PATHWAYS TO LOW CARBON TRANSPORT IN THE EU

FROM POSSIBILITY TO REALITY

REPORT OF THE CEPS TASK FORCE ON TRANSPORT AND CLIMATE CHANGE

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This report is based on discussions in the CEPS Task Force on "Transport and Climate Change". The group met four times between January and September 2011. Participants included senior executives from a broad range of stakeholders, including business and industry, business associations, international organisations, member states, academic experts and NGOs. A full list of members and invited guests and speakers appears in Appendix 1.

The members of the Task Force engaged in extensive debates over the course of four meetings and submitted comments on earlier drafts of this report. Its contents reflect the general tone and direction of the discussion, but its recommendations do not necessarily represent a full common position agreed by all members of the Task Force, nor do they necessarily represent the views of the institutions to which the members belong.

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PREFACE

It is widely recognised that global greenhouse gas emissions need to be reduced drastically to avoid further damage to the world's climate. The transport sector accounts for about one-quarter of EU greenhouse gas emissions and therefore has an important part to play in the EU's efforts to move towards a low-carbon economy. This report identifies strategies to achieve a 60% reduction in greenhouse gas emissions from European transport in 2050 in the most cost-effective way. Action should be taken now and concrete policy measures are therefore proposed. I hope this report stimulates the development of more effective policies towards sustainable transport.

This strategy to promote low-carbon transport is the result of extensive discussions in a Task Force with participants from the car, oil and transport industries, from environmental NGOs and from European and national government agencies. I would like to thank all participants for their commitment and input. The Task Force sought facts and arguments rather than paying heed to special interests. I am very grateful to the participants in the Task Force that they put this approach into practice: arguments count!

Finally, I would like to thank Christian Egenhofer, Arno Behrens, Vasileios Rizos and Monica Alessi for all the effort they put into preparing the meetings of the Task Force and in drafting and redrafting this report.

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EXECUTIVE SUMMARY – KEY MESSAGES

The starting point of this CEPS Task Force was to identify measures that will need to be taken to meet the target put forward by the European Commission's Transport White Paper i.e. to achieve a 60% greenhouse gas (GHG) emissions reduction in the transport sector in 2050 compared to 1990 levels. Politically, this target has been discussed as the EU's contribution to address climate change in a context of worldwide cooperation. Chapter 2 concerns the past successes and future challenges in the fields of transport and environment, while chapters 3 and 4 consider the main policies. While the analysis is essentially qualitative, Chapter 5 provides two illustrative pathways for achieving the European Commission's target, based on broad estimates about the possible contribution of different measures. This chapter also details a series of policy measures that should be taken in the very short term to accelerate progress towards achieving the required emissions reduction. It should be noted that the report focuses on the EU and does not take into account the implications of developments in international climate change negotiations.

The report has identified the following key findings:

1. The ambitious 60% GHG reduction objective is possible, but it has a cost. It will require a comprehensive policy strategy that needs to be both credible and adequate. It will be credible if it starts implementing policies here and now, i.e. adopts measures such as standards, taxation or infrastructure development consistent with the long-term objective. It will be adequate if the measures, in their entirety, have the potential to meet the target while neither undermining the internal market for transport nor its affordability.
2. This report argues that the biggest part of total transport reductions required in the EU could come from more energy-efficient vehicles, combined with the gradual introduction of low-carbon fuels and new engine technologies. Eco-driving and efficient transport systems could provide for the other – much smaller shares of – reductions.

3. The key policy for reducing GHG emissions in road transport is the steady tightening of emissions standards in line with the technological frontier. Such emissions standards have worked to date for CO as well as for NOx and particles, although these air pollutants are technically different. NOx and particles are a side effect of combustion and can be removed by end-of-pipe technologies, whereas CO_2 is a necessary result of the combustion in the internal combustion engine fuelled by fossil fuels. From a regulatory perspective the functioning is similar; the steady tightening of standards will first incentivise combustion efficiency and in parallel speed up the deployment of new low-carbon technologies and fuels, such as vehicles running on low-carbon electricity, hydrogen, compressed natural gas or sustainable biofuels. These technologies will be needed to progressively meet standards.
4. The measures to promote energy-efficient vehicles and low-carbon technology should be based on the full life cycle ('well-to-wheel') as far as is practicably possible. Until methodologies for calculating 'well-to-wheel' emissions are agreed upon, the most appropriate way will be to regulate energy efficiency per vehicle combined with the CO_2 content of the fuel, based on practical methodology. As the standards' stringency increases, so does the need for an effective combination of both fuel and vehicle standards, based on well-to-wheel emissions.
5. Setting clear-cut standards for vehicle efficiency and fuels that allow manufacturers of cars and other vehicles to anticipate the direction of future standards. Such standards are effective in overcoming barriers to the introduction of more efficient vehicles and fuels, whilst creating regulatory certainty for product developers and manufacturers.
6. To reinforce the incentives from emissions standards, member state governments can differentiate existing transport taxes according to the CO_2 emissions of vehicles and the energy content and CO_2 emissions of fuels. Leverage can be enhanced by local and city governments' incentives for efficient and low-carbon vehicles in line with local circumstances and choices, on condition that the structure of incentives – not the level – is aligned across the EU, i.e. that vehicles are labelled across Europe in a harmonised way according to

carbon-efficiency, or whatever other measure or metric the EU will choose after 2020.

7. There are five main technological routes towards low-carbon transport:
   - Improving the energy efficiency of vehicles (including hybridisation) has huge potential, both in the short and long run,
   - Electric, and plug-in hybrid and hybrid vehicles, using electricity from low-carbon sources,
   - Hydrogen vehicles fuelled from renewable or zero GHG sources,
   - Gas vehicles using natural gas and biogas, and
   - Biofuels with a positive well-to-wheel effect on GHG emissions.

   The Task Force strongly recommends focusing on incentives to reduce well-to-wheel emissions of GHGs in a technologically neutral way instead of stimulating specific technologies. By using technology- neutral incentives, in the long run the market forces will select the most efficient technologies. This should result in a fleet of vehicles with a much better energy efficiency using different low-carbon fuels for different applications, whatever the most cost-effective combination is. Focusing on one specific technology – e.g. electric vehicles[1] – might slow down the transition to low-carbon transport. However, low-carbon transport technologies, which have network effects, i.e. require dedicated infrastructure, where research, demonstration and early deployment are too risky for private investors alone or where scale effects for new technologies (e.g. battery costs) exist, may require specially designed public support for a fixed, limited period of time.

8. The transport system can become more energy and/or carbon efficient, by higher load factors and occupancy rates, by co-modality combining different modes of transport, by better urban planning and by reducing mileage. However, in the past this area has only yielded limited success because efficient shift gains were neutralised by volume growth and second, available policy measures (e.g. pricing, regulatory measures) were not used to their full potential.

[1] Even if the White Paper analysis suggests that without full electrification of passenger transport the EU GHG emissions targets cannot be met.

The Task Force estimates that a better transport system can reduce GHG emissions from transport to a considerable extent. Rational transport pricing should also ensure that each mode pays for the full costs, including externalities, and provide sources for infrastructure investment. This should include carbon and energy taxing, for example, as proposed in the amendment of the Energy Tax Directive.

9. To achieve the 60% reduction in GHG from transport in 2050, cost-effective and step-wise action needs to be taken from now on. Full deployment of current technologies and further development of low-carbon technology are expected to take many years. But action now is crucial to show political commitment to the long-term target. Postponing policy development to beyond 2020 or even 2030 will undermine the credibility and predictability that transport providers, vehicle and fuels producers, technology providers or investors need.

The Task Force identified 15 measures[2] towards low-carbon transport that can be taken immediately:

(1) The EU should continue and accelerate setting predictable and progressively tightening CO_2 emissions standards for road vehicles and ships, where reduction potential exists.

(2) Define a realistic test procedure and test cycle as close as practical to real world conditions, including accounting for carbon benefits of components.

(3) The EU should expand the EU-wide labelling obligation for cars to include vans, and harmonise EU labelling systems.

(4) Member states and, where appropriate, regional and local governments should differentiate sales, vehicle and company car taxes according to CO_2 emissions.

(5) The EU and member states should use public procurement and incentives to fleet managers as tools to accelerate the deployment of more fuel-efficient vehicles and low-carbon fuels if these measures are cost-effective.

(6) The EU should develop a commonly agreed GHG accounting methodology for logistics and, as far as possible, push for global methodologies.

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[2] Measures are described in detail in Chapter 5.

(7) The EU should allow for full cabotage[3] in road transport.

(8) The EU and member states should continue supporting the introduction of eco-driving systems in vehicles in order to change driving behaviour and encourage continuous training.

(9) The EU must push member states to align taxation levels of different fuels and vehicle types and stop indirect subsidies.

(10) Member states should consider strategies to compensate for the taxation shortfall from fuels due to higher fuel economy by, for example, gradually adapting the minimum fuel tax level in the EU to increase incentives to shift to higher fuel economy and to keep total tax paid constant in real terms for both the consumer and the state revenues.

(11) The EU and member states should maintain support for research, development and early deployment of the entire array of promising low-carbon technologies.

(12) The EU should continue to implement an ambitious differentiated co-financing rate for low-carbon TEN-T projects.

(13) The EU and member states should ensure that there is no further delay in the application of advanced communication, navigation and surveillance (CNS) systems and air traffic management (ATM) systems.

(14) Member states, in co-operation with the EU, should improve walking and cycling facilities, co-modality and seamless transfer.

(15) Member states should enforce speed limits in all modes.

While these measures can only be a start, they could demonstrate that the EU is not avoiding hard choices, thereby signalling its willingness to embark on a credible strategy.

[3] Cabotage means that national carriage of goods for hire or reward can be carried out by non-resident hauliers.

1. INTRODUCTION

The transport sector is a strategic sector that is fundamental to all economic activity. Transport costs are an input factor for all products and services, and transport itself constitutes an important component of the European economy. According to the European Commission's (2011:5) White Paper, the sector represents some 5% of GDP and directly employs some 10 million people. Transport connections and networks are also cornerstones of European integration. The White Paper (European Commission 2011, p. 3) states that "efficient transport is vital *[for]* the ability of all of *[Europe's]* regions to remain fully and competitively integrated in the world economy".

Economic growth, progressive European integration and improved quality of transport itself have led to a substantial increase in transport volumes in recent decades.[4] These positive developments have gradually made apparent the negative side effects of mass transport in Europe, including congestion, air and noise pollution, increasing oil import dependency, injuries and deaths, as well as substantial amounts of greenhouse gas GHG emissions.

Prior to the economic crisis, European transport GHG emissions had been rising quickly, even though they have recently been flat to decreasing due to the recession. Transport emissions now account for almost one-quarter of total GHG emissions. The White Paper (European Commission 2011, p. 3) concludes that in order for the EU to reach its long-term mitigation objective,[5] "a reduction of 60% of GHGs by 2050 with respect to

[4] On average, passenger transport increased by 1.6% annually between 1995 and 2008 – mainly driven by air and road transport – while freight transport increased by 2.3% over the same period – primarily by road and sea transport.

[5] This refers to the EU objective of cutting GHG emissions by 80-95% by 2050; the European Commission's Roadmap for moving to a competitive low-carbon economy COM (2011) 112 final describes the pathway towards achieving this.

1990 is required from the transport sector".....″in the context of the necessary reductions of the developed countries as a group". This reduction objective is complemented by a set of technology deployment targets (European Commission 2011, p. 9):

- To "halve the use of 'conventionally-fuelled' cars in urban transport by 2030"
- To "phase them out in cities by 2050", and
- To "achieve essentially CO_2-free city logistics in major urban centres by 2030".

The targets have not been adopted by the Council of Ministers or the European Parliament. However, the latter has called for 2020 targets by mode.[6]

This CEPS Task Force Report takes as a starting point the European Commission's ambition of achieving a 60% GHG emissions reduction by 2050 compared to 1990, which translates into roughly a 70% reduction based on the 2008 level. Drawing on these assumptions, the CEPS Task Force Report develops pathways towards a low-carbon EU transport system compatible with the EU's objective. It identifies a set of concrete policy measures that would need to be implemented over time but also in the very short term to match the ambition. To the extent possible, this CEPS Task Force Report quantifies the contributions that individual measures can make. This report does not address the implications for EU transport policy if there is no global response to climate change.

The report is organised as follows: Chapter 2 reviews the past successes of EU transport policy in the environment field and draws lessons for reducing greenhouse gases. Chapters 3 and 4 assess the potential that lies in technology and in a better transport system respectively, whilst Chapter 5 sets out the necessary actions that are to be taken from now on and in future decades. The main body of the report is complemented by an Executive Summary including Recommendations. The full list of Task Force members is provided in Appendix 1.

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[6] The European Parliament's (2011) Report on the Roadmap to a single European Transport Area called for a 20% CO_2 reduction (compared to 2010 levels) in road transport and 30% in shipping and air transport across European airspace by 2020. It also called for a reduction of 20% in noise and energy consumption in rail transport.

