these improvements can be attributed to the economic downturn. They may therefore not point to long-term improvements.

This leads to another observation: although the EU is generally moving in line with the 'target path' toward the 60 % emissions cut, it does not mean that transport-related impacts are on a continued and uniform downward trend every year. For example, transport energy consumption actually rose slightly in 2011 compared with 2010 (0.1 %), while overall transport GHG emissions (including aviation but excluding international maritime) in 2010 only reduced by 0.4 % compared to 2009.

A third caveat is that many targets are not moving in the right direction at all. While there have been improvements in CO_2 average tailpipe emissions from new passenger cars, there has not been enough progress on the consumption of oil in transport or on meeting the related goal of sourcing 10 % of transport fuel from renewable sources. In spite of the increase in sales of electric vehicles in 2010 and 2011, alternatively-fuelled vehicles still only accounted for 4 % of all vehicles in the on-road fleet in 2010. Support is needed at the EU and Member State level to increase uptake of alternatively-fuelled vehicles and ensure that customers are able to compare these vehicles with conventional vehicles.

Other important findings from Chapter 2 include:

- Freight transport demand is still highly sensitive to changes in gross domestic product (GDP). Demand for freight transport increased by 5.4 % in 2010, a faster rate than the increase in European Union GDP. At the same time, passenger demand fell slightly. Recent increases in the fuel price have not significantly affected transport demand.

- Transport GHG emissions, as defined in the White Paper, remain 26 % above 1990 levels (this covers the EU-27, excludes international maritime and includes international aviation). Transport emissions will need to be reduced by 68 % from 2010 to 2050 in order to meet the key target set out in the European Commission White Paper.

- Between 2009 and 2010, all air pollutant emissions from transport except nitrogen oxide (NO_X) decreased by between 2.5 % and 10 %. In the period from 1990 to 2010, emissions of the main pollutants contributing to acidification, particulate matter (PM) and ozone (O_3) formation decreased in the EEA-32. But in spite of these reductions in pollutant emissions, road transport continues to significantly affect urban air quality, and many cities continue to face air quality problems. In 2010, the nitrogen dioxide (NO_2) annual limit value was exceeded at 44 % of Europe's urban traffic stations, while it was exceeded at 4 % of the urban background stations and only at very few rural background stations. Meanwhile, the percentage of traffic locations that have recorded an excess of the daily limit value for particulate matter with a diameter of 10 micrometers or less (PM_{10}) increased in 2010 compared to 2009.

- International shipping currently contributes to nearly 87 % of all sulphur oxides (SO_X) emissions caused by transport.

- Noise from road transport affects many people. In the largest European cities (with populations of more than 250 000) almost 70 million people, or more than 62 % of the population of the cities analysed, are exposed to long-term average road traffic noise levels exceeding 55 decibels (dB) L_{den} (the EU threshold for excess exposure, indicating a weighted average noise during the day, evening and night). At night, more than 48 million people in the same urban areas are exposed to long-term average road noise levels higher than 50 dB L_{night} (the EU threshold for excess exposure at night time).

Chapter 3 looks in greater detail at the split in overall transport demand between freight transport and passenger transport. The latest data suggests that there is still a strong link between transport demand and economic growth. Freight transport demand in particular is very sensitive to economic trends, decreasing much faster than the rate at which GDP fell from 2008 to 2009, but increasing at a faster rate than the increase in GDP from 2009 to 2010. However, passenger transport demand fell slightly in 2010 despite the return to GDP growth, breaking the expected coupling with economic output.

Chapter 4 offers an overview of the transport sector's impact on air quality. It discusses the contributions made by all modes of transport to pollution emissions as well as to so-called 'secondary' air pollutants. This chapter also looks at the issue of why 'real world' driving conditions have not delivered the reductions in emissions that might have been expected from test-cycle results.

These considerations of air pollution are all framed by the broader issue of air policy, also dealt with in Chapter 4. Alongside the recently published *Air quality in Europe — 2012* report (EEA, 2012b), this report aims to inform the review by the European Union of the Thematic Strategy on Air Pollution.

Local effects of transport on urban air quality are further examined in **Chapter 5**. This chapter analyses the road traffic contribution to exceedances of air quality standards in many cities and other urban areas. It also investigates further the specific features of traffic and the urban environment that help to explain the disparity between trends in emissions estimates (generally decreasing) and ground level concentration of air pollutants (not decreasing at the same pace as emissions). It also investigates how various transport activities increase air pollutant concentrations significantly at and around sea ports and airports.

Chapter 6 focuses on the regional scale effects of transport on air quality. Transport sources of air pollutants affect air quality over a wide area by emitting pollutants that undergo atmospheric transformation processes, occurring up to several days after the initial pollutant release. This chapter analyses the different contribution and nature of the emissions from road, shipping and aviation transport.

Finally, **Chapter 7** summarises the main messages stemming from the report and provides a conclusion of the most important aspects presented in previous chapters.

1 Introduction

The Transport and Environment Reporting Mechanism (TERM) began as part of a project dating from 1998 that aimed to better integrate transport and environment strategies in Europe. The indicators originally developed by EEA for TERM aimed to both assess progress towards this integration and to provide general information to the public about the links between transport and the environment.

This original purpose of the indicators has been slightly modified in the light of the White Paper on Transport launched in 2011 (EC, 2011a). This White Paper led to an adaptation of the TERM reporting, so it could measure progress towards a series of new goals including assisting in measuring progress towards the 60 % reduction in greenhouse gas (GHG) emissions from transport (including aviation but excluding international maritime) by 2050. The European Parliament resolution on the new Transport White Paper specifically asked the European Commission to carry out an annual assessment of progress (EP, 2011a). TERM fulfils the environmental part of this request.

TERM 2011 already introduced the Transport and Environment Reporting Mechanism Core Set of Indicators (TERM-CSI) to facilitate such an assessment. These comprise the original set of indicators formulated before the 2011 White Paper, as well as the indicators that were subsequently developed to assess progress towards the new goals, including those contained in the White Paper. TERM 2011 also provided the baseline against which progress will be checked. However, it should be understood that the baseline was not complete, as most of the data were not available for 2010. The baseline has to be completed in TERM 2012.

TERM aims to offer the most relevant and up to date information on the main issues regarding transport and environment in Europe, particularly the areas for which targets have been set. TERM aims to present this information in a visual way so the reader can rapidly assess the degree to which progress has been made.

In addition to this general role, TERM also seeks to provide the relevant information on a specific topic of interest every year. For 2012, the focus will be on transport emissions and air quality.

Figure 1.1 presents the overall methodology designed for the TERM reports, with an update reflecting the two main objectives for TERM 2012.

Scope of the report

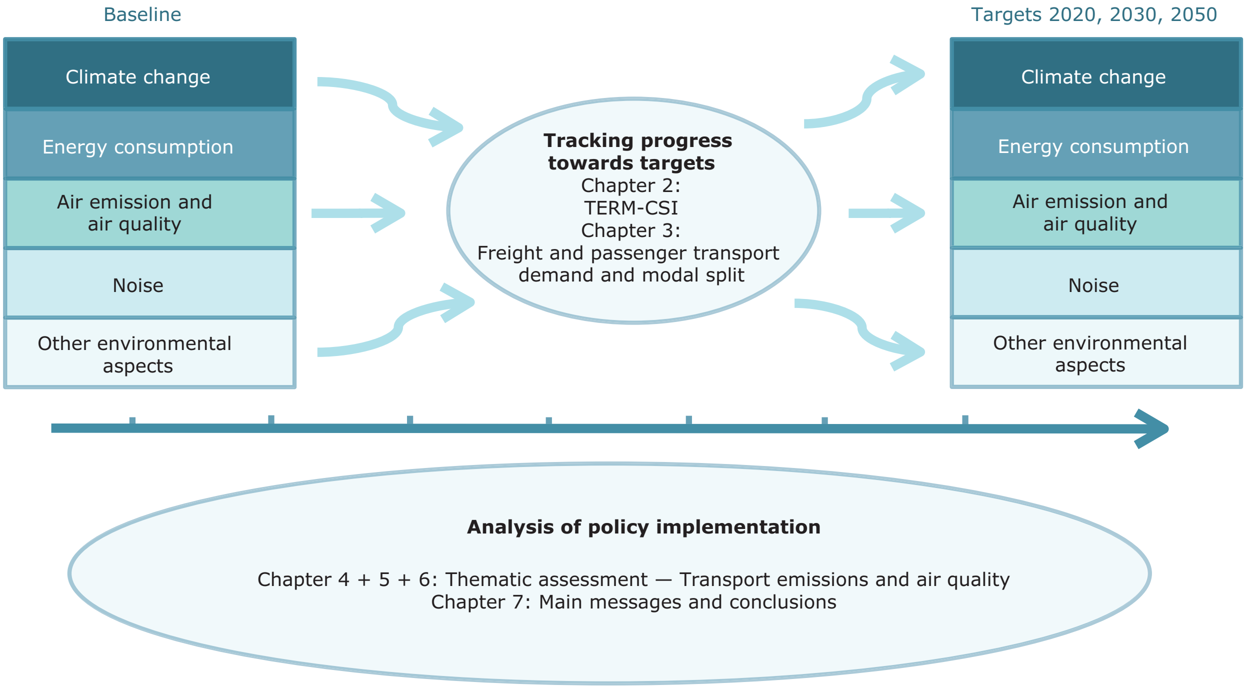
The report aims to cover all 32 EEA member countries (for more on country grouping terminology, see Box 1.1). Where data are not complete, this is

Box 1.1 A note on country groupings

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

- EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.
- EU-10: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.
- EU-12: EU-10, Bulgaria and Romania.
- EFTA-4: Iceland, Liechtenstein, Norway and Switzerland.
- EU-25: EU-15 and EU-10.
- EU-27: EU-15 and EU-12.
- EEA-32: EEA member countries (EU-27, EFTA-4 and Turkey).

Figure 1.1 Conceptual map for the TERM approach: TERM 2012 structure



Source: EEA, 2012.

generally noted in the metadata section, where different country groupings are also described. For some indicators, EU-27 data have been prioritised, as policy targets and goals are specifically developed for these countries, but a reflection based on the available EEA-32 data has been included as far as possible.

In terms of time, most indicators cover the years since 1990, subject to data availability. However, there are cases where data for some Member States have only become available recently, or where the transition from a centrally planned to market economy has led to such big changes that comparisons over time become irrelevant. In other cases, only recent data are presented as older data are not relevant for the analysis.

2 TERM Core Set of Indicators

2.1 Introduction

The European Commission's White Paper on transport (EC, 2011a) acts as a framework to guide future policy developments in the transport sector over the next decade. The White Paper sets out 10 goals for a competitive and resource-efficient transport system. These goals serve as benchmarks for achieving the target of a 60 % reduction in GHG emissions from transport by 2050 target (from 1990 levels).

The TERM 2011 report identified targets for the coming decade and beyond in EU transport and environment policy (see Annex 2). These targets range from the short term to the long term (i.e. up to 2050). They included targets from the White Paper on transport, but also other key transport and environment-related policy and legislation, such as the *Roadmap for Moving to a Competitive Low Carbon Economy in 2050* (EC, 2011b) and the various regulations setting carbon dioxide (CO_2) emission targets for new passenger cars (EC, 2009a) and light commercial vehicles (EC, 2011c). They also include targets from the the Renewable Energy Directive (RED) (EC, 2009b) and the Fuel Quality Directive (FQD) (EC, 2009c).

This chapter contains an overview of progress towards each of these targets, giving a summarised 'at a glance' status. Progress is measured against the relevant base year identified in the target and examines data from the EU-27. For each target, the latest available data are presented.

The TERM 2011 report introduced a new format for TERM, featuring 12 TERM-CSIs enabling monitoring of the most important aspects of transport impacts. Other TERM indicators that are updated on a less frequent basis are also available, giving a wider coverage of transport impacts (see Annex 5 for an overview of all TERM indicator fact sheets, although it should be noted that not all indicators are published every year). The 12 TERM-CSIs are listed in Table 2.1.

The latest available data for the 12 TERM-CSIs are presented in a series of summary boxes, giving detail on their trends and developments (Section 2.3.). All the targets identified apply to the EU-27 Member States only, and therefore the exercise of showing progress towards targets is focused on EU-27. However, where possible, these summary boxes contain data for the wider EEA-32 member countries, giving information on the progress of EEA member countries that are not members of the EU. The non-EU-27 countries covered by the EEA (Iceland, Liechtenstein, Norway, Switzerland and Turkey) tend to share overall policy goals, so their progress is, as far as possible, also assessed. But this is done on an individual basis in order to respect national variations.

In addition to the snapshot assessment of progress against the key targets provided by the TERM-CSIs summary boxes, Section 2.2 aims to provide an even shorter overview of progress towards these EU-27 policy targets. The information will show the progress from the base year towards each target deadline in a synthetic manner.

2.2 Overview of progress towards transport goals

The key environmental target of the White Paper is to achieve a 60 % reduction in GHG emissions from transport by 2050 (including aviation but excluding international maritime emissions). This reduction is to be achieved against a base year of 1990. As transport emissions have increased since 1990, achieving the target will actually require an even greater reduction compared to 2010 emissions. In order to achieve this overall GHG reduction, a series of indicative targets have been identified in both the White Paper and other transport-related documents. These indicative targets are designed to ensure that suitable progress is made towards achieving the overall GHG emissions reduction. However, due to the direct relationship between transport activity and oil consumption, and therefore between transport and GHG emissions, the continuing increase in transport demand suggests that major efforts are needed to significantly reduce the unwanted effects from this sector.

Table 2.1 TERM Core Set of Indicators (TERM-CSIs)

TERM 01	Transport final energy consumption by mode
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 12a/b	Passenger transport volume and modal split
TERM 13a/b	Freight transport volume and modal split
TERM 20	Real change in transport prices by mode
TERM 21	Fuel prices and taxes
TERM 27	Energy efficiency and specific CO_2 emissions
TERM 31	Uptake of cleaner and alternative fuels
TERM 34	Proportion of vehicle fleet meeting certain emission standards

The 2012 TERM report assesses progress towards both the overall GHG reduction target and these indicative targets (where data are available). This is presented in Table 2.2. Key aspects of Table 2.2 include:

- In each case, the definition of the target and the policy paper or regulation where this is defined is presented.
- The specification of the target, both the targeted reduction and the year in which this reduction or fixed figure is to be met, is also provided in the column 'where we want to be'.
- The available 'observed' data for the latest years (2009, 2010 and 2011) is presented under the column 'where we are (current trends vs. target path)'. These data are to be readily comparable with what was defined as the base year as well as with the value that corresponds to that of the 'target path' for the latest years.
- An indication of whether the progress met is in line with the 'target path' is given by assigning colour to the 'observed' cell each year: green if progress is in line, otherwise red.
- The final column 'Last annual trend' shows the degree of progress compared to the previous year in which data are available. The column is marked in green if there is annual progress in moving towards reaching the target.

However, defining the path for each target is not straightforward. Targets are set for a specific year, but the rate of progress to achieve them is not usually defined. Various impact assessments have provided useful details on the advantages and disadvantages of possible policy options by assessing their potential impact, including modelling exercises that can define expected rate of progress towards the target.

One such impact assessment, which accompanied the 2011 Transport White paper (EC, 2011d), undertook a modelling exercise to explore four alternative policy options aimed at transforming the EU transport sector into a sustainable system by 2050 and thus reaching the target of 60 % reduction in GHG emissions from transport by 2050 (including aviation but excluding international maritime emissions).

- Policy Option 1, 'business as usual', would lead to unsatisfactory results.
- Policy Option 2 would meet the target largely through improved efficiency within each mode of transport, through improved logistics, by modal shift (moving to different types of transport) and by reducing mobility.
- Policy Option 3 would rely heavily on developing and deploying technologies in particular in the long-term (2030–2040).
- Policy Option 4 essentially represents an intermediate approach between Policy Option 2 and Policy Option 3.

The White Paper concluded that, after the modelling exercise, Policy Option 3 should be discarded because it incorporated a high degree of uncertainty associated with the technological component. Meanwhile, it was felt that results did not point to huge differences between Policy Option 2 and Policy Option 4.

The European Commission then selected Policy Option 4 as its 'preferred policy option' since 'it offers the advantage of greater balance between system improvement and technological development, offering a more balanced solution to the trade-offs across the economic, social, and environmental domains' (EC, 2011d).

The results coming from this modelling exercise show the expected values of GHG emissions for every five years (from 1990 to 2050) if the 'preferred policy option' is implemented to meet the target. These values are therefore used to define the 'target path' and monitor progress towards the GHG reduction target. However, no similar information is available for the indicative targets, and the 'target path' for these targets should be built using a simpler methodology (see Box 2.1).

Targets

For a number of the targets, no base year is specified. In these cases, several different approaches have been adopted depending on the target in question. For the target to increase the share of renewable energy in the transport sector, the latest percentage share is reported (2010 in this case), while the base year is set for 2009 in order to provide an assessment of progress.

For the targets to reduce average type-approval emissions for new passenger cars and light vans, the latest status is compared to 2010 (the first year for which data were officially monitored) in order to report percentage progress towards the target.

For the target to shift road freight to rail/waterborne transport, the goal is that a total of 30 % of road freight travelling more than 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050. However, while data on road freight above and below 300 km has recently become available, it is not available for rail so progress towards meeting this target cannot yet be reported. This is also the case for the target to increase use of low carbon sustainable fuels in aviation, as current data shows no evolution (0.0 % share) and therefore it is not yet being reported.

Box 2.1 Understanding Table 2.2

Reducing transport GHG emissions: In the case of the key target, each year's data will be compared with the target path defined in the European Commission's Policy Option 4 (the 'preferred policy option') in order to meet the transport GHG reduction target by 2050. A further description of the content of this policy option is presented in Annex 3, together with detailed representation of the comparison between real data and the target path defined accordingly.

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 shows 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 only available every five 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 'latest annual trend', the colour green indicates when the latest data show improvement compared to the previous year in which data are available.

Indicative targets: In order to assign a colour for the cells for the indicative targets, a similar methodology has been followed. However, as there were no official estimations on the target path to be followed, this path is calculated by plotting a straight line from the base year data to the target year data, i.e. assuming a linear trend towards the target (see Annex 3 for more details and a graphical representation of the comparison between real data and the linear trend). At this point, it is clear that this is a subjective assessment of progress with the only aim being 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 not expected in the first years as a normal consequence of fleet renewal and technology uptake, among other circumstances, including temporal breakdowns or recessions. However, these circumstances will be explained when assessing the annual progress, and can also be checked against the evolution of different TERM-CSIs. 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) and therefore different speeds to meet the targets, forecast in official scenarios and documents, are taken into account.

Table 2.2 Transport goals overview — 2012

	Source	Target	Unit	Where we were		Where we want to be		Where we are (current trends vs. target path)						Latest annual trend
				Base year		Target		2009		2010		2011		
				Year	Value	Year	Value	Target path	Observed	Target path	Observed	Target path	Observed	
Key target	*Roadmap for Moving to a Competitive Low Carbon Economy in 2050* (EC, 2011b) and Transport White Paper (EC, 2011a)	Transport GHG (including international aviation, excluding international maritime shipping)	Mt CO_2	2008	1 105	2030	884 (– 20 %)	1 098	1 068	1 098	1 064	1 101	n.a.	– 0.5 %
				1990	845	2050	338 (– 60 %)							
Indicative goals	Transport White Paper (EC, 2011a)	EU CO_2 emissions of maritime bunker fuels	Mt CO_2	2005	167	2050	100 (– 40 %)	161	160	159	152	158	n.a.	– 5.1 %
	Passenger Car CO_2 EC Regulation 443/2009 (EC, 2009a)	Target average type-approval emissions for new passenger cars	g CO_2/km	2010	140	2015 2020	130 95	n.a.	146	140	140	138	136	– 3.3 %
	Impact assessment-accompanying document to the White Paper. (EC, 2011d)	Reduction of transport oil consumption	ktoe	2009	412 456	2050	123 737 (– 70 %)	412 456	412 456	405 414	411 405	398 372	n.a.	– 0.3 %
	Renewable Energy Directive 2009/28/EC (EC, 2009b)	10 % share of renewable energy in the transport sector final energy consumption for each Member State (here EU-27 average as a proxy)	%	2009	4.20 %	2020	10.00 %	4.20 %	4.20 %	4.73 %	4.70 %	5.25 %	n.a.	11.9 %

Summary

The base year for all of the indicators is still relatively recent with trends still uncertain for this period, but the table does indicate that there has been recent improvement, even though this can be mainly attributed to the economic recession in large parts of Europe. Nevertheless, transport GHG reduction target for maritime emissions can be met if trends follow a similar path to the one they have followed since 2008 (as emissions were reduced by 11 % in 2009 followed by a 5 % reduction in 2010). The target set for CO_2 type-approval emissions from new passenger cars looks feasible, as relevant legislation is currently proving to be effective. In the case of the main transport GHG reduction target (transport, including aviation, but excluding maritime) the reductions obtained since 2007 have placed actual figures in line with the 'target path', even though there was a weak reduction in 2010 (0.4 %). The challenge will be to maintain or even improve these trends when the economic situation resumes to pre-recession levels.

Meanwhile, there has been modest progress in the Member States towards reaching the targets to reduce transport oil consumption and increase the share of renewable energy in the transport sector to 10 %. However, this rate of progress is still too slow and on current trends, neither of these two goals will be met.

Several of the targets identified in Annex 2 cannot be measured as data are not yet available. As a result progress cannot be assessed. This may change in the short term as Eurostat and Member States are working together with the European Commission to provide official data to monitor these targets. Table 2.3 outlines the current status in relation to these targets.

2.3 Overview of the 2012 TERM-CSIs

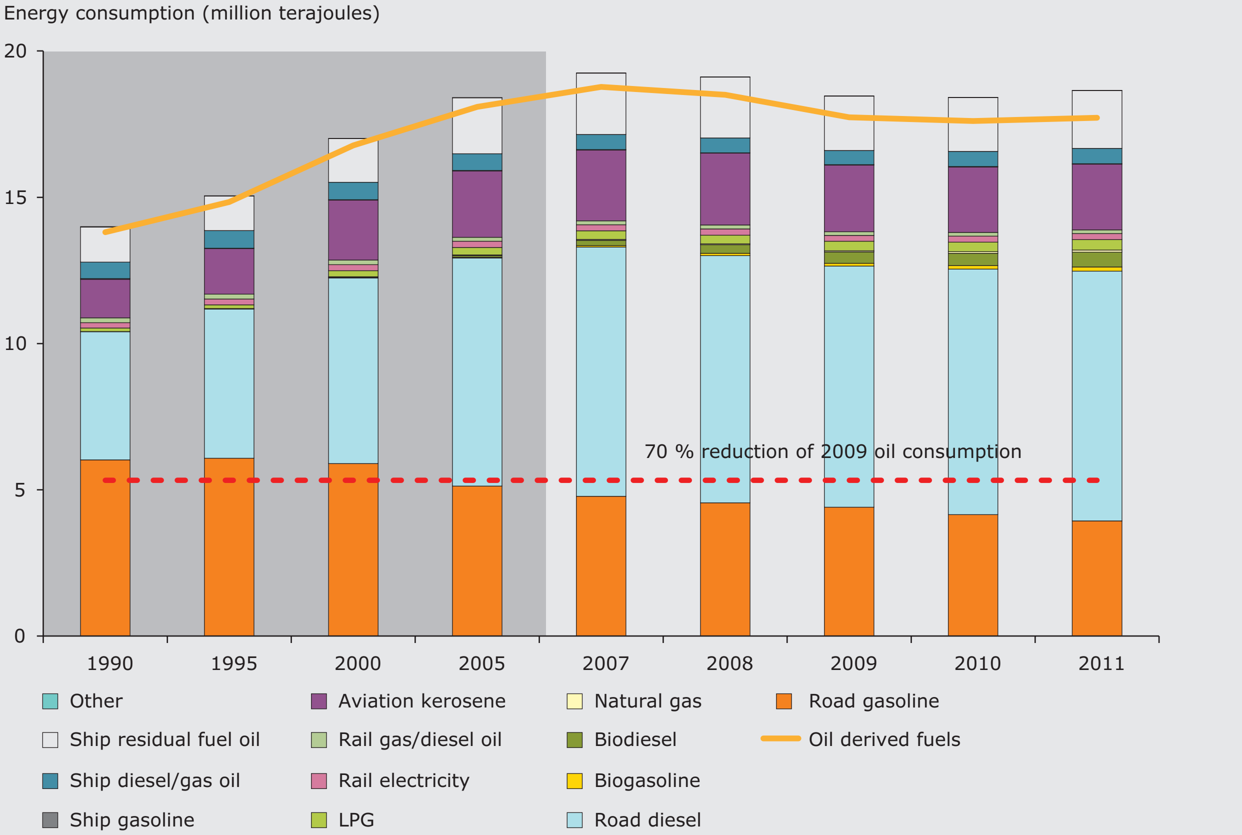
The TERM 2011 report introduced a new format for TERM, featuring 12 TERM-CSIs enabling monitoring of the most important aspects of transport impacts. The 12 TERM-CSIs are listed in Table 2.1 above, and each is subsequently described in more detail in this section. Boxes 2.2 to 2.13 provide more detailed overviews of each of the TERM-CSIs, including related targets and monitoring and key messages.

Table 2.3 Targets that cannot yet be monitored

Source	Target		Comment
Transport White Paper (EC, 2011a)	Reduce use of conventionally-fuelled cars in urban transport	50 % by 2030	The White Paper goal relates not to vehicle numbers, but to share in urban passenger kilometres (pkm). No known date when this can be monitored across EU-27.
		100 % by 2050	
	Majority of medium distance passenger transport should go by rail	50 % pkm over 300 km by rail by 2050	Only currently indirectly monitored through modal shares.
Fuel Quality Directive (FQD) 2009/30/EC (EC, 2009c)	Fuel suppliers to reduce lifecycle GHG of road transport fuel	6 % (versus 2010), up to 10 % through additional voluntary measures	The requirements of the FQD will come into force in 2013. The European Commission is currently determining how this will be monitored, but it is likely to be separated from the existing Member State fuel quality monitoring obligations through the Fuel Quality Monitoring System (FQMS).
International Maritime Organisation (IMO) MARPOL Annex VI EEDI Regulations (IMO, 2011a)	New maritime ship efficiency via the Energy Efficiency Design Index (EEDI)	10 % (versus 2010 reference) by 2015	The EEDI is scheduled to enter into force on 1 January 2013 for new flagged ships in developed countries, and 2019 for new ships in developing countries. It will be the responsibility of the IMO to monitor progress towards this target. However, the EC is planning to set up monitoring, reporting and verification procedures for shipping GHG emissions, focussing on total emissions (rather than EEDI metrics).
		15–20 % (2010 (2010 reference) by 2020	
		30 % (2010 reference) by 2025	

Box 2.2 TERM 01: Transport final energy consumption by fuel

Transport energy consumption (EEA-32 excluding Iceland and Liechtenstein)



Notes: 2011 data estimated using internal market deliveries for international maritime bunkers, road transport and aviation (domestic and international).

Latest available data: 2010 (2011 estimated).

Source: Eurostat.

Related targets and monitoring

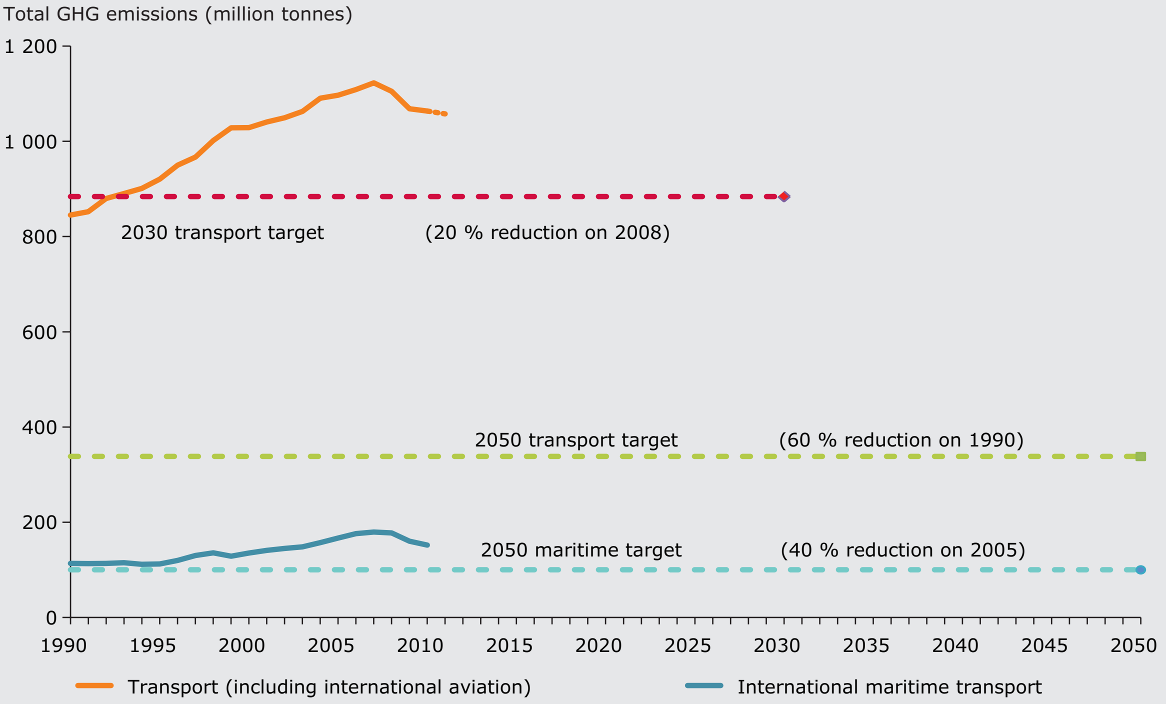
The impact assessment which accompanied the EC's Transport White Paper (EC, 2011d) suggests that a 70 % reduction of transport oil consumption from 2009 levels should be achieved by 2050.

Key messages: Using current fuel sales data as a proxy for estimating total transport energy consumption in 2011, it appears that transport energy consumption increased by 0.1 % compared to 2010; however, this is still 4.3 % lower than its peak in 2007. Combined energy use for aviation, rail and shipping has reduced by 5.2 % between 2007 and 2011. The greatest reduction was for domestic navigation (10.2 %), followed by aviation (5.7 %) and rail (5.3 %). Road transport represents the largest energy consumer, accounting for 72 % of total demand in 2011. It has also been the least affected by the economic downturn, falling by only 3.9 % between 2007 and 2011.

Outside the EU-27, over the last decade Switzerland's growth in road transport energy use has been below the EU-27 average, while its rail energy use has increased compared to an average reduction across the EU-27. By contrast, Norway and particularly Turkey have seen road transport energy use grow faster than the EU-27 while Turkey's rail energy use has fallen substantially more than in EU-27 Member States.

Box 2.3 TERM 02: Transport emissions of GHGs

EU-27 transport emissions of GHG



Notes: The orange line includes proxy data for 2011, which is an EEA preliminary estimate (EEA, 2012a). It was originally estimated excluding international bunkers. In order to show 2011 data covering the same scope as in previous years, the 2010 value of international aviation emissions was added to the 2011 proxy. This corresponds to the basic assumption that international aviation emissions did not change between 2010 and 2011, which would in fact be similar to the trend observed in 2009–2010 (– 0.1 %). In the figure, the 2010–2011 trends are marked with a dashed line.

Latest available data: 2010 (2011 estimated).

Source: EEA, 2012.

Related targets and monitoring

Transport GHG emissions to be reduced by 20 % from 2008 levels by 2030, and at least 60 % from 1990 levels by 2050; maritime bunker emissions to be reduced by 40 % from 2005 levels by 2050 (EC, 2011a).

The EU has committed to achieving a 30 % reduction in total GHG emissions in the event of an ambitious and comprehensive global agreement, and a 20 % reduction unilaterally by 2020 (from 1990 levels).