2. TRANSPORT AND THE ENVIRONMENT: PAST SUCCESSES AND FUTURE CHALLENGES

Average mobility per person increased substantially over the past 200 years due to major advances in technology and services that influenced travel speed. While the average daily distance travelled per person has grown significantly, considerable research on historical and future mobility patterns has indicated a constant trend in average daily travel time. Schäfer and Victor (2000) put this trend into numbers and estimate that average travel time remains constant at about 1.1 hour per person per day – independent of income levels and the transport mode used. This finding is very relevant for transport policy since it implies that faster transport may lead to longer travel distances in the long term and thereby potentially higher emissions, unless technology changes (Bleijenbergm, 2012). Nevertheless, the concept of constant travel time has also occasioned controversy. Mokhtarian & Chen (2003) identify inconsistencies in the available literature and claim[7] that further research is required to better take into account all factors affecting the amount of travel.

Figures 2.1 and 2.2 show the development of freight and passenger transport between 1970 and 2009. As shown in Figure 2.1, freight transport increased by 82% during this time period, mainly driven by the expansion of road freight, which tripled its mileage to some 1,500 billion tonne-kilometres until 2009. Rail freight, on the other hand, lost about 30% of its mileage in the 40 years under consideration. Figure 2.3 shows that in a no-

[7] In particular, they claim that activity-related factors, such as activity duration and time spent on other activities, have not received the necessary attention in the studies examining the constant travel time concept.

policy-change scenario,[8] rail freight will have similar annual growth rates to road freight between 2005 and 2050. This only implies that the trend of rail freight constantly losing ground compared to road freight is expected to be reversed, since road transport will still dominate total freight transport.

Turning towards passenger transport, Figure 2.2 shows that the total distance travelled by European citizens (excluding aviation) increased by 139% between 1970 and 2009. This increase was solely driven by private cars, which in 2009 covered 83% of the total person-kilometres travelled. The rail sector only played a marginal role in passenger transport, representing a share of 7% of total passenger kilometres in 2009, compared to 13% in 1970. Aviation is not included in this data; however, Figure 2.4 shows that growth in aviation has outpaced all other modes of transport, and is expected to do so until 2050 (and beyond).

The European Commission projects that in the absence of additional policies beyond those adopted by March 2010 (i.e. in the Commission's White Paper Reference scenario) passenger transport activity (in p-km, incl. international aviation) would increase by 51% between 2005 and 2050,[9] while freight transport activity (in t-km, including international maritime) would increase by 82%. Despite improvements in fuel efficiency and increases of the share of renewables, this would result in CO_2 emissions that are 35% above 1990 levels in 2050.[10] Due to the fact that other sectors (e.g. power generation) are expected to decarbonise at a much faster pace, the transport sector's share in EU CO_2 emissions could increase from about

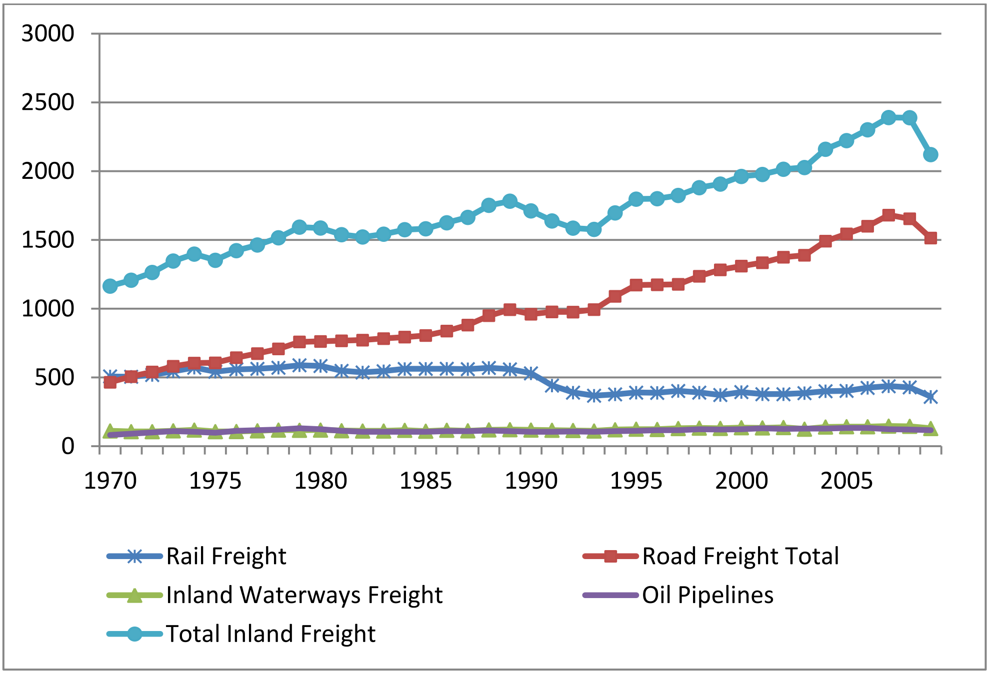
[8] The European Commission's Reference Scenario assumes no further policy intervention in the field of transport beyond March 2010.

[9] The European Commission (2011b) forecasts that growth in passenger car activity will be smaller in comparison with other passenger transport modes; this is attributed to the potential saturation of passenger car demand in some EU15 countries. The US Energy Information Administration (2011) and the International Transport Forum (2012) also indicate signs of saturation of vehicle use in more advanced economies.

[10] In the Commission's White Paper Reference Scenario, energy use of passenger cars is assumed to decrease by 11% between 2005 and 2030 (due to the implementation of the Regulation setting emission performance standards for new passenger cars), while the share of renewable energy sources would increase from 10% of total energy consumption in transport in 2020 to 13% in 2050.

one-quarter today to almost 50% in 2050. Similarly, the EU's transport system would remain highly dependent on fossil fuels, which would still cover 89% of its energy demand in 2050. The Commission concludes that without any further policy intervention today's system of mobility is not likely to reach the EU target to reduce GHG emissions by at least 60% by 2050, compared to 1990 (European Commission 2011b, p. 19).

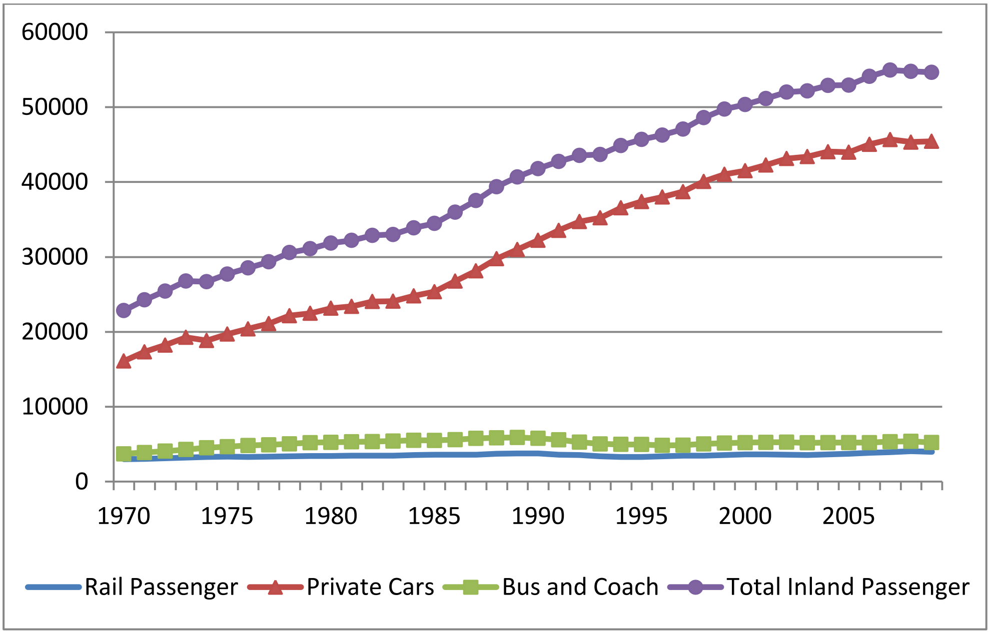
Figure 2.1 Historical development of EU27 freight transport, 1970-2009 (billion t-km)



Note: The effects of the economic crisis are strongly visible with a decrease of total EU27 freight transport of more than 11% from 2008 to 2009.

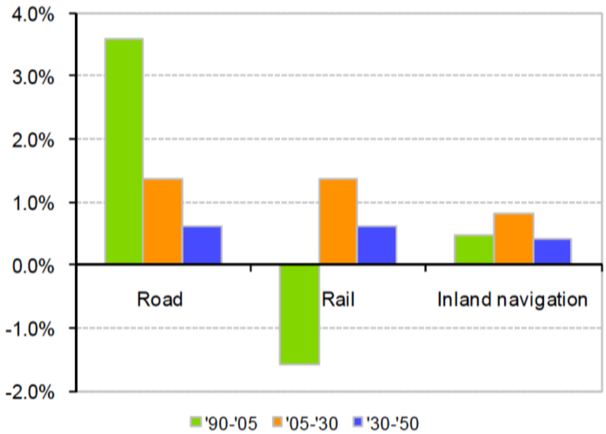
Source: ITF/OECD, own estimations and calculations.

Figure 2.2 Historical development of EU27 passenger transport, 1970-2009 (billion t-km)



Source: ITF/OECD, own estimations and calculations.

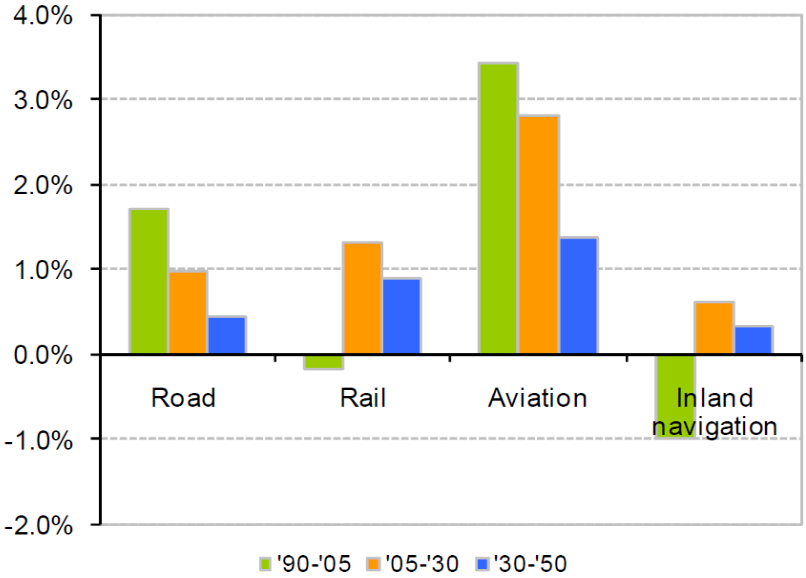
Figure 2.3 Average growth rate per year in freight transport activity (t-km, in %), 1990-2050



Note: For each mode of freight transport, the first column shows average growth from 1990-2005, the second from 2005-2030, and the third from 2030-2050.

Source: European Commission (Impact Assessment White Paper), Reference Scenario.

Figure 2.4 Average growth rate per year in passenger transport activity (p-km, %), 1990-2050



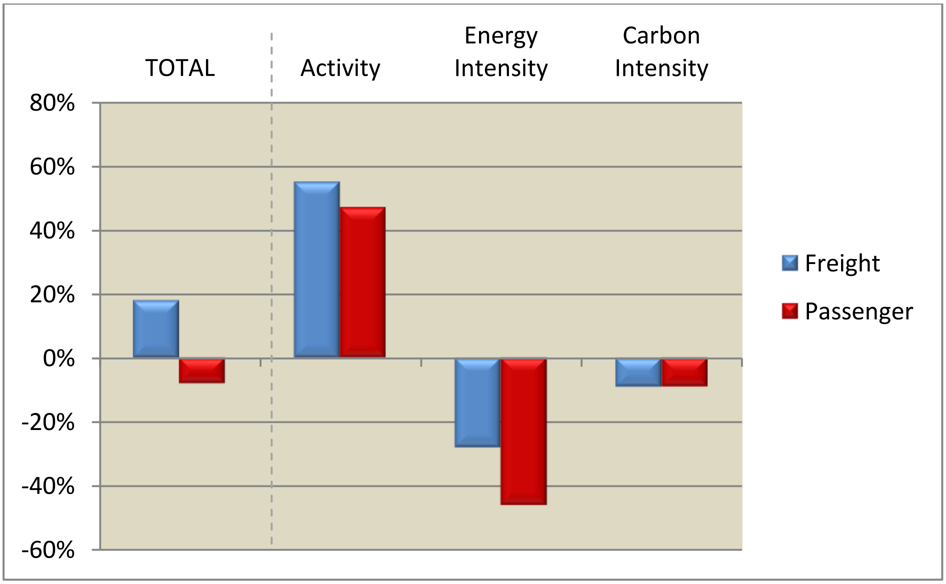
Note: For each mode of passenger transport, the first column shows average growth from 1990-2005, the second from 2005-2030 and the third from 2030-2050.

Source: European Commission (Impact Assessment White Paper), Reference Scenario.

Figure 2.5 shows transport CO_2 emissions projections from 2005 until 2050, separated for freight and passenger transport. While passenger-related CO_2 emissions are expected to slightly decrease, CO_2 emissions from freight are projected to grow, leading to a slight net rise of CO_2 emissions from transport between 2005 and 2050. The main reason for this increase in CO_2 emissions is the growth in transport activity, which outpaces reductions in energy intensity of vehicles and carbon intensity of fuels.[11]

[11] A more detailed analysis reveals that for freight, the overall 18% increase of CO_2 emissions (equivalent to 88 Mt of CO_2) can be attributed to the aggregate of a 55% increase in CO_2 emissions due to growth in activity, a 28% decrease in CO_2 emissions due to a decrease in the energy intensity of transport and a 9% decrease

Figure 2.5 Decomposition of tank-to-wheel[a] CO_2 emissions in the European Commission's Reference Scenario[b] (2005-2050) separated for freight and passenger transport



[a] Tank-to-wheel emissions refer to vehicle exhaust emissions.

[b] The European Commission's White Paper Reference Scenario assumes no further policy intervention in the field of transport beyond March 2010.

Source: Own compilation based on European Commission (Impact Assessment White Paper).

Reaching the EU's long-term GHG emissions reduction targets will thus require substantial efforts in the transport sector. This CEPS Task Force took as a starting point the figure of a 60% reduction compared to 1990 as was put forward by the EU Commission's White Paper and the underlying modelling (European Commission, 2011b).

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in CO_2 emissions due to a decrease in carbon intensity of the energy used. The 8% CO_2 emissions cut of passenger transport (equivalent to 60 Mt of CO_2) results from the aggregate of an increase in transport activity (equivalent to a 47% increase in passenger transport emissions), a decrease in energy intensity (equivalent to a reduction by 46% in passenger transport emissions) and a decrease in the CO_2 intensity of fuels (equivalent to a reduction by 9% in passenger transport emissions).

While GHG emissions reductions of this magnitude would appear to be a daunting task for transport policy, the EU has coped with similar challenges before. The most notable examples are reductions in the emissions of air pollutants from transport vehicles, including carbon monoxide (CO), nitrogen oxide (NOx) and emissions of particulate matter (PM). Figure 2.6 shows the development of EURO emissions standards for gasoline-powered passenger cars. While in 1992 CO emissions limits were at 2720mg/km, they had decreased to 1000mg/km by 2005. Similarly, NOx emissions limits were reduced from 150mg/km in 2000 to 60mg/km by 2009. This represents decreases of 63% and 60% in about 10 years, respectively. As regards diesel-powered passenger cars (Figure 2.7), CO emissions limits decreased from 2720mg/km in 1992 to 500mg/km in 2005. Similarly, NOx emissions limits will be curbed from below 970mg/km in 1992[12] to 80mg/km in 2014, while PM emissions limits decreased from 140mg/km in 1992 to 5mg/km in 2009. Emissions reduction per km thus amount to 82% (CO), about 90% (NOx) and even 96% (PM) over the past two decades, respectively.

Figure 2.8 shows that EURO standards for emissions of particulate matter (PM) have led to a decrease of overall PM10 emissions from transport activities by 33% between 1990 and 2007. This has been achieved despite strong growth in passenger transport of more than 31% over the same period.

A comparable trend is likely to develop for CO_2 from cars and vans. Existing emissions standards follow a downward trend similar to those for NOx and particles (European Commission, 2011b). Technically speaking, NOx and particles on the one side and CO_2 on the other are not comparable. In the case of the former, pollutants are a side effect of combustion and can be removed by end-of-pipe technologies. This is different from CO_2, which is a necessary result of the combustion in the internal combustion engine. However, for both stricter standards – provided that cost-effective technologies exist – will drive higher efficiency of the internal combustion engine while speeding up the deployment of new low-carbon technologies and fuels.

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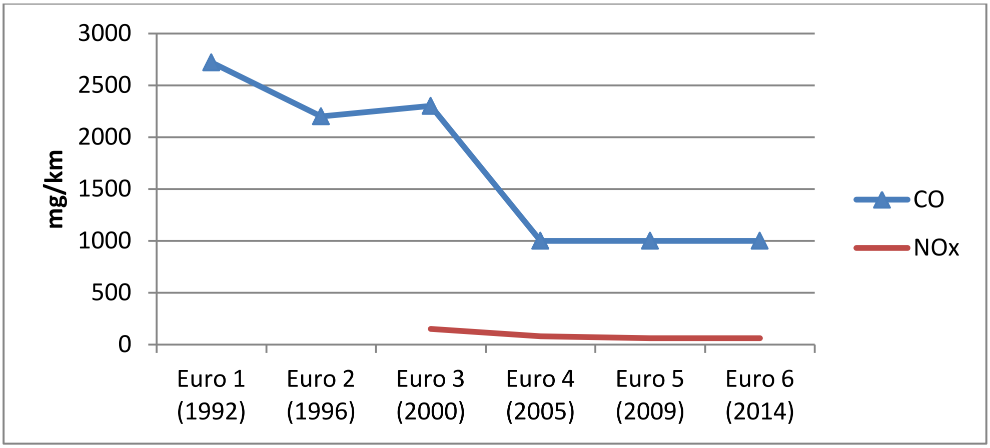
12 The EURO 1 standard of 970mg/km includes both hydrocarbons (HC) and nitrogen oxides (NOx). Separate standards for NOx have only been introduced with EURO 3 in 2000 (both for gasoline- and diesel-powered passenger cars).

The Commission (2011b) stresses that the decarbonisation of the transport sector depends initially on technology development towards clean and efficient vehicles based on conventional internal combustion engines. Only when new technologies have become cost-effective will the market allow the deployment of low-carbon vehicles. New and improved technologies and fuels would contribute to substantial energy intensity improvements, which are projected to reach some 70% in EU transport. According to European Commission projections, the energy intensity of passenger transport would decrease by about 65% between 2005 and 2050, mostly due to the enforcement of CO_2 standards,[13] but also due to other measures like eco-driving and fuel efficiency labelling. For freight transport, energy intensity would reduce by around 50% due to intensive policies with the objective of managing demand and encouraging modal shift, provided this is feasible.

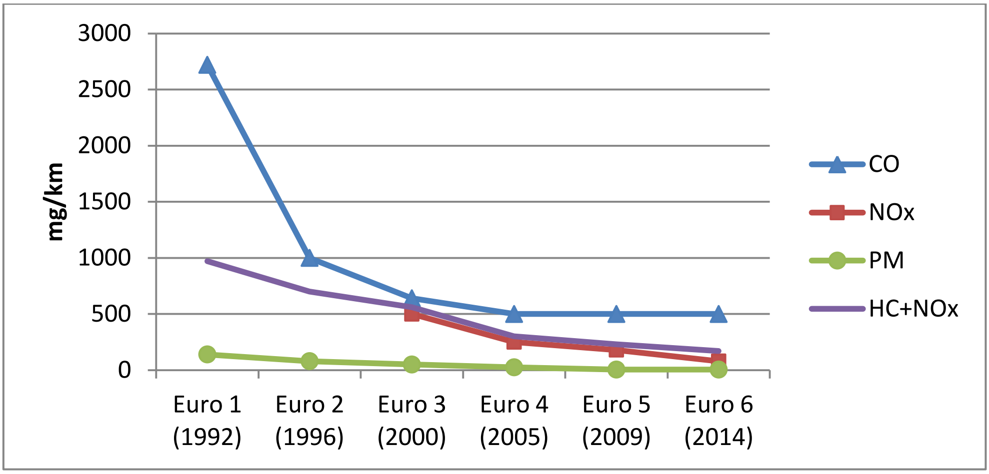
Figure 2.6 EU emission standards developments for gasoline-powered passenger cars (mg/km)



Note: CO=carbon monoxide emissions, NOx=nitrogen oxide emissions.
Source: Own compilation based on www.dieselnet.com.

[13] In its Impact Assessment, the EU Commission (2011b, p. 76) supports the view that CO_2 standards "*correspond to de facto energy efficient standards*" since currently the transport sector depends almost entirely on fossil fuels. However, this may not be the case as other technologies (for example electricity and hydrogen) increase their market penetration. Beyond 2020 other kinds of standards such as energy efficiency standards may gain prominence as a transport policy tool.

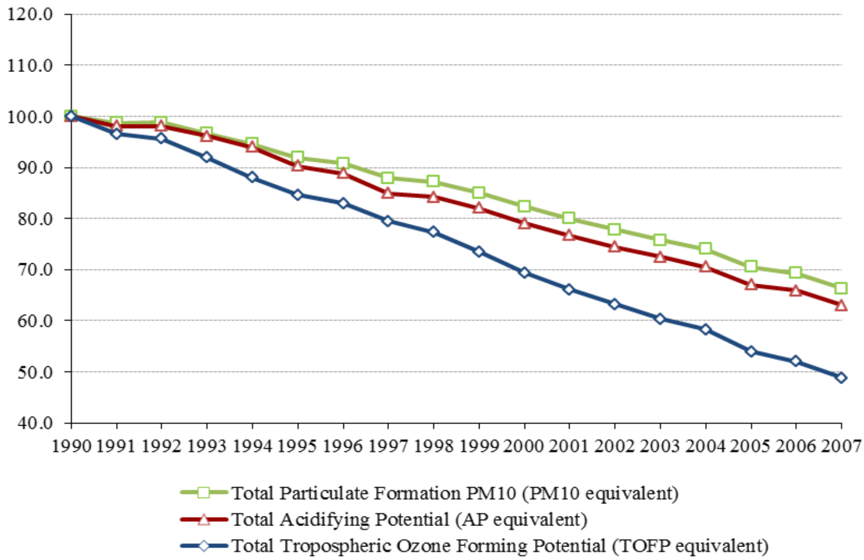
Figure 2.7 EU emission standards developments for diesel-powered passenger cars (mg/km)



Note: CO=carbon monoxide emissions, NOx=nitrogen oxide emissions, PM=emissions of particulates, HC+NOx=combined emissions of hydrocarbons and nitrogen oxides.

Source: own compilation based on www.dieselnet.com

Figure 2.8 Total reduction of total NOx and particles (PM10) (specific emissions x km travelled)



Source: Eurostat, EEA (in European Commission, 2011).

3. ACCELERATING DEVELOPMENT AND DEPLOYMENT OF FUEL EFFICIENT VEHICLES AND LOW CARBON FUELS

The previous chapter has shown that technological progress has been able to reduce pollutants such as NOx and particles (PM10). Major energy efficiency improvements of current vehicles are also still possible. For example, the Global Fuel Economy Initiative GFEI carried out an extensive review of studies on the potential improvement of the fuel efficiency of vehicles and concluded that the average fuel economy of the global vehicle fleet can be improved by at least 50% by 2050 (IEA et al., 2009) including both OECD countries and non-OECD countries. It cites several studies on reducing new car fuel consumption by between 30% and 50% between 2005 and 2030. GFEI (IEA et al., 2009, p. 4) finds that:

> ...the technologies required to improve the efficiency of new cars 30% by 2020 and 50% by 2030...mainly involve incremental change to conventional internal combustion engines and drive systems, along with weight reduction and better aerodynamic.

Whilst with full hybridisation of a wider range of vehicles, a 50% improvement is judged theoretically and technically possible by 2030. And indeed projections for the EU indicate that fuel demand by 2030 from cars – and with it CO_2 – will stabilise at the 1980 level because tighter standards will offset the increase in the vehicle fleet. This is also confirmed by data presented by Schneider (2011). The same effects could be achieved in other OECD countries if standards became similar to the trajectory of EU standards (IEA et al., 2009, p. 7).[14] This trend will also reach emerging

[14] Cutting vehicle fuel use per km in half will halve the rate of CO_2 emissions from vehicles, although variation is possible due to different fuel types, annual distance driven per vehicle, and general in-use conditions that can cause vehicles to perform differently.

economies, meaning that emissions from transport are projected to plateau at around 2040 (ExxonMobil, 2012). As documented by TNO et al (2011), recent studies show a reduction potential of up to 70% compared to 2002 average levels for cars with internal combustion.

While such emissions reductions will require progress in engine technology, this technological potential can only be reached if the whole transport value chain of all transport modes is optimised including fuels, infrastructure, logistics or international agreements, sometimes described as an integrated approach. This will also require that incentives are aligned with carbon efficiency, among others doing away with environmentally harmful subsidies.[15]

There are various promising technology routes available such as improving energy efficiency of vehicles, electric and hybrid vehicles, using electricity from low-carbon sources, hydrogen from renewable or zero carbon emissions sources, gas vehicles using natural gas and biogas or biofuels with a positive overall effect on GHG emissions. While all these technologies offer great potential, it is not yet clear what the mix of these technologies might be in the future. Promoting all technologies allows the market to choose the appropriate technology. See also section 3.5. The main issue is not only technology per se but also how all these promising technologies will gain prominence in the market.

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[15] In a study by the European Environment Agency (2007), direct subsidies to the transport sector are estimated to range between €270 to €290 billion per year, not including issues such as value of privileged regulation, land-use policy, etc. Note that not all of these subsidies should be considered environmentally harmful but the size of them gives an indication about the potential impact of subsidies. Road transport receives the majority of the above total (€125 billion), mainly in the form of infrastructure subsidies. Aviation receives preferential tax treatment through exemptions from fuel tax and VAT. Their annual value is estimated at €27-35 billion. Rail receives about €73 billion annually in the form of either infrastructure subsidies or fare reduction subsidies. Water-borne transport also receives €14 to €30 billion.