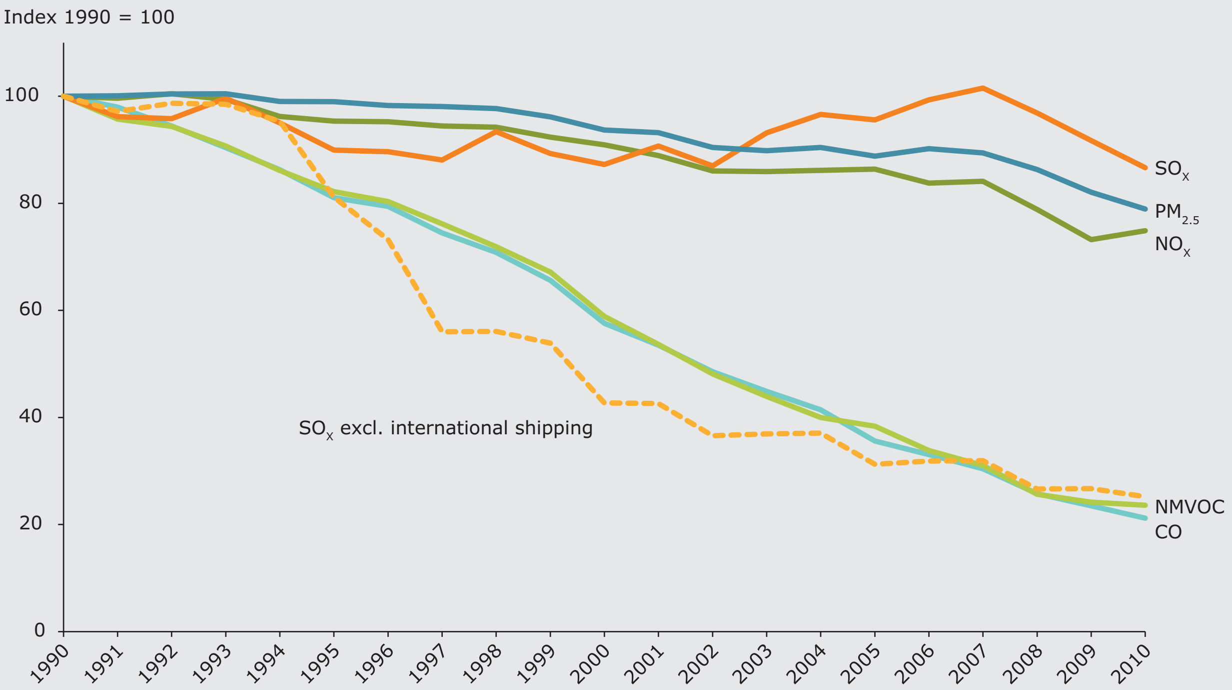
Key messages: In 2010, transport (including bunkers) accounted for 24 % of GHG emissions from all sectors in the EU-27. Transport GHG emissions excluding international maritime (i.e. including just international aviation), as the target defined in the White Paper, were 26 % above 1990 levels. In 2010, transport emissions including from international aviation decreased by 0.4 % compared to 2009. The EEA's preliminary estimates indicate that transport emissions fell by a similar amount in 2011 (EEA, 2012a). International aviation experienced the largest percentage increase in GHG emissions from 1990 levels (+ 90 %), followed by international maritime (+ 34 %). The decline in GHG emissions from road transport over the past three years can be mainly explained by a decline in freight transport demand related to the economic recession and higher fuel prices.

While progress has been made towards meeting the 2030 transport and the 2050 maritime targets, transport emissions (excluding maritime) will need to be reduced by 68 % from 2010 levels to meet the 2050 target.

The GHG transport emissions, including international aviation, of the EFTA-4 countries have also followed a very stable path over the last three years, with a slight reduction from 2008 to 2009 but a small increase during 2010 that offset 2009 decrease. Data for Turkey reveal a reduction path from the 2007 peak, with 13 % less GHG emissions in 2010.

Box 2.4 TERM 03: Transport emissions of air pollutants

Trend in emissions of air pollutants from transport in EEA-32



Note: Sulfur oxides (SO_x) (upper line) trend is significantly different from last year as emissions from international shipping for Spain are this year included. This has made SO_x trend more stable from 1990 to 2002 while increasing thereafter, reaching 1990 levels in 2007. Emissions decreased since 2007, reducing 1990 levels by 14 % in 2010.

Latest available data: 2010.

Source: EEA, 2012.

Related targets and monitoring

Iceland, Liechtenstein, Norway, Switzerland and Turkey are not members of the European Union and do not have emission ceilings set under the National Emission Ceilings Directive (NECD) 2001/81/EC (EC, 2001). However, Norway and Switzerland have ratified the UNECE LRTAP Gothenburg Protocol, requiring them to reduce their emissions to the agreed ceiling specified in the protocol by 2010. Liechtenstein has also signed, but has not ratified the protocol.

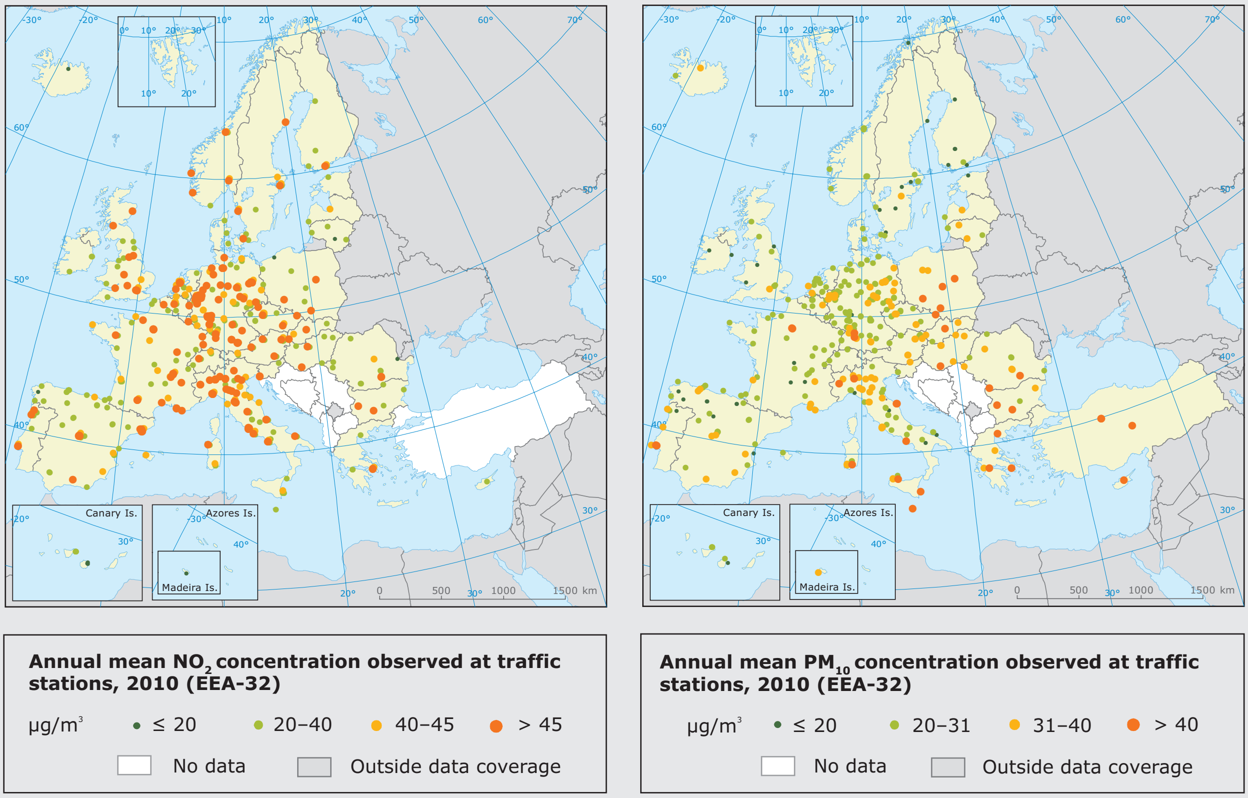
Directive 2008/50/EC (EC, 2008) sets limit values for the atmospheric concentrations of main pollutants, including sulphur dioxide (SO_2), nitrogen dioxide (NO_2), airborne particulate matter (PM) with a diameter of 2.5 micrometers or less ($PM_{2.5}$) or a diameter of 10 micrometers or less (PM_{10}), lead, carbon monoxide (CO), benzene (C_6H_6), and ozone (O_3) for EU Member States.

Progressive introduction of Euro emissions standards has substantially reduced emissions of NO_x, CO, volatile organic compounds (VOCs) and PM. In addition, aiming to achieve long-term GHG reductions for the transport sector (see Box 2.3) will also help reduce emissions of air pollutants from transport.

Key messages: Between 2009 and 2010, all air pollutant emissions from transport, except NO_x, decreased (ranging between 2.5 % and 10 %). During the period 1990 to 2010, the main pollutants that contribute to acidification and particulate and ozone formation have shown a decreasing trend in emissions in the EEA-32 (with fluctuations in some years). The largest percentage decreases over this period have been for CO (76 %) and non-methane volatile organic compound (NMVOC) (75 %). However, increases in shipping activity since 1990 have offset some of the reductions elsewhere, in particular for SO_x, but also for NO_x and PM. International shipping currently contributes to nearly 87 % of all transport SO_x emissions. The rise of road freight transport explains most of the increase in NO_x in 2010.

Box 2.5 TERM 04: Exceedances of air quality objectives due to traffic

Annual mean NO_2 concentration observed at traffic stations, 2010 (left) and annual mean PM_{10} concentration observed at traffic stations, 2010 (right)



Notes: For representation reasons, dots are moved to prevent overlapping. Dark green dots remain in position, while light green dots are slightly moved to the east, yellow dots to the north and orange dots to the west.

The two highest PM_{10} concentration classes (red and orange) correspond to the 2005 annual limit value (LV) (40 µg/m³), and to a statistically derived level (31 µg/m³) corresponding to the 2005 daily LV. The lowest class corresponds to the WHO air quality guideline for PM_{10} of 20 µg/m³.

Latest available data: 2010.

Source: EEA, 2012.

Related targets and monitoring

Directive 2008/50/EC (EC, 2008) on ambient air quality and cleaner air for Europe, regulating ambient air concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), lead, benzene, carbon monoxide and ozone.

EU limit values on concentrations of NO_2 in ambient air (limit values have to be met by 1 January 2010):

- An annual mean limit value for nitrogen dioxide of 40 µg NO_2/m³ has been set for the protection of human health.
- An hourly limit value of 200 µg NO_2/m³ not to be exceeded more than 18 times a calendar year has also been set.

EU limit values on concentrations of PM_{10} in ambient air (limit values had to be met by 1 January 2005):

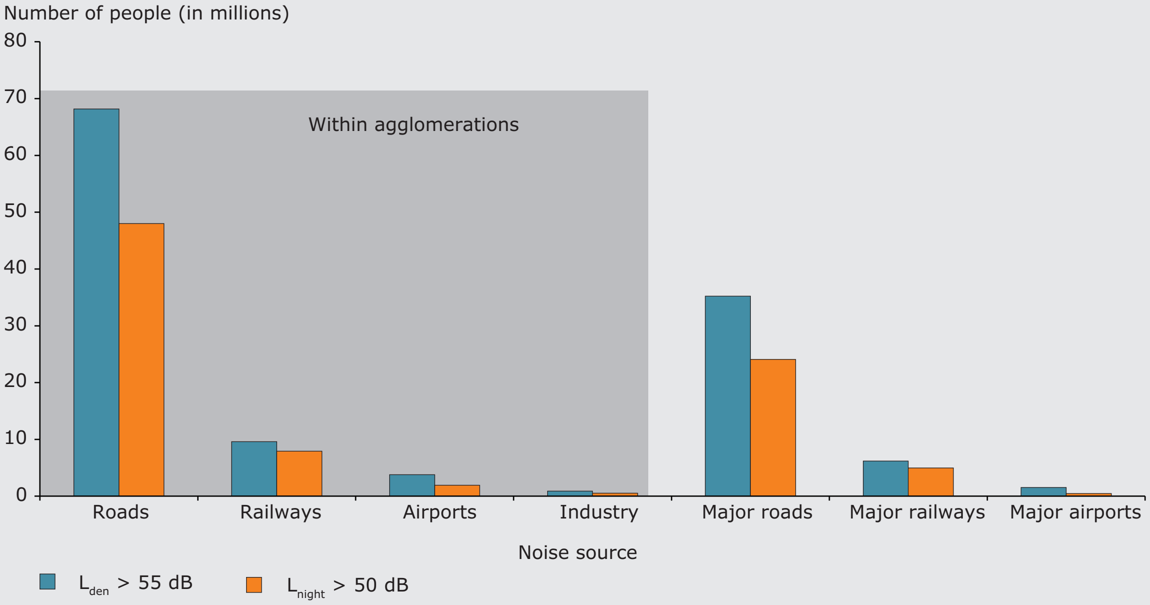
- A limit value for PM_{10} of 50 µg/m³ (24 hour average, i.e. daily) has been set, not to be exceeded more than 35 times a calendar year.
- A limit value of 40 µg/m³ as an annual average has also been set.

Key messages: In 2010, the NO_2 annual LV was exceeded at 44 % of the traffic stations. The annual LV is exceeded at 4 % of the urban background stations but only at very few rural background stations.

The PM_{10} daily LV was exceeded at 33 % of the traffic stations, 29 % of urban background stations, and 17 % of 'other' stations (mostly industrial) within the EU. These figures have increased for traffic locations compared to 2009 (EEA, 2012b).

Box 2.6 TERM 05: Exposure to and annoyance by traffic noise

Number of people (in millions) exposed to transport noise



Note: The data are based upon a 2007 reporting deadline and covers the EU-27 plus Norway and Switzerland.

Latest available data: first round noise maps and related data in accordance with Directive 2002/49/EC relating to the assessment and management of environmental noise as reported to EEA up to 30 June 2012.

Source: EEA, 2012.

Related targets and monitoring

The aim is to reduce the number of people exposed to, and annoyed by, traffic noise levels that endanger health and quality of life (EC 2002/49/EC), (World Health Organization Burden of Disease from Environmental Noise (WHO, 2011a)), (Night Noise Guidelines for Europe (WHO, 2009)). Note that the WHO recommends night noise levels not higher than 40 dB $L_{night,outside}$ in order to protect public health. However, presented here are the values higher than 50 dB, which is the lower limit of assessment according to Directive 2002/49/EC. In other words, assessments have not yet been made to the WHO recommended level.

Distance to target/trends: To date, only one round of noise mapping and assessment has been reported to the EEA according to Directive 2002/49/EC. The second round assessments were due to have been completed in June 2012 and should be reported before the end of the year. Until then, the distance to target cannot be fully assessed. In an effort to bridge the gap in data availability and knowledge-based policy development, the EEA has put in place an improved reporting mechanism for round two noise maps, which will facilitate the delivery of data relating to the WHO recommended levels by December 2012.

With regards to vehicle noise, a proposal to amend the legislation to reduce noise emissions from vehicles (including cars, vans, buses, coaches, light and heavy trucks) was adopted by the European Commission (EC, 2011e) in December 2011. The proposal recommends that noise limits are reduced and that a new and more reliable test method is developed to reflect better real-world driving conditions and that noise limits are reduced.

Similarly, on 1 November 2012, the new EU regulation on labelling of tyres entered into force (Regulation 1222/2009 amended by Regulation 228/2011). The new label provides information on fuel efficiency, wet grip and external rolling noise through clear pictogrammes.

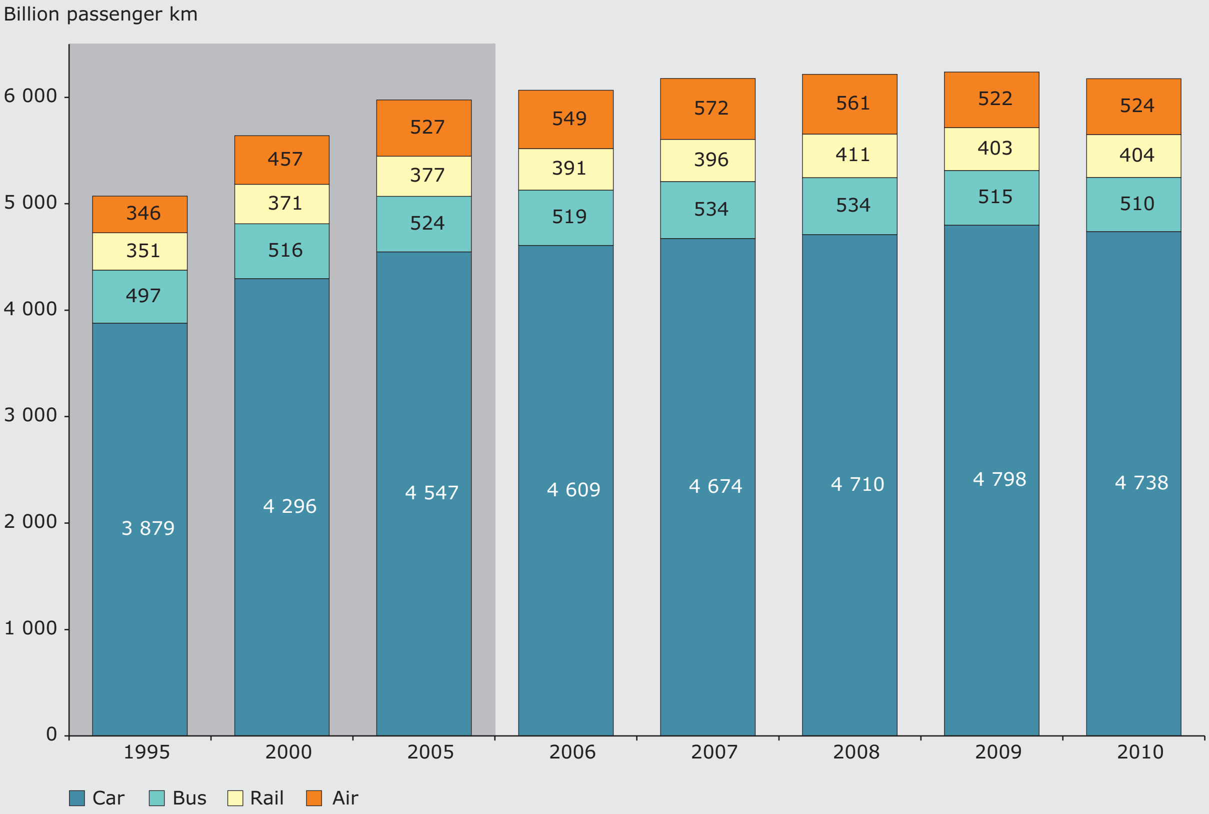
Key messages: Noise from road transport affects a large number of people: in the largest European cities (with populations of more than 250 000) almost 70 million people are exposed to long-term average road traffic noise levels exceeding 55 dB L_{den} (weighted average day, evening, night). That equates to more than 62 % of the population of those same cities. Of these, around 15 % are exposed to noise levels above 65 dB L_{den}.

At night in the same urban areas, there are more than 48 million people exposed to long term average road noise levels higher than 50 dB L_{night}. As a result, 44 % of the population is exposed to noise levels during sleeping hours that can cause adverse health effects. Outside urban agglomerations, over 35 million people are exposed to damaging levels of noise from major roads during an average day period and over 24 million people at night.

Although the scale of exposure is less than for road traffic, significant numbers of people remain exposed to high levels of noise from rail and aircraft.

Box 2.7 TERM 12a/b: Passenger transport volume and modal split within the EU

Passenger transport volume (billion passenger kilometre (pkm)) (EU-27)



Note: Latest available data: 2010.

Source: Eurostat, 2012.

Related targets and monitoring

By 2050, the majority of medium-distance passenger transport should go by rail (EC, 2011a).

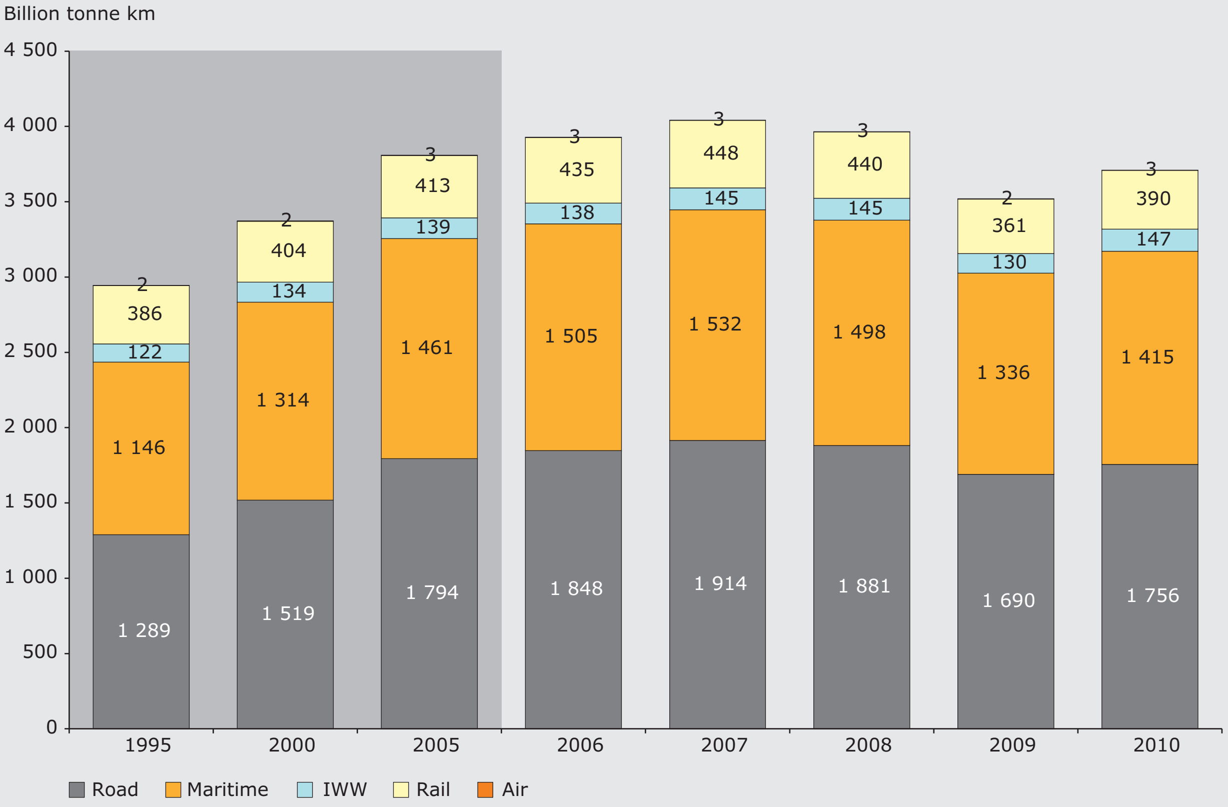
Key messages: Between 2009 and 2010, passenger transport demand decreased by nearly 1 %. Prior to this, it had grown steadily since 1995, but at a slower rate than GDP. The largest increases have been in air (51.5 %) and car (21.5 %) demand between 1995 and 2010. However, the economic recession has led to a decline in demand between 2009 and 2010 (– 0.9 %). The car dominates (inland pkm excluding powered two wheels) passenger transport mode share at 84 %, followed by bus (9 %) and rail (7 %).

Non-EU-27 countries show faster growth in demand than the EU-27 average over the period 2000 to 2010, particularly Turkey and Iceland at 38 % and 28 % increases respectively, compared to 9 % for EU-27. However in terms of modal share, Switzerland has a lower share for cars and a much higher share for rail (17 %) than the EU-27 (7 %). Turkey has a much lower share for cars due to much more prominent (though declining) bus use (45 % share compared to 9 % for the EU-27). Iceland and Norway have a higher car share than the EU-27 (both at 89 %).

Further information: Passenger and freight transport demand and modal split (Chapter 3).

Box 2.8 TERM 13a/b: Freight transport volume and modal split

Freight transport volume (billion tonne kilometre (tkm)) (EU-27)



Note: Latest available data: 2010.

Source: Eurostat, 2012.

Related targets and monitoring

A total of 30 % of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050, facilitated by efficient and green freight corridors (EC, 2011a).

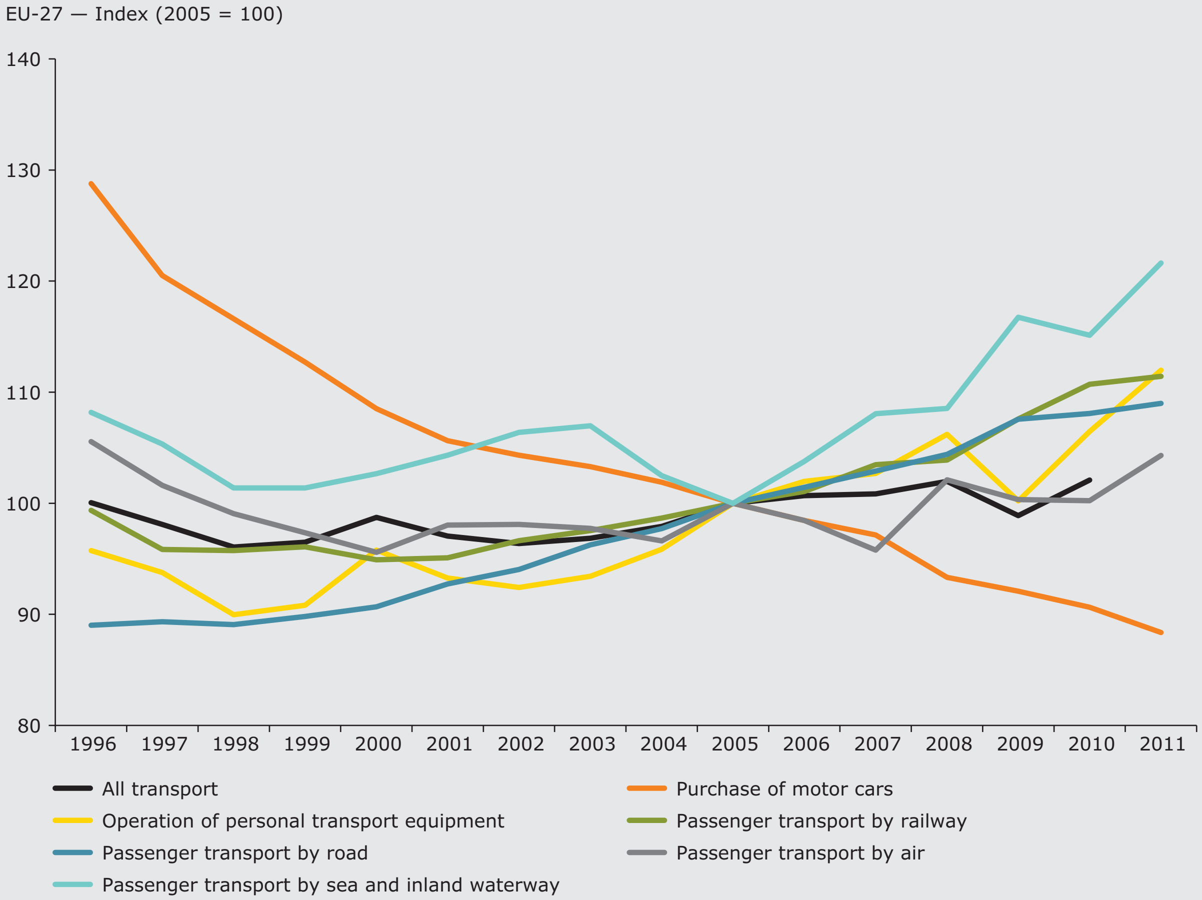
Key messages: Between 2009 and 2010, freight transport volume in the EU-27 increased by 5.4 %, having fallen significantly between 2007 and 2009 (12.9 %). Factors such as the economic slow-down and rising fuel prices may be the main reasons for this previous decline, which was steeper than the fall in GDP. Road transport dominates (inland) freight transport mode share at 77 %, followed by rail (17 %) and inland waterways (IWW) (6 %).

Freight transport growth in non-EU-27 countries has been higher at 19 % than the EU-27 average (between 2000 and 2010) of 12 %. However, this is not as high as growth in the EU-12 (70 %). Looking at the modal split of inland transport adjusted for territoriality in 2009 (most recent Eurostat data on transport done within each country regardless of the nationality of the haulier), 18 % of the EU-27's average inland transport use was by rail. For Slovakia, Sweden and Switzerland 35 % of all inland transport use was by rail. The Baltic countries (Lithuania, Estonia and Latvia) reached 70 %, 73 % and 85 % respectively (Eurostat, 2012c) as most of its road transport, based on haulier nationality, is long-distance.

Further information: Passenger and freight transport demand and modal split (Chapter 3).

Box 2.9 TERM 20: Real change in transport prices by mode

Real change in transport prices by mode in the EU-27



Note: Evolution of transport prices for consumers (2005 = 100), Harmonised Indices of Consumer Prices (HICP). Real price indices of passenger transport in the EU-27 Member States, relative to overall consumer price index.

Latest available data: 2011.

Source: Eurostat 2012.

Related targets and monitoring

Monitoring changes in transport prices by mode is considered a relevant variable to assess whether the system is favouring more sustainable modes of transport.

Key messages: From the reference point of 2005, the purchase price of motor cars has steadily reduced over the period to 2011 in comparison to average consumer prices. Over the same period, the cost of operating personal transport has fluctuated, but stayed higher than 2005 prices, as has passenger transport by air, both continuing to increase from 2010. The cost of passenger transport by sea and inland waterways, railways and roads has increased steadily over the same period.

Box 2.10 TERM 21: Fuel prices and taxes

Nominal and real fuel prices in the EU-27 (EUR/litre)

Note: Real prices are indexed to 2005.

Latest available data: May 2012.

Source: DG ENER and Eurostat, 2012.

Related targets and monitoring

Fuel prices, including taxes, are seen as a useful signal of the 'internalisation' of external environmental costs, since fuel consumption is an excellent proxy for GHG emissions produced by transport use.

The Phase I stage (2011–2016) of action 39 of the White Paper on Transport (EC, 2011a) therefore indicates that motor fuel taxation should be revised to take account of the energy and CO_2 component. Guidelines will be developed for the application of internalisation charges to road vehicles, covering the social costs of congestion, CO_2 (if not included in fuel tax) local pollution, noise and accidents.

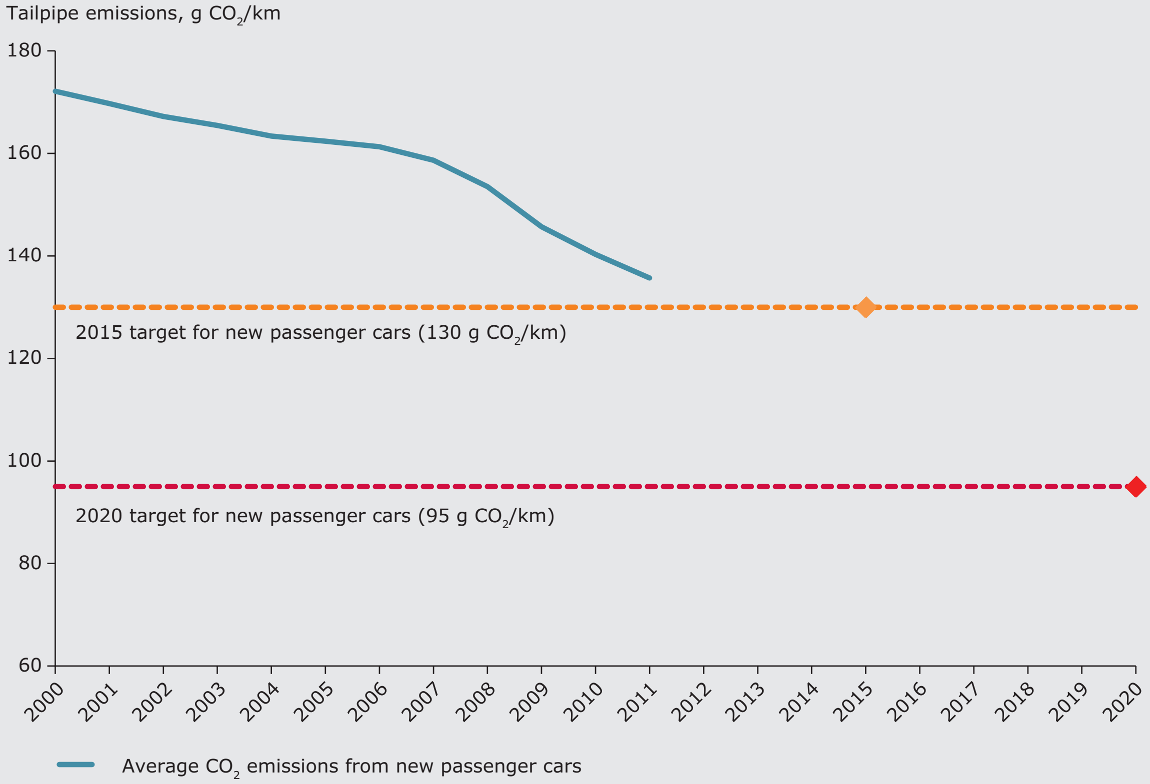
At present, fuel taxation for the two principal transport fuels is 54 % for Euro-Super 95 and 47 % for diesel oil (EU weighted average total taxation on 10 September 2012 (EC, 2012a)).

Key messages: Between May 2011 and May 2012, the average real price of fuel has increased from EUR 1.14 litre to EUR 1.20 litre. Since 1980, the real price of all transport fuels (expressed as the equivalent consumption in unleaded petrol, corrected for inflation to 2005 prices) has fluctuated. Real prices per litre peaked in summer 2008 at around EUR 1.25, but then fell by around a third later that year, largely due to a significant drop in the price of crude oil. Since then, in 2009 and early 2010, real prices recovered to just over one euro per litre.

The average real price in June 2010 was EUR 1.04 per litre, just 5 % higher than the price in 1980. By the end of May 2012, average fuel prices had risen again to EUR 1.20 per litre. However, during March and April 2012, average fuel prices once again reached the peak prices seen in summer 2008.While the price of fuel can influence the demand for transport and the efficiency with which fuel is used, it is clear that recent increases in the fuel price have not significantly affected transport demand. The process leading to price internalisation (including external costs on the final price) has not significantly changed, whereas recent fuel price increases can be attributed to a rise in the base oil price. Price per litre of Euro-Super 95 has increased 48 % without taxes in the last two years (since September 2010), and 26 % with taxes (excise duty and other indirect taxes plus value added tax (VAT)) (EC, 2012b).