3.1 Emissions standards are the key

There is still significant scope for tightening EU car emissions standards,[16] notably to bring them closer to the technological frontier, something confirmed by the "50 by 50" analysis (IEA et al., 2009). To achieve this, emissions standards and regulatory targets for GHG emissions over the foreseeable period, possibly up to 2050, will need to be tightened (e.g. Skinner et al. 2010). This type of regulation can be extended to other modes of transport such as shipping or aviation, although the latter have a considerably longer lead time as fleet turnover moves from 10 years for light duty to 30 years or more for aviation and ships 2.[17] Adopting more stringent standards faster could contribute significantly to reducing global GHG emissions from transport.

Significant improvements in fuel economy can be delivered from improved vehicle components whose performance is not reflected, or only partly reflected, in the standard car fuel economy tests (IEA et al., 2009, p. 13). Examples are air conditioning or equipment to provide information on instantaneous and average fuel consumption. The EU has therefore adopted a number of regulations addressing these components. For example Regulation (EC) No 661/2009 requires all new car models to be equipped with low rolling resistance tyres by November 2013. This will be extended to all new cars by November 2014. A second phase, with stricter rolling resistance limits, will apply for new car models from November 2017 and all new cars from November 2018. For heavy duty vehicles, Nylund (2006) assesses the potential for significant savings in fuel consumption: the weight and aerodynamics of the vehicle up to 30%, tyres

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[16] EU emissions standards for GHG emissions are already in place for passenger cars and vans. Discussions on similar standards for heavy duty vehicles (trucks and buses) that are responsible for approximately 25% of total EU road transport emissions are ongoing (more information at http://tinyurl.com/cr2x5m3).

[17] In 2011, the IMO adopted amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships, adding a new chapter 4 to Annex VI on Regulations on energy efficiency for ships to make mandatory the Energy Efficiency Design Index (EEDI), for new ships, and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. As for aviation to and from the EU, emissions are included in the EU Emissions Trading System (ETS) from 2012. The ETS effectively caps emissions of the included sectors.

5 - 15%, different air deflectors 4 – 8%, type of trailer 3 - 5%, and lubricants 1 - 2% whilst the fuel consumption of a heavy-duty vehicle under dynamic driving conditions is however primarily determined by the weight of the vehicle and the driving-cycle.

Box 3.1 CO_2 emissions standards for cars and vans

The EU has adopted CO_2 emissions standards for cars (Regulation 443/2009/EC) and vans[18] (Regulation 510/2011/EC).

Passenger cars registered in the EU need to achieve a fleet average of 130 grams per kilometre (g/km) by 2012, almost a 20% reduction from the situation prior to the Regulation.[19] The regulation is phased in over the period from 2012 to 2015. Manufacturers must meet their average CO_2 emission targets in 65% of their fleets in 2012, 75% in 2013, 80% in 2014 and 100% from 2015. A target of 95g/km is also specified for the year 2020. To meet this target, the Commission (2012d) has proposed a 'super credits' system in favour of low-emitting vehicles; however, the modalities[20] of how this target will be reached are to be approved by the European Parliament and the Council.

The mirror regulation to cut CO_2 emissions from light-duty vehicles (i.e. vans) will cut emissions from vans to an average of 175 grams of CO_2 per kilometre by 2017 – with the reduction phased in from 2014 – and to 147g CO_2/km by 2020. These cuts represent reductions of 14% and 28% respectively compared with the 2007 average of 203 g/km. The corresponding long-term target for 2020 is 147g/km, for which the modalities are again to be approved by the European Parliament and the Council.

In addition to stimulating the deployment of advanced technologies and thereby driving technological progress, such standards have further benefits. First, they can be an effective way of overcoming the barriers in

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[18] This includes vehicles used to carry goods weighing up to 3.5t (vans and car-derived vans, known as 'N1') and which weigh less than 2610kg when empty and account for around 12% of the market for light-duty vehicles.

[19] In both Regulations a so-called limit value curve implies that heavier cars/vans are allowed higher emissions than lighter cars/vans as long as the average fleet average is preserved.

[20] They refer to Regulation implementation aspects that determine how the target can be met (European Commission, 2012d).

investing in fuel economy that would be profitable from a societal perspective. Second, standards – whether on fuel economy or CO_2 – increase regulatory certainty for manufacturers, suppliers and technology providers faced with long investment cycles, enabling them to bring new technology to market (IEA et al., 2009). In the longer term, indicative targets might also be possible to assist the development of the kind of technology that involves much more than incremental improvement.

To be truly effective, EU regulation will need to take into account well-to-wheel (WTW)[21] emissions, i.e. emissions over the full life cycle. While life-cycle analysis should play a bigger role over time, to date, estimating GHG emissions accurately remains a challenge due to a lack of agreement on methodologies and availability of data.[22] In the case of vehicles with internal combustion engines, the majority of GHG emissions (approximately 85% of all GHG emissions from transport use) stem from the burning of fuels in vehicles, typically described as 'tank-to-wheel',[23] while only 15% originates from production, refining and distribution of fuel and embedded energy in vehicle construction.

Setting emission standards requires appropriate test procedures, i.e. *testing* that reflects the real-life fuel consumption of vehicles. A report by IEA (et al., 2009:14-15) claims that to date, "real fuel consumption on the road tends to be higher than the laboratory tests used to certify new vehicles", mainly due to discrepancies arising in stop-go, urban driving conditions and because of the rules and conditions of the test cycles themselves. The same report argues that there might be merit in establishing a common standard for eco driving equipment for the EU or beyond, i.e. an additional and complementary standard test to provide drivers with information on the level of fuel consumption they might expect to achieve on the road. There is further evidence to support the view that official test procedures undervalue the real-life fuel consumption and

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[21] The amended EU Fuel Quality Directive (FQD) in Article 7a requires that WTW GHG emissions per unit of energy supplied be reduced by a minimum of 6%, and up to 10%, by 2020.

[22] For further details on life-cycle GHG emissions of fuels, see the results from a CEPS workshop on "Comparing Life Cycle Analysis of Crude Oil" (http://tinyurl.com/d4ms2gz).

[23] For further information see: JRC (2005) and follow-up studies.

CO_2 emissions of cars. For example, in a recent study for the European Commission, Kadijk et al. (2012) illustrate certain flexibilities in the existing test procedure that could enable the laboratory tests to achieve lower CO_2 values than in real-world driving conditions. The importance of testing goes beyond setting standards however. It is also relevant for other aspects, such as labelling and CO_2 differentiation of taxes (see sections 3.2 and 3.3).

Currently, experts from governments and automobile manufacturers are in the process of developing a new harmonised test procedure for light-duty vehicles to be adopted worldwide within the World Forum for Harmonization of Vehicle Regulations of the United Nation Economic Commission for Europe (UN/ECE/WP29). The European Commission (2010a) has recognised that a harmonised test procedure would reduce the testing burden for the industry and allow regulators across the globe to benchmark according to a common metric. The new test procedure is expected to be completed in 2014.[24]

Policy issues on emissions standards and testing include institutional questions, i.e. who does what and transparency about the process. To fit with EU climate change objectives, a challenge for EU policy will be to ensure that the new global test cycle improves transparency and accurately reflects 'real consumption', i.e. ensures the correlation between the reduction measured on the type of approval test and the effects on emissions under real-world driving conditions. Otherwise, emission standards become ineffective and therefore the EU would be better off introducing its own test cycle.

3.2 CO_2 differentiated taxes and charges

Fiscal or financial incentives such as taxation are powerful complementary tools in the hands of member states, regional or local governments to accelerate the market penetration of vehicles and components with higher efficiency and a lower carbon footprint, adapted to local preferences and circumstances. The most important examples are taxes on vehicles.

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[24] The new test procedure, namely the World Light Duty Test Procedure (WLTP), aims to provide more accurate emissions and fuel consumption values; more information and latest updates about the development process at (http://tinyurl.com/ctt9q5p).

Governments typically levy taxes on sales and vehicles. Only recently have such taxes been differentiated according to vehicle fuel economy or CO_2 emissions whereby governments differentiate between higher and lower emissions vehicles in order to stimulate consumers to buy fuel-efficient or low-carbon vehicles.[25]

For example, in Japan, tax incentives for fuel-efficient vehicles were introduced in 2001, accelerating the penetration of fuel-efficient vehicles, with 80% of passenger cars clearing the 2010 fuel efficiency standards by 2004 (IEA et al., 2009:13).

Another powerful instrument is CO_2 differentiation of the fiscal treatment for company cars. Company cars in Europe are a huge market. Each year, European companies buy about 50% of all new cars sold in the EU, including cars used in the course of business, such as hire cars or taxis, as well as pooled cars that are not available for employees' private use, i.e. fleet management (Van Essen et al., 2010, p. 36). This makes the area of company car taxation a tool to drive low-carbon technology deployment. Company car taxation can become an especially powerful tool to steer companies to buy more fuel-efficient or lower carbon fuels. Such an initiative would also have a spill-over on the second-hand market, which largely consists of ex-company cars. This is in stark contrast to today's situation where the fiscal treatment of company cars often constitutes a subsidy for cars and car use, irrespective of their fuel efficiency and therefore lead to an increase in transport volume as well as to the purchase and use of less fuel-efficient vehicles (Van Essen et al., 2010: 35-37; Copenhagen Economics, 2010).

3.3 Labelling

Consumer information, including labelling, is meant to influence car purchasing decisions by consumers selecting a fuel-efficient vehicle, although fuel costs are only a very small part of the full-life costs of

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[25] In the literature, there is still debate on the effectiveness of different taxes, notably registration taxes versus (annual) circulation taxes, while evidence-based analysis on this subject remains limited; see COWI (2002); Ryan et al. (2006); Van Essen et al. (2010). Van Essen et al. (2010:31) find that elasticity of vehicle ownership with respect to price is estimated to be -0.4 to -1.0, meaning that a 10% increase in total vehicle costs reduces vehicle ownership by 4-10%.

ownership. More importantly, vehicle labelling is also a precondition for differentiated car taxes (see section 3.2). Under EU law, a fuel economy label must be attached to the windscreen of all new passenger cars at the point of sale, containing an estimate of fuel consumption, expressed in litres per 100 kilometres or in kilometres per litre (or in miles per gallon), and of CO_2 emissions.[26] The "50 by 50 Report" (IEA et al., 2009:15) recommends this approach, but insists that there is a need for a more harmonised application of the criteria underpinning the differing labelling systems across the EU so as to provide consistent signals to consumers and manufacturers across the car markets.

This need can be illustrated by Table 3.1, which highlights the absence of consistent signals about CO_2 emissions across the EU and Switzerland. Depending on whether they are based on absolute or relative values of CO_2 emissions, European rating systems may provide contradictory information about the emission performance of the same vehicles. For example, in Germany heavier cars may acquire a higher rating than smaller ones, despite their higher tested CO_2 emissions (in grams per kilometre), due to the weight-based relative rating system (IEA, 2012).

Table 3.1 Vehicle CO_2 ratings across European countries

	Tested CO_2 emissions (gCO_2/km)	France	UK	Belgium	Switzerland	Germany	Spain
		Absolute Values			Relative values		
Smart Fortwo MHD	98	A	A	A	A	C	C
Ford Focus 1.6 TI-VCT	139	C	E	C	B	D	A
Lexus RX450h	148	D	F	C	A	A	A

Source: IEA (2012).

[26] Regulation (EC) No 1137/2008; *OJ L 311*, 21.11.2008.

Consistent signals are also important for logistics, which offers a significant improvement potential by a combination of supply-chain optimisation such as shifting transport modes or customer-specific measures for improving their carbon footprint, e.g. the use of new carbon-saving technologies (see also Chapter 4).

3.4 Predictable, progressive and harmonised incentives

Incentives only work if they are aligned with a consistent objective, predictable and subject to a common European or even global framework to provide scale effects to the developers, manufacturers, infrastructure investors, service providers and users. An example that illustrates this need is the fiscal treatment of vehicles according to CO_2 performance in the EU, where to date incentives have lacked alignment and consistency across member states and sometimes have been discontinued or even reversed (Perkins, 2011).

Practically this means that incentives should be consistent with EU objectives on low-carbon transport (i.e. technologies and fuels) in a non-discriminatory manner (i.e. technology-neutral) and should be progressive over time, i.e. standards being tightened regularly and in a predictable manner avoiding discontinuity while keeping cars affordable; and that their basic feature such as performance requirements, testing and labelling are subject to a common framework.

The other particularly important field is fuel taxation. Fuel taxes provide incentives to shift to more fuel-efficient vehicles, at least over time,[27] although purchase, ownership or circulation taxes are generally considered to be more effective in providing incentives for a shift to more fuel-efficient vehicles.[28]

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[27] The "50 by 50 Report" (IEA et al., 2009, p. 14) argues that the difference in fuel taxes between the US and the EU was at least partially responsible for the 15% difference in their average fuel economy. Other reasons include the difference in income levels and the design of CAFE Regulations favouring light trucks over cars.