Box 2.11 TERM 27: Energy efficiency and specific CO_2 emissions

Average emissions for new cars (tailpipe g CO_2/km, EU-27)



Note: 2011 data are provisional.

Latest available data: 2011.

Source: DG CLIMA and EEA, 2012.

Related targets and monitoring

There is an average passenger car emissions target of 130 g CO_2/km for the new car fleet by 2015, and a target of 95 g CO_2/km from 2020 onwards (Passenger Car CO_2 EC Regulation, 443/2009).

Vans have a target of 175 g CO_2/km by 2017 (phased in from 2014) and of 147 g CO_2/km by 2020 (Van CO_2 Regulation, 510/2011). Average emissions of CO_2 for the new car fleet are monitored annually by the European Commission and the EEA.

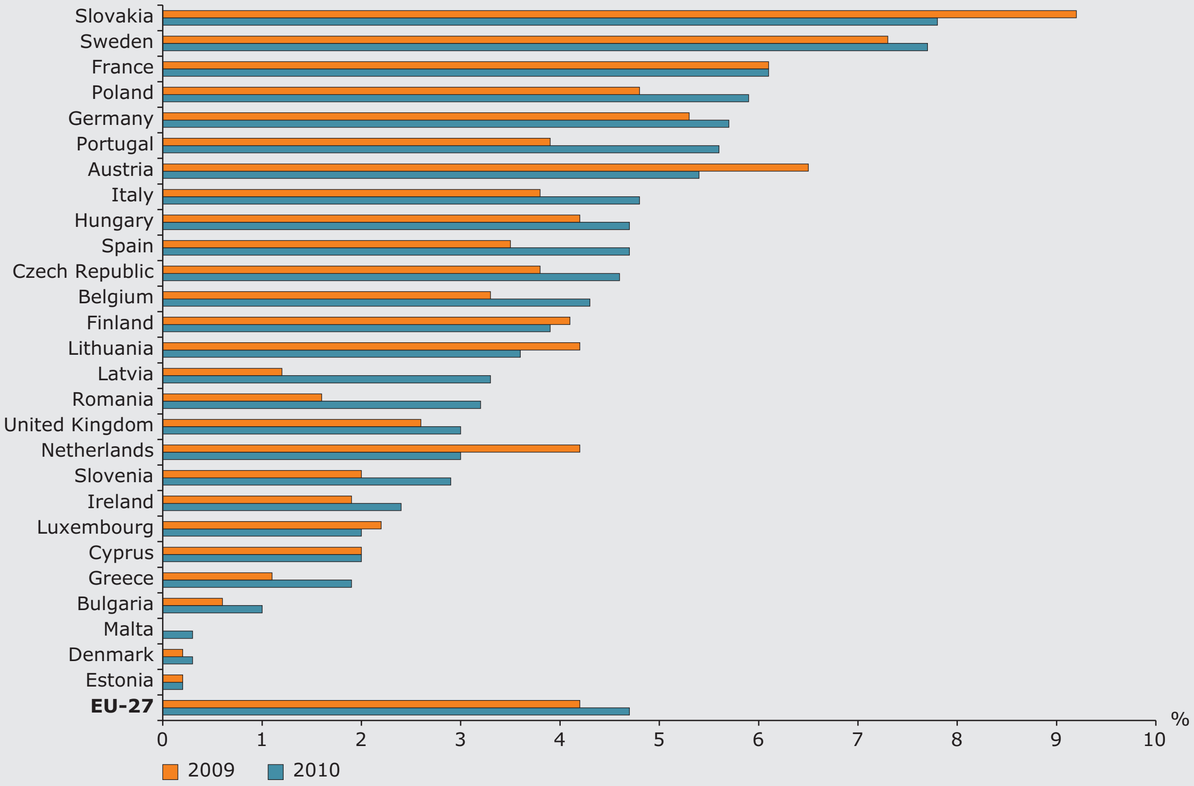
Key messages: CO_2 emissions from the new passenger car fleet in the EU-27 decreased from 140.2 g CO_2/km in 2010 to 135.7 g CO_2/km in 2011.

The overall trend is one where average emissions of CO_2 have decreased steadily since 2000. If similar progress is made each year, then the 2020 target for passenger cars for achieving a fleet average of 95 g CO_2/km will also be achieved. However, there is also discussion regarding the real fuel consumption of vehicles, and therefore CO_2 emissions (see Section 4.3)

Data to monitor the average emissions of CO_2 for the new van fleet are not yet available. Member States will be required to monitor and deliver this data from 2012. However, it has been estimated that average CO_2 emissions for the new van fleet decreased from 203 g CO_2/km in 2007 to 181 g CO_2/km in 2010 (TNO et al., 2012).

Box 2.12 TERM 31: Share of renewable energy in the transport sector

% share of renewable energy in fuel consumption of transport by EU-27 Member State



Note: This indicator is calculated on the basis of energy statistics covered by the Energy Statistics Regulation and the methodology of the relevant indicator described in Directive 2009/28/EC. However, the contribution of all biofuels is included in this indicator and not only those satisfying the sustainability criteria (Eurostat, 2012).

Latest available data: 2010.

Source: Eurostat, 2012.

Related targets and monitoring

All EU Member States are to achieve a 10 % share in renewable energy by 2020 for all transport (Renewable Energy Directive, 2009/28/EC). It had been expected that this target would be met primarily through biofuels. However there are growing concerns regarding the issue of indirect land use change (ILUC), which may substantially reduce the greenhouse gas emissions savings associated with the use of biofuels produced from crops used for food or feed. In October 2012 the European Commission published a proposal to limit to 5 % the use of food-based biofuels to meet the 10 % renewable energy target of the Renewable Energy Directive. In this case, non-crop-based second generation biofuels would therefore be needed alongside greater use of renewable electricity in transport.

Low carbon sustainable fuels in aviation are to reach 40 % by 2050 and EU CO_2 emissions of maritime bunker fuels are to be reduced 40 % (if feasible 50 %) by 2050 compared to 2005 levels. (EC, 2011a). It should be possible to monitor aviation fuel and maritime bunker fuels via GHG reporting for bunkers under the United Nations Framework on Climate Change (UNFCCC).

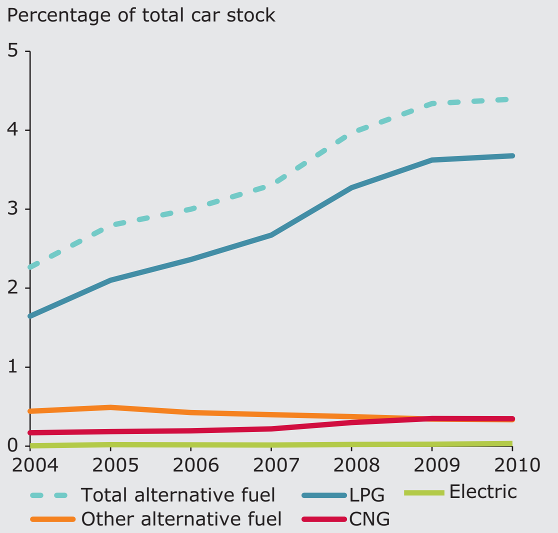
Fuel suppliers are to reduce emissions of GHGs by between 6 % and 10 % by 2020 relative to 2010 fossil fuels (Fuel Quality Directive, 2009/30/EC). It is anticipated that this will be monitored from 2013 and included in TERM.

Key messages: Between 2009 and 2010, the average EU-27 Member State share of renewable energy in the transport sector increased from 4.2 % to 4.7 %. This is almost half of the 10 % share by 2020 target contained in the Renewable Energy Directive (RED) if this was applied to the EU-27 as a whole instead of to each Member State. Some individual Member States already achieve a 7 % share in 2010, with Slovakia (7.8 %) and Sweden (7.7 %) being two notable examples. Most Member States have seen an increase of renewable energy use in the transport sector between 2009 and 2010.

Examining non-EU-27 countries, Norway had a 3.9 % share of renewable energy in the transport sector in 2010 while Croatia reached a 0.4 % share. Biofuels do not play a significant role in Switzerland, but more than 50 % of all electricity is sourced from renewable sources. Virtually the entire rail network is electrified and it achieves a much higher share for rail use for both passenger and freight transport than the EU-27 average.

Box 2.13 TERM 34: Proportion of vehicle stock by alternative fuel type (selected EEA-32 member countries)

Percentage of car stock by alternative fuel type, selected EEA-32 member countries

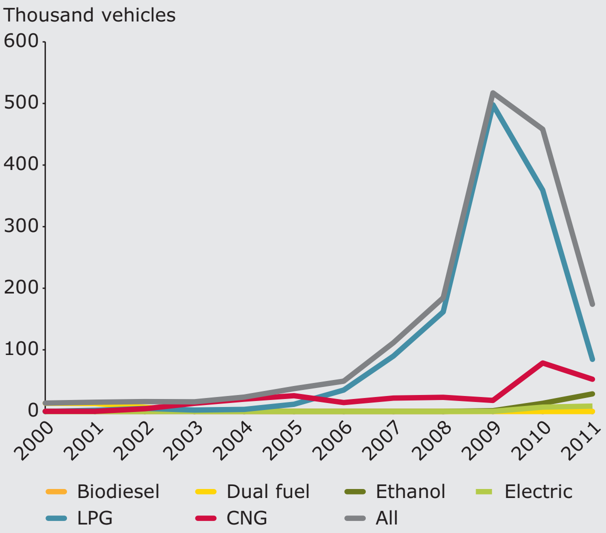


Note: Car stock for Austria, Belgium, Estonia, Finland, France, Hungary, Italy, Latvia, Liechtenstein, Luxembourg, the Netherlands, Norway, Poland, Sweden, Switzerland, Turkey, and the United Kingdom.

Latest available data: 2010.

Source: Eurostat, 2012.

Thousands of passenger cars newly registered by alternative fuel type, EU-27



Source: EEA, 2012c.

Related targets and monitoring

There are no specific targets for the percentage of the vehicle fleet that use alternative fuels, but the European Commission aims for European cities to be free of conventionally fuelled cars by 2050 (EC, 2011a).

For both conventional and alternatively fuelled vehicles, Euro 6/VI emissions will begin to be introduced from 2013 for heavy duty vehicles (i.e. heavy goods vehicles and buses/coaches), from 2014 for passenger cars, and from 2015 for light goods vehicles (LGV).

Key messages: Since 2004, alternatively-fuelled cars have increased steadily in the fleet, comprising just over 4 % of all vehicles in 2010. The majority of these are Liquid Petroleum Gas (LPG) vehicles. Electric vehicles currently comprise only 0.03 % of the total fleet.

Registrations of alternatively-fuelled vehicles showed an increasing trend for LPG vehicles from 2006 onwards. However, LPG registrations declined rapidly from 2009, caused mainly by the significant drop in France and Italy, a drop that was precipitated by the change in economic incentive schemes.

Further information on the different vehicle technologies can be found in Box 4.4.

3 Freight and passenger transport demand and modal split

Freight transport demand increased sharply in 2010, exceeding GDP growth. Rail freight marginally increased its share from its lowest level in 2009 to just 17 % in EU-27. Passenger transport demand fell slightly in 2010 despite the return to GDP growth. Modal split for passenger transport remains stable for EU-15 Member States with car modal share at well over 80 %. In the EU-12, car modal share has reached EU-15 levels in some Member States, however, bus modal share increased marginally from its lowest level in 2009.

3.1 Introduction

This chapter explores the levels of demand that are driving transport usage across Europe. These demands, and the methods of transport used to satisfy them, largely determine the resulting environmental impacts. Looking to the concept of decoupling, data suggests that the link between transport demand and the economy remains unbroken. Freight transport demand is very sensitive to economic trends, decreasing much faster than the GDP fall in 2008 and 2009, while increasing significantly in 2010 at a higher rate than GDP. This supports the statement made in TERM 2011 that transport-related externalities showed a positive evolution albeit driven by the wrong reasons. This chapter summarises and assesses the available data on transport demand for road, rail, air and sea and its relationship with GDP.

3.2 Freight transport

Prior to the economic recession, freight by road, rail and inland waterways in the EEA-32 experienced more than a decade of continued growth. This included an average annual rate of approximately 3 % during the period from 1997 to 2007, leading to a pre-crisis peak in overall freight demand. The effects of the recent recession brought freight volumes back to levels seen in mid-2003, a decline in total tonne kilometres (tkm) of more than 12.5 %. Data collected in 2010 show a renewed growth in freight demand of 5.3 % over 2009 levels in the EEA-32 member countries. However, preliminary data up to the end of 2011 show a slowdown and near stagnation in freight demand in the EU-27, indicating the possibility of decline in 2012 (ITF 2012).

Road haulage accounted for 80 % of inland freight movements within the EEA-32 in 2010 (excluding Liechtenstein). Total road freight volumes in this group of countries increased by over 16 % in the last decade, yet levels still remain below the all-time peak recorded in 2007. The road freight sector in EU-12 has proved more resilient through the recent recession compared to Western European economies. Volumes in the EU-12 Member States reached a record high following a 9 % increase between 2009 and 2010. This was driven by the double-digit growth recorded by Cyprus (12.9 %), Latvia (30.5 %), Poland (16.7 %) and the Czech Republic (15.3 %). Poland now ranks as the second largest country in terms of total road freight volumes after Germany, recording growth in all categories of transport. However, when the territorial-based statistics are considered (i.e. road freight transport within each country, regardless of the nationality of the freight forwarder who performs this transport) data shows that Poland is the sixth country in terms of total road freight volumes, and Polish hauliers are by far the most active in international road freight transport (Eurostat, 2012c). The latest analysis of trends in EU road freight transport made available by Eurostat (2012d) shows that European road freight transport (in tkm) declined by 1 % in 2011. Only cabotage recorded a slight increase, while national, international, and cross trade transport all declined.

Rail freight volumes in EEA member countries grew steadily between 1997 and 2007, at an annual rate of just under 1 % per annum. Most of this growth occurred in the EU-15, which saw a 22 % increase. In contrast, rail freight in the majority of the EU-12 Member States has been in long term decline; a trend most pronounced in the Czech Republic, Poland and Romania. All EEA member countries (except Latvia, Norway and Turkey) experienced steep declines in rail freight demand during the economic recession, and in 2009 overall rail freight volumes were more than 18.5 % lower than the all-time peak in 2007. The latest data (2010) for EEA-32 show a 7.9 % increase against 2009, with volumes recovering to 2003 levels.

Shares of national and international freight movements are strongly linked with geographical location. Countries registering the highest share of international transport are in key corridors within the European market. In the Baltic States of Estonia and Latvia, which are situated at the European/Russian border, international transport accounted for 91 % and 89 % respectively of total transport in 2010. For those countries that are not located between major commercial markets, such as the United Kingdom and Turkey, the share is much lower, at 2 % and 9 % respectively (Eurostat, 2012a). Box 3.1 offers a brief analysis of the data available to monitor the European Commission's White Paper on Transport's goal on modal shift for freight transport.

Maritime freight transport makes up 40 % of the total freight transport demand in EU-27 Member States. Even considering the effects of the recession, steady growth over the past decade or so has seen this demand reach levels that were 7.9 % higher in 2010 compared to levels in 2000. Two years of decline during the recession brought demand for maritime freight transport back down to 1999 levels. However, a strong return to growth in transport demand in 2010 reclaimed half of this reduction, substantially helped by double-digit growth in both the gross weight of goods and the volume of containers handled at Europe's three largest ports, Rotterdam, Antwerp and Hamburg (Eurostat, 2012b).

Box 3.1 Analysis of the White Paper freight target

In 2011, the EC published its third decennial Transport White Paper detailing the following freight specific distance-based target relating to rail and road modes:

30 % of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050.

This distance-based target is likely to present challenges for both water and rail services and infrastructure. Although the 30 % shift of road transport freight demand above 300 km only constitutes a minor shift in proportion to the entire freight transport market (less than 10 % of tkm in proportion to the total of road, rail, sea, IWW, air and pipelines), the absolute volume shifted is significant relative to the smaller rail and waterborne freight sectors. Road freight deliveries currently make up 75 % of the total freight volume over 300 km, rail 21 % and IWW 4 %.

Analysis of the latest data on tkm and vehicle-km for various categories of road freight above and below 300 km that has recently been made available by Eurostat (2012b) provides the following information:

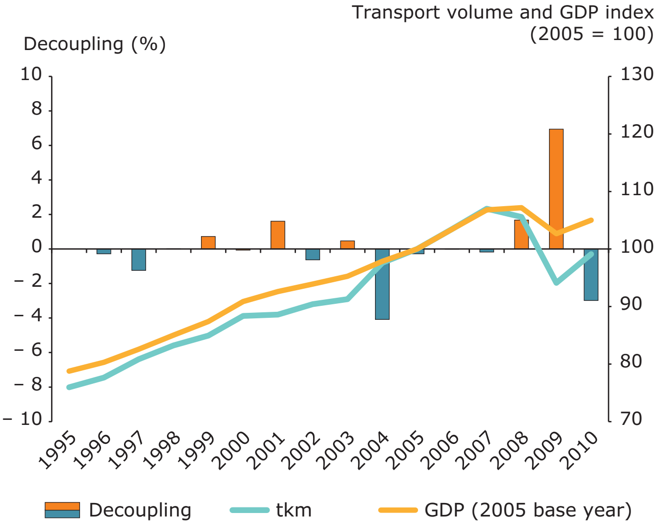
- Road freight tonne-kms are relatively equally split between below 300 km (45 %) and above 300 km (55 %). Thus a shift of 30 % of road freight over 300 km implies a shift of 16.5 % of total road freight.
- The majority of road freight (40 %) is materials and chemicals (e.g. metals/wood/rubber/plastics/man-made fibres). This breaks down into 21 % above 300 km and 19 % below 300 km.
- The next biggest category is food and agricultural products (27 %). Here the majority, 15 percentage points, is over 300 km, compared to 12 percentage points below 300 km.
- The remaining 33 % of road freight is made up of furniture, machinery, removals, transportation equipment, mixed goods, fossil fuels and other minor categories. Most of these categories are transported more than 300 km.
- Within the EU-27, a significant number of countries made more than half of their road freight volumes in trips of more than 300 km. These are Lithuania (90 %), Slovenia (81 %), Slovakia (80 %), Latvia (76 %), Bulgaria (76 %), Romania (73 %), Czech Republic (72 %), Estonia (71 %), Poland (71 %), Portugal (71 %), Spain (70 %), Hungary (69 %), Luxembourg (61 %), Netherlands (51 %), and Sweden (just over 50 %). Also Croatia makes the majority of its tkm in trips of more thanr 300 km, while Norway and Switzerland shows lower percentages (47 % and 22 % respectively).
- European freight transport travelling less than 300 km decreased by 9 % between 2007 and 2011. Tkm in movements of more than 1 000 km are 16 % below 2007 levels (Eurostat, 2012d), while movements of more than 300 km but less than 1 000 km decreased by 6 % since 2007.

Note: These data are based on sample surveys carried out in the reporting countries, i.e. EU Member States, Croatia, Liechtenstein, Norway and Switzerland, and record the road goods transport undertaken by vehicles registered in these countries.

Figure 3.1 Freight transport volumes and GDP (EEA-32 excluding Liechtenstein)

Freight transport demand has proven to be highly sensitive to changes in GDP over the course of the recession. The fall in economic output in 2009 produced a significantly more pronounced decline in freight volumes. Similarly, the return to growth in 2010 has been matched by a greater level of growth in freight volumes. Between 2009 and 2010, total tkm for road, rail and inland waterways increased faster than the increase in GDP. Consequently, the decoupling effect between freight demand and GDP seen during the recession partially reversed, and therefore the link between transport demand and economy is stronger in 2010 than in 2009.

Even though the first signs of freight decoupling in 2009 have partially reversed in 2010, the reference scenario in the Transport White Paper and 2050 Roadmap foresees the average growth rate of GDP outpacing the average growth rate of freight demand by 2030. The expected result is a total decoupling of freight demand from GDP of 3.3 % over the same period.



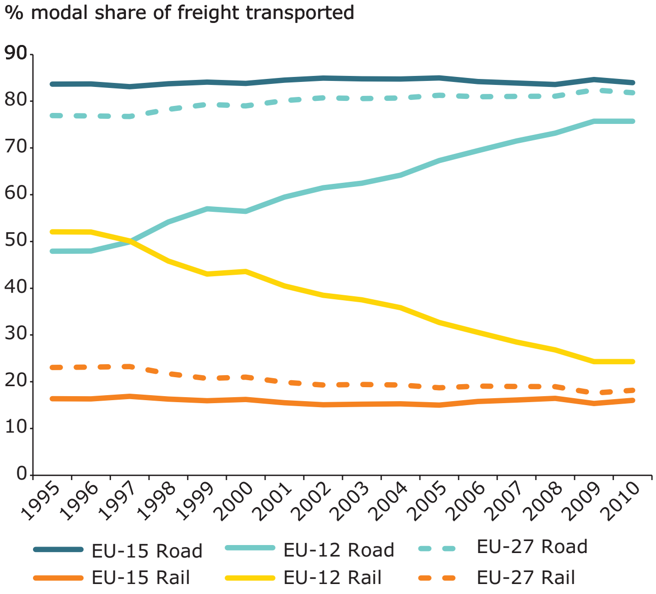
Notes: The two curves show the development in GDP and freight transport volumes, while the columns show the level of annual decoupling. Orange indicates faster growth in GDP than in freight transport while blue indicates stronger growth in freight transport than in GDP. The data refer to road, rail and inland waterways. The large change in 2004 is tied to a change in methodology, but no correction figure exists (see metadata for more details).

Source: Eurostat, 2012b.

Figure 3.2 Freight modal split between road and rail (EU-27)

Although rail has traditionally had a higher modal share in the EU-12, this has been falling rapidly. Over the past decade, rail's share of the road/rail total has fallen from 44 % to 24 % in the EU-12. This shift has resulted from increased trade with EU-15 Member States where road transport already dominates the freight sector, and a decline in trade with former Soviet Union countries, where market liberalisation led to a decline in heavy industry and use of rail.

In the EU-15, the share of rail freight has not changed significantly. Overall rail share in the EU-27 was 18.2 % in 2010; a slight increase from 2009, where it fell to its lowest level at 17.6 %.



Source: Eurostat 2012.

3.3 Passenger transport

Passenger transport demand (passenger kilometre (pkm) of car, bus and rail but excluding air) in the EEA-32 member countries increased by 10.1 % between 2000 and 2010, at an annual rate of just less than 1 %. The rate of growth in EU-12 Member States was more than double that seen in EU-15 Member States, but EU-12 had a much lower pkm volume in the year 2000. The absolute increase in pkm in EU-12 Member States was only two-thirds. Despite more than a decade of sustained growth, passenger transport demand in the EEA-32 has actually slowed since 2008 with demand actually declining by 0.9 % in 2010, breaking the expected coupling with economic output. This reflects the ingrained nature of many passenger journeys and suggest that passenger mobility does not have the same type of sensitivity to economic growth as freight demand. The drop in transport demand in 2010 is likely to be driven by a combination of socio-economic and demographic factors, as well as the continued increase in fuel prices (see Box 2.10) and uncertainty over future disposable income.

In 2010, car journeys accounted for 74 % of all internal EU-27 passenger transport demand (in pkm including road, rail, air and sea). Between 2000 and 2010, car transport demand in EEA-32 member countries increased by 11 %. Car transport demand in the EU-12 rose by 51 %, compared to 6 % in the EU-15. Bulgaria and Poland alone make up 60 % of the growth. This typifies the potential for growth within the EU-12 Member States caused by initial low motorisation rates, rapid economic growth and increased access to second-hand foreign car markets following EU accession.

Over the past decade, rail passenger demand in EEA member countries has increased by just over 10 %. Most of this increase can be attributed to a 16 % increase in the EU-15 region, of which four-fifths originates from the five largest economies, Italy, France, Germany, Spain and the United Kingdom. EU-15 Member States have invested heavily in high-speed rail (HSR) in the past decade, increasing track capacity by 140 % (UIC, 2011), resulting in an 80 % increase in passenger-km by HSR in 2010 (DG MOVE, 2012). However, this increase has not been uniform across all countries. Italy, for example, has not yet seen an increase in rail passenger-km for medium-long distance travel despite increased HSR track capacity. In contrast, passenger travel by rail in the EU-12 states has decreased by 28 % over the previous decade, losing out to road transport. This trend must be reversed if the White Paper target that the majority of medium distance passenger transport should be by rail is to be met.

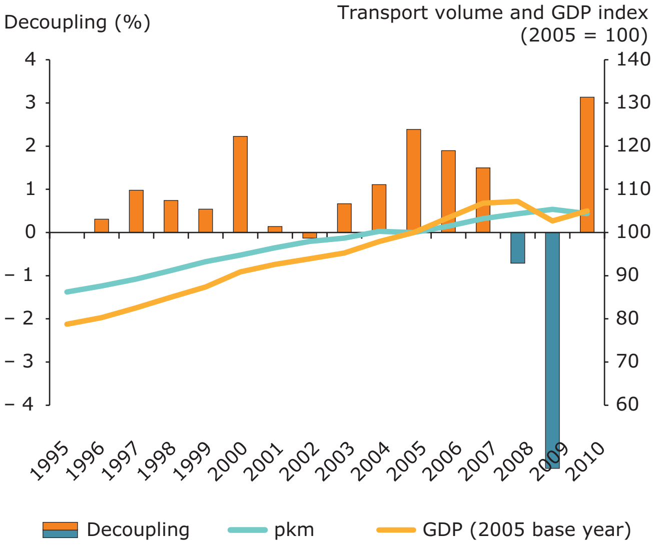
Air passenger transport has shown the greatest growth of any passenger mode in the period from 2000 to 2010 — an increase of 11 % in the EEA-32 region as a whole. Until the recent economic recession, Europe has followed the global trend of an average annual increase of between 3.5 % and 4 %. The recession led to more than a year of contraction in air transport demand, with total air passenger kilometres in Europe falling by nearly 9 % between 2007 and 2009. A weak return to growth in 2010 and 2011 highlighted the strong link between air travel and welfare. The outlook for slow economic growth in 2012 will likely see air traffic decline by 1.7 %, with a weak recovery expected for 2013 (+ 1.6 %). However, despite the recent slow-down, the expectation for future decades is for a return to an annual growth rate of between 2 % and 3 % (Eurocontrol, 2012).

There are signs that the rapid expansion of low-cost air travel that followed successive deregulation of European airspace may be reaching saturation point. Full-fare airline traffic grew by 4.1 % in 2011 over 2010, faster than the 3.9 % increase in traffic from low-cost airlines (Eurocontrol, 2012). Much of the initial expansion in low-cost flights was fuelled by the addition of 10 EU Member States in 2004 and the further addition of Bulgaria and Romania in 2007. Yet these markets have also matured in recent years as supply has quickly matched demand for business and leisure air travel. Improvements in road infrastructure within new Member States have also enhanced continental connections; serving to reduce both rail and air-travel demand as road travel remains the favoured mode for journeys under 500 km. For these distances, aviation has a minor share (1 %), whereas cars make up the majority of trips at 72 % share (TML, 2010).

Figure 3.3 Trends in passenger transport demand and GDP (EEA-32 excluding Liechtenstein)

The pre-crisis trend in passenger transport demand among EEA-32 member countries has been one of continued year-on-year growth. The rate of this growth in the EU-12 is over twice that experienced by the EU-15. During this period, the increase in passenger transport demand has been slower than the rate of GDP growth, resulting in a sustained decoupling of passenger transport demand from GDP.

Data for the last three years fluctuates significantly. During 2010 GDP rebounded to growth whereas passenger transport demand fell, showing a decoupling of over 3 %. One of the factors that may have contributed to this is the sharp rise in fuel prices between 2009 and 2010 (see Box 2.10), but the trend also suggests a possible levelling off in overall passenger demand.



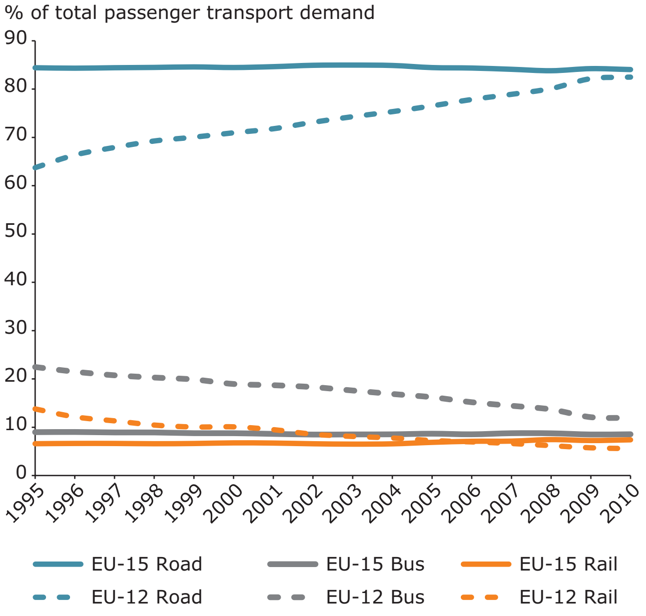
Notes: The two curves show the development in GDP and passenger transport volumes, while the columns show the level of annual decoupling. Orange indicates greater growth in GDP than in transport, while blue indicates stronger growth in transport than in GDP. The data refer to road, rail and bus modes of transport.

Source: Eurostat, 2012.

Figure 3.4 Passenger transport modal split (EU-27)

Cars represent the largest share of inland passenger transport in the 32 EEA member countries. Bus travel had the second largest modal share in all but seven European countries where rail accounted for a higher percentage of pkm (Austria, France, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom).

During the last decade (2000–2010), the magnitude of modal shift towards road transport in EU-12 Member States has generally been much higher than in the EU-15 Member States. This is predominantly due to a significant shift in demand from rail and bus to cars in the EU-12, particularly in five eastern European countries: Bulgaria, Estonia, Poland, Romania and Slovakia. Here the modal share of cars increased from 60 % to 85 %. As a result, the previously more balanced modal split in EU-12 Member States has practically reached the almost homogeneous road-based modal split in the EU-15.



Source: Eurostat, 2012.

4 Air policy review and transport

Road transport is a particularly significant source of NO_x emissions, responsible for a third of total emissions in 2010 in Europe. Shipping is a substantial source of SO_2 emissions, contributing 19 % of total emissions in 2010. Both sectors also contribute considerably to PM emissions. Under 'real-world' driving conditions, emissions from road vehicles exceed the limits specified in the test cycle. Successive emission standards for diesel vehicles have not delivered the improvements anticipated under real-world conditions.

4.1 Overview of air policy

The EU has introduced and implemented various legal instruments with the objective of achieving levels of air quality that do not adversely impact human health and the environment. Some regulate emissions from specific sources or sectors either by setting requirements on product quality (such as the sulphur content in fuel), or by setting emission limits. Others set limits on total national emissions, for example the National Emission Ceilings Directive (EC, 2001). In addition, the Air Quality Directive (EC, 2008) on ambient air quality and cleaner air for Europe regulates concentrations of SO_2, NO_2, PM_{10}, $PM_{2.5}$, CO, O_3, benzene and lead. In the case of non-compliance with air quality limit and target values stipulated in the directive, local and regional Member State administrations must develop and implement air quality management plans in areas where exceedances occur (EEA, 2011a).

As a result of these policies, air pollutant emissions in Europe have decreased over the last decade, resulting in improved air quality (for some pollutants such as SO_2, CO or benzene). However, due to complex links between emissions and air quality, as well as a number of uncertainties associated with emission estimates, reductions have not always produced a corresponding decline in ground level concentration of air pollutants. For example, the decrease in NO_x transport emissions (27 % between 2001 and 2010 in the EU-27) is considerably greater than the fall in NO_2 annual mean concentrations of approximately 8 % measured at stations close to traffic between 2001 and 2010 (EEA, 2012b). This is attributed primarily to the increased proportion of NO_x emitted directly as NO_2 from the exhaust of more modern diesel vehicles using catalyst systems for controlling emissions of other pollutants. In simple terms, the 'euro standards' for vehicle emissions have not succeeded in bringing down real NO_2 emissions to the levels set out in the legislation. Further discussion on this disparity can be found in Sections 4.3 and 4.5 and Chapter 5.

Indeed exceedances of air quality standards still occur in many cities and urban areas (EEA, 2012b). Acknowledging that continuous efforts are needed to meet air quality standards and mitigate the negative impacts of air pollution on human health and the environment, the European Commission has proposed the following milestone:

By 2020, the EU's interim air quality standards will have been met, including in urban hot spots, and those standards will have been updated and additional measures defined... (EC, 2011h).

Among other measures, the European Commission will review EU air pollution policies by 2013 and propose an upgraded strategy looking beyond 2020, assessing how air quality standards, emissions standards and further measures can be used to reduce emissions from key sources. To secure emission reductions in the short-term, the European Commission will continue with agreed preparatory actions and initiatives, such as revising the sulphur content of bunker fuels as well as reviewing and further reducing emissions from vehicles and machinery.