[28] For example, Van Essen et al. (2010, p. 32) conclude that "to date, however, empirical evidence on the responsiveness of automobile purchases to various forms of taxation is sparse", leaving a lot of uncertainty as to the effects of changes in total cost of ownership from a consumer's point of view; see also COWI (2002) in support of and Vance and Mehlin (2009) against this view.

Increasing vehicle efficiency will reduce fuel tax revenues for governments in absolute terms and this risks a gradual weakening of the incentives stemming from fuel taxation. Maintaining the fuel tax related incentive for more fuel-efficient vehicles will therefore require adapting the level of fuel taxes. Additionally, in conjunction with adapting fuel taxation, the gradual application of road pricing could also offset the potential revenue losses by treasuries due to more efficient vehicles, and maintain the purchasing power of the consumer. This approach would affect all vehicles in the same way and would be in line with the EU objective of all sectors paying the full marginal cost. See also the section on transport pricing in chapter 4.

3.5 Research, innovation and early deployment

Government incentives such as standards, tax incentives or labels should be technology neutral to enable the market to identify the most efficient technology. There is one potential exception, however: research & development (R&D), demonstration and in some – well-defined cases – early deployment where technology-specific measures are justified. Yet such technology-specific measures should be defined so that they keep all technology routes open.

Providing public funding for R&D, and sometimes demonstration, is therefore generally uncontroversial. More controversial is the question of help for deployment or, as it is sometimes called, 'pilot testing' of 'promising' technologies as this is no longer technology neutral. Governments are generally wary, with good reason, about engaging in technology-specific support by 'picking winners', because, among other problems, the record of such policies is generally considered to be poor.

On the other hand, some (low-carbon) transport technologies have network effects, i.e. require dedicated infrastructure[29] or investment in technologies that can be too risky for private investors because of time horizons (e.g. hydrogen). Technology-specific public intervention may also be justified to reap the scale effects of new technologies (e.g. battery costs), if indeed scale effects are physically and economically within reach.

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[29] Examples are charging stations for EVs, hubs and loading stations for co-modality of systems for seamless transfer.

There is no single answer to the question of which 'technology-specific' strategies are warranted. Instead they need to be tailor-made for each technology. These policies will depend on the nature of the barriers (e.g. financial, technological, market, non-market etc.), related to technology maturity, i.e. i) proven technologies that show potential for commercial deployment, ii) proven technologies that are not yet commercially competitive and, iii) unproven technologies with significant research and development costs (Nùñez Ferrer et al., 2011). The European Commission's Transport White Paper (2011, p. 12) states that the Commission "will devise an innovation and deployment strategy for the transport sector in close co-operation with the Strategic Energy Technology (SET-Plan)". In September 2012, the European Commission (2012b) adopted a Communication on transport research, innovation and deployment as a first step towards a European transport-technology strategy. The Communication provides the initial proposals for a new European transport innovation strategy and bases its analysis on scientific documents by the Joint Research Centre (JRC).[30]

Such a strategy needs to cover all (promising) technologies alike. The main promising routes to a strong CO_2 reduction from transport are:

- Improving the energy efficiency of vehicles, including hybridisation
- Electric, and plug-in hybrid and hybrid vehicles, using electricity from low- carbon sources
- Hydrogen from renewable or zero-carbon sources
- Gas vehicles using natural gas and biogas
- Biofuels with a positive overall effect on GHG emissions, including e.g. ILUC

As a rule, governments should not subsidise the deployment of specific technologies. Such subsidies are generally less efficient than the 'horizontal', i.e. technology-neutral measures that we have discussed above. If, for reasons mentioned above, subsidies are justified however, it is important to grant them only temporarily. Otherwise, the risk increases

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[30] For the purposes of this Communication the JRC produced two scientific documents; the first one assesses the strategic transport technologies while the second examines the status of R&D efforts, institutional capacities and barriers to innovation. Both reports are available at (http://tinyurl.com/buzdnsc).

that governments pick technology winners for narrow national industrial policy motives with a negative effect on the economy as a whole.

3.6 Fuels legislation

The uptake of renewable energy sources for transport, including biofuels, is promoted in the EU via two legislative documents. The Renewable Energy Directive (RED) issues[31] a legally binding commitment for all member states to source at least 10% of the final consumption of energy in transport from renewable sources, while the Fuels Quality Directive[32] (FQD) obliges member states to gradually reduce life-cycle greenhouse gas emissions of fuels by at least 6% by 2020.

The legislative framework has been criticised on at least two grounds. The first is that actual GHG reductions achieved by biofuels are overstated because indirect land-use changes are not accounted for. Even though Directives include sustainability criteria for biofuels, they have been criticised for promoting the use of biofuels while overlooking the consequences of indirect land-use change (ILUC) i.e. the GHG effects and impact on biodiversity of converting non-agricultural land elsewhere for biofuel production (Kampman et al., 2012; Kretscmer & Baldock, 2013). As early as 2008, the JRC (2008) expressed concerns about the uncertainties related to the emissions from land use change. Further studies[33] prepared for the European Commission have strengthened the evidence base[34] for the impacts of indirect land-use. In response to the above concerns, in October 2012 the Commission (2012c) issued a proposal to amend the RED

[31] See Article 3(4) of the Directive 2009/28/EC on the promotion of the use of energy from renewable sources.

[32] See Article 7(a) of the Directive 2009/30/EC amending Directive s 98/70/EC and 1999/32/EC and repealing Directive 93/12/EEC.

[33] See Laborde (2011), Hiederer et al. (2010) and Marelli et al. (2011).

[34] It is noteworthy that during a workshop held at the European Parliament in February 2013, the representative from JRC supported the view that all models and historical-based approaches currently indicate a net emissions increase due to ILUC. The presentations are available at (http://tinyurl.com/chaz9do).

and FQD. The proposal limits the contribution of biofuels from food crops[35] towards the attainment of the renewable energy target for transport to a maximum share of 5%.[36]

The second criticism relates to the Fuels Quality Directive (FQD), which requires fuel suppliers to reduce life-cycle GHG emissions of the fuel per unit of energy they put on the market.[37] The fuel suppliers are free to choose how to achieve these targets. They can either use more biofuels or alternative fuels, or decrease their emissions by reducing flaring and venting at production sites (upstream) outside of Europe. The question is whether the 'tracking' of footprints is possible or not, and whether the measure is enforceable. A particular controversy is over the possibility to obtain reliable data for GHG emissions of all or even the majority of global crude sources. In the absence of data, it will be difficult to enforce the measure and this could even generate fraudulent practices.

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[35] According to the Commission's proposal (2012c, p. 14) the list of fuels from food crops with a high risk of ILUC emissions includes "biofuels and bioliquids produced from cereal and other starch rich crops, sugars and oil crops".

[36] This has been criticised for failing to sufficiently mitigate the risks associated with the GHG emissions from ILUC. The emissions from ILUC are introduced in the draft legislation merely as a reporting obligation (Kretscmer & Baldock, 2013). In a joint position (available at http://tinyurl.com/culzw7f) a group of environmental NGOs has urged the European Parliament and Council in to introduce in the sustainability criteria of both the RED and FQD factors that would take into account the emissions from ILUC to guarantee equal treatment between food and non-food biofuels according to their life-cycle carbon performance. In a research paper produced for the International Council on Clean Transportation, Malins (2012) also suggested that ILUC factors should be included in the EU fuel policy.

[37] This will require a (mandatory) reduction of at least 6% compared to the EU-average level of GHG emissions in 2010 with interim targets by 2014 and 2017.

4. A BETTER TRANSPORT SYSTEM

Many attempts have been made to reduce transport growth, to increase vehicle load factors and to change the modal split. In the past, these efforts had limited effect. In theory, it is possible to increase the efficiency of the transport system substantially, but the practice has shown that it is hard to change trends that are founded in economics and consumer preferences. Effective policy measures that would change trends are very difficult, if not impossible to adopt because of political opposition. In practice this has meant that effective policy measures are largely unacceptable, and acceptable policy measures are largely ineffective in changing mobility patterns. Nevertheless, potentially acceptable measures to improve the transport system do exist.

4.1 Urban density and transport: some reductions

The link between urban density and emissions is complex and depends, inter alia, on various factors including energy supply sources, the location of industrial activities and the level of economic development. Urban transport is responsible for about a quarter of total transport CO_2 emissions. A study of Toronto showed that when the distance to the city centre increases and the density of population decreases, car emissions dominate total emissions (VandeWeghe & Kennedy, 2007).[38] As a result, compact cities have greater accessibility and are therefore somewhat more energy and carbon efficient than a dispersed built environment. Mass transit is economical in dense urban areas, mainly as a function of the volume of passengers and is attractive because of the low speed of cars. In addition to mass transit, cycling and walking can offer further contributions. In most cases, both the road and rail network will need to be

[38] For example, the low-density suburban development of the city of Toronto, Canada has been estimated to be 2 to 2.5 times more energy and greenhouse gas intensive than its town centre (Norman et al., 2006).

upgraded to increase its robustness to avoid frequent failures, for example. Altogether this could result in modest CO_2 emissions reductions of around 5-10%[39] (Bleijenberg, 2012).

4.2 ICT and eco-driving support systems

Opinions are divided over the potential influence of new Information and Communication Technologies (ICT) on travel time. One school of thinking believes that ICT will reduce demand for transport because of the possibility to communicate – in person – without the need to travel. That would therefore reduce travel time. An opposing view states that ICT will enable people to perform other tasks whilst travelling, i.e. communicating via phone or e-mail, working and reading. That could in turn incentivise people to increase the time they spend on travelling. To date there is no evidence that the consecutive ICT revolutions have affected average travel time (Bleijenberg, 2012).

The use of ICT for all modes of transport has been a central point of reference in various recent EU publications. In its Impact Assessment, the EU commission (2011b) argues that ICT can support an improved management of transport flows, which solves some congestion problems and uses existing infrastructure capacity more efficiently. One particular application of ICT is eco-driving support systems[40] that offer feedback to the drivers of vehicles on fuel consumption, emissions, driving speed limits and congestion levels. It has also been suggested that these systems have the potential to be part of a ‘pay as you drive’ framework (Baptista et al., 2012) that internalises external costs and ensures that transport users pay the full cost of their activities (European Commission, 2011).

A report by the European Commission (2010) foresees that just by following the instructions of the shift indicators, emissions can be reduced by 6%.[41] However, additional appropriate incentives are needed to

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[39] It is to be noted, however, that these figures should be considered as approximate estimates since assessing the impact of urban density on mobility is a highly complex task, involving a range of assumptions.

[40] ICT are often deployed in road networks as a means to influence travel behaviour and limit travel speed (Baptista et al., 2012).

[41] See measure 8 in section 5 for more estimates about the emissions reduction potential of eco-driving support systems.

encourage eco-driving, as behavioural change is difficult to impose and tends to be short-lived. That point is further discussed in Chapter 5 where immediate actions are outlined, concluding that ICT developments could contribute to between 5% and 15% energy savings.

4.3 Efficient co-modality for an integrated European transport area

One of the objectives included in the European Commission's White Paper (2011) is to allow shifting 30% of road freight over 300 km to other modes such as rail[42] or waterborne transport by 2030, and more than 50% by 2050" by overcoming fragmentation, better co-ordination and other incentives. This approach has been challenged by the European Automobile Manufacturers Association (2011),[43] which argues that policies should aim at achieving efficient co-modality, in which all transport modes are optimised and integrated in order to achieve seamless transport and reach the EU GHG reduction targets. Thus, modal shift would be an outcome of a policy to reduce GHG emissions and not a policy objective *per se*.

The European Parliament (2011, p. 6) approved the 10 goals for a competitive and resource-efficient transport system and the targets included in the White Paper for 2050 and 2030 but supports the viewpoint that:

> efficient co-modality in passenger mobility and goods transport throughout the entire chain of transport and logistics services – measured in terms of economic efficiency, environmental protection, energy security, social, health and employment conditions, safety and security, and taking account of territorial cohesion and the geographical environment in individual countries and regions – should be the guiding idea for future transport policy […].

[42] According to Eurostat 2010 data, rail represents 17.1% of inland freight transport, while railways, trams and metros account for 7.1% of inland passenger transport. Data available at http://tinyurl.com/dyxkrxu and http://tinyurl.com/4rkrwjj.

[43] During the CEPS Task Force meeting on 26th of September 2011 it was claimed that internal studies carried out by Volkswagen indicate that in Germany a modal shift of 30% of road freight over 300 km would require an increase in rail freight transport of 94% by 2030 with a trebling of costs, well above what the study considers a reasonable increase of 24%, see Dinse, 2011).

Box 4.1 Potential and policies for modal shift

Rail

In assessing the options for shifting the balance between modes of transport, the European Commission (2011b) suggests that long-distance freight holds the greatest promise for shifting additional freight transport to rail.[44] Whether this will materialise will depend on demand. Research has also indicated that the maximum potential share of rail in freight transport is in the range of 31–36%; in this case rail would dominate long-distance transport (Den Boer et al., 2011).