Transport is one of the main sources of air pollution in Europe, particularly in cities and urban areas such as towns, airports and sea ports. Key air pollutants emitted from combustion engines in all modes of transport include NO_x, PM, CO, and VOCs. However, non-exhaust emissions of PM are also released due to the mechanical wear of brakes, tyres and road surfaces, and are not currently regulated. Emissions of VOCs also come from gasoline evaporation during refuelling and from vehicle and fuel storage tanks.

This and the following two chapters of this report review the contribution of air pollutant emissions from transport to air quality and the linkages between policies addressing air quality and climate change.

4.2 Contribution of transport to emissions and air quality

Figure 4.1 shows the contribution made by different sources to emissions of different pollutants in EEA-32 member countries in 2010. Transport is a particularly significant source of NO_X emissions in most countries, ranging from 20 % in Norway to 74 % in Luxembourg. However, it should be noted that, under international reporting procedures, certain countries may choose to report road transport emissions based either on the fuel used or the fuel sold within the country. The two approaches can lead to significant differences for countries where 'tank tourism' occurs, i.e. where fuel purchased within a country is actually used outside the country and vice versa (EEA, 2012d). In Luxembourg for example, the price of petrol remains one of the lowest in the EU, inducing 'fuel tourism' and negative externalities in terms of pollution and congestion. In fact, cross-border purchases of diesel and petrol accounted for 75 % of sales in 2010 (EC, 2012c).

The TERM 03 indicator (Box 2.4) shows the trend in emissions of most pollutants from transport in EEA-32 member countries since 1990. Emissions of different pollutants have been falling but at different rates. The decline has occurred in spite of a growth in transport activities reflected by various indicators such as energy consumption (TERM 01, Box 2.2) and passenger (TERM 12, Box 2.7) and freight (TERM 13, Box 2.8) transport volumes since 1990.

The downward trend for most pollutants has followed the progressive introduction of tighter Euro emission standards on new road vehicles supplemented by improvements in fuel quality driven by EU Fuel Quality Directives. Tighter regulations in emissions from new diesel engines for railway locomotives and the sulphur content of marine fuels have also contributed to this downward trend in emissions in more recent years. The trends in emissions of key pollutants NO_X and $PM_{2.5}$ have been tempered by the increased market penetration of diesel vehicles since 1990. This is reflected in the final energy consumption by fuel indicator (TERM 01) and by the growth in car registrations by fuel type in the EEA (EEA, 2012c). Diesel vehicles generally emit more of these pollutants per kilometre than their gasoline equivalents, particularly black carbon which has impacts on health and the climate (see Box 4.1) but also NO_2.

Although emissions from transport have been declining, there are still many areas where limit values for NO_2 and PM_{10} are exceeded across Europe mainly due to road traffic. For example, NO_2 annual limit values were exceeded at 44 % of traffic monitoring stations; the daily limit value for PM_{10} was exceeded at 33 % of traffic sites; and the $PM_{2.5}$ annual target value was exceeded at 6 % of traffic sites across the EU in 2010 (EEA, 2012b).

Concentrations of NO_2 and PM_{10} measured at a particular location are influenced by a variety of local and distant sources. Source apportionment techniques are used to establish the contributions made by transport and other sources. Using this approach, the EU-27 averaged contribution of urban and local traffic to PM_{10} concentration is estimated to be 34 % (measured at 29 urban traffic sites). These figures ranged from 13 % (Duisburg) to 61 % (Glasgow) illustrating the wide variation in contribution according to specific local conditions. The averaged contribution of urban and local traffic to NO_2 concentration is estimated at 64 % (measured at 74 urban traffic sites) (Sundvor et al., 2012).

Box 4.1 Black carbon particles

Black carbon (BC) particles are carbonaceous particles that absorb light and are a component of fine particulate matter ($PM_{2.5}$). As well as being a 'short-lived climate forcer', in other words a warming agent with a relatively short lifetime in the atmosphere (Ramanathan and Carmichael, 2008), BC particles can also adversely affect human health (WHO, 2012). Unlike $PM_{2.5}$, BC is produced solely from combustion processes and in urban areas it is a component of $PM_{2.5}$ which has a strong association with traffic emissions. BC is therefore a potential tracer which can be used to monitor the impacts of transport policies on vehicle exhaust emissions of PM (Reche et al., 2011). A recent report for DG Environment estimated that 68 % of all BC emitted in EU-27 Member States was from vehicle exhausts, the vast majority from diesel vehicles (IIASA, 2012). Emissions are predicted to fall in the future in line with reductions in PM exhaust emissions. Concentrations of BC in urban sites can reach 3–14 % of PM_{10} levels in Europe and can reach levels of 8 $\mu g/m^3$ at kerbside sites (Sundvor et al., 2012).

Figure 4.1 The contribution of the transport sector to total emissions of the main air pollutants in 2010 (EEA-32)

Note: Labels are not shown for those transport sub-sectors contributing < 1 % to total emissions.

Source: EEA, 2012.

4.3 Real-world emission performance of vehicles

Under real-world or 'normal' driving conditions, emissions from vehicles often exceed the test cycle limits specified in the Euro emission standards (see Box 2.16 of the TERM 2011 report (EEA, 2011b)). Several studies (Pelkmans and Debal, 2006; Vojtisek-Lom et al., 2009; Rubino et al., 2007; Weiss et al., 2012) have indicated that real world NO_x emissions of light-duty diesel vehicles might substantially exceed Euro 2–5 emission limits. Tests performed by JRC (Weiss et al., 2011) on passenger cars and light commercial vehicles show that Euro 3–5 diesel vehicles exceed the emission limits by a factor of 2–4 in real world driving. The exceedance can be much higher on sub-sections of individual 'on-road' tests which are comparable in duration to standard laboratory testing with the New European Driving Cycle (NEDC). The exceedance also occurs with heavy duty vehicles (HDV), albeit to a lesser extent (Verbeek et al., 2010). The emission factors used by EU Member States for estimating emissions when developing inventories have been updated to reflect this as far as possible, such as in the COPERT 4 road transport emissions model (Emisia, 2012).

There is further evidence from roadside remote sensing of emissions that the divergence could be even greater than indicated by currently available emission factors (Carslaw et al., 2011; Beevers et al., 2012). Roadside remote sensing is a technique which measures the concentration of pollutants in the exhaust plume of every vehicle that passes the sensing equipment. Further remote sensing studies in the Netherlands (Velders et al., 2011) have highlighted the problem with Heavy Goods Vehicles (HGVs) equipped with Selective Catalytic Reduction (SRC) for NO_X control. Many HGVs use this technology to meet the Euro V standards, but while it appears effective at high speeds, under low-load urban conditions, the technology is much less efficient due to the low exhaust temperatures making the catalyst ineffective at reducing NO_X in the tailpipe. If this technology is used, emissions from Euro V vehicles can therefore actually be higher than the Euro IV equivalents under so called slow urban conditions unless the technology has been optimised (HBEFA, 2010).

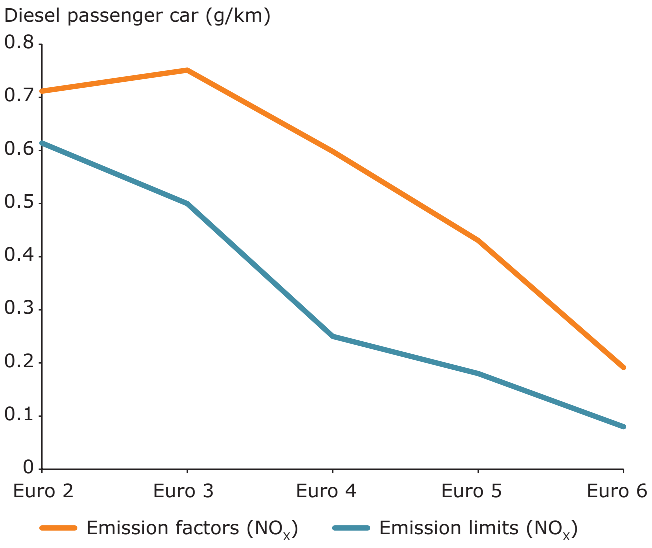
As a longer term solution, the European Commission is developing new test procedures aimed at more accurately reflecting real world conditions.

4.4 Contribution of transport to secondary air pollutants

A fraction of the air pollutants PM_{10}, $PM_{2.5}$ and all ozone emissions are secondary pollutants formed in the atmosphere over a large area via the chemical interaction of other pollutants such as NO_X, SO_2, VOCs and ammonia (NH_3). About 30 % of PM_{10} measured is in the form of secondary inorganic sulphate and nitrate aerosols, which are

Figure 4.2 Trends in diesel NO_x emission factors and type approval emission standards

For diesel light duty vehicles, the divergence between expected and real-world emissions was evident from the introduction of the Euro 3 standards implemented in 2000. Figure 4.2 shows the change in real-world NO_x emission factors in urban conditions for diesel cars with different Euro standards along with the change in the type-approval standards. Euro 6 standards do not come into force until 2014 so there are no real-world emission measurements on Euro 6 vehicles. The emission factors are estimated by taking the percentage reduction in NO_x emissions between the Euro 5 and Euro 6 standards and applying this to the real-world Euro 5 emissions factor.



Note: Care is needed when interpreting this figure. The NO_x emissions limit for a Euro 2 diesel car is deduced as the limit was set for combined pollutants (Hydrocarbons (HC) + NO_x) and the test procedure changed between Euro 2 and Euro 3. The trend of NO_x emission factors is based on emission functions provided by COPERT 4 at speed 33.6 km/h.

Source: NO_x emission factors (Emisia, 2012) and emission limits (EC, 1994; EC, 1998 and EC, 2007).

formed from the transformation of gaseous SO_2, NO_X and NH_3 emitted from various sources. The proportion of these aerosols in $PM_{2.5}$ is larger but not so well determined (EEA, 2011a). Secondary organic aerosols are formed from atmospheric oxidation and subsequent condensation of various VOCs (EEA, 2011a; AQEG 2005). Transport sources emit all these precursor gases (see Figure 4.1), and emissions from one region can affect levels of $PM_{2.5}$, PM_{10} and ozone in another. VOCs refer to a large group of compounds emitted from many different sources and each individual compound has a different reactivity and propensity to form ground-level ozone. Exhaust and evaporative emissions from gasoline vehicles are the dominant source of VOCs within the transport sector, contributing 19 % to the total VOCs emitted in 2010.

Transport is a relatively small emitter of SO_2 because of the low sulphur content of fuels used in road transport, aviation and rail compared with fuels used in other combustion sources. However, higher emissions currently occur from shipping, as the international maritime sector is responsible for 87 % of all SO_X emitted by the transport sector in 2010. With SO_2 and NO_X emissions declining from other sectors, shipping will make a larger relative contribution to secondary inorganic aerosols in Europe.

4.5 Air quality and climate change linkages

The relationship between air pollution and climate change is strong but complex. In the context of designing policies to mitigate against the impacts of climate change it is essential to consider the linkages between air pollution and climate change in order to maximise synergies, avoid unintended consequences and understand and evaluate trade-offs (see Box 4.2).

Policies and measures targeting climate change may contribute substantially to reducing or increasing air pollution. Reducing emissions may warm or cool the atmosphere because several of these pollutants exhibit a positive or a negative climate-forcing impact, either directly or indirectly. For example, particles have direct climate impacts: sulphate aerosols reflect solar radiation leading to net cooling; while BC aerosols absorb solar radiation leading to warming. Therefore, while reducing SO_2 emissions from shipping and PM emissions from road traffic will both reduce exposure to BC, the former will lead to a warming effect, the latter to a cooling effect (Balkanski et al., 2010). Indirect impacts include aerosols altering cloud properties and NO_X promoting tropospheric O_3 formation that warms the atmosphere. Ground-level O_3 is the third most important contributor after CO_2 and methane to positive radiative forcing potential.

Box 4.2 Advantages and disadvantages of widely applied emission abatement technologies

Three-way catalytic converters are used to reduce emissions of unburned hydrocarbons, CO and NO_X from gasoline vehicles. Reductions of around 70–90 % have been achieved. However, their introduction has been associated with an increase in tailpipe emissions of NH_3, a source of secondary particulates, by over a factor of 10. However, gasoline vehicles remain a relatively low source compared to other sources of this gas mainly from the agriculture sector. Low sulphur fuels, which help improve catalyst performance, have been reported to reduce the formation of nitrous oxide (N_2O), a greenhouse gas, while favouring the formation of NH_3 (Mejía-Centeno et al., 2007). However, catalyst systems fitted on current gasoline cars generate lower emissions of these gases than older generation catalyst systems.

A diesel particulate filter (DPF) is an exhaust after-treatment technology, which reduces PM emissions from diesel vehicles by 85 % or more. DPFs will also reduce BC emissions, helping to reduce global warming. However, some evidence suggests that certain DPFs with catalytic filter regeneration systems have a small negative impact on fuel economy as well as increasing primary NO_2 emissions (Carslaw, 2005). The impact on fuel economy is variable and dependent on DPF technology and duty cycle.

Selective Catalytic Reduction (SCR) is a technology used to reduce NO_X emissions from diesel vehicles. Reductions of around 60–80 % are achieved. However, there is evidence to suggest that this can lead to higher emissions of N_2O as well as potentially increasing NH_3 (MECA, 2010). Again, many factors are at play that do not allow for a precise quantification of how significant these unintended emissions are.

Exhaust gas recirculation (EGR) is a technique whereby a portion of an engine's exhaust gas is re-circulated back through the engine cylinders. Depending upon the engine type, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture and/or reduces peak combustion chamber temperatures. This, in turn, reduces the formation of NO_X (Ladommatos et al., 2000; Zheng et al., 2004). The effect of EGR on NO_X emissions is variable but is typically around 40–80 %.

Over the last few decades, there has been a large shift from petrol to diesel passenger cars in Europe, due to lower diesel fuel costs and better fuel economy offered by diesel cars. This has been further encouraged by taxation policies aiming to reduce transport CO_2 emissions (see Box 4.3). According to the European Automobile Manufacturers' Association (ACEA, 2012), 19 Member States have introduced passenger car taxes that are totally or partially based on the car's CO_2 emissions and/or fuel consumption. However, diesel engines typically emit higher rates of NO_X, NO_2 and PM compared to gasoline engines and their increased uptake is an important factor contributing to the air quality challenges faced by many cities in Europe. The European Commission's Transport White Paper target to halve the use of conventionally fuelled cars in urban transport by 2030 and phase them out in cities by 2050, would have significant air quality benefits and it will be important to find a way to track progress towards this. Box 4.4 gives examples of potential co-benefits in achieving this target.

The targets in the 2011 European Commission's White Paper on Transport have the potential to bring substantial benefits to air quality. However, policy options to achieve them need to be assessed taking into account the full implications for air quality and GHG emissions from the production, supply and use of alternative technologies or fuels. Well to Wheels (WtW) and life-cycle analysis can help assess policy in a holistic way to optimise the co-benefits and prevent any unintended consequences.

Electric and hybrid vehicles could substantially improve local urban air quality in areas where they achieve a high fleet penetration. The use of the electric train can also increase energy efficiency and minimise or even eliminate tailpipe CO_2 emissions. While hybrids tend to offer substantial emission abatement especially in urban driving, overall emissions of CO_2, NO_X, SO_2 and PM of electric vehicles mainly depend on the average European power generation mix. Currently, these emissions are quite high due to the increased contribution of coal power plants, an effect which is expected to decline with the introduction of newer and cleaner plants. Emissions of air pollutants will generally decrease by switching to renewable energy sources. Uptake of vehicles that incorporate regenerative braking, such as electric and hybrid vehicles, will also reduce non-exhaust emissions relating to tyre and brake wear (AEA/TNO/CE Delft, 2012).

In addition to the technological improvements, non-technical measures can improve tailpipe air pollutant emissions in relation to fuel savings. Examples include eco-driving and speed reduction which can produce fuel efficiency savings of between 8 to 25 % (AEA/TNO/CE Delft, 2012). Policies to reduce speed, congestion charge schemes and other measures can encourage a shift to walking and cycling.

Box 4.3 CO_2-emissions from new passenger cars in Belgium

From 2005 onwards Belgium gave tax incentives for buying new cars emitting less than 115 g CO_2/km, offering a reduction of 15 % of the purchase price for a car emitting less than 105 g CO_2/km and 3 % for a car emitting between 105 and 115 g CO_2/km. Initially the impact from such a policy seemed relatively small. A decision was then made in 2007 to offer a direct discount on the purchase price. Furthermore, from 2008 onwards the tax deductibility of company cars became directly linked to CO_2 emissions.

From 2008 to 2011, the CO_2 emissions from new passenger cars decreased sharply. For private cars the share of vehicles purchased with emissions less than 105 g CO_2/km, the preferred option, showed a marked increase. More and more models of this class of car were coming onto the market. In 2010, tax deductibility of company cars emitting less than 60 g CO_2/km became more beneficial. However, new company cars are generally more powerful than new private cars and emit on average 10 g CO_2/km more. With an average CO_2 emission of new cars of 127 g CO_2/km, Belgium had already reached the 2015 target of 130 g CO_2/km in 2011. However, it is uncertain if such a decrease will continue. Due to budget cuts, the direct discounts for private low CO_2 cars were suspended in 2012.

Although incentives assisted in reducing CO_2 emissions, the resulting effect was less beneficial for other air pollutants. Because diesel cars emit on average less CO_2 than petrol cars, the incentives led to an increase in diesel powered cars that was in any case already high in Belgium. This strong dieselisation of 63 % in 2010 also came about from a difference in excise duty between petrol and diesel fuel and contributed to the exceedance of several environmental targets in 2010.

The Belgian regional authorities are responsible for the car registration tax for new and second hand cars. In Flanders, this tax has recently been reformed and relates to fuel type, CO_2 emissions, euro-classification, particulate filter and real NO_x-emissions. This is an attempt to gain a balance between CO_2 emissions and NO_x on PM emissions.

Box 4.4 Potential climate interaction and co-benefits from different technologies

Electrified vehicles mainly comprise of Battery Electric Vehicles (BEVs) and Hybrid Electric Vehicles (HEVs), either full or semi hybrids, as well as variations such as Range Extender Electric Vehicles (REEVs), a combination of battery with an internal combustion engine (ICE) acting as a range extender and Plug-in Hybrid Electric Vehicles (PHEVs), which are essentially hybrid vehicles capable of charging directly from the grid.

Hydrogen Fuel Cell Vehicles (HFCVs) can also be considered electric vehicles, since they use fuel cells as an energy converter, producing electricity from chemical reaction, which results in zero tailpipe emissions of NO_x and SO_x compared to conventional gasoline and diesel vehicles (Euro 5 standards). Tailpipe emissions of PM from hydrogen vehicles are also zero, but overall PM levels in a country will depend on the fuel production process (AEA/TNO/CE Delft, 2012). Fuel-cell Range Extender vehicles (FCREVs) are a combination of a BEV with a fuel-cell range extender and their performance in terms of emissions is expected to be somewhere between a BEV and a HFCV.

Flexi-fuel Vehicles (FFVs) use high liquid biofuel blends (such as E85) which demonstrate slightly higher energy efficiency and can potentially substitute current conventional fuels while reducing GHG emissions, subject to the availability of sustainable biofuels. Biodiesel is the diesel equivalent biofuel.

Methane vehicles (Compressed Natural Gas — CNG) represent a mature technology, which from a reduction of emission of NO_x and particles as well as a moderate reduction in CO_2, compared to their gasoline or diesel driven equivalents. Natural gas can moreover be blended with bio-methane, generated from biomass, leading to a further reduction of CO_2 emissions. Methane could be also used in the form of Liquefied Natural Gas (LNG) for fuelling combustion engines in boats and ships and heavy duty road transport vehicles, up to now mainly through dual fuel systems (engines burning together diesel and methane), which can offer significant CO_2 reduction. As an alternative, dedicated gas engines can deliver low pollutant emissions (mainly NO_x and CO) and CO_2 reduction.

Liquefied Petroleum Gas (LPG) vehicles employ another mature form of ICE fuel, a by-product of the hydrocarbon fuel. LPG fuel can be environmentally beneficial by offering a reduction of CO_2 emissions, lower NO_x emissions and no soot at all; nevertheless, retrofitted LPG vehicles can emit, on average, more than twice as much NO_x and 2.5 times as much PM as gasoline vehicles (Vonk et al., 2010).

The table below summarises the effect on emissions when applying the aforementioned vehicle technologies.

Vehicle technology/ reduction	**CO_2**	**NO_x**	**SO_x**	**PM**	**CO**	**HC**
Petrol	Tailpipe: 143 g/km Europe 2010 registrations (type-approval cycle), real-world tailpipe 10–15 % higher WtW ~ 160 g/km	0.045 g/km (Euro 5 1.4–2 l)	Very low	0.017 g/km (PM_{10}, Euro 5 1.4–2 l)	0.594 g/km (Euro 5 1.4–2 l)	0.086 g/km (Euro 5 1.4–2 l)
Diesel	Tailpipe: 139 g/km Europe 2010 registrations (type-approval cycle), real-world tailpipe 12–20 % higher WtW ~ 143 g/km	0.433 g/km (Euro 5 < 2 l)	Very low	0.018 g/km (PM_{10}, Euro 5 < 2 l)	0.105 g/km (Euro 5 < 2 l)	0.016 g/km (Euro 5 < 2 l)
Hybrid electric	18–20 % less WtW than a standard petrol car (160 g CO_2/km WtW) or a standard diesel (143 g/km WtW) respectively	Lower than conventional cars	Lower than conventional cars	Lower than conventional cars	Lower than conventional cars	Lower than conventional cars
Mild hybrid	Similar to conventional cars	Slightly lower than conventional cars	Slightly lower than conventional cars	Slightly lower than conventional cars	Slightly lower than conventional cars	Slightly lower than conventional cars
PHEVs	WtW emissions depend on carbon intensity mix, 45 % WtW less than petrol equivalent, diesel PHEV has 5–7 % lower WtW emissions than diesel car for coal power plant production	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation	Very low, in addition to power generation	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation

Box 4.4 Potential climate interaction and co-benefits from different technologies (cont.)

Vehicle technology/ reduction	**CO_2**	**NO_x**	**SO_x**	**PM**	**CO**	**HC**
BEVs	Zero tailpipe, WtW emissions depend on carbon intensity mix, ~ 60 % WtW lower than petrol (160 g/km WtW), 445 g CO_2/KWh carbon intensity	Zero tailpipe, in addition to power generation	Zero tailpipe, in addition to power generation	By material wear only, in addition to power generation	Zero tailpipe, in addition to power generation	Zero tailpipe, in addition to power generation
REEV	Zero tailpipe in electric mode, similar to PHEV on average, WtW emissions depend on carbon intensity, diesel/gasoline REEVs have 34 % lower WtW GHG than diesel/gasoline cars respectively, for 467 g CO_2/KWh carbon intensity	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation	Very low, in addition to power generation	Zero (urban conditions) to slightly lower than hybrids. in addition to power generation	Zero (urban conditions) to slightly lower than hybrids, in addition to power generation	Zero (urban conditions) to slightly lower than hybrids. in addition to power generation
HFCV	Zero tailpipe, WtW emissions depend on hydrogen production method: 25–100 % WtW (RES electrolysis) lower than conventional cars	Zero tailpipe, in addition to hydrogen production	Zero tailpipe, in addition to hydrogen production	By material wear only, in addition to hydrogen production	Zero tailpipe, in addition to hydrogen production	Zero tailpipe, in addition to hydrogen production
FCREV	Zero tailpipe in battery mode, WtW emissions: between a BEV and a HFCV depending on power generation	Zero tailpipe, in addition to hydrogen production/power generation	Zero tailpipe, in addition to hydrogen production/power generation	By material wear only, in addition to hydrogen production/power generation	Zero tailpipe, in addition to hydrogen production/power generation	Zero tailpipe, in addition to hydrogen production/power generation
FFV (E85)	WtW emissions depend on bioethanol production method, Tailpipe: 0–10% less than petrol	18 % lower than petrol	Zero tailpipe	34 % less than petrol	20 % lower than petrol	Similar to petrol or higher (extreme conditions)
Biodiesel (B20)	WtW emissions depend on biodiesel production method. Tailpipe: 2 % lower than Euro 3 diesel, less than 1% gain or loss depending on biodiesel source	1–2 % more than diesel	Very low, similar to conventional vehicles	10–20 % lower than diesel	5–11 % lower than diesel	10 % lower than diesel
LNG	20–24 % lower than petrol	Lower or similar to petrol	Very low, similar to conventional vehicles	Lower or similar to petrol	Lower than petrol	Similar to petrol (CH_4 due to unburned methane)
CNG	24 % lower than petrol, retrofitted vehicles can be less efficient	Lower or similar to petrol	Very low, similar to conventional vehicles	Lower or similar to petrol	Lower than petrol	Similar to petrol (CH_4 due to unburned methane)
LPG	10–22 % lower than petrol, retrofitted vehicles can be less efficient	Between ~ 7 % lower to 15 % higher than petrol	Very low, similar to conventional vehicles	Similar to petrol, but up to 150 % higher for retrofitted bi-fuel cars	0–57 % lower than petrol	Slightly lower than petrol

Note: Well to Wheels (WtW) evaluation concentrates on the energy use and GHG emissions of fuel production and vehicle use. It is not a life-cycle analysis as it does not consider the energy or the emissions involved in building the facilities and the vehicles (JRC, 2008).

The information included in this box is the result of a literature review. All references can be found in Annex 1 and in the References (page 58).

Source: Emisia, 2012 (European Topic Centre for Air and Climate Mitigation (ETC/ACM)).

5 Local effects of transport on urban air quality

Road traffic contributes significantly to exceedances of air quality standards in many cities and other urban areas. Various transport activities also increase air pollutant concentrations significantly at and around sea ports and airports. Local policies and actions are essential in order to decrease pollutant concentrations at urban areas, particularly at roadside locations.

Emissions from transport have a local effect on air quality close to the point of release. This includes urban areas with a large contribution from local traffic, but also in areas close to sea ports, airports and railway terminals.

5.1 Urban traffic and air pollution

Air quality in urban areas is largely influenced by local traffic. Since the late 1990s concentrations of NO_2 and PM_{10} in urban areas have not been declining in line with emission trends. Figure 5.1 shows the trends in NO_2 and PM_{10} concentrations measured at urban background and traffic locations in selected European cities over the last decade. While most urban background sites show a decrease in the annual mean NO_2 and PM_{10} concentrations, those at traffic sites show a less consistent downward trend for NO_2 and are usually above the annual mean limit value of NO_2 ($40\ \mu g/m^3$).

The disparity between trends in emissions estimates and ground level concentration of these pollutants was discussed in Chapter 4 in relation to the real-world emission performance of vehicles. However, there are further specific features of the traffic and urban environment that add to this disparity.

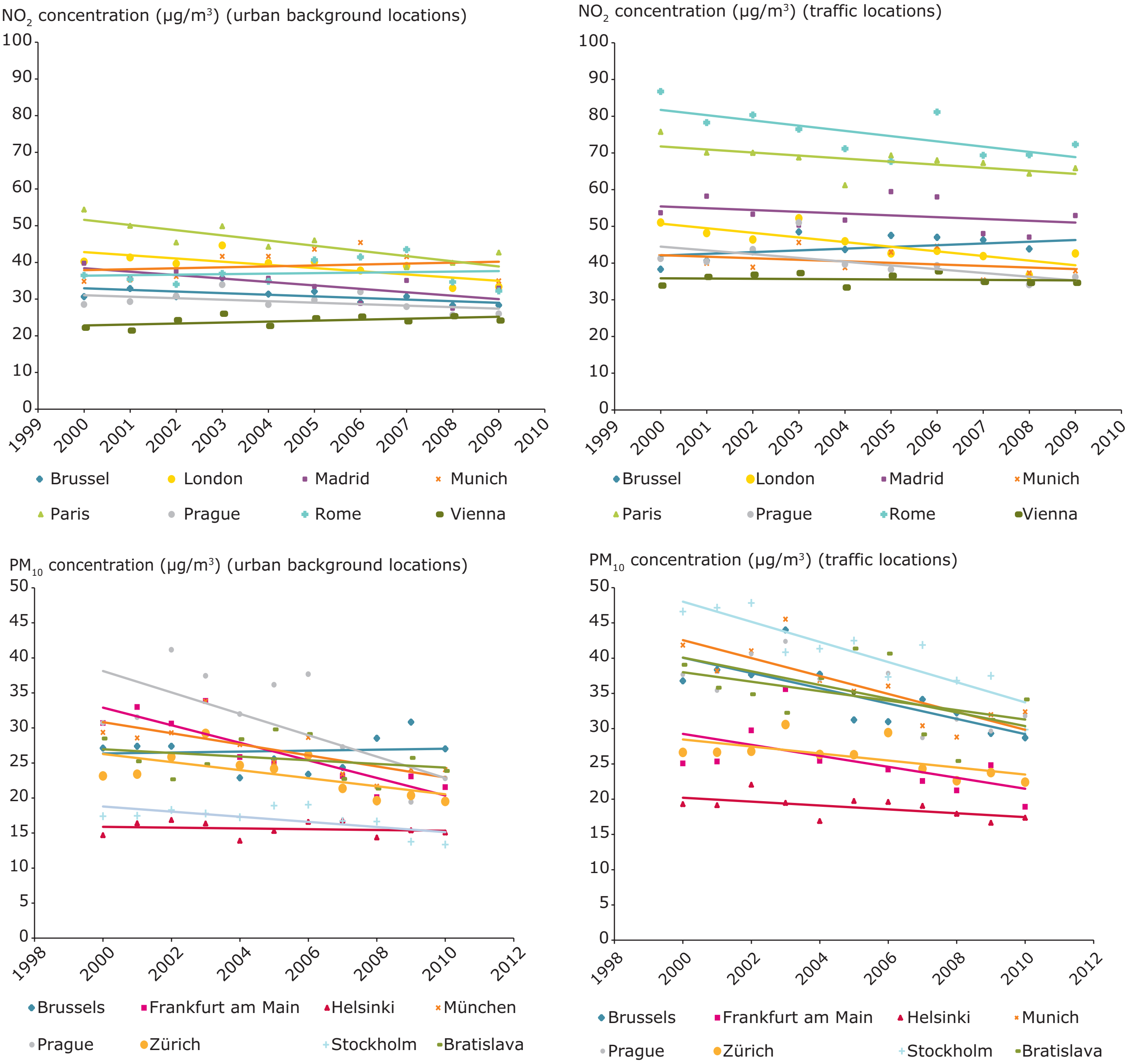
Vehicle composition in urban areas is generally different to the national composition. Actions to improve air quality need to take account of the local composition to ensure targeted measures are implemented. For example, buses, mopeds and motorcycles make up a higher proportion of vehicle composition in urban areas than they do nationally. Buses can emit high levels of NO_X and PM unless measures are taken which ensure that they meet strict emission standards. Mopeds and motorcycles are high emitters of CO and VOCs, particularly older models.

In addition, 'slow, stop and start' congested urban traffic conditions and frequent short journeys can result in higher emissions per kilometre compared to free-flowing longer journeys. This is a consequence of increased cold engine operation, higher fuel consumption and less efficient performance of exhaust emission abatement systems. Measures that reduce traffic congestion may therefore benefit air quality in the immediate area, although the full impacts need to be assessed over a wider area to ensure that traffic and emissions are not simply moved elsewhere.

Other characteristics of the urban environment can increase the impact of traffic emissions on air quality. For example, the presence of high buildings on either side of the road, common in many city centres, creates a 'street canyon', which reduces the dispersion of the emitted pollutants from traffic sources and can lead to significantly higher concentrations locally.

An additional reason for this disparity, in particular for NO_2 concentrations at traffic sites, is the increased proportion of NO_X emitted directly as NO_2 from vehicles, due to the increased market penetration of diesel vehicles and the fitting of pollution control devices (see Box 2.17, TERM 2011 (EEA, 2011b)). Primary emissions of NO_2 directly emitted from traffic have a significant impact on air quality in urban areas, particularly at roadside locations where NO_2 concentrations are already close to limit value (Carslaw and Beevers, 2005; Grice et al., 2009). Increases in the fraction of NO_X emitted as NO_2 began in 2000 with the introduction of Euro 3 diesel passenger cars fitted with exhaust treatment devices such as oxidation catalysts (used

Figure 5.1 Trends in NO_2 and PM_{10} concentrations at urban background and traffic locations



Notes: Top: NO_2 concentration in selected cities from 2000 to 2010 at urban backgound and traffic locations.

Bottom: PM_{10} concentrations in selected cities from 2000 to 2010 at urban backgound and traffic locations.

Values are presented for single monitoring stations that provide reliable time series data for the period 2000 to 2010. Selected cities have at least one background and one traffic station that provide such reliability and can therefore be compared for analysis. Therefore, this figure does not represent air quality results citywide, but rather serves as a snapshot of the different trends in background and traffic stations wherever comparable long-term time-series data are available. Because the different lines represent individual measurement points, there can be a significant effect from local changes in traffic flows.

Source: EEA, 2012.

to reduce emissions of CO, HC and PM) and catalyst-based particulate traps retrofitted on urban buses (Carslaw et al., 2011).