According to the European Commission (2011b) the modal shift is held back due to, among others, a number of barriers that hinder the development of an integrated European rail area, such as protectionist regulations, an incomplete implementation of EU legislation, lack of common standards and a failure to invest in rail infrastructure. The latter is put forward as part of the reason for the decline of rail. Ludewig (2011) finds[45] that in comparison with motorway length, rail track length saw only a small increase in EU15 between 1970 and 2008. Moreover, rail traffic increased only marginally since 2007, while road traffic almost tripled. He also argues that "similar growth levels could be reached by rail with similar levels of investments as in road".

Despite the potential benefits of the need to increase the share of rail in freight transport, there is a growing body of research indicating that the carbon benefits of rail might not be as high often suggested. Åkenam (2011) points out that the indirect effects of new rail tracks such as emissions related to construction, operation and maintenance should not be neglected when weighing up the benefits and drawbacks of new high-speed rail connections. Using a parametric model for the calculation of the net carbon benefit from shifting from other travel modes to high speed rail, Westin & Kågeson (2012) argue that offsetting the large embedded emissions[46] from large rail

[44] Rail transport is estimated to be responsible for only 0.7% of the total transport sector's CO_2 emissions (European Commission, 2011b). However, as specified by Eurostat, rail transport data do not include emissions from electricity use; this is of significant importance considering that electric traction is responsible for around two-thirds of final energy consumption in rail transport (more information at http://tinyurl.com/co7nh26).

[45] In particular, he claims that rail track length decreased by 14% in EU15 between 1970 and 2008, while motorway length increased by 3.5 times during the same period.

[46] Their calculation includes emissions from the whole lifecycle such as those resulting from the maintenance of network and recycling of materials.

infrastructure requires high traffic volumes and significant traffic diversion from aviation to rail. This implies that in some cases, such as in sparsely populated regions, it might be more expedient to upgrade existing lines and encourage people to substitute air travel with telecommunications than to invest in high-speed rail. The findings of studies[47] for other modes of transport further highlight the need to take into account the whole life-cycle CO_2 emissions from new technologies. The picture that emerges from the discussion above is that assessing the possible benefits from modal shift requires a holistic approach to ensure that all aspects of new policy options are taken into consideration.

Waterways

Waterways transport is credited with some potential to reduce emissions from freight transport, but is hindered by present logistics. The 2011 mid-term evaluation of the TEN-T programme 2007-2013 (Steer Davies Gleave, 2011) reports that waterway freight transport is a long way from being exploited efficiently. To address these challenges, the European Commission (2011a) aims at developing a 'European Maritime Transport Space without Barriers' that is meant to ensure free maritime movement in and around Europe. The objective is to reduce the administrative barriers in EU ports (such as customs, veterinary and plant protection control), by the means, amongst others, of 'Blue Lanes' (fast-track procedures) that will ensure the speedy transport of goods. Other targets are improving the efficiency of seaports and reducing the fragmentation of the overall institutional and regulatory framework.

4.4 Green logistics

There is considerable potential for carbon emissions reductions in the logistics sector, as acknowledged by the European Commission's Freight Transport Logistics Action Plan (2007). An example in this field is the green programme by Deutsche Post DHL (Hess, 2011) aiming to achieve a 30% increase in carbon efficiency by 2020 for all products and goods. The programme includes a combination of measures such as shifting transport modes, applying customer-specific measures for improving their carbon footprint (e.g. the use of new carbon-saving technologies), preparation of

[47] A study conducted by Patterson et al. (2011) on emissions from passenger cars shows that although electric and hybrid generate lower life-cycle CO_2 emissions than traditional cars, they entail higher emissions from manufacturing and disposal.

carbon footprint reports for the customers and off-setting of non-avoidable carbon emissions at product level.

Nevertheless, reducing the carbon footprint of logistics at EU level is by no means an easy task and requires interventions across a wide range of transport policy areas. Progress in this sector is hindered by the inadequate internal market for all transport modes, the absence of efficiently functioning rail freight corridors and the lack of financial incentives for intermodal solutions for freight coming into or going out of the EU. The application of carbon pricing (ETS, carbon taxes), road charges (Eurovignette III) or in-kind measures (e.g. privileged access to city centres) would assist in improving the sustainability of transport logistics. It has also been stressed that a standardised load factor measurement would optimise the capacity utilisation of trucks and encourage the development of technologies for measuring load factors. This could lead to the creation of bodies responsible for collecting data for the industry and certification schemes, but still any advancement of this kind requires a commonly agreed carbon accounting methodology to establish the overall verified carbon footprint and/or certify reductions achieved (Hess, 2011).

4.5 Getting (transport) prices right

Transport pricing is critical to achieving a better and more efficient transport system. There are more than 40 years of history of transport pricing, including the internalisation of external costs and marginal social cost pricing. Marginal social cost pricing is now widely accepted as the economic principle towards a more efficient transport system. Typically, studies estimating the marginal social costs of different transport modes, vehicle types and infrastructure categories include those related to the management and maintenance of infrastructure on the one hand, and on the other to internalising external cost such as:

- accident costs not covered by insurance,
- air pollution, including GHG emissions,
- noise nuisance.

The security of energy supply, i.e. oil import dependency is another recent example.[48]

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[48] 'Marginal' means that each additional (marginal) vehicle should pay the costs that it imposes to society while 'social' refers to all costs, including the so-called

In addition to the 'efficiency argument', transport taxes are also meant to raise revenues for general governmental services (defence, education, social assistance etc), thus serving as a tool to achieve a politically desired distribution of income and wealth.

Fixed vehicle or sales taxes have often been preferred over taxes reflecting mileage or CO_2 performance due to equity concerns. There is, however, evidence that an increase in user charges and simultaneously a decrease in fixed taxes would create additional incentives for energy and carbon efficiency improvements. According to ECMT (2000) and Van Essen et al. (2008), this would require an approximate doubling of existing rates for transport charges per kilometre in most countries. Charges for lorries would also need to be adjusted in this case. Currently truck charges do not cover the marginal social costs[49] in many countries. If such changes are effected, they should be kept revenue neutral.

Taking into account the triple objective of efficiency, equity and revenue raising, this report proposes the following order of EU transport taxation:

- Taxation policy should start with taxes that are based on performance factors and ensure a level playing field; marginal social cost pricing is a good starting point and includes externalities;
- To ensure consistency of CO_2 pricing across the economy a CO_2 component should be integrated into the existing taxation system in alignment with the economy wide price;
- Transport taxation policy, however, is also designed to raise revenues, leading to a net contribution from motorists to the treasury: the guiding principle should be to raise revenues by the use of the least distorting taxes.

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external costs. Economic valuation methods are used to estimate 'shadow prices' when market prices are not available, e.g. for all categories except infrastructure costs. Typically, studies show a range in the resulting marginal social cost, but the research is robust enough for use in policy-making.

[49] ECMT (2000) proposes differentiating charges on a territorial basis by employing instruments such as kilometre charges and road tolls rather than raising national taxes and charges. A detailed discussion can also be found in Van Essen et al. (2008).

Key elements in this area are the Energy Tax – currently under review – and Eurovignette III Directives.

Energy Tax Directive

The EU energy tax Directive[50] establishes minimum tax rates for mineral oils, coal, natural gas and electricity, when these energy products are used as motor and heating fuels or for the production of electricity. Originally meant to improve the functioning of the internal market by reducing distortions in competition between mineral oils and other energy products, more recently objectives have been enlarged to include more efficient use of energy so as to reduce dependence on imported energy products and limit greenhouse gas emissions. The Directive authorises member states to grant tax advantages to businesses that take specific measures to reduce their emissions. The proposed revision aims at equal treatment of all fuels and the inclusion of CO_2 taxation, bringing for example rates of diesel, LPG, LNG, CNG in line with rates of petrol although with exemptions for biofuels. This would increase consistency, for example doing away with 'preferential treatment' for diesel,[51] LPG and CNG but also by equal taxation of carbon between the ETS and the transport sector. This consistency is lacking when it comes to aviation and maritime transport, however, because of the international obligations of the EU. This is, inter alia, why aviation is covered by the EU ETS. Electricity is already included in the ETS.

Fuel taxes directly proportional to the energy content of fuels are likely to encourage fuel efficiency. Such an approach would treat all technologies the same way and ensure the lowest CO_2 reduction cost to society. This would be the case if the CO_2 cost component is equivalent to the ETS price. Currently, however, ETS prices would only have a limited

[50] Council Directive 2003/96/EC of 27 October 2003, last amended Directive 2004/75/EC , OJ L 195 of 2.6.2004.

[51] Because diesel cars are so much more fuel-efficient, they should survive under a fuel-neutral tax regime. The UK experience seems to confirm this: despite equal tax on a litre of diesel and petrol, and a diesel penalty in the company car tax system, UK diesel car sales are at the EU average. In the – hypothetical – case of a significant drop of diesel car registration as a result of changed taxation, car manufacturers would have to step up innovation in petrol engines to meet EU car emissions standards. This could even offer better chances in the global market.

effect in contributing to the White Paper's objectives, if at all, but this would gradually change if the ETS price increases. Taxes should nevertheless be revenue neutral, i.e. not raising or decreasing state revenues in the balance while incentivising energy efficiency and establishing an economy-wide CO_2 price.

Eurovignette

Unlike taxes on cars, for trucks there is an EU framework for including external costs when member states impose tolls or levy 'user charges' more broadly. The revised Eurovignette Directive,[52] applicable in principle to trucks over 3.5 tonnes – although member states can exempt trucks up to 12 tonnes under certain conditions – allows member states to factor in certain external costs such as air and noise pollution as well as take into account road congestion. It does not allow climate change externalities (i.e. cost of CO_2 emissions) to be charged, however, which are to be internalised by the fuel tax.

4.6 Infrastructure and Trans-European Networks

The development of an efficient Trans-European Transport Network (TEN-T) that enables the economic, social and territorial cohesion of the European Union lies at the heart of the EU's transport policy.[53] To date, TEN-T projects aiming to provide the infrastructure required for the smooth operation of the internal market have suffered from slow progress and have mostly focused on national rather than EU priorities (HLG, 2003; Van der Geest & Núñez Ferrer, 2011). This is gradually changing, however, partly because new EU objectives such as climate change require both more urgency and EU focus, as also indicated by the Commission's proposal for TEN-T (see below).

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[52] Directive 2011/76/EU that amends the Directive 1999/62/EC was adopted in September 2011 and required member states to transpose it into national legislation within two years following its publication in the EU's Official Journal (October 2011).

[53] Detailed information about the Trans-European Transport Network (TEN-T) can be found in the European Commission's website (http://tinyurl.com/ayv4so5).

Box 4.2 Transport infrastructure funding in the EU

TEN-T projects receive funding from various sources such as the TEN-T Programme, the Cohesion Fund, the European Regional Development Fund (ERDF), loans from the European Investment Bank (EIB) and private-public partnerships (Ruijters, 2012). The budget[54] of the TEN-T Programme for the period 2007-2013 is about €8 billion.[55] As part of the Multi-Annual Financial Framework for the period 2014-2020, in 2011 the European Commission (2011e) proposed a significantly larger budget for transport infrastructure projects, i.e. €31.7 billion, – to be invested through a new single funding instrument[56] for infrastructure projects in Transport,[57] Energy and Communications, namely the 'Connecting Europe Facility'. Nevertheless, the Council recently reduced[58] the budget to about €23.2 billion. This figure includes €10 billion to be used from the Cohesion Fund for transport projects in the eligible countries.[59]

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54 During the TEN-T policy review an expert group (TEN-T Policy Review Expert Group 5, 2010, p.10) addressed the "important discrepancy between the investment needs required for the completion of the TEN-T and the funding available".

55 More details on the breakdown of TEN-T funding can be found at (http://tinyurl.com/9wach5z).

56 According to the European Commission (2011e), the new instrument aspires to enable a simple, coherent and harmonious implementation of EU project financing across the three crucial sectors. It also aims to attract further funding from the private and public sectors by rendering infrastructure projects more credible and coordinating more effectively private partners and financial institutions.

57 The Commission (2012) proposed that the bulk of the available budget (about 80-85%) should finance a list of pre-identified projects on the so-called 'core network' that represents the strategically most important parts of the Trans-European Transport Network. However, this approach has also attracted criticism on the basis of the methodology used to select the projects (Van Essen et al., 2012). The list can be found in Annex Part I of the proposed Regulation COM(2011) 665 establishing the Connecting Europe Facility, while maps of the core network are included in Annex I of the proposed Regulation COM(2011) 650 final on Union guidelines for the development of the trans-European transport network.

58 The Council's conclusions about the Multiannual Financial Framework are available at (http://tinyurl.com/ay9gd6k).

59 The list of countries eligible for the Cohesion Fund includes countries with a Gross National Income (GNI) per capita of less than 90% of the EU average (see http://tinyurl.com/cr5ggm5).

Aiming to raise significant additional funds and deal with the decrease in financing due to the financial crisis, the Commission has put forward the project bond initiative. Under this initiative, the EU budget can support the EIB to cover a portion of the risks (up to 20%) of the project's senior dept. This could result in a multiplier effect of about 15-20 and therefore about €2 billion of EU funding could mobilise around €40 billion of investments (European Commission, 2011e; European Commission, 2012). The pilot phase for project bonds under the Connecting Europe Facility framework was launched[60] for the period 2012-2013 in November 2012, but no specific projects had been signed with this instrument in the first quarter of 2013.

In December 2011 the EU Commission submitted a proposal[61] for the new TEN-T Guidelines that includes decarbonisation aspects in articles[62] related to the objectives of TEN-T and low-carbon innovations. Additionally, the proposal for the new funding formula for TEN-T projects (see Box 4.2 above) foresees[63] a higher[64] co-financing rate of up to 10% for low-carbon projects. However, the proposal makes no mention of the specific methodology or mechanism to assess the climate impacts of transport infrastructure projects; to this end, it has been suggested that the above-mentioned incentive for low-carbon projects needs to be supplemented with additional details and explicitness (Van Essen et al., 2012; Transport & Environment et al., 2012).

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[60] The pilot base was established by Regulation No. 670/12 of the European Parliament and of the Council.

[61] Prior to the Commission's proposal, in the context of the TEN-T policy review, the expert group on 'TEN-T Planning' (TEN-T Review Expert Group 1, 2010) proposed that the new TEN-T Guidelines should encourage initiatives aimed at cutting carbon emissions from transport. Regarding the financing of TEN-T projects, another expert group (TEN-T Policy Review Expert Group 5, 2010) stressed the need to better take into account EU major targets in the field of climate change, among others.

[62] See Articles 4, 22 and 39 of the proposed Regulation COM(2011) 650 final on Union guidelines for the development of the trans-European transport network.

[63] See Article 10(5) of the proposed Regulation COM(2011) 665 establishing the Connecting Europe Facility.

[64] This option does not apply to the €10 billion transferred from the Cohesion Fund to finance transport projects in the eligible countries (See Box 4.2).

5. ACTION NOW

So far this CEPS Task Force Report has highlighted the contribution that technology can make (chapter 3) and singled out the areas where cost-effective potential exists to improve the transport system (chapter 4). This concluding chapter identifies the policy actions that need to be taken in order to meet the EU's self-declared GHG emissions reduction objective.

While the exact emissions-reduction potential for transport volume, efficient transport systems, eco-driving and low-carbon technologies are, and will remain, subject to debate, this CEPS Task Force has agreed on broad ranges of reduction potential to reach the European Commission's target of reducing CO_2 emissions from transport by 60% by 2050 compared to 1990 levels. This is equivalent to reducing emissions by about 70% compared to 2005 levels.

Figure 5.1 provides two illustrative pathways for achieving the EU's CO_2 reduction target, based on broad estimates by the CEPS Task Force. In Pathway A, low-carbon technologies (vehicles and fuels) offer the bulk of reductions required. Eco-driving and efficient transport systems provide for the other – much smaller shares of – reductions. This pathway does not require a reduction of transport volume. This pathway will require strict efficiency standards for vehicles including the accompanying measures detailed in section 3. In Pathway B, low-carbon technologies are responsible for a somewhat lower share of emissions reductions; although still make the biggest contribution of any measure. Here demand reduction will be required (10%).[65] The other two measures – eco-driving and a more efficient transport system – are responsible for a significantly bigger share, with 15% and 20% respectively.

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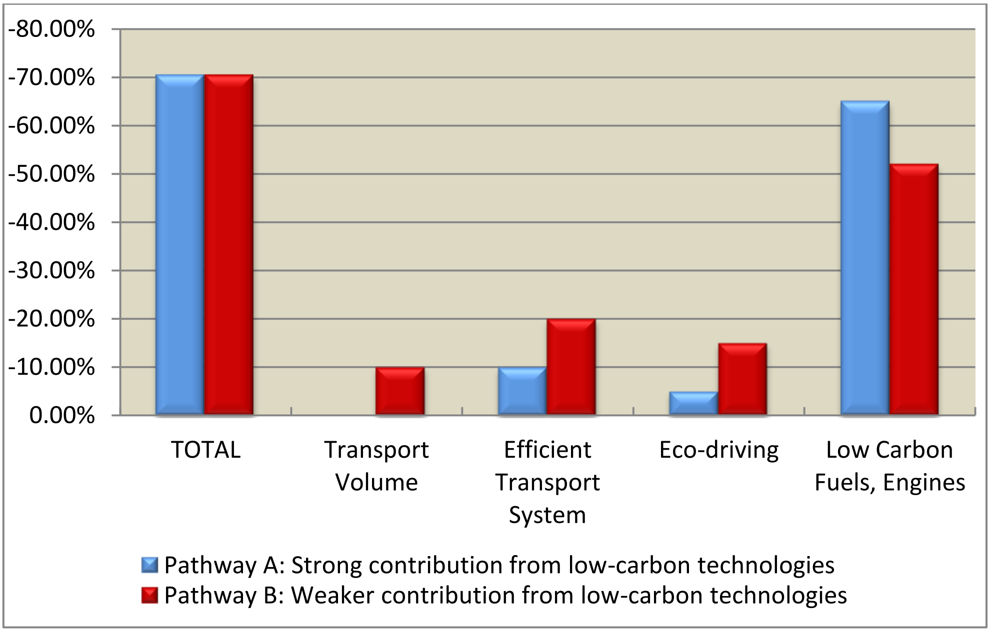
[65] The European Commission's White Paper (2011, p. 5) states that curbing transport is not an option for achieving its 60% (1990 levels) reduction target.

Figure 5.1 Illustrative pathways for achieving the required CO_2 reduction from transport



Source: CEPS Task Force on Transport and Climate Change.

Notes:

1) Figures present broad and illustrative estimates by the CEPS Task Force.
2) Carbon reduction figures are based on a formula in which the estimated factors for the four different types of CO_2 reduction (transport volume x efficient transport system x eco-driving x low-carbon fuels, engines) are multiplied to achieve the total reduction of 70%.
3) Pathway A shows that the EU Commission's target could be achieved through a significant contribution from low-carbon engines/fuel technologies and much smaller shares from eco-driving and efficient transport systems. In Pathway B, low-carbon technologies are responsible for a somewhat lower share of CO_2 reductions but still make the biggest contribution of any measure. Eco-driving and a more efficient transport system provide significantly larger CO_2 reductions (15% and 20% respectively). Demand reduction (10%) is also necessary to achieve the EU's target.
4) The Commission's target of reducing transport-related CO_2 emissions by 60% by 2050 compared to 1990 levels is equivalent to reducing transport-related CO_2 emissions by around 70% compared to 2005 actual emissions.
5) Transport Volume = changes in demand, i.e. demand reduction (refers to passenger per kilometre for passenger transport and tonne per kilometre for freight transport).

6) Efficient Transport System = higher occupancy rates and load factors, modal shift to more efficient transport such as rail, water (where this delivers the highest carbon benefits, see section 4.3), cycling and walking, more efficient logistics.
7) Eco-driving = better traffic flow.
8) Low Carbon Fuels, Engines = energy and carbon efficiency improvements due to better and different propulsion technologies and fuels.

If the EU wants to reduce the GHG emissions in line with Commission or European Parliament objectives, cost-effective action should be taken now. Three inter-related reasons stress the need for immediate action:

- Government action consistent with EU transport and climate change objectives will provide a clear and unequivocal signal that policy-makers are serious about reduction objectives. A well thought out, stepwise approach will ensure steady progress in alignment with member states' financial capabilities. This practical approach will ensure the credibility and the predictability that transport providers, vehicle producers, technology providers or investors need.
- Second, achieving the White Paper target will require change over decades. While change will 'evolve' gradually, initiation will be required now. Many cost-effective technology solutions exist and can be implemented now. Other technologies will only bear fruit later but in order to stand a chance in the market, some will need to be tested by piloting and by developing infrastructure.
- Finally, early GHG emissions reductions slow down the growth of GHG concentrations; the cause of climate change. Cost-effective reductions will provide win-win outcomes. With CO_2 emissions staying in the atmosphere for a long time, i.e. decades, 'avoided' emissions will still benefit the global climate in decades to come.

With this in mind this Report has – in addition to the measures discussed in chapters 3 and 4 - identified 15 policy measures described as 'low-hanging fruit' to be implemented within a very short period from now. Measures selected as low-hanging fruit meet the triple requirement of

i) being effective in reducing a non-marginal amount of GHG emissions,
ii) being easy to implement from an administrative point of view – which is not necessarily the same as being easy politically – and
iii) being economically feasible by not being prohibitively expensive.

Against this background, the Task Force has identified the following policy measures to be implemented immediately:

Measure 1: The EU should continue to set and accelerate the setting of predictable and progressively tightening CO_2 standards for cars, vans and ships

The single-most important measure for the EU is to continue to set CO_2 emissions standards[66] – as is already happening,[67] see Chapter 3 – in line with the technological frontier, although not exceeding it and it shows also safeguard affordability. Comparable standards can be set for vans,[68] ships[69] or aircraft and, if possible, for trucks. Standards must be technology-neutral, predictable and progressive, also to provide assurance to manufacturers and their suppliers, technology providers and operators as to the speed and direction of emerging standards.

There is significant potential in almost all transport modes (see also 3.1).

- Trucks can reduce emissions through better aerodynamics (aerodynamic trailers – up to 10%, teardrop trailers up to 23%, aerodynamic fairings 0,1% to 6,5%), improved rolling resistance (low rolling resistance tyres 5%, wide tyres 6-10%, tyre pressure 7-8%), refrigeration systems (10-20%) and improvements in powertrain

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[66] While the EU is currently focusing on CO_2 standards, looking beyond 2020 at other standards such as energy efficiency could be applied (see footnote 15).

[67] There has been a decreasing trend in car emissions in the EU since 2000 (from 172.2g CO2/km av. in 2000 to 145.7 av. in 2009). In 2009, 65% of passenger cars sold were already meeting the EU 2012 emissions target of 130 g CO2/km. Engine size and components have changed, with vehicle mass having lightened on average. (COM(2010) 656 final). A second target for 2020 of 95g CO2/km was announced for further consideration. (Regulation (EC) No 661/2009).

[68] The EU Regulation No 510/2011 of 11 May 2011[68] for vans sets a target of 147g CO2/km for 2020. The emissions reductions expected are 60 million tons or 4% of emissions reductions effort by 2020. The Commission's impact assessment does not, however, calculate the possible increase in the number of vans over the period. This might reduce the positive impact.

[69] Notably, the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships have been added to MARPOL Annex VI Regulations (see footnote 19).

technology (hybrid powertrains have a CO_2 reduction potential of 0 to 30%, averaging around 6%, Baker et al., 2009).

- For aircraft, using lighter materials can reduce emissions by 7-13%; and production updates for aircraft currently being built could reduce emissions by 7-18%. New aircraft designs are expected to enable CO_2 emissions reductions by 20 to 35% by 2020, and after 2020 by 25% to 60% (IATA, 2009).
- In shipping, emissions can be reduced by up to 10 to 50% through design or operation. The total reduction of both combined can be in the range of 25- 75%, depending on the ship (IMO, 2009).
- Cars through more efficient air conditioning systems can significantly reduce emissions.
- Lightweight components have a significant reduction potential and can easily be applied.[70]

Measure 2: Define a realistic test cycle as close to real world conditions as practicable including accounting for carbon benefits of components

A precondition for ensuring that reductions are 'real' is that measurement procedures reflect vehicles' CO_2 emissions based on real driving behaviour rather than on test conditions, which may contain significant deviations from actual consumption. Including components will incentivise their use as well. A particular problem is the large range of flexibilities available to manufacturers which appear to lead to road load factors that do not seem to be repeatable in independent tests.

Measure 3: Expansion of the EU-wide labelling

Based on a test cycle, each new car has its own label that aims to inform consumers about its fuel efficiency and carbon emissions. This labelling

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[70] According to the European Aluminium Association (2007), on average, switching to lightweight hang-on parts (door, hoods, etc.) can save 40kg per vehicle over their full life span, which would correspond to a life-time CO_2 emissions reduction of 10 million tons at current fleet size. The hang-on parts are not an integrated part of the vehicle body and can therefore easily be changed without fully re-engineering the car. According to Ragnarsson (2011) – based on the analysis of Koffler & Rhode-Brandenburger (2010) - if all new cars registered in Europe per year (about 12 million) reduced their weight by 50kg, total CO_2 emissions would decrease by 12 million tons over their full life span.

scheme should be expanded to include vans, while cars should generally carry their label throughout their whole lifecycle. Additionally, label systems across the EU need to be harmonised to provide consistent signals to consumers.[71]

Measure 4: Differentiate sales, vehicle and company car taxes at member state and local level based, as far as practically possible, on well-to-wheel CO_2

Recent initiatives to differentiate vehicle, sales, circulation or company car taxation on the basis of vehicle fuel economy or CO_2 by some member states should be encouraged across the EU. This will provide incentives in a consistent, progressive and harmonised way for manufacturers and their suppliers, technology providers, infrastructure investors and service providers to shift to more fuel-efficient vehicles.

A precondition is a harmonised 'base' in the form of an EU-wide test cycle and expressed by a label. This would allow member states and local governments to tax and levy charges according to agreed EU-standards without risking barriers to free movement or inconsistent incentives.