Typically gasoline vehicles emit less than 5 % of their NO_X emissions as NO_2. For diesel vehicles equipped with exhaust treatment technology, the figure is 20 % to 70 % (EEA, 2011b). The presence of buses, taxis and other diesel vehicles in towns and cities can therefore lead to higher emissions of primary NO_2 from traffic in urban areas compared with non-urban areas.

The ratio of NO_2 to NO_X can also increase due to photochemical reactions in the atmosphere (Mavroidis and Chaloulakou, 2011). NO_X emitted from vehicles in the form of nitric oxide (NO) is converted to NO_2 in the atmosphere by reaction with available ozone (AQEG, 2009). If total NO_X emissions decline, there will be proportionally more ozone available to convert NO to NO_2 and an increase in the NO_2/NO_X ratio in ambient air is to be expected in all urban areas.

The introduction of successive Euro standards and abatement technologies have also reduced exhaust PM emissions from vehicles. As already noted in Section 4.1, emissions from tyre, brake and road surface wear (often referred as 'non-exhaust' emissions) are not currently regulated. As exhaust emissions are expected to continue to decline in the future, the contribution of non-exhaust PM to overall PM emissions is becoming increasingly important. In 2010, non-exhaust emissions of $PM_{2.5}$ constituted 32 % of the emissions from the road transport sector in the EU-27 Member States, compared to just 14 % in 1990. For PM_{10}, the contribution has increased from 22 % in 1990 to 45 % in 2010.

Detailed source apportionment studies in the United Kingdom indicate that non-exhaust traffic sources were responsible for around 15 % of PM_{10} concentrations at traffic monitoring stations and around 12 % of $PM_{2.5}$ concentrations (AEA, 2011). The average non-exhaust traffic contribution at urban traffic sites is considerably higher in areas where there is extensive use of studded tyres and road sanding during the winter (e.g. 59 % for Stockholm) (Hak et al., 2010).

Traffic induced re-suspension of road dust also contributes to the ambient PM concentrations. However, it is difficult to quantify its effect with conventional emission inventory approaches. Road dust re-suspension is strongly influenced by the available quantity of road dust and other factors such as ventilation of the street and wetness of the road surface (TNO, 2012). Box 5.1 summarises some potential abatement measures.

5.2 Impacts of road transport policies and measures on air quality in European cities

Measures for reducing the impact of transport emissions on urban air pollutant concentrations can be either technical or non-technical. Technical measures might include cleaner burning combustion chamber designs or fitting abatement technologies, whereas non-technical measures can include incentives for the purchase of new cleaner vehicles, encouraging car-sharing to reduce demand, or restricting road traffic in certain areas. There are examples of these in many European cities.

Technical and non-technical measures set out in regional air quality transport plans in Italy have been assessed to establish their potential effectiveness and the frequency with which the measures were applied. Of the transport measures, incentives for new diesel HDVs were found to be the most effective for reducing both NO_X and PM_{10} emissions from transport, but the uptake of this

Box 5.1 Abatement measures to reduce non-exhaust PM emissions

The amount of wear emissions and road dust re-suspension are influenced by factors such as tyre types, vehicle speed, road surface conditions (e.g. wetness of the road) and pavement properties (Hussein et al., 2008; Gustafsson et al., 2009).

Potential measures to reduce road dust include reducing the use of studded tyres, changing road surface materials, reducing speed, street sweeping and dust binding (TNO, 2012). The optimum approach varies from situation to situation; for example, reduced use of studded tyres has shown to be an effective way to reduce PM_{10} levels in a Stockholm study. Safety should, however, be considered when regulating the use of studded tyres (Norman and Johansson, 2006). The application of dust suppressants has been trialled in several European cities, such as Klagenfurt, Bruneck, Lienz, and London. It has been shown to have the potential to reduce daily PM_{10} concentration by 10 % to 40 % (TfL, 2011a; VTI, 2010), although the effect is short-lived (e.g. 3–4 days).

measure was low as it had only been adopted for one region (D'Elia et al., 2009).

A number of cities have introduced Low Emission Zones (LEZ) to define standards which vehicles must meet in order to be allowed into the city. The rules governing the types of vehicles covered and the standards that must be met vary from country to country and from city to city (see Box 5.2 for Berlin example).

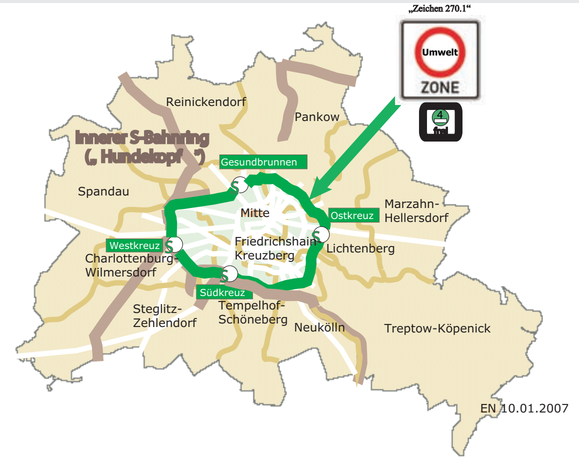
The Berlin example shows the positive impact of such a scheme being implemented in a large European city. However, recent research carried out in the Netherlands concluded that the introduction of low-emission zones directed at heavy duty vehicles in five Dutch cities did not have a measurable effect on traffic-related pollution (Boogaard et al., 2012). According to measurements taken, there were modest improvements in particulates concentrations which could be related to other changes over time. Smaller improvements were found in other pollutants such as NO_X. However, it should be highlighted that this Dutch example only had an effect on trucks, not private cars and vans, and covered only a small area of the cities concerned. Only one of the streets surveyed, where traffic intensity had been reduced in addition to the implementation of the LEZ, offered significant air quality improvements. The policies were therefore qualified as too modest to produce significant gains in air quality (Boogaard et al., 2012). LEZs in Amsterdam, Copenhagen and London (the latter recently extended to cover vans) currently only apply to a subset of vehicles (e.g. HGVs and buses), which limits their impact. An overview of the application of LEZs in Europe can be found at http://www.lowemissionzones.eu/.

Congestion charging has been introduced in a number of cities, including London, Milan and Stockholm. So far it has not been possible to attribute a direct contribution of the congestion charge to changes in air pollutant emissions or concentrations. However, the London transport authority (Transport for London) has stated that congestion is back to pre-charging levels. This suggests that the reduction in congestion since the introduction of this scheme in 2003 improved air quality levels compared to the 'do-nothing' alternative. A Stockholm congestion tax was introduced in January 2006 leading to a 10–15 % decrease in traffic as a result of the introduction of

Box 5.2 Berlin's Low Emissions Zone (LEZ)

In Berlin, the environmental zone (as the LEZ is known in Germany) has been in place since 1 January 2008. In stage 1, all vehicles (passenger cars, busses, coaches, LDVs and HGVs) deciding to enter the low emissions zone were required to meet one of the following criteria:

	Diesel vehicles	Petrol vehicles
Red sticker	Euro 2/II or Euro 1/I + particle filter	Euro 1/I with a catalytic converter
Yellow sticker	Euro 3/III or Euro 2/II + particle filter	
Green sticker	Euro 4/IV or Euro 3/III + particle filter	



One of the three stickers had to be bought and placed in the vehicle before entering the zone. From 1 January 2010 stage 2 of the environmental zone was introduced meaning that only vehicles with green stickers were allowed into the area.

During the first stage of the environment zone the emissions of diesel soot were reduced by 24 % in the first year and 32 % in the second year compared to an assumed trend without the existence of an environment zone. However, the second stage resulted in a higher reduction: after one year of its implementation 58 % (173 tonnes) less soot particles were emitted compared to an assumed trend without the existence of an environment zone. Emissions of NO_X were also reduced thanks to the creation of the environment zone. Following the move to a second stage, 20 % (1 517 tonnes) were mitigated compared to previous trends. The abatement of pollutants was achieved through modernising passenger cars and lorries (Berlin Information, 2012).

The results obtained by using the source apportionment analysis from 2007 show a 3 % reduction in PM_{10} concentration (Lutz, 2009).

the charge (Herczeg, 2011). A recent study increases the level of traffic reduction to 30 %, and states that this reduction has increased slightly over time. In addition, public support has also increased, likely linked to the reductions in congestion and emissions (Börjesson et al., 2012). Milan's congestion charge was only introduced in January 2012.

Cities also control traffic emissions through management of the municipal vehicle fleet, including buses. For example, there are no longer any conventional diesel buses running in Madrid with 31 % of the municipal vehicle fleet running on Compressed Natural Gas (CNG) and 68 % on biodiesel (with a 20 % mix). Buses operated in London also meet a minimum Euro IV standard for PM through retrofit or replacement programmes with some hybrid electric buses operating on strategic routes (TfL, 2011b).

Campaigns to encourage switching from driving to cycling or walking can also reduce air quality pollution in addition to having other benefits, such as health benefits from physical exercise. The health benefits from cycling are considered to significantly outweigh the disadvantages such as the potential for accidents and additional exposure to air pollution (Rabl and Nazelle, 2012; AEA/TNO/CE Delft, 2012). A case study based on Barcelona's 'Bicing' cycle-sharing scheme estimated that 12 deaths per year were avoided and 9 kt CO_2 were saved by users of the scheme. No estimates of reduced air pollutant emissions were reported. Similar cycle-sharing initiatives are in place in Lyon, Stockholm, Seville, Paris, Toulouse, Milan, Brussels and London (Rojas-Rueda et al., 2011). However, the potential for cycle-sharing schemes to save GHG and other harmful emissions depends on the amount of motorised journeys that have been replaced by bicycles. The Barcelona example necessitated the transport of the bicycles by van from one docking station to another to make sure that they were always available at all stations. This suggests that full emissions accounting has to take place to fully demonstrate the benefits of such a scheme (Beroud and Anaya, 2012).

5.3 Air pollution around sea ports and airports

Local air quality can also be a concern around transport hubs such as sea ports and airports. Historically, these hubs were developed in close proximity to urban areas, so air pollutant emissions affected people living and working nearby. A complex array of activities occurs at airports and sea ports and it is important that policies to manage the environment are developed with these in mind. In particular, plans for expansion and development at airports and harbours need to account for the whole range of activities occurring within and around the premises, including the effects on local traffic.

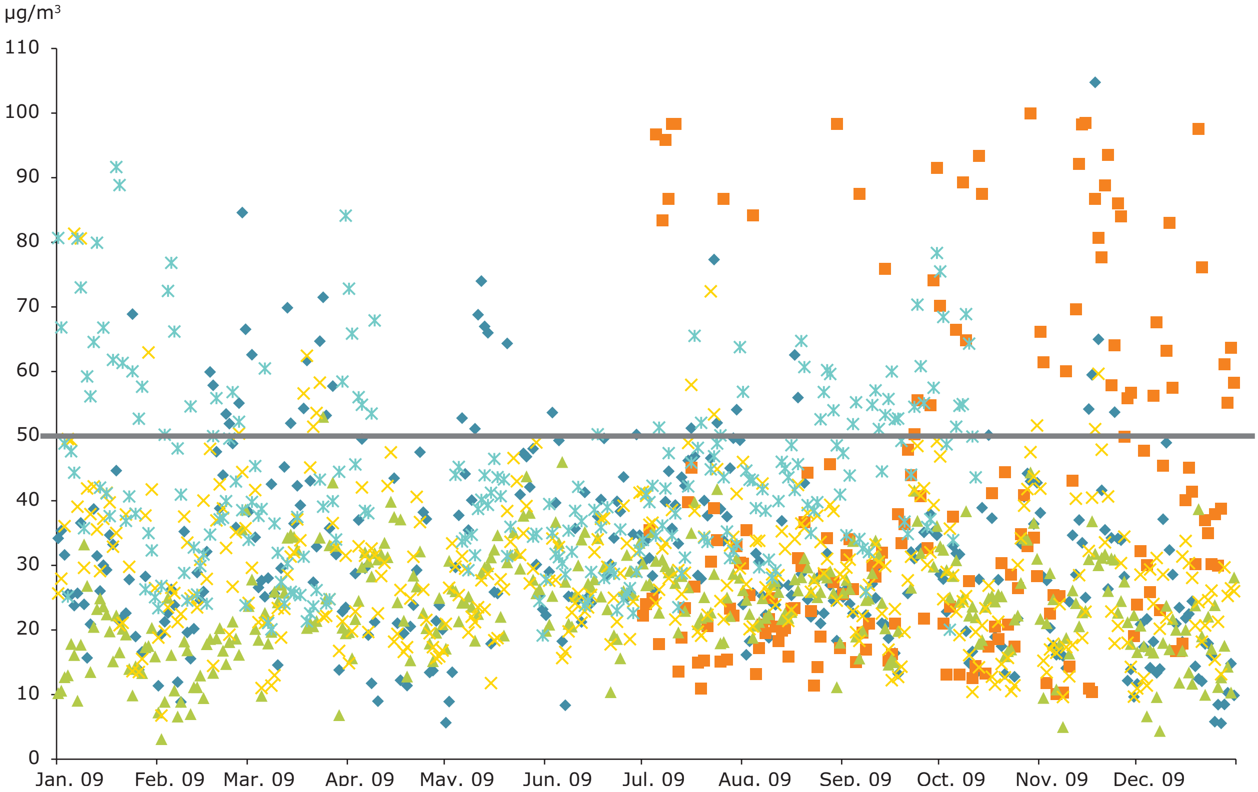
Air pollution around sea ports

The main sources of air pollution around sea ports associated with harbour transport activities are marine vessels and other land-based mobile sources. Marine emissions come primarily from diesel engines (main and auxiliary engines) operating on oceangoing vessels (e.g. tankers, roll-on/roll-off ships, bulk carriers, container ships) and harbour vessels (e.g. ferries, fishing vessels, dredges, tugs and tows). Land-based mobile sources can include cargo handling equipment (e.g. terminal tractors, cranes, container handlers), locomotives and other vehicles (trucks, buses, support vehicles) operating within the port area. The main pollutants of concern around sea ports are SO_X, NO_X, PM and VOCs.

While emissions from road vehicles and off-road machinery at ports are regulated by European directives, emissions from the vessels themselves are less controlled. However, the introduction of limits on the sulphur content of marine fuels used by vessels at EU ports and in Sulphur Emission Control Areas has helped to reduce SO_2 and PM emissions from ships (see Box 6.4 for policies that limit the sulphur content of marine fuels). In fact, a recent study (Schembari et al., 2012) on the impact of the regulation on ship emissions on air quality in Mediterranean harbours concluded that SO_X emissions from shipping sharply decreased in EU ports. This was after measuring key air quality parameters in Mediterranean harbours before and after the entry into force of the low-sulphur requirements in January 2010 (Directive 2005/33/EC). The average decrease in concentrations of SO_2 is reported to be in the region of 66 %, while measurements taken in a non-EU port showed similar levels.

As part of a European project (APICE, 2011) air quality and meteorological data were collected from five European port cities. Figure 5.2 illustrates the daily variation and exceedances of PM_{10} concentrations during 2009 at a monitoring station that is directly affected by the port in each of these five European port cities. As a next stage, the project will apply a source apportionment approach

Figure 5.2 Daily variation (in µg/m³) of PM_{10} concentrations in 2009



Note: The horizontal line represents the daily PM limit value (50 µg/m³) set in the Air Quality Directive (EC, 2008), which has 35 permitted exceedances per year. Venice data availability commenced in July 2009

Source: APICE, 2010.

(see Box 5.3) to deduce the relative contributions of various sources on particle concentrations at the selected port cities.

The impact assessment which accompanied the proposal for an amendment of Directive 1999/32/EC relating to a reduction in the sulphur content of certain liquid fuels (EC, 2011f), identified sixteen ports, including major European cities such as Rotterdam, Antwerp and Marseille, which are situated in air quality management zones where the daily PM_{10} limit value was exceeded in 2007 or 2008. In the case of Rotterdam and its surrounding suburbs and municipalities, the daily PM_{10} limit value was exceeded at a number of locations, as well as the NO_2 limit value, the latter primarily along major arterial roads in urban centres. Shipping is estimated to contribute 8 % and 19 % to ambient PM and NO_X concentrations respectively (DCMR, 2006). A shipping contribution of 19 to 37 % to SO_2 concentrations has also been estimated through modelling (DCMR, 2010).

Based on worldwide model simulations, the contribution of shipping to NO_2 concentrations from some intermediate sized ports may exceed 10 %, when situated in regions with quite low background pollution. However, for most ports the contribution to NO_2 is in the range 0.5–5 %. The pattern for SO_2 concentrations is quite similar; the relative contribution being slightly higher (Dalsoren et al., 2009).

Air pollution around airports

The main sources of air pollution around airports are aircraft, stationary sources and other mobile sources. Aircraft emissions are mainly associated with fuel combusted in the engines and auxiliary power units (APU), as well as tyre and brake wear. In terms of local air quality, emissions during the landing take-off (LTO) cycle are important, as they include emissions produced during idle, taxi to and from terminal gates, take-off and climb-out, and approach to the airport. Emissions from stationary sources are largely associated with power generation (including heating/cooling units). Other mobile sources include ground support equipment (e.g. mobile generators, tugs, baggage

Box 5.3 Source apportionment using monitored data

Source apportionment studies throughout Europe are in agreement when identifying the following source types for PM_{10} and $PM_{2.5}$ concentrations:

- vehicular source (vehicle exhausts, traffic etc.);
- crustal source (local or regional re-suspension, city dust, crustal material, road dust, etc.);
- sea-salt source (sea-salt, sea-spray and marine source);
- mixed industrial/fuel-oil combustion and a secondary aerosol source (probably representing the same source type (Viana et al., 2008).

A six-week data comparison study that took place at an urban background site in Marseille in 2011 suggested that the estimated relative contribution of the different sources on air quality concentrations varies considerably when using different monitoring equipment, analytical techniques and source apportionment methodologies. For example, under the source group 'road transport' (direct and indirect emissions from traffic) estimates generally ranged from 11 % to 19 % of the $PM_{2.5}$ mass, while under the source group 'industrial and shipping emissions', estimates ranged from 1 % to 34 % of the $PM_{2.5}$ mass. The discrepancies in the latter source group are assumed to be due to the presence/absence of secondary aerosol particles (from all sources) as a result of the different approaches employed. When secondary sources are considered together with industrial and shipping sources, estimates are in closer agreement (ranging from 47 to 58 %) (APICE, 2012).

handling equipment, fuel trucks/loaders), airside vehicles (service vehicles, tankers, catering trucks) and other traffic that facilitate access to the airport (e.g. buses, taxis, trucks, passenger cars, rail). The main pollutants of concern around airports are NO_X, PM (including ultrafine particles — see Box 5.4) and VOCs.

Several studies have evaluated the air quality around airports in Europe, the results of which gave rise to concerns. For example, high NO_2 concentration levels are often measured at London's Heathrow airport. During 2011, the annual average limit value was exceeded at one monitoring site within the airport boundary and two sites within a 2 km distance of the airport (GLA, 2012). The contribution to NO_X concentrations from Heathrow airport activities has been assessed based on measurement data close to the airport. The results show that aircraft NO_X sources can be detected at least 2.6 km from the airport, even though the airport contribution at that distance is very small. Approximately 27 % of the annual mean NO_X and NO_2 concentrations at the airfield boundary could be attributed to airport operations, with less than 15 % at background locations 2–3 km downwind of the airport (Carslaw et al., 2006). Modelling undertaken at Heathrow Airport on emissions data from April 2008 to March 2009 confirms the above by estimating relatively high (about 30 %) airport-related NO_X concentrations within the airport boundary, decreasing considerably with distance (11–19 % at about half a kilometre away) (HAL, 2011).

Another example is Zurich Airport, where monitoring data in 2008 were above the limit values for NO_2, PM_{10} and O_3 in the centre of the airport and at other locations dominated by road traffic. Dispersion modelling and sensitivity analysis were also undertaken in 2008 to assess the contribution from activities at Zurich Airport to ambient air quality, particularly on NO_2. The results show that airport activities significantly impact the air quality at the airport perimeter (> 25 %) for NO_2. The airport contribution to NO_2 concentrations decreases rapidly with distance and becomes less than 10 % within one kilometre from the airport boundary (Flughafen Zürich, 2009). Additional conclusions from this study that are applicable to other airports are outlined below:

- the significance of airports in the context of local air quality is not only determined by the total emissions in the airport area but also the different heights at which emissions occur;
- ground-based airport activities, typically from road vehicles, contribute more towards high concentrations within the airport boundaries and along the access roads where exposure is greatest compared to aircraft. Aircraft emissions are dispersed over a larger area, but generally result in lower concentrations;
- the distribution of NO_X concentration is more dependent on meteorological conditions than on a variation in emissions.

The air quality impacts from the closure of national airspaces and the suspension of air traffic due to the volcanic eruption in Iceland in 2010 were assessed at, and around, 14 airports across Europe. The closure of airspace also affected other airport operations, such as transport to and from the airport. During the airspace closure, lower NO_2 concentrations were observed, showing a correlation with the reduction in air traffic. However, the study considered this correlation weak in view of wider observations, based on one month's monitored data. The study concluded that the major disruption and reduction of flight activity did not significantly reduce air quality concentrations of NO_2; nonetheless, the very local effects resulting from the emissions changes were noted (i.e. monitoring stations at or close to the airport showed lower NO_2 concentrations). Meteorological conditions such as wind speed showed a more significant influence on measured concentrations (ACI, 2010).

Box 5.4 Ultrafine particles at airports

Ultrafine particles are particles with a diameter of less than 100 nanometres. There are no regulations specifically targeting these particles, although these are thought to be particularly harmful to human health.

Various studies have noted that aircraft contribute considerably to ultrafine particle pollution, as do road vehicles and ships. (US EPA, 2010; Paulsen, 2009). More recently in 2010–2011, a study focusing on air pollution at Danish airports conducted stationary measurements of ambient air quality at and around Copenhagen Airport. With regards to ultrafine particles, the study found that the average 24 hour concentration within the airport boundaries at one site was two to three times higher than on city streets with heavy traffic, while ultrafine particle concentrations within the airport boundaries at two other sites were only 20–30 % below those in streets with heavy traffic. This shows that concentration levels varied significantly within the airport boundaries. It is interesting to note that the two stations that showed lower concentrations are the official monitoring stations used in accordance with the environmental approval, while the one with the highest concentration was an additional one, placed in the airport yard close to employees loading and handling aircrafts. During the main working hours, concentrations within the airport boundaries were higher than those on city streets with heavy traffic. This was the case for two stations for which monitoring data were available (The Danish Ecocouncil, 2012).

6 Regional scale effects of transport on air quality

Road transport contributes to background PM pollution, due to NO_x and VOC emissions from vehicles, whilst VOCs, CO and NO_x emissions across Europe all contribute to regional ozone formation. Surface concentrations of NO_2 and SO_2 over much of the world's oceans (and at some coastal areas) are attributed primarily to shipping, contributing considerably to the formation of secondary PM on land and formation of ground-level ozone across the northern hemisphere. Aviation also contributes to background air pollution due to pollutant emissions released during the landing and take-off cycle, as well as during the cruise phase at altitudes above 3 000 feet.

Transport sources of air pollutants affect air quality over a much wider area by emitting pollutants which undergo atmospheric transformation processes, occurring up to several days after their initial release:

- Emitted NO_X, SO_2 and NH_3 form secondary particulate matter, comprised of inorganic aerosols of ammonium nitrate, ammonium sulphate and ammonium chloride.
- Organic aerosols are formed from the atmospheric oxidation of VOCs.
- Ozone is formed from the reaction of NO_X with VOCs and CO in the presence of sunlight (see Box 6.1 for information on transport's impact on atmospheric ozone).

Some pollutants, such as PM, may be both primary (i.e. emitted directly from a source) and secondary (i.e. formed from other primary pollutants in the atmosphere). Understanding the contributions made by transport sources to regional scale air pollution in different areas requires sophisticated models, combining atmospheric physics and chemistry with meteorologically-driven transport processes.

Source apportionment techniques help determine the contribution of secondary air pollution produced from different sources to air quality observed in urban areas, i.e. the background concentration.

6.1 Background air pollution from road transport

The effect of urban traffic on local air quality, along with specific policies and measures implemented to improve air quality in cities has been discussed in Sections 5.1 and 5.2. However, at any given location, the background concentrations of $PM_{2.5}$, PM_{10} and NO_2 will be influenced by traffic emissions from the whole surrounding region including motorways, other towns and cities and even other countries.

Road vehicles were responsible for around 33 % of NO_X, 14 % of VOC, 29 % of CO emissions, 14 % of PM_{10}, and 15 % of $PM_{2.5}$ (including non-exhaust emissions) in EU Member States in 2010 (TERM 03). Road transport remains the most polluting transport mode with respect to NO_X, CO and VOC emissions. Policy measures such as reducing speed limits can help address this (see Box 6.2).

The most important pollutant emissions from road transport contributing to secondary PM formation are NO_X. Significant proportions of the total NO_X emitted from road transport occur on motorways and other major roads connecting major conurbations. These types of roads will have more HGV traffic than roads in urban areas (den Boer et al., 2011). HGVs were responsible for around 20 % of NO_X emissions in EEA-32 member countries in 2010 and much of this will have occurred on motorways and major roads away from towns and cities.

Emissions of NH_3 form ammonium sulphate and nitrate particles in the atmosphere, which make a significant contribution to the aerosol mass in $PM_{2.5}$. NH_3 is emitted mainly from agricultural sources and waste disposal, but around 2 % of emissions in EEA-32 member countries came from road transport in 2010. Emissions of NH_3 from road vehicles are not regulated, although legislation is to be introduced covering emissions of ammonia from

Box 6.1 The impact of the different modes of transport on atmospheric ozone

Ozone (O_3) is formed from regional sources of precursor gases, such as transport, but additional O_3 is transferred to Europe above the boundary layer in the free troposphere and then brought to lower altitudes. This additional O_3 comes from mixing from the stratosphere and formation from emissions of precursor gases on inter-continental scales occurring from both natural (e.g. lightning, soil, fire, and vegetation) and anthropogenic sources. It has been estimated that annual average ground-level concentrations originate from stratospheric O_3, natural precursor sources, anthropogenic sources of precursors within the region and anthropogenic precursors transported in from outside the region. Each process contributes to 20–25 % of the global annual average ground-level concentrations (HTAP, 2010).

Models indicate that in the northern mid-latitudes, intercontinental transport of air pollution typically peaks in spring and autumn, and is smallest during the summer months when O_3 levels are highest due to the peak in production from local and regional emissions (HTAP, 2010). A study by Derwent et al. (2008) has estimated the relative contribution of European, North American and Asian sources and the stratospheric contribution to the ground-level O_3 concentrations at a rural location in southern England throughout 2006. The results show variability across a single year at this western European site.

Emissions from all transport sources (aircraft, shipping and road transport) contribute to O_3 formation globally in the troposphere. The rate of formation depends on where and when the O_3 precursor gases are emitted. Different chemical composition of the atmosphere and other atmospheric conditions — such as solar radiation — prevail and drive the formation of O_3 at various altitudes, in different regions of the world and at different times of the year. As a result, global scale dispersion models for air pollutants have been used to assess the contribution of transport modes to O_3 formation in the troposphere (Koffi et al., 2010; Hoor et al., 2009). The model simulations indicate that road transport emissions have the strongest influence on the formation of O_3 in the middle and upper troposphere in the Northern Hemisphere, while shipping emissions seem to have the strongest influence on formation of O_3 in the lower troposphere, especially over oceanic regions. The particular chemical composition and atmospheric conditions at higher altitudes in the troposphere result in the highest efficiency of O_3 formation per emitted NO_X molecule for aircraft emissions made at high altitudes in the troposphere (more details in Hoor et al., 2009). O_3 formed throughout the vertical extent of the troposphere (by e.g. aircraft emissions of precursors in the upper troposphere) may be moved to the ground by atmospheric dynamic processes, thereby contributing to population exposure to ambient ground-level O_3.

HDVs in 2013. Gasoline cars remain the dominant road transport source where NH_3 is formed as an unintended by-product of the reduction of NO_X in three-way catalyst systems. However, more modern catalyst systems are believed to produce less NH_3 and emission factors are believed to have peaked at Euro 2 standards (EEA, 2009b). NH_3 can also be emitted by slippage from incorrectly functioning urea-based selective catalytic reduction (SCR, see Box 4.2) abatement systems used to control tailpipe emissions of NO_X (Kean et al., 2009).

Thus, road transport contributes to NH_3 concentrations detected in ambient air. For example, in Barcelona, road traffic was identified as a significant source of NH_3. Its effect was more evident in an urban background traffic-influenced area (Pandolfi et al., 2012). Furthermore, it is readily transported in the atmosphere and can acidify land and surface waters, meaning its negative impacts can be felt in remote ecosystems (Heeb et al., 2008). Further attention may be needed to this pollutant and the role of traffic sources in local and regional production of ammonium aerosols, particularly as use of urea-based SCR systems for NO_X control for diesel vehicles becomes more widespread.

Road transport across Europe also contributes to O_3 formation over a large spatial scale from the sunlight-initiated reactions involving emitted VOCs, CO and NO_X. Emissions of VOCs and CO from transport have decreased more than NO_X over the last 20 years. This is mainly due to the tighter standards on VOC and CO emissions from gasoline vehicles coupled with further controls on evaporative losses of fuel vapours and dieselisation of the car fleet. Diesel cars tend to emit less VOCs and CO than gasoline cars, but more NO_X.

The frequency of occurrences of very high O_3 concentrations has generally decreased over Europe due to the reduction in precursor emissions in recent decades. However, annual mean O_3 concentrations have remained relatively static, reflecting a considerable contribution from the long-range transport of O_3 and its precursors in the northern hemisphere (EEA, 2012b).

Although emissions of NO_X lead to O_3 formation over extended regions (horizontally and vertically in the troposphere — see Box 6.1), the proportion of NO_X emitted as NO depletes ozone locally. Ozone concentrations are therefore typically lower in urban areas with large traffic sources of NO than

Box 6.2 Speed limits and their effects on emissions and concentrations

Lower speed limits on motorways are expected to reduce fuel consumption and pollutant emissions, particularly for passenger cars. It has been estimated that a reduction of the motorway speed limit from 120 to 110 km per hour would reduce fuel consumption by 12 % for diesel cars and 18 % for gasoline cars, if smooth driving (i.e. little acceleration and braking) and total compliance with speed limits is assumed. In reality, fuel savings are likely to be lower, approximately 2 % to 3 %, due to a variety of factors such as driving patterns, fluctuations in driving speeds and traffic congestion (EEA, 2011c).

Various studies have assessed the impacts of speed reductions on motorways on air pollutant emissions. A 4 % NO_x emission reduction has been estimated when decreasing maximum speed limits from 120 to 80 km/h on Swiss motorways, while peak O_3 levels decreased by less than 1 % (Keller et al., 2008). Daily average concentrations of NO_2, SO_2 and PM_{10} have been estimated to decrease by 6 %, 5 % and 3 % respectively when limiting the speed to 80 km/h on motorways, dual carriageways and main roads in the Barcelona Metropolitan area (Gonçalves et al., 2008).

Stricter speed limits and speed management policies, such as speed control by camera surveillance, have been introduced in various countries to improve road safety, as well as reduce emissions from motorway traffic. For example, in the Netherlands speed management reduced NO_x emissions 5 % to 30 % and PM_{10} emissions 5 % to 25 % (Keuken et al., 2010).

The European Parliament Transport Committee has called for 30 km/h speed limits to be introduced in all residential areas, primarily to improve the safety of children (EP, 2011b). While reducing residential speed limits from 50 km/h to 30 km/h should not be expected to result in large rises or falls of most pollutants, modelling using real-life urban drive cycles indicates that PM exhaust from diesel vehicles may show a significant decrease (Int Panis et al., 2011). In addition, lower speed limits in residential areas can help in further promoting active travel. This may reduce numbers of short motorised journeys which can be some of the most polluting as the engine and emissions aftertreatment system may not reach efficient operating temperatures.

compared to O_3 concentrations in rural areas. This effect may result in 10–15 % lower exposure to O_3 concentrations in urban areas compared to rural areas.

The policy significance of this is twofold:

- Population in rural areas are typically exposed to higher O_3 concentrations than in cities;
- Further reduction of NO_X emissions from traffic sources may lead to an increase in O_3 concentrations in cities and wider urban population exposure to O_3 in cities.

However, in addition to O_3, health concerns of NO_2 trigger NO_X reduction efforts and the optimal solution therefore requires a coordinated effort to reduce O_3 precursor emissions from all sources across Europe and outside Europe in order to bring further reductions in O_3 concentrations in urban areas.

6.2 Effects of shipping emissions on air quality

Emissions from ships in a regional context are dependent on the quantity and quality of the fuel consumed as well as the engine type. The quality of the fuel is important as vessels use bunker fuels with high sulphur content, thus SO_X and PM emissions from shipping are high. As an indication, the sulphur content of standard marine fuel (i.e. heavy fuel oil) is currently 2 700 times higher than that of conventional diesel for cars (JRC, 2010). Fuel consumed per distance also affects emission levels. This varies for each ship, as it depends on a variety of factors including the condition of the engine and the shape and roughness of the hull. The type and specifications of the engines also influence fuel consumption, which then affects emission levels (see Box 6.3). Emissions from the maritime transport sector represent a significant source of air pollution, especially for SO_2, NO_X and PM. Ships were responsible for around 21 % of SO_2, 19 % of NO_X, 3 % of VOC, 8 % of PM_{10}, 12 % of $PM_{2.5}$ and 2 % of CO emissions (international and national) in EEA member countries in 2010 (EEA, 2012d). In terms of the shipping sector's performance when compared to other transport modes, shipping is responsible for the majority of SO_2 emissions, and it also contributes considerably to NO_X and PM emissions.

Maritime emissions in Europe increased constantly during the period 1995–2010 due to the rise in transport demand (see EEA Air pollutant emissions data viewer — LRTAP Convention). Emissions from ships are expected to decrease in future years, mainly as a result of improved fuel quality and improved engine technology, driven by various policies that have been put in place for ships (see Box 6.4 for more details). The highest reductions are anticipated to be SO_X and PM

Box 6.3 Uncertainties associated with estimates of emissions from ships

It is important to note that the maritime emission estimates reported by EEA member countries can be derived using either a fuel-based approach or an activity-based approach. A fuel-based approach relies on the quantities of fuel sold for shipping activities gathered from nationally collected data. This is considered to be the most commonly used approach for estimating emissions. However, estimates do not accurately represent EU emissions. For example, fuel used by vessels operating in the EU but bunkering outside the EU are not included in these estimates, although this affects the EU's air quality. In addition, fuel used by vessels that may be re-fuelling in the EU but operating primarily in other regions, is included in the estimates. The uncertainty increases when international and domestic emissions are reported separately.

An activity based approach relies on ship movement information for individual ships. Various studies have estimated emissions from ships in EU waters or calling at EU ports using this approach. These estimates vary significantly, highlighting the uncertainties associated with the approach, in particular the quality and the completeness of the activity data and the assumptions used. To give an indication, estimates of CO_2 emissions from different studies ranged from 62 to 121 Mt within 200 nautical miles of the EU coast in 2000/2001, and from 77 to 112 Mt for ships calling at UK ports in 2005/2006 (JRC, 2010). These estimates seem to be considerably lower than the official data reported by EEA member countries.

shipping emissions. However, when considering the current policy outlook, emission reductions for other pollutants may not be realised. In particular, if growth in shipping activity is factored in then emissions may increase if further action is not taken (e.g. NO_X emissions are likely to increase if a NO_X Emission Control Area is not introduced). Shipping tkm activity is currently forecast to grow by almost 90 % by 2050 (AEA/TNO, 2010).

The effect of ship emissions on local air quality around sea ports has been discussed in Section 5.3. However, a considerable proportion of ship emissions are released at sea away from urban areas. Nevertheless, pollutants, especially O_3 precursors, are transported in the atmosphere over long distances, contributing to background concentrations and air quality problems on land.

Therefore, air pollution from ships, even at sea, leads to adverse impacts on health and the environment, such as acidification and eutrophication. In addition to this, BC (a component of PM) is also emitted by ships through the incomplete combustion of diesel fuel. BC releases in artic shipping routes are particularly damaging and magnify its positive climate-forcing effect (IMO, 2011c).

Box 6.4 Policies for controlling pollutant emissions from the maritime sector

The International Maritime Organization (IMO) regulates emissions from ships with MARPOL Annex VI (the Regulations for the Prevention of Air Pollution from Ships). This sets limits on NO_x and SO_x emissions and prohibits deliberate emissions of ozone depleting substances. It also contains provisions allowing for special SO_x Emission Control Areas (ECAs), where stricter emission limits apply. In Europe, the Baltic Sea, the North Sea and the English Channel are designated as SO_x ECAs. A revised Annex VI with significantly tighter emission limits was adopted in October 2008. The revised regulations also allow ECAs to be designated for PM and/or NO_x. The Baltic Sea States have submitted joint proposal to the IMO to designate the Baltic Sea as a NO_x ECA (MEPC, 2011). In July 2011, a new chapter to Annex VI was added on Regulations on energy efficiency for ships that makes mandatory the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. These are expected to reduce fuel consumption, so may also reduce emissions of certain air pollutants.

At a European level, Directive 2005/33/EC, amending Directive 1999/32/EC that sets the maximum permissible sulphur content of marine fuels, introduced the IMO concept of SO_x ECAs and the associated stricter fuel standards. In addition, stricter fuel standards were also introduced for ships at berth or anchorage in EU ports and for passenger ships on regular service to EU ports. In October 2012 the Council of the European Union adopted a directive amending Directive 1999/32/EC, to align this with the latest IMO provisions. Even with these stricter limits, the 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 10 ppm sulphur limit imposed on fuels for road transport, railways and non-road mobile machinery. Finally, the CO_2 reduction target for the marine sector (EC, 2011a) may reduce emissions of certain air quality pollutants due to reduced quantities of fuel being burned.

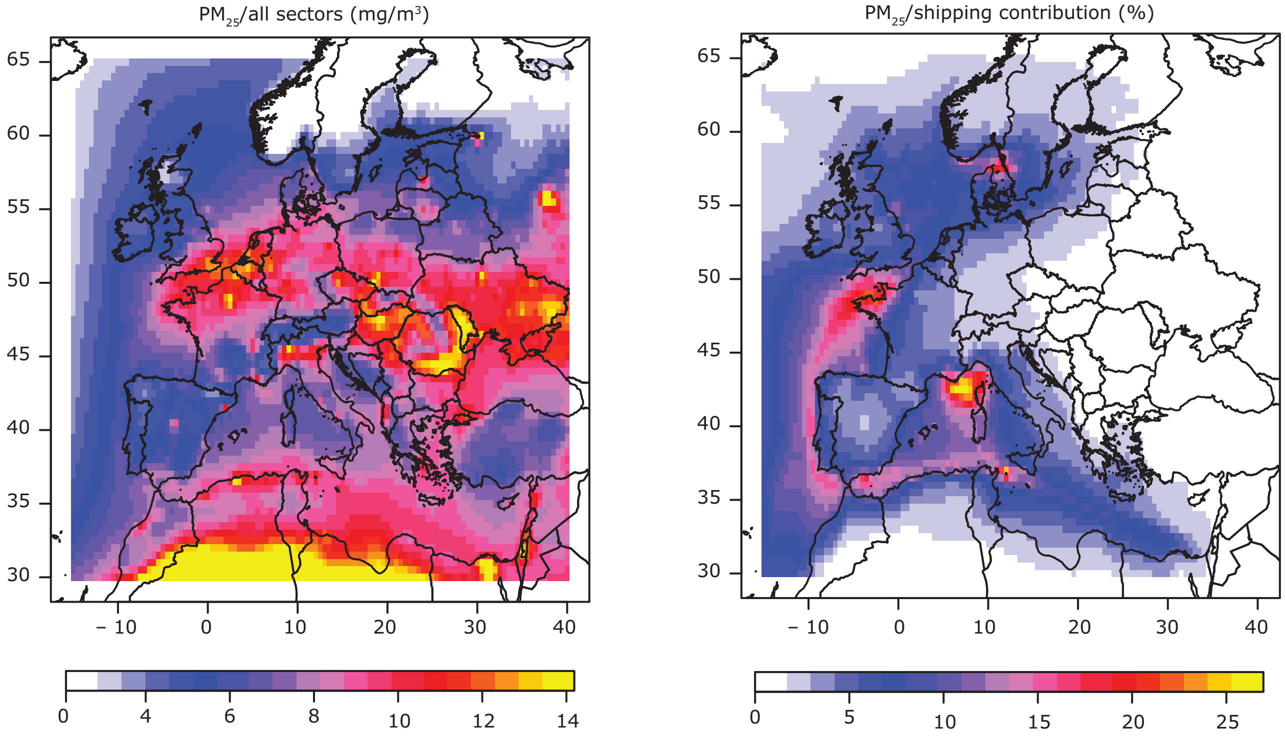
Ship emissions are a dominant contributor over much of the world's oceans to surface concentrations of NO_2 and SO_2, with a large contribution over some coastal zones. In 2004, global shipping emissions were estimated to contribute to ground level O_3 by 5 % to 15 % in western Europe and to nitrogen through precipitation by 25 % to 50 % and 25 % to 35 % in coastal regions of Scandinavia and south-west Europe respectively. Ships contribute to total sulphur deposition in these regions by 10 % to 25 % (Dalsoren, 2009).

A study that assessed population exposure and mortality rates due to regional background primary $PM_{2.5}$ and secondary inorganic PM concentrations within the European Monitoring and Evaluation Programme (EMEP) domain during the period 1997–2003, estimated that primary $PM_{2.5}$ and secondary PM concentrations from international shipping represented 9 % and 12 %, respectively of the total seven year average concentrations in Europe respectively. Secondary PM concentrations originating from international shipping were found to be higher off-shore than over land, affecting a much larger area than primary particles. The inter-annual variability for both primary and secondary concentrations is approximately 6 % to 7 %, and depends on both emissions and meteorology (Andersson et al., 2009). Modelled concentrations of $PM_{2.5}$ shows that shipping contribution can be as high as 25 % (see Map 6.1).

The importance of shipping emissions is further exemplified in a review of scientific papers focusing on air and climate impacts from the maritime sector (Eyring et al., 2009). For example, the contribution of NO_X and VOC shipping emissions to summertime mean surface O_3 concentrations has been found to vary from 5 % to 15 % in coastal areas of north-western Europe. In addition, in the Mediterranean region during summer, primary ship emissions are high and production of secondary sulphate aerosols from shipping accounts for 54 % of the mean sulphate aerosol concentration.

As described in Box 6.4, there are various policies in place for controlling pollutant emissions from ships. In particular, the revised MARPOL Annex VI is expected to reduce SO_2 emissions from ships considerably. As a result of the implementation of the revised MARPOL Annex VI in the European Monitoring and Evaluation Programme (EMEP) domain, 2015 PM_{10} concentrations are expected to

Map 6.1 Modelled concentration of total $PM_{2.5}$ (µg/m³) and relative contribution attributed to the shipping sector (%)



Notes: The relative contribution of the shipping sector is computed by comparing a reference simulation including all activity sectors and a simulation where all the emissions induced by the shipping activities are set to zero. More details in Annex 1.

Source: The shipping sector's impact on air quality and climate change (EEA Technical report in preparation) decrease by 20 % to 30 % in coastal areas around the North Sea, English Channel and Baltic Sea, and by up to 10 % in the northern part of Europe. In the Mediterranean, which is not currently a designated Sulphur Emission Control Area (SECA) for shipping, PM_{10} concentrations are expected to rise as a result of increasing formation of secondary inorganic aerosol arising from SO_2 emissions.

In 2020, PM_{10} concentrations are expected to decrease further with the largest reductions seen in non-SECA coastal areas, i.e. the Mediterranean Sea, the Black Sea and the remaining North-Atlantic as a result of a stricter worldwide sulphur limit (AEA, 2009). This limit will take effect in 2020, unless a decision is taken that it is not possible for ships to comply by that date.

6.3 Effects of aviation emissions on air quality

Emissions from the aviation sector contribute very little to EU-27 total emissions. International and national aviation (including both the LTO and cruise cycle) was responsible for around 4 % of NO_X emissions, and less than 1 % of SO_2 emissions, VOC emissions, PM emissions and CO emissions in EU Member States in 2010 (TERM 03). Emissions of CO and VOC from aviation are generally low, when compared with emissions from other transport modes. NO_X emissions are relatively high when compared to other pollutants, even though the International Civil Aviation Organisation (ICAO) has established aircraft engine emission standards for NO_X and has gradually made these more stringent over time. Nevertheless aviation continues to be a growth sector and it is important to have appropriate policies in place to control pollution (see Box 6.5).

When compared to other transport modes, a key difference for aviation is that aircraft emissions occur at different altitudes as emissions are released during the whole flying cycle. Activities below 3 000 feet (i.e. about 915 m) are commonly referred to as the LTO cycle, comprising taxi-out, take-off, climb out, landing approach and taxi-in. Activities that take place at altitudes above 3 000 feet include the climb out, cruise and descent.

The effect of aircraft emissions on local air quality around airports has been discussed in Section 5.3. It should be noted that emissions above 3 000 feet are typically not considered when undertaking local air quality assessments for airports. However, it has been estimated that NO_X and SO_2 emissions in the non-LTO phases are dominant and constitute over 90 % of the total aircraft emissions in Europe, whilst for CO and non-methane VOCs emissions were estimated to be about 40 % of total emissions. Global non-LTO NO_X emissions have a small but still significant impact on surface air quality in Europe; more specifically they contribute 1 % to average annual secondary inorganic aerosol, NO_2 and O_3 concentrations. The contribution of LTO emissions from aviation is generally an order of magnitude smaller; thus considered to be of little significance for European air quality at a regional scale.

However, specifically for NO_2 concentrations in the vicinity of airports, European non-LTO and LTO NO_X emissions have been estimated to contribute 1 % to 2 % to surface concentrations (Tarrasón et al., 2004) though at some large airports such as Heathrow the combined contribution of emissions from aircraft and other airport operations make a larger contribution to surface concentrations of NO_2 (Carslaw et al., 2006) (see Section 5.3).

Box 6.5 Key policies for controlling emissions from the aviation sector

Pollutant emissions from aircraft are regulated by the International Civil Aviation Organisation (ICAO) through its Committee on Aviation Environmental Protection (CAEP). Emission standards for engines are currently in place for smoke, unburned hydrocarbons (HCs), CO and NO_X during the LTO cycle. For the latter, since its first introduction in the 1980s, the NO_X standard has been reduced by 50 %. An aircraft CO_2 emissions standard is expected to be established by 2013 (ICAO, 2010). A PM certification standard is expected to be established by 2016.

The EU ETS Directive (2003/87/EC) and its subsequent amendments established an emission trading system that sets a limit on the total amount of certain GHGs emitted by the sectors covered. Aviation is one of these sectors, so airlines receive tradeable emission allowances for a certain level of CO_2 emissions and after a year need to surrender a number of allowances equal to actual emissions. This measure may reduce fuel consumption, which could reduce air pollution; however, more fuel-efficient engines tend to operate with a higher pressure ratio and emit more NO_X. Furthermore, the low carbon sustainable fuels target for the sector (EC, 2011a) may also reduce emissions of the air quality pollutants SO_2 and PM due to their lower sulphur content (SWAFEA, 2011). In addition, the deployment of the modern air traffic management infrastructure, the Single European Sky ATM Research (SESAR) project by 2020 is expected to achieve 10 % of fuel savings, leading to a 10 % reduction of CO_2 emissions per flight (Eurocontrol, 2010).

7 Main messages and conclusions

The TERM 2012 report seeks to provide the first assessment of progress towards transport-related targets from a range of policy documents and legislation identified in the TERM 2011 report (see Annex 2).

For a number of these targets, the means and methodology to measure progress has yet to be refined. However, it has been possible to measure progress towards the key target of reducing GHG emissions, and some of the indicative targets.

Progress towards meeting the GHG reduction target can be assessed by comparing current GHG emissions from transport against a 'target path'. This is defined as the estimated line of progress from the base year until the target year, and with the exception of the transport GHGs reduction target, this is set as a straight line from the base year to the target year (considering mid-term targets where available). The 'target path' for reducing 60 % of GHG emissions from transport by 2050 (including aviation but excluding international maritime emissions) has been taken from the European Commission's impact assessment supporting the White Paper on Transport (EC, 2011d).

Where data are available, progress has been mixed. Transport energy consumption actually rose slightly in 2011 compared to 2010, while overall transport GHG emissions (excluding maritime) in 2010 only reduced by 0.4 % compared to 2009. The base year for all of the targets is still relatively recent, with trends still uncertain for this period. Moreover, recent improvements in GHG can be mainly attributed to the economic recession.

When comparing progress with each 'target path', transport GHG values (one for maritime emissions and one for transport, including aviation, but excluding maritime) for 2009 and 2010 reduction target are in line with their target path. This is the case also for the target set for CO_2 type-approval emissions from new passenger cars, where legislation proves to be effective also for the latest year available (2011). Meanwhile, reaching the targets to reduce transport oil consumption and the 10 % share of renewable energy in the transport sector for each Member State are both showing modest progress, although not enough to meet the desired levels when compared with their 'target path' values for 2010.

A range of alternative fuels are required in the market, including electricity, hydrogen biofuels, methane (compressed natural gas (CNG) and biomethane), LPG and others. However, market penetration depends on the availability of appropriate infrastructure, which should be in line with technology developments and market penetration rates of vehicles powered by alternative fuels. Appropriate support at the Member State and EU level is required to increase uptake of alternative fuels (i.e. fiscal incentives for consumers, provision of infrastructure, etc.), as well as ensuring that potential consumers are able to compare alternatively fuelled vehicles with conventional vehicles (i.e. through labelling). The proportion of alternatively fuelled vehicles has increased to just over 4 % of all vehicles in 2010 (based on selected EEA member countries). In 2010 and 2011, sales of electric vehicles increased significantly (from less than 200 vehicles to almost 9 000 in the EU-27) while those of LPG and CNG declined sharply

The results observed in the TERM core set of indicators indicate a minor reduction of negative environmental impacts of transport. Due to the limited degree of this reduction, and the passenger and freight transport demand values, the reduction in negative environmental effects from transport can be essentially attributable to efficiency gains (including improvement in logistics and vehicle performance, introduction of more efficient vehicles, and use of less tailpipe-GHG-intensive fuels). Overall, the challenge remains to prevent an increase of negative environmental impacts once the economic climate improves across the European Union. In addition to improvements in technology, transport demand also needs to be optimised by means of a modal shift, moving transport from more environmentally harmful modes to less environmentally harmful modes.

Air pollutant emissions from transport are also of great concern. Key air pollutants emitted from combustion engines in all modes of transport include NO_X, PM, CO and VOCs. Non-exhaust emissions of PM are also released due to the mechanical wear of brakes, tyres, and road surfaces. PM emissions from mechanical wear of this sort are not currently regulated. In addition, transport sources of air pollutants affect air quality over a much wider area than the local environment by emitting pollutants that undergo atmospheric transformation processes. This can occur up to several days after their initial release. Road transport contributes the most to background PM pollution, but the contribution of shipping to secondary PM on land and formation of ground level O_3 is also significant.

The EU has introduced and implemented various legal instruments in order to achieve levels of air quality that do not adversely impact human health and the environment. As a result of these policies, air pollutant emissions in Europe have decreased considerably over the past decades, resulting in improved air quality. However, due to complex links between emissions and air quality, as well as a number of uncertainties associated with emission estimates, reductions have not always produced a corresponding decline in ground level concentrations of air pollutants. For example, the decrease in NO_X transport emissions (which fell by 27 % between 2001 and 2010 in the EU) is considerably greater than the fall in NO_2 annual mean concentrations (which fell by approximately 8 % measured at stations close to traffic, between 2001 and 2010) (EEA, 2012b). This can be attributed to the fact that emission standards for diesel vehicles have not delivered the improvements anticipated under real-world conditions (including the increased proportion of NO_X emitted directly as NO_2 from the exhaust of more modern diesel vehicles).

Action to reduce emissions (GHG, air pollutants and noise) from vehicles through shifting to alternative modes (the 'shift' principle) and to cleaner fuels and improved vehicle technology (the 'improve' principle), should be complemented by better managing transport demand (the 'avoid' principle). The TERM 12a/b and TERM 13a/b indicators monitor passenger and freight transport demand respectively. The passenger transport indicator shows that passenger transport demand has been increasing steadily since 1995. A marginal decline only started in 2010, most likely due to the sharp rise in fuel prices and as a reaction to the economic crisis where increasing unemployment meant less commuting. A similar upward trend was seen for freight transport volumes, with a downturn in demand from 2007. This can be attributed, in all likelihood, to the economic slowdown but also in response to rising fuel prices. As transport demand is linked to both economic activity in society, and to average trip distances, it can indicate the success of 'transport avoidance' policies. If transport demand grows slower than the economy it indicates an increase in the efficiency with which we use transport (e.g. shorter trips for the same purpose), while increases above the economic growth rate indicate that we are becoming less efficient (e.g. longer trips for the same purpose). It is therefore important to continue to monitor transport demand and its links to economic growth as a way of assessing the resource efficiency of our economy's use of transport.

Acronyms and abbreviations

ACEA	European Automobile Manufacturers' Association
APU	Auxiliary power units
BaP	Benzo(a)pyrene
BEV	Battery electric vehicle
CAEP	Committee on Aviation Environmental Protection
CH_4	Methane
C_6H_6	Benzene
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-equivalent	Carbon dioxide equivalent
dB	Decibel
DG CLIMA	Directorate-General for Climate Action
DG ENER	Directorate-General for Energy
DG MOVE	Directorate-General for Mobility and Transport
DPF	Diesel particulate filter
DPSIR	Driving forces, pressures, state of the environment, impacts and societal responses
EC	European Commission
ECA	Emission Control Areas
EEA	European Environment Agency
EEDI	Energy Efficient Design Index
EFTA	European Free Trade Agreement
EGR	Exhaust gas recuperation
ELV	End-of-life-vehicle
EMEP	European Monitoring and Evaluation Programme
EU-ETS	European Emissions Trading Scheme
ETS	Emissions Trading Scheme
EV	Electric vehicle
FQD	Fuel Quality Directive
GDP	Gross domestic product
GHG	Greenhouse gas
HC	Hydrocarbons
HDV	Heavy duty vehicle
HFCV	Hydrogen fuel cell vehicles
HGV	Heavy goods vehicle
HSR	High speed rail
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
IWW	Inland waterways
JRC	Joint Research Council

ktoe	kilo tonne oil equivalent
LEZ	Low Emission Zone
L_{den}	Day-evening-night noise indicator
L_{night}	Night time noise indicator
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LRTAP	Long-range Transboundary Atmospheric Pollution
LTO	landing take-off
LV	Limit value
MARPOL	International Convention for the Prevention of Pollution from Ships
MJ	Megajoule
MTOE	Mega tonne oil equivalent
Mt CO_2-equivalent	Million tonnes of CO_2-equivalent.
NECD	National Emission Ceilings Directive
NEDC	New European Drive Cycle
NG	Natural gas
NH_3	Ammonia
NMVOC	Non-methane volatile organic compound
NO	Nitrogen monoxide
N_2O	Nitrous oxide
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbons
PEMS	Portable Emission Measurement System
PM	Particulate matter
$PM_{2.5}$	Particulate matter with a diameter of 2.5 micrometers or less
PM_{10}	Particulate matter with a diameter of 10 micrometers or less
pkm	Passenger-kilometres
POP	Persistent organic pollutants
ppm	Parts per million
RED	Renewable Energy Directive
SCR	Selective catalytic reduction
SECA	Sulphur Emission Control Area
SEEMP	Ship Energy Efficiency Management Plan
SESAR	Single European Sky ATM Research
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
TERM	Transport and Environment Reporting Mechanism
TERM-CSI	Transport and Environment Reporting Mechanism — Core Set of Indicators
tkm	Tonne-kilometres
UIC	International Union of Railways
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compound
WHO	World Health Organization
WLTP	Worldwide harmonised Light-duty Test Procedure
WtW	Well to Wheels

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Annex 1 Metadata and supplementary information

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

- EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.
- EU-10: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.
- EU-12: EU-10, Bulgaria and Romania.
- EFTA-4: Iceland, Liechtenstein, Norway and Switzerland.
- EU-25: EU-15 and EU-10.
- EU-27: EU-15 and EU-12.
- EEA-32: EU-27, EFTA-4 and Turkey.

Chapter	Supplementary information	
1 Introduction	**Figure 1.1** **Source:**	**Conceptual map for the TERM approach: TERM 2012 structure** EEA, 2012
2 TERM Core Set of Indicators	**Table 2.1** **Source:**	**TERM Core Set of Indicators (TERM-CSIs)** EEA, 2012
	Table 2.2 **Note:** **Source:**	**Transport goals overview** Progress towards meeting transport specific targets from policy and legislation. Data from various sources. EEA, 2012
	Table 2.3: **Note:** **Source:**	**Targets that cannot yet be monitored** Information regarding transport specific targets from policy and legislation for which no monitoring data are currently available. **EEA, 2012**
	Box 2.1 **Source:**	**Discussion on target paths on progress towards goals** EEA (2012)
	Box 2.2 **Note:** **Source:**	**TERM 01 Figure** EU-27 plus Norway, Switzerland and Turkey. Covers the years 1990, 1995, 2000, 2005, 2007, 2008, 2009, 2010 and 2011. EEA indicator, TERM 01. Based on data (tables NRG_100A and nrg_102m) from Eurostat (2012)
	Box 2.3 **Note:** **Source:**	**TERM 02 Figure** EU-27 emissions of GHG emissions from 1990. EEA indicator, TERM 02. http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer
	Box 2.4 **Note:** **Source:**	**TERM 03 Figure** EEA-32 data for 1990–2010 from reporting under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP). EEA indicator, TERM 03. http://www.eea.europa.eu/data-and-maps/data/data-viewers/air-emissions-viewer-lrtap
	Box 2.5 **Note:** **Source:**	**TERM 04 Figures** EEA-32 Annual mean NO_2 and PM_{10} concentrations observed at traffic stations, 2010. EEA indicator, TERM 04. Based on data from AirBase v5, Urban Audit.
	Box 2.6 **Note:** **Source:**	**TERM 05 Figure** Current base year/date: 2007 EEA indicator, TERM 05. Based on data from Noise Observation and Information Service - NOISE
	Box 2.7 **Note:** **Source:**	**TERM 12a/b Figure** Passenger transport passenger-km for the EU-27 for 1995, 2000, 2005 and 2010. EEA TERM 12a/b indicator, DG MOVE statistical pocketbook (2012).

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	Box 2.8	**TERM 13a/b Figure**
	Note:	Freight transport tonne-km for the EU-27 for 1995, 2000, 2005 and 2010.
	Source:	EEA TERM 13a/b indicator, DG MOVE statistical pocketbook (2012).
	Box 2.9	**TERM 20 Figure**
	Note:	EU-27 real change in transport prices. Data series covers 1996–2011. Evolution of transport prices for consumers (2005 = 100), Harmonised Indices of Consumer Prices (HICP). Real price indices of passenger transport in the EU-27 Member States, relative to overall consumer price index (CP00: all items, global index)
	Source:	EEA indicator, TERM 20. Based on data from Eurostat (2012) Harmonised Indices of Consumer Prices.
	Box 2.10	**TERM 21 Figure**
	Note:	Coverage is EU-27 for 1980–2012.
	Source:	EEA indicator, TERM 21. Based on data from Eurostat (2012).
	Box 2.11	**TERM 27 Figure**
	Note:	Average CO_2 emissions for new cars sold in the EU-27 for 2000–2011.
	Source:	EEA indicator, TERM 27. Based on data from European new passenger car CO_2 monitoring compiled by EEA and DG CLIMA.
	Box 2.12	**TERM 31 Figure**
	Note:	Coverage is EU-27 for 2009–2010.
	Source:	EEA indicator, TERM 31. Based on data from Eurostat [tsdcc340] — Share of renewable energy in fuel consumption of transport (2012)
	Box 2.13	**TERM 34 Figure (cars)**
	Note:	Includes data for 17 of the EEA-32 member countries: Belgium, Estonia, France, Italy, Latvia, Luxembourg, Hungary, the Netherlands, Austria, Poland, Finland, Sweden, the United Kingdom, Liechtenstein, Norway, Switzerland, and Turkey. Data covers the period 2004–2010, since data prior to this (back to 2000) had significant additional data gaps.
	Source:	EEA indicator, TERM 34. Based on data from Eurostat (2012)
	Figure:	Thousands of vehicles newly registered by alternative fuel type, EU-27
	Note:	Thousands of vehicles registered by alternative fuel type, EU-27.
	Source:	EEA (2012).
3 Passenger and freight transport demand and modal split	**Figure 3.1**	**Freight transport volumes and GDP (EEA-32 excluding Liechtenstein)**
	Note:	Data from Liechtenstein is not included as it was not available as part of the dataset. GDP is expressed in euros at 2000 prices. Freight transport is defined as the amount of inland tonnes-kilometre (road, rail, inland waterways) travelled every year in the EEA-32. Data for short-sea shipping and pipelines are not included. The two curves show the development in GDP and freight transport columns, while the columns show the level of annual decoupling. Green indicates faster growth in GDP than in transport while blue indicates stronger growth in transport than in GDP. The large change in 2004 appears to be tied to a change in methodology but no correction figure exists.
	Source:	EEA Core Set Indicator 036 (based on Eurostat, 2012).
	Figure 3.2	**Freight modal split between road and rail**
	Note:	Percentage share of land freight transport between road and rail transport mode for EU-12, EU-15 and combined EU-27.
	Source:	EEA Core Set Indicator 036 (based on Eurostat, 2012).
	Figure 3.3	**Trends in passenger transport demand and GDP (EEA-32 excluding Liechtenstein)**
	Note:	Data from Liechtenstein is not included as it was not available as part of the dataset. GDP is expressed in euros at 2000 prices. Passenger-kilometres includes transport by road, rail and bus. There is no agreement among the EU Member States on how to attribute the passenger-kilometres of international intra-EU flights, therefore aviation data are not included in the figure. The two curves show the development in GDP and passenger transport volumes, while the columns show the level of annual decoupling. Green indicates faster growth in GDP than in transport while blue indicates stronger growth in transport than in GDP.
	Source:	EEA Core Set Indicator 035 (based on Eurostat, 2012).
	Figure 3.4	**Passenger transport modal split**
	Note:	Passenger transport modal split, excluding Liechtenstein.
	Source:	EEA Core Set Indicator 036 (based on Eurostat, 2012).
4 Air quality policy review and transport relevance	**Figure 4.1**	**The contribution of the transport sector to total emissions of the main air pollutants in 2010 (EEA-32)**
	Note:	Labels are not shown for those transport sub-sectors contributing < 1 % to total emissions. Data for 2010, coverage: EEA-32.
	Source:	EEA indicator TERM 03. EEA (2012). Data from LRTAP data viewer http://www.eea.europa.eu/data-and-maps/data/data-viewers/air-emissions-viewer-lrtap online

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	Figure 4.2	**Trends in diesel NO_x emission factors and type approval emission Standards**
	Note:	The NO_x emissions limit for a Euro 2 diesel car is deduced as the limit was set for combined pollutants (HC + NO_x) and the test procedure changed between Euro 2 and Euro 3. The trend of NO_x emission factors is based on emission functions provided by COPERT 4 at speed 33.6 km/h.
	Source:	AEA. NO_x emission factors obtained from COPERT 4 version 8.1. Emission limits data from relevant European directives.
	Box 4.4	**Potential climate interaction and co-benefits from different technologies**
	Note:	The information included in this table is the result of a literature review undertaken by Emisia, 2012 (European Topic Centre for Air and Climate Mitigation (ETC/ACM)).
	Sources:	EEG-FTF, 2011; EC, 2009b; EC, 2009c; Yanowitz and McCormick, 2009; EPA, 2002; Vonk, W.A., Verbeek, R.P., Dekker, H.J., 2010; Ricardo, 2011; Ntziachristos, L., Gkatzoflias, D., Kouridis, C. and Samaras, Z., 2009; Ntziachristos L and DilaraP, 2012; Van Vliet, O., Brouwerb, A.S., Kuramochi, T., Van den Broek, M. and Faaij, A., 2011; Thiel, C., Perujo, A. and Mercier, A., 2010; Lipman, T.E. and Delucchi, M.A., 2010; Garraín, D., Lechón, Y. and de la Rúa, C., 2011 ; Jaramillo, P., Samaras, C., Wakeley, H. and Meisterling, K., 2009; JRC, 2008; Van Vliet, O.P.R., Kruithof, T., Turkenburg, W.C. and Faaij, A. P. C., 2010; Westerholm R et al., 2007; EMEP/EEA emission inventory guidebook, 2009.Lejon, S., Svärd, A., Sandström-Dahl, L. and Tuominen, J., 2009.; Zervas, E. and Panousi, E., 2010; Bach, C., Alvarez, R., Winkler, A., 2010; Mellios, G., Hausberger, S., Keller, M., Samaras, C., Ntziachristos, L., 2011.
5 Local effects of transport on urban air quality	**Figure 5.1**	**Trends in NO_2 and PM_{10} concentrations at urban background and traffic locations**
	Note:	Trends in NO_2 and PM_{10} concentrations at urban background and traffic locations. Eight cities: Brussels, London, Madrid, Munich, Paris, Prague, Rome and Vienna
	Source:	EEA TERM04 (2012)
	Figure 5.2	**Daily variation (in µg/m³) of PM_{10} concentrations in 2009**
	Note:	Daily variation (in µg/m³) and exceedances of PM_{10} concentration during 2009, for five cities: Venice, Barcelona, Thessaloniki, Genoa and Marseille. The red line shows the daily limit value. In all ports concentrations were found to be lower on Sundays due to lower vehicle circulation.
	Source:	APICE (2010) Available online at: http://www.apice-project.eu/img_web/pagine/files/Results/Apice_WP3%20Report.pdf
6 Regional scale effects of transport on air quality	**Map 6.1**	**Modelled concentration of total $PM_{2.5}$ (µg/m³) and relative contribution attributed to the shipping sector (%).**
	Note:	Modelled concentration of total $PM_{2.5}$ (µg/m³) and relative contribution attributed to the shipping sector (%). The results are based on a simulation with the Chemistry Transport Model CHIMERE (Bessagnet et al., 2008) using anthropogenic emission of the Global Energy Assessment for the present day (Riahi et al.,2012) and the meteorological year 2007 (Re-analysis providing reference global meteorological fields for the past years-interim reanalyses of European Centre for Medium Range Weather Forecast downscaled with the Weather Research and Forecast mesoscale meteorological model). The relative contribution of the shipping sector is computed by comparing a reference simulation including all activity sectors and a simulation where all the emissions induced by the shipping activities are set to zero. (Skamarock et al., 2008)
	Source:	The shipping sector's impact on air quality and climate change (EEA Technical report in preparation).
Annex 4	**Source:**	EEA, 2012b.