Measure 5: Use public procurement & incentives to fleet managers as tools to accelerate the deployment of more fuel-efficient vehicles

The magnitude of the EU public procurement market (i.e. the purchase of goods, services and public works by governments) is very significant.[72] In the US, public procurement has been used to support low-carbon technologies, including transport. At the EU level, Directive 2009/33[73] marks the first step towards this direction.

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[71] More details about labelling and issues of concern across the EU can be found in section 3.3.

[72] According to the European Commission, total public procurement amounts to some 19% of EU GDP (2008 data). Total annual vehicle procurement by public authorities has been estimated to be in the order of 110 000 passenger cars, 110 000 light duty vehicles, 35 000 lorries and 17 000 buses for EU-25. The corresponding market shares are slightly below 1% for cars, around 6% for vans and lorries, and around one third for buses (Source: COM(2005) 634 final and http://tinyurl.com/aw78sc6).

[73] Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles.

The uptake of more fuel-efficient vehicles can also be accelerated by tax or other incentives to fleet operators.

Measure 6: Develop a commonly agreed carbon accounting methodology for logistics

There is substantial potential to reduce the ecological footprint in logistics by moving towards 'green logistics'. To this end, the EU should develop a commonly agreed carbon accounting methodology to establish the overall verified carbon footprint. A provisional transport energy and GHG accounting methodology has been prepared by CEN.[74] Globally, such standards can be developed by an international standardisation body such as the ISO and apply across the sector. The development of accounting methodologies is necessary but not sufficient. Reducing the carbon footprint, essentially based on supply-chain optimisation, will also require other changes such as efficient carbon pricing, a true internal market for all transport modes, including inter- and co-modality and the more rapid deployment of more fuel-efficient vehicles (as covered above).

Measure 7: Full cabotage in road transport

In the road sector present limitations to cabotage are still responsible for a large number of empty truck trips. Of 183 billion truck-kms in the EU in 2008, 24% carried no load. Using EU-27 statistics with 2008 as a reference year, Visser & Francke (2010) estimate[75] that the new EU legislation that allows some liberalisation of cabotage can lead to a 0.7% decrease in empty truck trips, thereby reducing total road emissions by 0.5%. A further full liberalisation of cabotage could reduce emissions by 1.6%. However, this only represents a proportion of overall empty running, much of which is due to structural issues such as specific types of vehicle not having back loads (e.g. milk, fuel or chemical tankers, concrete mixers, rubbish trucks, aggregates trucks).

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[74] PREN 16258 Methodology for calculation and declaration on energy consumption and GHG emissions in transport services (goods and passenger transport).

[75] Their estimates are based on the assumption that liberalisation will eventually lead to a smaller number of trucks carrying no load through more competition and therefore more efficient operations.

Measure 8: Continue to install eco-driving support systems in vehicles

Eco-driving electronic systems offering feedback[76] to the driver on fuel consumption can be very cost-effective low-hanging fruits for most means of transport. Eco-driving courses may be also introduced in the driving schools and specialised training[77] for professional drivers.[78] According to the European Automobile Manufacturers Association (2007), eco-driving leads to a reduction in fuel consumption of up to 25% after training, with a considerable long-term effect of 7% under every-day driving conditions. Nylund (2006) estimates the fuel reduction potential from applying electronic systems in heavy duty vehicles at 5-15%, while Christie and Ledbury (2011) also provide similar estimates for the rail sector (up to 15%).

From the above it can be concluded that the installation of eco-driving support systems should be further supported. However, reductions from eco-driving – like other behavioural changes - are difficult to enforce and tend to be short-lived. In order to ensure that the high level of savings will be sustained in the long term, continuous training will need to be encouraged.[79] This could become subject to a voluntary agreement between

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[76] According to the EU Commission (2010, p. 6), "low tyre pressure can increase fuel consumption and CO_2 emissions by 4%, reduce tyre lifespan by 45% and cause accidents, while fitting tyre-pressure monitoring systems (TPMS) can contribute to both greater fuel efficiency and safety". Regulation (EC) No 661/2009 mandates all M1 category vehicles (passenger cars) to be equipped with an accurate tyre pressure monitoring system to inform the driver in case of loss of pressure and thereby contribute to optimal fuel consumption and road safety. The Regulation also foresees that new car models must be equipped with gear shift indicators by 2012 and all new cars by 2014. It is expected that just by following the instructions of the shift indicators, emissions can be reduced by 6% (COM(2010) 656 final).

[77] A number of commercially available systems promise to achieve a good level of fuel saving by operators.

[78] McKinnon & Piecyk (2010) suggest that training programmes for professional drivers can improve fuel efficiency by up to 10%.

[79] Eco-driving has the highest potential in the area of private driving. In the case of commercial driving, policies tend to shield companies from fuel cost rise impacts (for example through tax exemptions, petrol subsidies, etc.), and there is evidence that this tends to make fuel savings a non-priority, or at worst gives perverse incentives to avoid investment in fuel saving.

manufacturers and the EU and/or member state governments or subject to a law. In road haulage or shipping there is evidence that market undermines the potential of eco-driving, which might require additional policy measures (Greater Than, 2011a, 2011b).

Measure 9: Align taxation levels of different fuels and vehicle types and stop indirect subsidies

In maintaining technology-neutrality and allowing all fuels and technologies to compete on an equal footing, there is a need to align taxation levels of different fuels as suggested by the proposed revision of the Energy Tax Directive for petrol, diesel, LNG, LPG, CNG or biofuels, unless their CO_2 benefits can be proved. At the same time, subsidies to aviation,[80] maritime transport,[81] company cars,[82] cruise tickets and fishing vessels, for example by exempting them from VAT, should be abolished to ensure that they pay the full marginal cost. In areas where international treaties prohibit charging VAT or other taxes, as for international (extra-

[80] Airlines do not only benefit from the fuel tax regime (see footnote 83 below) but are also granted VAT exemptions with respect to tickets for international flights. Whilst domestic passenger transport is subject to VAT taxation in almost all member states, international passenger transport is in most cases exempted by means of derogations. The European Commission's Staff Working Document Accompanying the Green Paper on the future of VAT COM(2010) 695 final provides the historical overview and current situation regarding the VAT exemptions applied to air and sea transport. In October 2012, the Commission launched a consultation on the review of existing legislation on VAT reduced rates; however, the VAT rate for passenger transport services is explicitly excluded from this consultation since the Commission (2012a, p. 8) regards it as a "much broader issue than the question of the VAT rate".

[81] Article 14 of the Energy Tax Directive Council (Directive 2003/96/EC) exempts fuel taxation in international aviation, maritime transport and fishing. EU member states are allowed to waive these exemptions for intra-EU traffic through bilateral agreements. These obligations are still included in the Commission's latest proposal for the revision of the Energy Tax Directive.

[82] Company cars constitute up to 50% of car sales. Fiscal incentives promote the use of larger cars with higher petrol consumption. It has been estimated that CO_2 emissions are boosted by about 21-43 Mt (equivalent to around 2-5% of road transport emissions) from those policies (Source: Copenhagen Economics, 2010).

EU) aviation or maritime transport, the EU should intensively seek global solutions to address the relevant externalities.

Measure 10: Adapt the minimum fuel tax level in the EU to keep incentives to shift to higher fuel economy and total tax paid constant in real terms

Although somewhat less important than vehicle and sales taxes in shifting vehicle owners to more highly efficient vehicles, fuel taxes do have a role in incentivising more efficient vehicles. Fuel taxes per km driven decrease in line with the efficiency improvement of the vehicle and incentives from fuel taxation will therefore decline. At the same time, transport fuel taxes constitute an important source of revenue for member states in the order of €170-180 billion annually. The ever-increasing fuel economy of vehicles will also reduce government revenues, which over time will create a major fiscal shortfall. To this end, in order to maintain the fuel tax incentive for more fuel-efficient vehicles, the level of the tax will need to be adapted. In addition to adapting the fuel tax level, another recommendation could be the development by governments of km-based road charges for trucks and some form of congestion charges in large cities, to internalise the cost of congestion.

Measure 11: Continue support for research, development, demonstration and piloting of the entire array of promising low-carbon technologies

The one possible exception to a technology-neutral approach are specific support measures for some low-carbon transport technologies that due to network and scale effects and/or long-time horizons are not profitable without government support. To overcome barriers, tailor-made measures for early deployment or piloting as it is sometimes called, will be needed for a short transition period. This will need to cover all promising technologies, including improving the energy efficiency of vehicles, electric and hybrid vehicles, using electricity from low-carbon sources, hydrogen from low-carbon sources, gas vehicles using natural gas and biogas and biofuels, with a positive overall effect on GHG emissions.

Measure 12: Continue implementing ambitious differentiated co-financing rates for low-carbon TEN-T projects

The European Commission's proposal for the new funding mechanism for TEN-T projects foresees a higher co-financing rate of up to 10% for projects reducing greenhouse gas emissions. This should be the first step in differentiating the co-financing rate for low-carbon TEN-T projects as they offer a higher European added value. A commonly agreed methodology for quantifying the climate change implications of transport projects would also enable a harmonised application of the above rule.

Measure 13: Ensure that there is no further delay in the application of CNS and ATM

CO_2 emissions reductions can be expected by advanced communication, navigation and surveillance (CNS) and air traffic management (ATM) systems, such as the US NextGen (Next Generation Air Transportation System) and the European SESAR (Single European Sky ATM Research). The potential for emissions reductions from the use of these technologies is estimated at 5% additional reductions from BAU emissions by 2050. Further savings of up to 10% are possible in the medium term. However, while these systems will result in one-off savings, they will also create additional air capacity, which might enable higher levels of air traffic. In this case, there will be an increase in CO_2 emissions, which can possibly offset the carbon benefits of the above systems.[83]

Measure 14: Improve walking and cycling facilities, co-modality and seamless transfer

The improvement of urban planning and urban transport, including walking and cycling facilities, has the potential to decrease the use of cars and can reduce emissions by 5-10%. These instruments are the competence of member states and local authorities, which in some instances will need to revise legislation and adapt funding priorities to facilitate the introduction of these measures.

For freight, a better cross-modal transport framework, together with strategically placed transport hubs, could reduce emissions significantly by

[83] A study by Van Essen & Van Grinsven (2012) provides some interesting information about the interaction between GHG policies for transport and congestion. The study concludes that while actions to reduce GHG emissions generally either reduce or have a neutral effect on congestion, this might not be the case with actions to reduce congestion. Specifically, some actions to reduce congestion can reduce GHG emissions e.g. pricing, while others can lead to increases in GHG emissions e.g. building road infrastructure.

facilitating modal shift.[84] EU assistance can be used to speed up the development of the necessary infrastructures through the different funds of the EU budget, in coordination with EIB loans, to support the network and infrastructure requirements.

Measure 15: Enforce speed limits in all modes

Enforcing speed limits holds significant potential in improving fuel efficiency and reducing CO_2 emissions (IEA, 2009). Considerable work has been done regarding the carbon benefits of enforcing speed limits. Gross et al. (2009) conclude[85] that speed enforcement on the UK motorways and trunk roads could offer short-term emissions savings of about 2-3%. Using a model to quantify the potential carbon emissions reductions in the UK between 2006 and 2010, Anable et al. (2006) estimate that enforcing the 70mph (112km/h) speed limit could annually prevent around 1 million tonnes of carbon emissions. Otten & Van Essen (2010) examine several scenarios with lower speed limits in the Netherlands and estimate that a modest decrease,[86] if accompanied by strict speed limit enforcement, could reduce in the short-term CO_2 emissions from passenger cars on motorways by about 6%.

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[84] A further shift to rail transport for freight from the present 18% share to a 31-36% share, for example, could reduce emissions by up to 7% of the total emissions from road and rail combined (Den Boer et al., 2011).

[85] They also claim that the impact of speed enforcement on the absolute cost and also the political acceptability of this measure need further assessment.

[86] This refers to speed limits of 110 and 90km/h or 100km/h everywhere. Interestingly, in their analysis the highest reduction in motorway emissions (30%) is attained in the long-term through an extreme scenario where a very low speed limit (80km/h) is sufficiently enforced.

GLOSSARY OF ABBREVIATIONS

ATM	Air Traffic Management
CO_2	Carbon Dioxide
CO	Carbon Monoxide
CNS	Communication, Navigation and Surveillance
EIB	European Investment Bank
EEDI	Energy Efficiency Design Index
ERDF	European Regional Development Fund
ETS	Emissions Trading System
FQD	Fuels Quality Directive
GDP	Gross Domestic Product
GFEI	Global Fuel Economy Initiative
GHG	Greenhouse Gas
GNI	Gross National Income
HC	Hydrocarbons
ICT	Information and Communication Technologies
ILUC	Indirect Land-Use Change
IMO	International Maritime Organization
JRC	Joint Research Centre
NextGen	Next Generation Air Transportation System
NOx	Nitrogen Oxide
OECD	Organisation for Economic Co-operation and Development
PM	Particulate Matter
RED	Renewable Energy Directive
R&D	Research and Development
SEEMP	Ship Energy Efficiency Management Plan
SESAR	Single European Sky ATM Research
SET	Strategic Energy Technology
TEN-T	Trans-European Transport Network
TPMS	Tyre-Pressure Monitoring Systems
WLTP	World Light Duty Test Procedure
WTW	Well-to-Wheel

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