Annex 2 Relevant transport targets up to 2050

Target	Target date	Source	Relevant indicator	Comments
Transport GHG (including international aviation, excluding international maritime shipping) 20 % ↓ (versus 2008) 60 % ↓ (versus 1990)	 2030 2050	Transport White Paper (EC, 2011a), 2050 Roadmap (EC, 2011b)	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 White Paper on Transport on the basis of the 2050 Roadmap.
EU CO_2 emissions of maritime bunker fuels 40 % ↓ (versus 2005)	2050	Transport White Paper (EC, 2011a)	TERM 02	
40 % share 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 50 % ↓ 100 % ↓	 2030 2050	Transport White Paper (EC, 2011a)	TERM 34	The White Paper goal relates not to vehicle numbers but to share in urban passenger kilometres
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 30 % shift 50 %+ shift	 2030 2050	Transport White Paper (EC, 2011a)	TERM 13a/b	Only indirectly monitored through modal shares
10 % share of renewable energy in the transport sector final energy consumption for each Member State	2020	Renewable Energy Directive 2009/28/EC (EC, 2009b)	TERM 31	
Fuel suppliers to reduce lifecycle GHG of road transport fuel 6–10 % ↓ (versus 2010 fossil fuels)	2020	Fuel Quality Directive 2009/30/EC (EC, 2009c)	TERM 31	To be monitored in future indicator updates
Target average type-approval emissions for new passenger cars 130 g CO_2/km 95 g CO_2/km	 2012–2015 2020	Passenger Car CO_2 EC Regulation 443/2009 (EC, 2009a)	TERM 27 and TERM 34	Phased in between 2012 (65 %) and 2015 (100 %)
Target average type-approval emissions for new light vans 175 g CO_2/km 147 g CO_2/km	 2014–2017 2020	Van CO_2 EC Regulation 510/2011 (EC, 2011c)	TERM 27 and TERM 34	To be monitored in future indicator updates
70 % reduction of transport oil consumption from today	2050	Impact assessment-accompanying document to the White Paper (EC, 2011d)	TERM01	This is interpreted as a 70 % drop in oil consumption in the transport sector from 2009 levels, as it is the latest data available

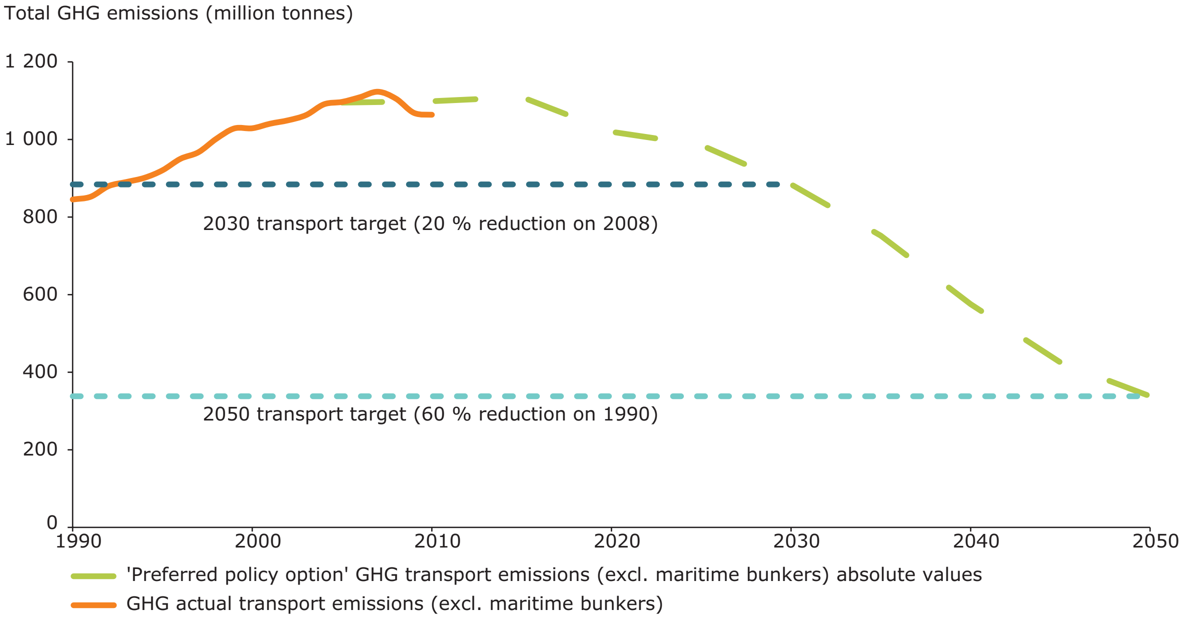
Annex 3 Explaining the target paths

Reducing transport GHG emissions:

The row 'Where we are (current trends vs. target path)' is marked green in the 'observed' cell for the years 2009 and 2010 because the latest data shows a value below that of the target path (defined by the *preferred policy option* — Policy Option 4) for these years. The graph below shows that the reduction achieved for both years is in line with the estimations done for both years 2009 and 2010 (i.e. actual data for 2009 and 2010 show further reductions than the '*preferred policy option*' value for both years).

The final row 'latest annual trend', is marked in green because the latest data (2010) shows a slight improvement compared to the previous year (2009).

			Key target	
Source			2050 Roadmap (EC, 2011b) and Transport White Paper (EC, 2011a), 2050	
Target			Transport GHG (including international aviation, excluding international maritime shipping)	
Unit			Mt CO_2	
Where we were	**Base year**	**Value**	1 105	845
		Year	2008	1990
Where we want to be	**Target**	**Value**	884 (– 20 %)	338 (– 60 %)
		Year	2030	2050
Where we are (current trends vs. target path)	**2011**	**Observed**	n.a.	
		Target path	1 101	
	2010	**Observed**	1 064	
		Target path	1 098	
	2009	**Observed**	1 068	
		Target path	1 098	
Latest annual trend			– 0.5 %	



Summary of the 'preferred policy option' (Policy Option 4) included in the Impact Assessment, text extracted from the Accompanying document to the White Paper 'Roadmap to a Single European Transport Area Towards a competitive and resource efficient transport system (EC, 2011d):

In short, Policy Option 4 '*the preferred policy option*' assumes full internalisation of externalities and elimination of distortions in taxation, in particular concerning VAT on international passenger transport, vehicle taxation and company car taxation. Similarly to Policy Option 2, it also includes policies with a strong focus on the completion of the internal market, infrastructure development. Like Policy Options 2 and 3, this policy option also relies on locally determined policies (pricing, support to public transport and non-motorised modes, integrated land planning) in urban areas. The intensity of the policy measures in urban transport is derived residually to achieve the 60% reduction target. However, the main difference compared to the rest of Options comes from the assumption that vehicles in all modes will be subject to CO_2 standards up until 2050. Battery costs for electric vehicles are assumed to be half way between Policy Options 2 and 3, to reflect an intermediate level of intensity of R&D policies.

Policy Option 4, as the rest of the policy options considered, covers all policy areas identified in which concrete policy measures could have a key role in stimulating the expected shift of the transport system to another paradigm. These policy areas are: pricing, taxation, research and innovation, efficiency standards and flanking measures, internal market, infrastructure and transport planning. However, the intensity of the measures is intermediate with respect to Policy Options 2 and 3, thus envisaging a balanced contribution of system improvement and technology measures to achieve the objectives set out. Measures influencing transport activity and modal choice, as well as those improving energy efficiency in a given mode and the carbon intensity of transport fuels are applied throughout the period gradually, reflecting the tightening constraint on CO_2 emissions.

Policy Option 4 can be described as eliminating distortions through pricing, CO_2 taxation and internalisation measures, but can also be characterised by investment in non-road infrastructure, relatively stringent CO_2 standards for all vehicles and relatively high investment in R&D.

On the other hand, Policy Options 2, 3 and 4 include the same energy price environment as the 'Effective and widely accepted technology' scenario from the Impact Assessment on 'Low-carbon economy 2050 roadmap' In the 'Effective and widely accepted technology' scenario, with global climate action, lower energy demand is assumed to keep energy prices at lower levels relative to the Reference scenario. Oil price is assumed to be 80 USD/barrel in 2030 and USD 70 per barrel in 2050 (in year 2008-dollars).

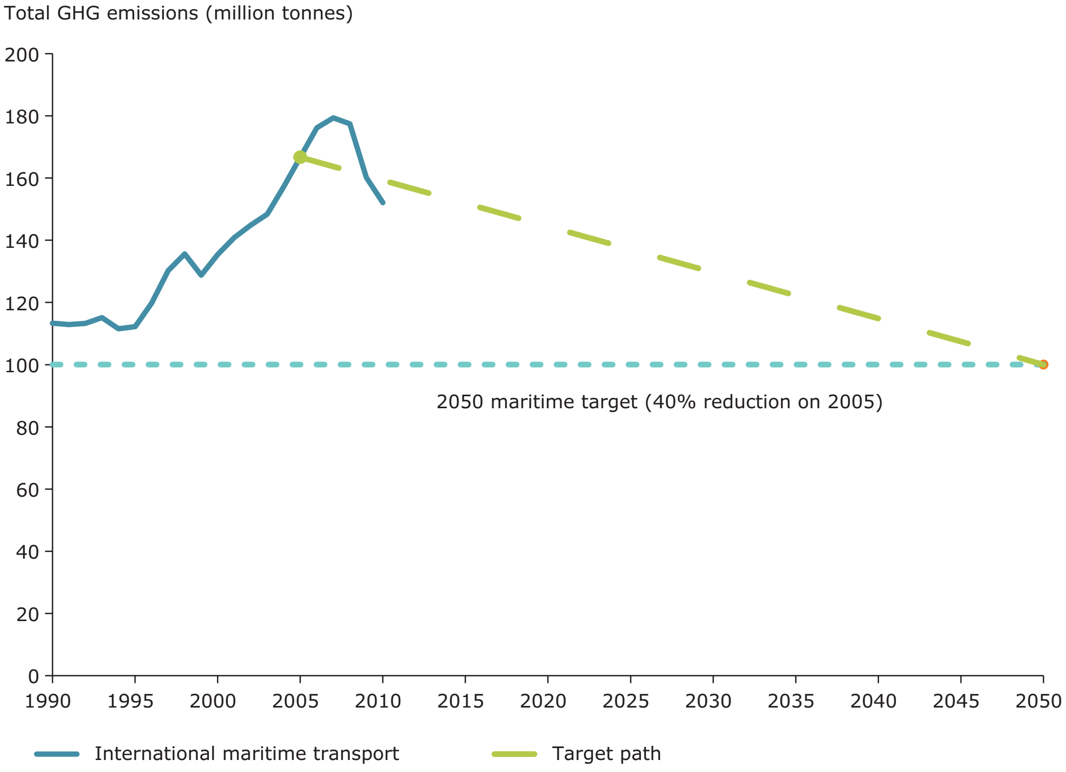
The European Commission is stating that a modelling exercise has been undertaken to provide a stylised quantitative assessment of the effectiveness and efficiency of the identified Policy Options. Modelling results build on established modelling frameworks including PRIMES, TRANSTOOLS, the PRIMES-TREMOVE transport model, TREMOVE and GEM-E3. A short description of each model is provided in the Transport White paper impact assessment (EC, 2011d). To this end, the European Commission has modelled the impact of the possible policy measures assuming a specification that does not necessarily correspond to what would actually be proposed at a later stage. Indeed, the precise specification of the policy measures referred to in the White Paper will be done at a later stage, following a more specific analysis and an individual Impact Assessment. In this sense, it is said that all Policy Options include a technology component that is low in Policy Option 2, moderate in Policy Option 4 and high in Policy Option 3. In this respect, if the technology does not deliver as it is projected in Policy Option 4, an approach closer to that in Policy Option 2 will be necessary in order to achieve the 60 % target by 2050. Policy Option 2 has a strong focus on the completion of the internal market, infrastructure development, pricing and taxation. The 60 % CO_2 emission reduction target is achieved largely through improved efficiency within each mode, better logistics, modal shift and reduced mobility.

EU CO_2 emissions of maritime bunker fuels

The row 'Where we are (current trends vs. target path)' is marked in green in the 'observed' cell for the years 2009 and 2010 because the latest data shows a value below that of the target path (defined by a straight line interpolation between the base year data and the target value by 2050) for these years. The graph below shows that the reduction achieved for both years is in line with the estimations done for both years 2009 and 2010 (i.e. actual data for 2009 and 2010 show further reductions than the 'target path' value for both years).

The final row 'latest annual trend', is marked in green because the latest data (2010) shows a slight improvement (5.1 % reduction) compared to the previous year (2009).

			Indicative goals
Source			Transport White Paper (EC, 2011a)
Target			EU CO_2 emissions of maritime bunker fuels
Unit			Mt CO_2
Where we were	**Base year**	**Value**	167
		Year	2005
Where we want to be	**Target**	**Value**	100 (– 40 %)
		Year	2050
Where we are (current trends vs. target path)	**2011**	**Observed**	n.a.
		Target path	158
	2010	**Observed**	152
		Target path	159
	2009	**Observed**	160
		Target path	161
Latest annual trend			– 5.1 %

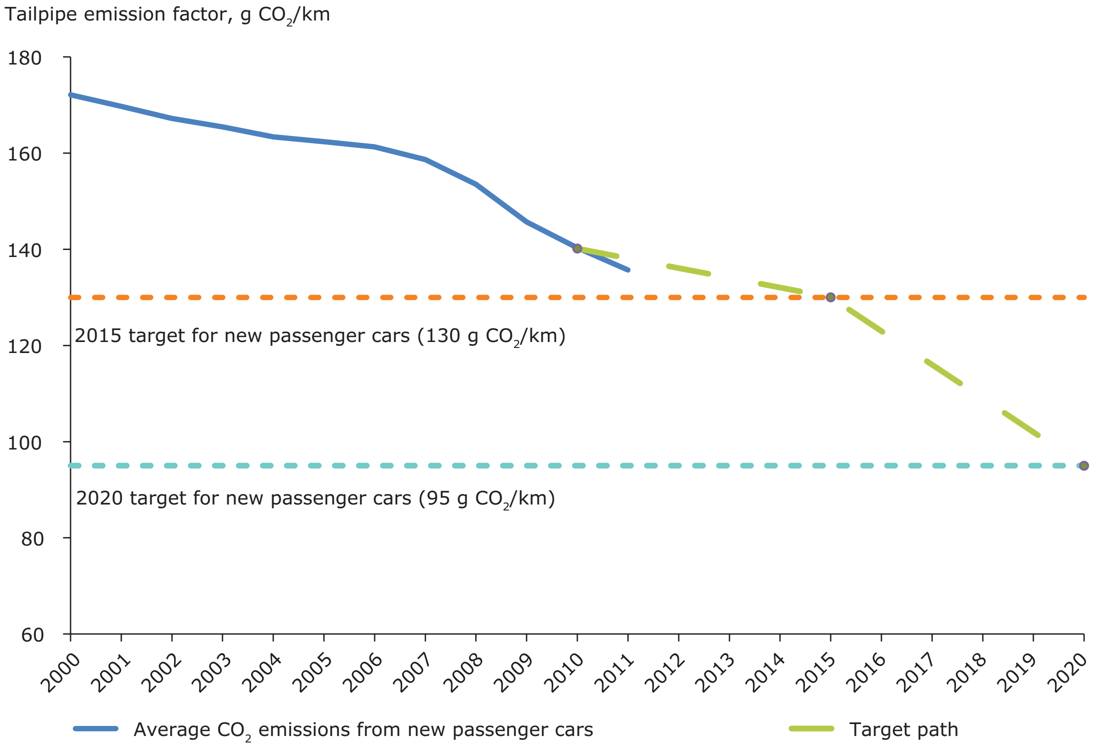


Target average type-approval CO_2 emissions for new passenger cars

The row 'Where we are (current trends vs. target path)' is marked in green for both 2010 and 2011 years because the 'observed' data show a value below that of the target path for both years. The graph shows that the reduction achieved is in line with what would be needed if a straight line trend towards the target (in this case intermediate target for the year 2015) is assumed.

The final row 'latest annual trend', is marked in green because the latest data (2011) shows a reduction in the average emissions compared to 2010 (3.3 % reduction).

			Indicative goals
Source			Passenger car CO_2 EC Regulation 443/2009 (EC, 2009a)
Target			Target average type-approval emissions for new passenger cars
Unit			g CO_2/km
Where we were	**Base year**	**Value**	140
		Year	2010
Where we want to be	**Target**	**Value**	130 95
		Year	2015 2020
Where we are (current trends vs. target path)	**2011**	**Observed**	136
		Target path	138
	2010	**Observed**	140
		Target path	140
	2009	**Observed**	146
		Target path	n.a.
Latest annual trend			– 3.3 %

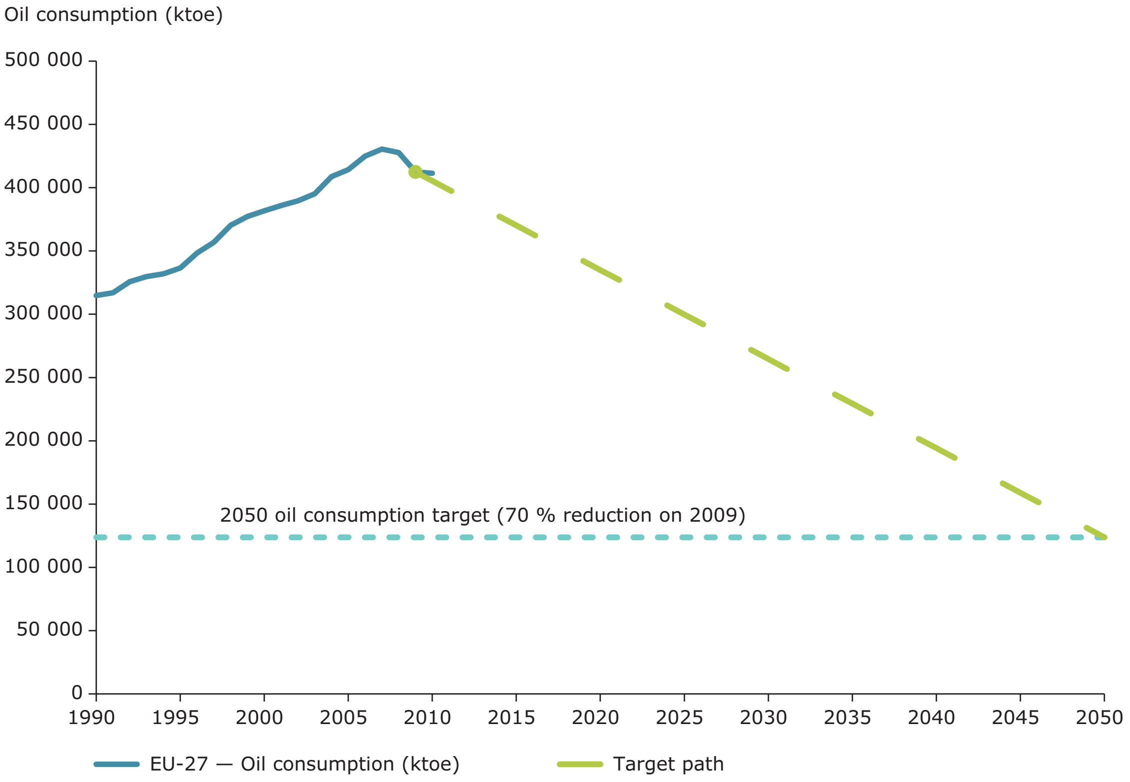


Reduction of transport oil consumption

The row 'Where we are (current trends vs. target path)' is marked in green for the year 2009 as the 'observed' value was in line with the reduction estimated in the 'target path' for that year. However, this 'observed' cell is marked in red for 2010 as the latest available data (from 2010) shows a value above that of the target path. The graph shows that the reduction achieved in 2010 is not sufficient with what would be needed.

However, the final row 'latest annual trend', is having green colour because the latest data (2010) shows a slight improvement (0.3 % reduction) compared to the previous year (2009), although not as much as the reduction estimated by the 'target path'.

			Indicative goals
Source			Impact assessment-accompanying document to the White Paper (EC, 2011d)
Target			Reduction of transport oil consumption
Unit			ktoe
Where we were	**Base year**	**Value**	412 456
		Year	2009
Where we want to be	**Target**	**Value**	123 737 (– 70 %)
		Year	2050
Where we are (current trends vs. target path)	**2011**	**Observed**	n.a.
		Target path	398 372
	2010	**Observed**	411 405
		Target path	405 414
	2009	**Observed**	412 456
		Target path	412 456
Latest annual trend			– 0.3 %



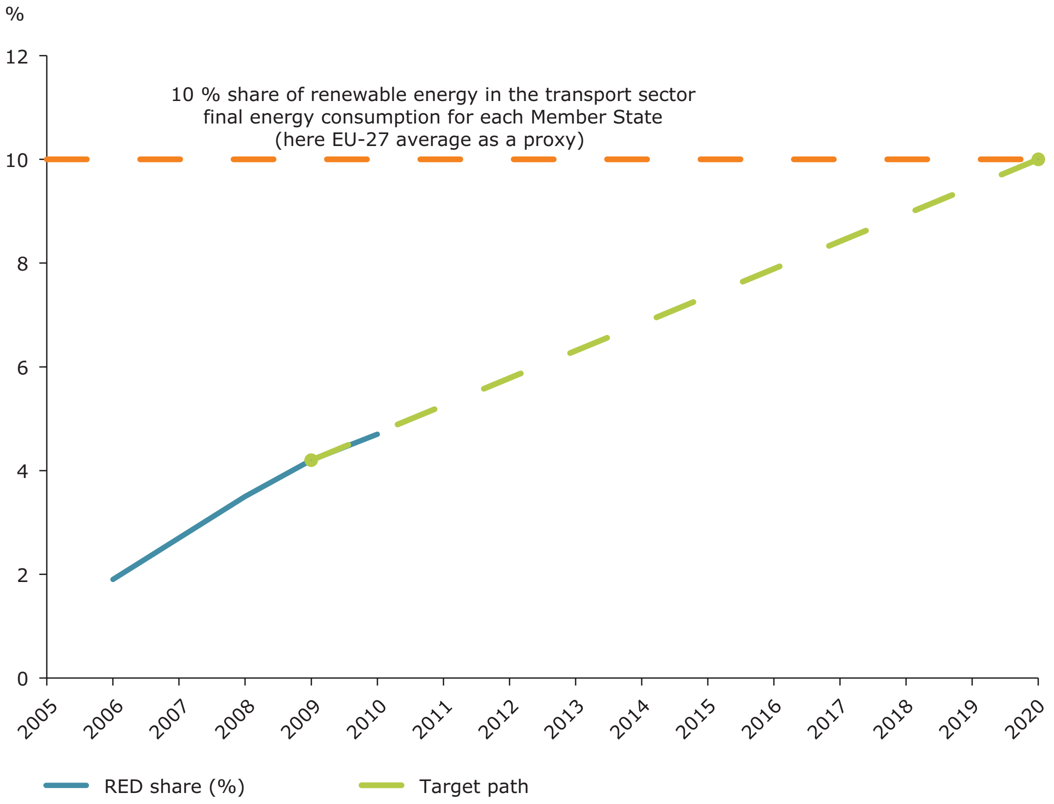
10 % share of renewable energy in the transport sector final energy consumption for each Member State

The row 'Where we are (current trends vs. target path)' is marked in green for the year 2009 as the 'observed' value was in line with the increase of renewable energy share estimated in the 'target path' for that year. However, this 'observed' cell is marked in red for 2010 as the latest available data (from 2010) shows a value that is not in line with that of the target path. The graph shows that the increase achieved in 2010 is not sufficient with what would be needed, although this difference is very small.

The final row 'latest annual trend', is marked in green because the latest data (2010) shows a 11.9 % improvement compared to the share achieved in the previous year (2009). The improvement is anyhow not as intense as the 'target path' estimations for 2010.

It is important to remember that this target applies to each Member State, but the average EU-27 Member State share of renewable energy in the transport sector has been calculated for representation purpose (see Box 2.11 for further Member States details).

			Indicative goals
Source			Renewable Energy Directive 2009/28/EC (EC, 2009b)
Target			10 % share of renewable energy in the transport sector final energy consumption for each Member State (here EU-27 average as a proxy)
Unit			%
Where we were	**Base year**	**Value**	4.20 %
		Year	2009
Where we want to be	**Target**	**Value**	10.00 %
		Year	2020
Where we are (current trends vs. target path)	**2011**	**Observed**	n.a.
		Target path	5.25 %
	2010	**Observed**	4.70 %
		Target path	4.73 %
	2009	**Observed**	4.20 %
		Target path	4.20 %
Latest annual trend			11.9 %



Annex 4 Major pollutants for which transport emissions are important

Particulate matter (PM)

PM is the general term used for a mixture of suspended particles in air, with a wide range in size and chemical composition. $PM_{2.5}$ refers to 'fine particles' that have a diameter of 2.5 micrometres or less. PM_{10} refers to particles with a diameter of 10 micrometres or less. It includes the 'coarse particles' (relatively large airborne particles) fraction in addition to the $PM_{2.5}$ fraction.

PM is either directly emitted as primary particles or is formed in the atmosphere as secondary particles from oxidation and transformation of primary gaseous emissions. The most important precursors for secondary particles are SO_2, NO_X, NH_3 and volatile organic compounds (VOCs). PM is either of natural origin (e.g. sea salt, naturally suspended dust, pollen, volcanic ash) or from anthropogenic sources, mainly from fuel combustion in vehicles, thermal power generation, incineration, and domestic heating, for example. In cities, vehicle exhausts, road dust re-suspension, and burning of wood, fuel or coal for domestic heating are important local sources.

PM can cause or aggravate cardiovascular and lung diseases, heart attacks and arrhythmias. It can affect the central nervous system and the reproductive system, and can cause cancer. The outcome can be premature death. Animals are affected in the same way as humans. PM also affects plant growth and ecosystem processes. Its effect on climate varies depending on particle size and composition: some particles are reflective and lead to net cooling, while others absorb solar radiation, leading to warming. Deposition of particles can lead to changes in surface albedo which in turn influences climate.

Ozone (O_3)

Ground-level (tropospheric) O_3 is not directly emitted into the atmosphere but formed from a chain of chemical mechanisms following emissions of precursor gases: NO_X, CO and VOCs. NO_X are emitted during fuel combustion, for example by industrial facilities and road transport. NO_X plays a complex role in O_3 chemistry: close to its source NO_X will actually deplete O_3 due to the scavenging reaction between the freshly emitted NO and O_3. VOCs are emitted from a large number of sources including road transport, refineries, paint, dry-cleaning and other solvent uses. Biogenic VOCs are emitted by vegetation, with amounts dependent on temperature. Methane (CH_4), a VOC and an important O_3 precursor, is released from coal mining, natural gas extraction and distribution, landfills, wastewater, ruminants, rice cultivation and biomass burning. Fire plumes from wild forest and other biomass fires as well as traffic emissions contain CO and can contribute to O_3 formation. There is a global background concentration of O_3 in air, partly resulting from the downward transport of stratospheric O_3 to the troposphere and partly from photochemical O_3 formation globally.

O_3 irritates eyes, nose, throat and lungs. It can destroy throat and lung tissues, leading to decrease in lung function; respiratory symptoms, such as coughing and shortness of breath; aggravated asthma and other lung diseases. O_3 can lead to premature mortality. Vegetation is damaged by O_3 injuring leaves, reducing photosynthesis, impairing plant reproduction and growth, and decreasing crop yields. O_3 damage to plants can alter ecosystem structure, reduce biodiversity and decrease plant uptake of CO_2. O_3 is also a GHG contributing to warming of the atmosphere.

Nitrogen dioxide (NO_2)

NO_2 is a reactive gas that is mainly formed by oxidation of NO. High temperature combustion processes (e.g. those occurring in car engines and power plants) are the major sources of NO_X, the term used to describe the sum of NO and NO_2. NO makes up the majority of NO_X emissions. A small part is directly emitted as NO_2, typically between 5 % and 10 % for most combustion sources, with the exception of diesel vehicles. There are clear indications that for traffic emissions, the direct NO_2 fraction is increasing significantly due to increased penetration of diesel vehicles, especially newer diesel vehicles (Euro 4 and 5), which can emit up to 50 % of their NO_X as NO_2.

NO_2 can aggravate lung diseases leading to respiratory symptoms and increased susceptibility to respiratory infection. NO_2 is oxidised further to nitrates and contributes to the acidification and eutrophication of soil and water, leading to changes in species diversity. NO_2 enhances sensitivity to secondary stress on vegetation and also acts as a precursor of O_3 and PM, with associated environmental and climate effects.

Carbon monoxide (CO)

CO is a gas formed during incomplete combustion of fossil fuels and biofuels. Road transport used to emit significant amounts of CO, but the introduction of catalytic converters reduced these emissions significantly. CO concentrations tend to vary with traffic patterns during the day. The highest CO levels are found in urban areas, typically during rush hours at traffic locations.

CO can lead to heart disease and damage to the nervous system (e.g. personality and memory changes, mental confusion and loss of vision). It can cause headache, dizziness and fatigue. CO affects animals in the same way as humans, although concentrations capable of causing these effects are unlikely to occur in the natural environment, except in extreme events such as forest fires. CO contributes to the formation of GHGs such as CO_2 and O_3.

Sulphur dioxide (SO_2)

SO_2 is emitted when fuels containing sulphur are burned. The key manmade contributions to ambient SO_2 derive from sulphurcontaining fossil fuels and biofuels used for domestic heating, stationary power generation and transport. Volcanoes are the most important natural source.

Epidemiological studies suggest that SO_2 can affect the respiratory system and lung functions, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Mortality and hospital admissions for cardiac disease increase on days with higher SO_2 levels.

SO_2 is a major precursor to $PM_{2.5}$, which is associated with significant health effects. In addition SO_2 and its oxidation products contribute to acidic deposition, causing adverse effects on aquatic ecosystems in rivers and lakes, damage to forests and acidification of soils. The major effects of deposited sulphur compounds are the loss of acid neutralisation capacity in soils and waters, loss of nutrients such as potassium or magnesium from soils and the release of toxic aluminium to the soil and waters. Depending on biogeochemical conditions, sulphur can initially be stored in soils with subsequent slow release (postponed acidification). Effects of SO_2 emissions reduction measures can thus be delayed for decades.

Non-methane volatile organic compounds (NMVOCs)

NMVOCs, important O_3 precursors, are emitted from a large number of sources including paint application, road transport, dry-cleaning and other solvent uses. Certain NMVOC species, such as C_6H_6 (benzene) and 1,3-butadiene, are directly hazardous to human health. Biogenic NMVOCs are emitted by vegetation, with amounts dependent on the species and on temperature.

For C_6H_6, incomplete combustion of fuels is the largest source. C_6H_6 is an additive to petrol and 80 % to 85 % of C_6H_6 emissions are due to vehicular traffic in Europe. Other sources are domestic heating, oil refining, and petrol handling, distribution and storage. Wood combustion can be an important local source of C_6H_6 in areas where wood burning can account for a large part of domestic energy needs.

C_6H_6 is a human carcinogen that can cause leukaemia and birth defects. It can affect the central nervous system and normal blood production, and can harm the immune system. C_6H_6 has an acute toxic effect on aquatic life. It bioaccumulates, especially in invertebrates, and can damage leaves of agricultural crops and cause death in plants. C_6H_6 is also a GHG contributing to the warming of the atmosphere. Moreover, it contributes to the formation of secondary organic aerosols, which can act as climate forcers.

Polycyclic aromatic hydrocarbons (PAHs)/Benzo(a) pyrene (BaP)

PAHs are a large group of persistent organic pollutants (POPs). BaP is an important PAH, found in fine PM originating from combustion. A main source of BaP in Europe is domestic home heating, in particular wood burning. Other sources include road traffic, rubber tyre wear and outdoor burning.

BaP is carcinogenic. Other effects may be irritation of the eyes, nose, throat and bronchial tubes. BaP is toxic to aquatic life and birds, and bioaccumulates, especially in invertebrates.

Annex 5 Overview of the TERM fact sheets

The TERM indicators have been published annually since 2000, subject to data availability. In 2000, the indicators appeared only in the annual TERM report but they have since been published individually on the EEA website. When the indicator set was originally defined, it was foreseen that the data, that was at that point limited, would eventually become available over time. For this reason, not all indicators have been published every year

		2000–2004					2005–2009					2010–2012		
TERM 01	Transport final energy consumption by mode	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 02	Transport emissions of greenhouse gases		x	x	x	x	x	x	x	x	x	x	x	x
TERM 03	Transport emissions of air pollutants	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 04	Exceedances of air quality objectives due to traffic	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 05	Exposure to and annoyance by traffic noise	x	x										x	x
TERM 06	Fragmentation of ecosystems and habitats by transport infrastructure	x	x	x									x	
TERM 07	Proximity of transport infrastructure to designated areas		x	x										
TERM 08	Land take by transport infrastructure	x	x	x										
TERM 09	Transport accident fatalities	x	x	x	x	x	x		x		x		x	
TERM 10	Accidental and illegal discharges of oil at sea		x	x		x								
TERM 11	Waste oil and tires from vehicles		x											
TERM 11a	Waste from road vehicles (ELV)	x	x	x										
TERM 12a/b	Passenger transport volume and modal split (CSI 035)	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 13a/b	Freight transport volume and modal split (CSI 036)	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 14	Access to basic services	x	x		x									
TERM 15	Regional accessibility of markets and cohesion		x		x									
TERM 16	Access to transport services	x	x											
TERM 18	Capacity of infrastructure networks	x	x	x	x	x	x				x		x	x
TERM 19	Infrastructure investments	x	x	x					x		x	x	x	
TERM 20	Real change in transport prices by mode	x	x	x		x	x		x		x	x	x	x
TERM 21	Fuel prices and taxes	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 22	Transport taxes and charges			x	x	x	x		x	x	x			
TERM 23	Subsidies						x							
TERM 24	Expenditure on personal mobility by income group				x	x		x		x	x	x	x	
TERM 25	External costs of transport	x	x	x	x	x		x		x	x			
TERM 26	Internalisation of external costs	x	x	x	x	x	x	x		x		x		
TERM 27	Energy efficiency and specific CO_2 emissions	x	x	x			x		x	x	x	x	x	x

		2000–2004					2005–2009					2010–2012		
TERM 28	Specific air pollutant emissions	x	x		x		x		x	x	x	x	x	x
TERM 29	Occupancy rates of passenger vehicles	x	x	x		x	x			x	x		x	
TERM 30	Load factors for freight transport		x	x		x	x			x	x		x	
TERM 31	Uptake of cleaner and alternative fuels (CSI 037)	x	x	x	x	x	x	x	x	x	x	x	x	x
TERM 32	Size of the vehicle fleet	x	x	x	x	x		x		x	x	x	x	x
TERM 33	Average age of the vehicle fleet	x	x	x	x		x		x	x	x	x	x	x
TERM 34	Proportion of vehicle fleet meeting certain emission standards	x	x	x	x	x		x		x	x	x	x	x
TERM 35	Implementation of integrated strategies	x	x	x		x								
TERM 36	Institutional cooperation		x	x		x								
TERM 37	National monitoring systems	x	x	x		x								
TERM 38	Implementation of SEA	x	x	x		x								
TERM 39	Uptake of environmental mgt. systems by transport companies	x												
TERM 40	Public awareness	x	x			x								

Annex 6 Data

This annex provides an overview of the key statistics that underpin the assessment in the report. It is generally based on data from sources such as Eurostat and the Mobility and Transport DG transport statistical pocketbook. For a full explanation of the data sources, see metadata in Annex 1.

Table A6.1 Freight inland transport volume by country (1 000 million tkm) (1996–2010) - excluding pipelines. Eurostat 2012b.

Table A6.2 Modal split of freight transport (% in total inland freight tkm) (1995, 2000, 2005, 20010) — excluding pipelines. Eurostat 2012b.

Table A6.3 Sea transport of goods (1 000 tonnes) (1999–2010). Eurostat 2012b.

Table A6.4 Total inland passenger transport (1 000 million pkm) (1995–2010): cars, trains, buses, trolley buses and motor coaches by country (1995–2010). Eurostat 2012b.

Table A6.5 Modal split of passenger inland transport (cars, trains, buses and motor coaches) by country (1995, 2000, 2005, 20010). Eurostat 2012b.

Table A6.6 Air passenger transport in EU-27 (1 000 million pkm) (1995–20010). DG MOVE, 2012, only domestic and intra-EU-27 transport; provisional estimates.

Table A6.7 Number of passenger cars per thousand inhabitants (1990, 1995, 2000, 2005, 2009, 2010). DG MOVE, 2012.

Table A6.8 Greenhouse gas emissions from transport in Europe (million tonnes, unless otherwise stated). Emissions of GHGs by country and sub-sector (1990, 2010). EEA data viewer, 2012.

Table A6.1 Freight inland transport volume by country (1 000 million tkm), excluding pipelines

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	43	45	47	51	54	57	58	59	60	58	62	61	59	49	51
Belgium	55	57	55	51	66	68	68	66	64	61	60	60	56	50	49
Bulgaria	13	14	13	11	12	13	14	15	18	20	20	21	23	26	29
Switzerland	17	18	19	19	21	21	21	21	22	22	23	23	26	24	24
Cyprus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Czech Republic	53	52	53	54	55	56	60	62	61	58	66	64	66	58	66
Germany	368	382	396	418	430	435	430	434	459	470	501	523	521	459	483
Denmark	23	23	23	25	26	24	24	25	25	25	23	23	21	19	17
Estonia	6	8	10	11	12	13	14	14	16	16	16	15	13	11	12
Spain	113	122	136	146	160	173	196	204	233	245	253	270	254	220	219
Finland	34	36	38	40	42	40	42	41	43	42	41	40	42	37	39
France	236	243	251	268	271	267	264	260	267	255	262	271	256	214	222
Greece	25	26	28	28	29	30	31	33	37	33	35	29	30	29	30
Hungary	23	24	28	28	29	27	27	27	31	36	43	48	48	45	45
Ireland	7	8	9	11	13	13	15	16	18	18	18	19	18	12	11
Iceland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Italy	197	201	203	199	208	208	213	194	219	235	211	205	204	185	194
Lithuania	12	14	14	16	17	16	20	23	24	28	31	35	35	30	33
Luxembourg	4	5	6	7	9	10	10	10	11	10	10	10	10	9	9
Latvia	15	17	17	16	18	20	21	25	26	28	28	32	32	27	28
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	108	115	123	129	125	125	122	124	139	132	132	131	130	114	123
Norway	15	17	18	18	18	18	18	19	20	21	23	23	24	22	23
Poland	125	132	132	127	130	126	128	134	156	162	182	205	217	224	260
Portugal	35	38	39	40	41	43	42	42	43	45	47	49	42	38	38
Romania	48	48	37	31	33	37	44	49	61	77	81	83	80	57	53
Sweden	52	54	52	52	55	53	56	57	58	60	62	64	65	55	60
Slovenia	6	7	7	7	8	10	10	10	12	14	15	17	20	18	19
Slovakia	29	29	31	30	27	26	26	27	29	33	33	38	40	36	37
Turkey	145	149	161	159	171	159	158	161	166	176	187	191	192	187	202
United Kingdom	181	186	189	185	184	183	183	186	185	183	188	192	182	159	165

Source: Eurostat, 2012b.

Table A6.2 Modal split of freight transport (% in total inland freight tkm) — excluding pipelines

	Road (%)				Rail (%)				IWW (%)			
	1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
Austria	63.5	64.8	64.1	56.3	31.6	30.6	32.8	39.0	4.9	4.5	3.0	4.7
Belgium	77.8	77.4	72.4	70.7	12.5	11.6	13.4	12.7	9.8	10.9	14.1	16.6
Bulgaria	36.3	52.3	70.8	68.1	60.0	45.2	25.4	10.7	3.7	2.6	3.7	21.2
Cyprus	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	57.8	68.0	74.4	79.0	41.7	31.9	25.5	21.0	0.5	0.2	0.1	0.1
Denmark	91.9	92.2	92.2	87.0	8.1	7.8	7.8	13.0	0.0	0.0	0.0	0.0
Estonia	28.7	32.7	35.4	45.8	71.3	67.3	64.6	54.2	0.0	0.0	0.0	0.0
Finland	71.7	75.8	76.5	75.0	28.1	24.0	23.3	24.8	0.2	0.3	0.2	0.2
France	76.4	75.3	80.5	82.2	20.7	21.3	16.0	13.5	2.8	3.4	3.5	4.3
Germany	63.9	65.3	66.0	64.9	18.9	19.2	20.3	22.2	17.2	15.5	13.6	12.9
Greece	98.8	98.5	98.1	98.0	1.2	1.5	1.9	2.0	0.0	0.0	0.0	0.0
Hungary	58.9	66.4	69.2	75.1	35.9	30.5	25.0	19.6	5.2	3.1	5.8	5.3
Iceland	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ireland	90.1	96.2	98.3	99.2	9.9	3.8	1.7	0.8	0.0	0.0	0.0	0.0
Italy	88.9	88.9	90.3	90.4	11.1	11.0	9.7	9.6	0.1	0.1	0.0	0.1
Latvia	15.8	26.5	29.8	38.1	84.2	73.5	70.2	61.9	0.0	0.0	0.0	0.0
Lithuania	41.9	46.6	56.1	59.1	58.0	53.4	43.9	40.9	0.1	0.0	0.0	0.0
Luxembourg	86.4	88.3	92.3	94.1	8.3	7.3	4.1	2.1	5.3	4.4	3.6	3.9
Malta	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	63.5	63.5	63.6	62.3	2.9	3.6	4.4	4.8	33.6	32.9	31.9	32.9
Norway	78.2	83.5	85.3	85.0	21.8	16.5	14.7	15.0	0.0	0.0	0.0	0.0
Poland	42.6	57.6	69.0	81.2	56.7	41.5	30.8	18.8	0.7	0.9	0.2	0.1
Portugal	94.1	94.7	94.6	93.9	5.9	5.3	5.4	6.1	0.0	0.0	0.0	0.0
Romania	48.4	42.9	67.3	49.2	44.0	49.1	21.7	23.5	7.6	7.9	11.0	27.2
Slovakia	51.0	53.2	68.9	74.8	44.3	41.7	28.9	22.0	4.7	5.1	2.3	3.2
Slovenia	51.8	65.0	77.3	82.3	48.2	35.0	22.7	17.7	0.0	0.0	0.0	0.0
Spain	90.3	92.8	95.2	95.8	9.7	7.2	4.8	4.2	0.0	0.0	0.0	0.0
Sweden	62.0	64.7	64.0	60.7	38.0	35.3	36.0	39.3	0.0	0.0	0.0	0.0
Switzerland	50.6	46.8	46.0	54.4	49.2	53.0	53.8	45.5	0.3	0.2	0.2	0.2
Turkey	93.0	94.3	94.8	94.4	7.0	5.7	5.2	5.6	0.0	0.0	0.0	0.0
United Kingdom	92.3	90.0	87.8	88.7	7.6	9.8	12.1	11.2	0.1	0.1	0.1	0.1

Source: Eurostat, 2012b.

Table A6.3 Sea transport of goods (1 000 tonnes)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU-27	:	:	:	3 334 802	3 452 336	3570238	3718691	3835969	3937528	3918669	3 445 521	3 640 954
Belgium	165 557	179 381	174 181	173 824	181 110	187889	206539	218 941	236 320	243 819	203 368	228 228
Bulgaria	:	:	20 192	20 390	21 358	23 125	24 841	27 513	24 900	26 576	21 893	22 946
Cyprus	:	:	:	7 220	7 258	6 837	7 305	7 676	7 516	7 962	6808	6 954
Denmark	97 213	96 533	93 972	94 283	103 954	100 373	99 688	107 674	109 660	106 096	90636	87 068
Estonia	:	:	40 383	44 682	47 048	44 808	46 546	49 998	44 964	36 191	38505	46 026
Finland	77 467	80 681	96 150	99 099	104 439	106 524	99 577	110 536	114 819	114 725	93239	109 326
France	315 153	325 789	318 188	319 032	330 135	334 035	341 470	350 334	346 825	351 976	315534	313 593
Germany	221 623	242 535	246 050	246 353	254 834	271 869	284 865	302 789	315 051	320 636	262863	275 953
Greece	112 549	127 750	122 171	147 692	162 534	157 892	151 250	159 425	164 300	152 498	135430	124 387
Iceland	5 034	5 164	4 966	4 771	4 981	5 308	5 653	5 917	:	:	:	:
Ireland	42 928	45 273	45 795	44 919	46 165	47 720	52 146	53 326	54 139	51 081	41829	45 071
Italy	425 914	446 641	444 804	457 958	477 028	484 984	508 946	520 183	537 327	526 219	469879	494 091
Latvia	:	:	56 827	51 978	54 652	54 829	59 698	56 861	61 083	61 430	60088	58 691
Lithuania	:	:	20 953	24 405	30 242	25 842	26 146	27 235	29 253	36 379	34344	37 869
Malta	:	:	:	4 990	5 215	5 303	5 283	5 452	5 254	5 501	5507	6 004
Netherlands	395 664	405 802	405 853	413 312	410 330	440 722	460 940	477 238	507 463	530 359	483133	538 702
Poland	:	:	46 210	48 111	51 020	52 272	54 769	53 131	52 433	48 833	45079	59 507
Portugal	58 794	56 404	56 164	55 599	57 470	59 071	65 301	66 861	68 229	65 275	61714	65 981
Romania	:	:	27 619	32 698	35 925	40 594	47 694	46 709	48 928	50 458	36094	38 122
Slovenia	:	:	9 146	9 305	10 788	12 063	12 625	15 483	15 853	16 554	13356	14 591
Spain	295 715	234 913	315 120	326 001	343 716	373 065	400 019	414 378	426 648	416 158	363536	376 391
Sweden	156 349	159 291	152 830	154 626	161 454	167 350	178 122	180 487	185 057	187 778	161823	179 579
United Kingdom	565 614	573 050	566 366	558 325	555 662	573 070	584 919	583 739	581 504	562 166	500863	511 875
Norway	:	:	:	190 034	186 781	198 199	201 678	196 818	198 507	193 368	182 635	195 132
Croatia	:	16 886	19 056	18 584	20 320	25 246	26 201	26 325	30 097	29 223	23 377	2 4329
Turkey	:	:	:	:	:	:	:	:	:	305 271	293 906	:

Source: Eurostat, 2012b.

Table A6.4 Total inland passenger transport (1 000 million pkm): cars, trains, buses, trolley buses and motor coaches, by country

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria	81	82	81	82	84	85	85	86	87	88	89	89	91	94	92	94
Belgium	118	118	120	123	126	127	129	131	132	134	136	137	141	139	141	138
Bulgaria	41	40	42	42	44	45	46	49	48	48	51	53	56	59	59	60
Cyprus	4	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7
Czech Republic	81	83	82	82	85	87	88	88	90	89	91	93	95	95	95	88
Denmark	58	59	60	61	62	62	61	61	61	62	62	62	64	64	64	64
Estonia	8	8	8	9	9	10	9	10	10	10	13	13	13	13	13	12
Finland	61	62	63	64	66	67	68	69	71	72	73	73	75	75	76	76
France	724	736	748	771	794	800	829	838	843	847	840	842	852	852	856	863
Germany	955	956	957	969	990	976	997	1 001	997	1 009	999	1 008	1 011	1 017	1 024	1 032
Greece	66	69	73	76	81	87	92	96	100	103	109	114	119	124	124	122
Hungary	70	71	71	72	73	75	75	76	77	78	77	80	80	80	78	76
Iceland	3	4	4	4	4	4	4	5	5	5	5	5	6	6	6	5
Ireland	38	39	41	43	44	46	48	48	49	50	52	54	57	59	57	55
Italy	749	764	775	797	802	857	866	874	881	889	828	830	829	828	870	851
Latvia	11	11	12	13	14	15	15	16	16	15	16	18	20	20	19	19
Lithuania	21	23	24	26	28	29	29	30	32	35	39	44	43	42	39	33
Luxembourg	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8
Malta	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
Netherlands	160	159	162	163	167	167	167	169	171	178	176	176	177	175	174	169
Norway	51	53	54	56	57	58	59	60	60	61	61	62	64	65	66	67
Poland	171	175	185	196	198	206	211	217	222	230	245	266	286	320	328	337
Portugal	69	72	76	80	84	87	88	92	96	98	100	100	101	102	101	98
Romania	71	74	74	73	74	75	75	74	76	78	81	84	87	91	94	93
Slovakia	37	36	35	35	36	36	36	37	36	36	37	37	37	36	34	34
Slovenia	21	23	24	24	25	25	25	25	26	26	26	27	28	29	30	30
Spain	307	320	329	344	363	373	380	386	392	404	413	412	424	427	431	415
Sweden	104	105	105	106	108	110	111	114	114	115	115	115	118	118	119	119
Switzerland	91	92	92	93	95	97	97	99	100	101	103	104	106	107	109	110
Turkey	144	154	164	169	170	172	163	167	171	185	200	213	225	235	234	238
United Kingdom	694	700	713	719	728	727	742	765	763	769	766	773	781	777	779	756

Source: Eurostat, 2012b.

Table A6.5 Modal split of passenger inland transport (cars, trains, buses and motor coaches), by country

	Cars (%)				Buses and coaches (%)				Rail (%)			
	1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
Austria	76.8	78.8	78.9	78.7	10.7	10.9	10.4	9.8	12.5	10.3	10.6	11.5
Belgium	83.2	83.4	80.3	79.3	11.1	10.5	12.9	13.3	5.7	6.1	6.8	7.4
Bulgaria	60.6	59.8	68.6	78.6	28.0	32.4	26.7	17.7	11.4	7.7	4.7	3.6
Cyprus	77.3	77.7	79.2	82.4	22.7	22.3	20.8	17.6	0.0	0.0	0.0	0.0
Czech Republic	67.2	73.1	75.5	76.2	22.9	18.5	17.2	16.9	9.9	8.4	7.3	6.9
Denmark	83.2	82.0	80.7	80.7	8.4	9.0	9.6	9.7	8.4	9.0	9.6	9.7
Estonia	67.6	69.8	77.0	81.6	26.9	27.5	21.1	16.4	5.5	2.7	1.9	1.9
Finland	81.7	83.4	84.9	84.9	13.1	11.5	10.3	10.0	5.2	5.1	4.8	5.1
France	86.6	85.9	85.7	84.3	5.7	5.4	5.2	5.7	7.7	8.7	9.1	10.0
Germany	85.4	85.2	85.8	86.0	7.2	7.1	6.7	6.1	7.4	7.7	7.5	7.9
Greece	66.9	72.8	78.3	81.9	30.7	25.1	20.0	16.9	2.4	2.2	1.7	1.1
Hungary	64.4	61.9	64.1	69.5	23.6	25.1	23.1	20.2	12.0	13.0	12.8	10.3
Iceland	88.6	88.6	88.6	88.6	11.4	11.4	11.4	11.4	0.0	0.0	0.0	0.0
Ireland	83.0	83.7	83.6	84.6	13.6	13.3	12.9	12.5	3.4	3.0	3.4	2.9
Italy	82.1	83.3	81.7	82.7	11.6	10.9	12.2	11.7	6.2	5.8	6.1	5.5
Latvia	70.0	79.0	76.2	86.2	17.1	16.1	18.2	9.9	12.8	4.9	5.6	3.9
Lithuania	75.1	88.5	89.4	92.0	19.6	9.4	9.5	7.1	5.3	2.1	1.1	0.9
Luxembourg	85.0	85.5	85.5	84.4	9.8	9.5	10.9	11.4	5.2	5.1	3.6	4.2
Malta	80.6	79.6	80.3	81.9	19.4	20.4	19.7	18.1	0.0	0.0	0.0	0.0
Netherlands	82.3	84.5	84.7	84.2	7.5	6.7	6.7	7.0	10.2	8.8	8.6	8.9
Norway	87.9	88.3	88.5	88.7	7.4	7.1	7.1	6.7	4.7	4.5	4.5	4.6
Poland	64.6	72.8	80.6	86.9	19.9	15.4	12.0	7.4	15.5	11.7	7.4	5.7
Portugal	76.5	81.7	85.1	85.5	16.5	13.6	11.1	10.4	7.0	4.6	3.8	4.1
Romania	56.2	68.3	75.5	80.0	17.3	16.1	14.6	13.6	26.5	15.6	9.9	6.5
Slovakia	49.1	66.3	70.7	77.6	39.4	25.8	23.4	15.8	11.5	7.9	6.0	6.6
Slovenia	77.6	82.9	85.4	86.5	19.5	14.3	11.6	10.7	2.8	2.9	2.9	2.8
Spain	81.7	81.1	81.9	81.4	12.9	13.5	12.9	13.2	5.4	5.4	5.2	5.4
Sweden	84.1	83.8	84.6	83.3	9.3	8.6	7.6	7.1	6.6	7.5	7.8	9.5
Switzerland	81.0	81.5	79.1	78.0	6.1	5.4	5.2	5.0	12.9	13.1	15.7	17.1
Turkey	36.5	45.9	50.0	52.5	59.4	50.7	47.5	45.2	4.0	3.4	2.5	2.3
United Kingdom	89.0	88.0	88.1	87.3	6.6	6.7	6.1	6.0	4.4	5.3	5.8	6.8

Source: Eurostat, 2012b.

Table A6.6 Air passenger transport volume for the EU-27 (1 000 million pkm)

	1 000 million pkm
1995	346
1996	366
1997	390
1998	409
1999	425
2000	457
2001	453
2002	445
2003	463
2004	493
2005	527
2006	549
2007	572
2008	561
2009	522
2010	524

Notes: These data are estimations, not actual statistics.
Only domestic and intra–EU-27 transport; provisional estimates.

Source: DG MOVE, 2012.

Table A6.7 Number of passenger cars per thousand inhabitants

	1990	1995	2000	2005	2009	2010	Change 2009–2010 %
EU-27	345	380	417	448	473	477	0.9
Austria	388	452	511	504	521	528	1.5
Belgium	387	421	456	468	479	482	0.6
Bulgaria	152	196	245	329	331	347	4.8
Cyprus	304	335	384	463	573	575	0.3
Czech Republic	234	295	335	386	422	427	1.1
Denmark	309	320	347	362	383	389	1.6
Estonia	154	269	339	367	407	412	1.3
Finland	388	371	412	462	519	535	3.2
France	476	481	503	497	500	502	0.5
Germany	461	495	475	493	510	517	1.4
Greece	170	207	292	387	454	461	1.6
Hungary	187	218	232	287	301	299	– 0.7
Iceland	468	445	561	625	652	649	– 0.5
Ireland	228	276	348	400	432	424	– 1.9
Italy	483	533	572	590	603	606	0.6
Latvia	106	134	236	324	402	286	– 29.0
Lithuania	133	199	336	428	509	521	2.4
Luxembourg	477	556	622	655	660	659	– 0.2
Malta	337	487	483	525	563	573	1.8
Netherlands	367	364	409	434	460	452	– 1.6
Norway	380	386	411	437	462	469	1.6
Poland	138	195	261	323	432	451	4.4
Portugal	185	255	336	397	419	421	0.5
Romania	56	97	124	156	198	202	2.0
Slovakia	166	189	237	242	293	307	4.8
Slovenia	294	357	435	479	517	518	0.1
Spain	309	360	431	463	478	480	0.4
Sweden	419	411	450	459	460	460	0.0
Switzerland	442	457	492	518	515	518	0.6
United Kingdom	361	378	425	469	470	470	0.0
Turkey		49	65	80	98	102	4.7

Notes: Passenger car stock at end of year n has been divided by the population on 1 January of year n+1.

Source: DG MOVE, 2012.

Table A6.8 Greenhouse gas emissions from transport in Europe (million tonnes, unless otherwise stated), by country and sub-sector

	Total transport excluding international aviation and navigation			Civil aviation			Road			Rail			Navigation		
	1990	**2010**	**Growth %**	**1990**	**2010**	**Growth %**	**1990**	**2010**	**Growth %**	**1990**	**2010**	**Growth %**	**1990**	**2010**	**Growth %**
EU-27	775.35	930.73	20	14.12	17.38	23	718.20	876.62	22	13.85	7.36	– 47	17.90	19.33	8
EU-15	696.03	804.70	16	13.72	16.89	23	649.61	755.47	16	8.17	5.21	– 36	17.38	18.99	9
Austria	14.03	22.45	60	0.03	0.06	99	13.56	21.89	61	0.20	0.16	– 16	0.01	0.01	– 22
Belgium	20.47	24.26	18	0.01	0.01	– 17	19.61	23.46	20	0.24	0.11	– 53	0.41	0.48	17
Bulgaria	6.79	7.95	17	0.14	0.05	– 66	6.09	7.51	23	0.36	0.07	– 81	0.06	0.00	– 100
Cyprus	1.18	2.31	97	0.00	0.00		1.18	2.31	97	0.00	0.00		0.00	0.00	
Czech Republic	7.77	17.45	125	0.15	0.01	– 94	6.40	16.98	165	0.66	0.29	– 56	0.06	0.01	– 78
Denmark	10.78	13.25	23	0.25	0.16	– 36	9.43	12.24	30	0.30	0.24	– 18	0.81	0.60	– 25
Estonia	2.49	2.26	– 9	0.01	0.00	– 68	2.31	2.08	– 10	0.16	0.16	1	0.02	0.02	7
Finland	12.76	13.57	6	0.39	0.26	– 34	11.06	12.00	9	0.19	0.10	– 50	0.45	0.57	27
France	121.21	132.15	9	4.29	4.57	7	114.54	125.27	9	1.08	0.48	– 55	1.09	1.28	18
Germany	164.72	154.73	– 6	2.34	2.01	– 14	152.62	146.84	– 4	2.90	0.95	– 67	2.08	0.76	– 63
Greece	14.91	23.00	54	0.72	1.32	82	11.99	19.18	60	0.23	0.07	– 69	1.97	2.41	22
Hungary	8.17	11.87	45	0.00	0.00		7.62	11.60	52	0.52	0.27	– 48	0.03	0.00	– 90
Iceland	0.62	0.90	45	0.03	0.02	– 33	0.53	0.84	60	0.00	0.00		0.06	0.04	– 41
Ireland	5.12	11.61	127	0.05	0.04	– 21	4.77	11.06	132	0.15	0.14	– 9	0.09	0.20	133
Italy	103.08	118.85	15	1.63	2.34	44	95.05	110.02	16	0.50	0.22	– 55	5.49	5.16	– 6
Latvia	3.00	3.22	8	0.00	0.00		2.40	2.96	24	0.60	0.23	– 61	0.00	0.02	2125
Liechtenstein	0.08	0.08	5	0.00	0.00		0.08	0.08	5	0.00	0.00		0.00	0.00	
Lithuania	7.76	4.57	– 41	0.01	0.00	– 82	5.32	4.12	– 23	0.35	0.19	– 47	0.02	0.02	11
Luxembourg	2.64	6.29	138	0.00	0.00	149	2.62	6.27	140	0.03	0.01	– 55	0.00	0.00	10
Malta	0.35	0.58	65	0.00	0.00	10	0.34	0.53	55	0.00	0.00		0.01	0.05	468
Netherlands	26.45	34.99	32	0.04	0.04	0	25.91	34.24	32	0.09	0.11	17	0.41	0.60	47
Norway	11.10	15.14	36	0.69	1.10	60	7.76	10.10	30	0.11	0.04	– 59	1.71	2.16	26
Poland	21.88	48.77	123	0.06	0.09	53	18.63	47.15	153	1.64	0.36	– 78	0.14	0.00	– 99
Portugal	10.31	18.94	84	0.23	0.40	74	9.63	18.26	90	0.19	0.05	– 73	0.26	0.23	– 13
Romania	12.16	15.13	24	0.02	0.33	1 234	11.05	14.13	28	0.90	0.44	– 51	0.19	0.21	10
Slovakia	5.03	6.65	32	0.01	0.01	– 25	4.59	6.55	43	0.43	0.10	– 77	0.00	0.00	
Slovenia	2.75	5.27	92	0.00	0.00	53	2.68	5.23	95	0.07	0.04	– 42	0.00	0.00	
Spain	54.98	91.42	66	1.78	3.55	99	51.24	83.87	64	0.42	0.26	– 38	1.51	3.58	136
Sweden	19.30	20.74	7	0.69	0.47	– 31	17.65	19.12	8	0.12	0.07	– 39	0.55	0.74	34
Switzerland	14.62	16.42	12	0.26	0.13	– 51	14.17	16.09	14	0.03	0.04	32	0.11	0.12	4
United Kingdom	115.26	118.46	3	1.27	1.65	30	109.94	111.73	2	1.55	2.23	43	2.25	2.36	5
Turkey	26.29	45.14	71	0.91	3.03	231	24.35	39.96	64	0.52	0.47	– 9	0.50	1.69	238

Source: EEA data viewer, 2012.

Table A6.8 Greenhouse gas emissions from transport in Europe (million tonnes, unless otherwise stated), by country and sub-sector (cont.)

	Other transport			International bunkers			International aviation			International maritime		
	1990	**2010**	**Growth %**	**1990**	**2010**	**Growth %**	**1990**	**2010**	**Growth %**	**1990**	**2010**	**Growth %**
EU-27	11.28	10.05	– 11	183.11	284.92	56	69.80	132.86	90	113.31	152.06	34
EU-15	7.15	8.14	14	170.82	271.29	59	64.76	126.56	95	106.07	144.72	36
Austria	0.22	0.32	43	0.92	2.11	130	0.90	2.07	131	0.02	0.03	70
Belgium	0.20	0.19	– 2	16.42	25.20	54	3.10	4.23	37	13.32	20.97	57
Bulgaria	0.15	0.32	120	0.99	0.88	– 11	0.72	0.51	– 30	0.27	0.38	39
Cyprus	0.00	0.00		0.93	1.45	55	0.75	0.86	15	0.18	0.58	221
Czech Republic	0.50	0.15	– 69	0.57	1.04	83	0.57	1.04	83	n/a,no	n/a,no	
Denmark	0.00	0.00		4.82	4.56	– 5	1.76	2.45	39	3.06	2.11	– 31
Estonia	0.00	0.00		0.69	0.81	19	0.11	0.11	5	0.58	0.70	21
Finland	0.67	0.64	– 4	2.87	2.34	– 19	1.02	1.68	64	1.85	0.66	– 64
France	0.22	0.55	152	16.59	24.00	45	8.64	16.09	86	7.95	7.91	0
Germany	4.79	4.16	– 13	20.13	33.76	68	12.14	24.79	104	7.99	8.97	12
Greece	0.00	0.01		11.23	10.97	– 2	2.47	2.11	– 15	8.75	8.86	1
Hungary	0.00	0.00		0.50	0.68	38	0.50	0.68	38	n/a	n/a	
Iceland	0.00	0.00		0.32	0.56	76	0.22	0.38	72	0.10	0.18	84
Ireland	0.06	0.17	165	1.14	2.77	143	1.08	2.34	116	0.06	0.43	657
Italy	0.41	1.11	168	8.63	16.59	92	4.20	9.51	127	4.43	7.08	60
Latvia	0.00	0.00		1.78	1.19	– 33	0.22	0.36	62	1.56	0.83	– 47
Liechtenstein	0.00	0.00		0.00	0.00	82	0.00	0.00	82	n/a,no	n/a,no	
Lithuania	2.06	0.23	– 89	0.72	0.61	– 15	0.40	0.15	– 64	0.32	0.47	46
Luxembourg	0.00	0.00		0.40	1.30	226	0.40	1.30	226	0.00	0.00	
Malta	0.00	0.00		0.47	3.68	677	0.21	0.32	52	0.26	3.36	1180
Netherlands	0.00	0.00		39.01	53.56	37	4.56	10.20	124	34.46	43.36	26
Norway	0.84	1.74	108	2.12	2.72	28	0.63	1.31	110	1.49	1.40	– 6
Poland	1.40	1.17	– 17	1.92	2.36	23	0.65	1.59	144	1.27	0.77	– 39
Portugal	0.00	0.00		2.87	4.26	48	1.48	2.63	78	1.40	1.63	17
Romania	0.01	0.02	240	3.54	0.64	– 82	0.80	0.50	– 38	2.75	0.15	– 95
Slovakia	0.01	0.00	– 78	0.13	0.14	10	0.06	0.10	64	0.07	0.04	– 42
Slovenia	0.00	0.00		0.05	0.14	190	0.05	0.07	52	n/a	0.07	
Spain	0.02	0.16	703	17.49	40.09	129	5.86	13.18	125	11.63	26.91	131
Sweden	0.30	0.34	13	3.62	8.91	146	1.35	2.09	55	2.26	6.82	201
Switzerland	0.05	0.05	– 1	3.16	4.33	37	3.10	4.30	39	0.06	0.03	– 45
United Kingdom	0.25	0.48	89	24.68	40.86	66	15.80	31.88	102	8.88	8.98	1
Turkey	–	–	–	–	1.19	–	–	0.43	–	–	0.76	–
United Kingdom	0.25	0.50	95	24.96	43.86	76	15.80	33.11	110	9.16	10.75	17

Note: n/a = not available/applicable, no = not occurring.

Source: EEA data viewer, 2012.

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