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STUDY

Policy Department
Structural and Cohesion Policies

ENERGY AND ENVIRONMENTAL ASPECTS OF THE TRANSPORT POLICY

TRANSPORT AND TOURISM

September 2007

EN

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Directorate General Internal Policies of the Union

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TRANSPORT AND TOURISM

ENERGY AND ENVIRONMENTAL ASPECTS OF TRANSPORT POLICY

STUDY

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TRANSPORT AND TOURISM

ENERGY AND ENVIRONMENTAL ASPECTS OF TRANSPORT POLICY

STUDY

Content:

The aim of this study is to identify economically and politically viable measures to enhance significantly energy efficiency and to reduce the negative impacts of transport activities.

The study is based on an in-depth literature review covering recent statistics, studies, notes etc. which analyse the different impacts and consequences of the emissions caused by different modes of transport and the recommendations made on how tackle the related problems. The literature review identified the most promising and cost-efficient short, medium and long-term measures, with particular attention being paid to energy and new technology developments.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ACEA/JAMA/KAMA	European, Japanese and Korean Automobile Manufacturers' Associations
ACARE	Advisory Council of Aeronautical Research in Europe
ACEA	European Automobile Manufacturers' Association
AEA	Association of European Airlines
AECMA	European Association of Aerospace Industries
APAT	Agenzia per la protezione dell'ambiente e per i servizi tecnici
AQEG	Air Quality Expert Group
ARC Europe	European Autoclubs Association
BAT	Best Available Technology
BAU	Business-As-Usual Scenario
BFE	Biofeedback Foundation of Europe
BGL	Bundesverband Güterkraftverkehr Logistik und Entsorgung
BTL	Biomass-to-Liquids
C_6H_6	Benzene
CAFE	Clean Air For Europe Programme
CARB	California Air Resources Board
CCGT	Combined Cycle Gas Turbine
CCS	CO_2 Capture and Sequestration
CDM	Clean Development Mechanism
CECED	European Committee of Domestic Equipment Manufacturers
CESA	Community of European Shipyards' Association
CFL	Compact Fluorescent Lamps
CH_4	Methane
CHP	Combined Heat and Power
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2eq	CO_2 equivalent emissions (1 t CH_4 = 21 t CO_2eq; 1 t N_2O = 310 t CO_2 eq)
COM	Commission Communication
CONCAWE	Conservation and Clean Air and Water in Europe
COP	Conference of the Parties
COP/MOP	Conference of the Parties serving as the meeting of the Kyoto Protocol
CTL	Coal To Liquids
DG ENV	Directorate-General Environment
DG TREN	Directorate-General Energy and Transport
EBB	European Biodiesel Board
EC	European Commission
ECCP	European Climate Change Programme
ECEEE	European Council for an Energy Efficient Economy
ECMT	European Conference of Ministers of Transport
ECSA	European Community Shipowners' Associations
EEA	European Environment Agency
EFFA	European Freight Forwarders Association
EFTA	European Free Trade Association
EMEP	European Monitoring and Evaluation Programme
EMP	Environmental Management Plan
EMPA	Materials science and technology research institution
ENTEC	Environmental and engineering consultancy
EP	European Parliament

EREF	European Renewable Energies Federation
ERRAC	European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
ESCO	Energy Service Company
ESPO	European Sea Ports Organisation
ETC/ACC	European Topic Centre on Air and Climate Change
ETS	Emissions Trading Scheme
EU-10	New Member States of the European Union since 2004
EU-12	New Member States of the European Union since 2004 and 2007
EU-15	The 15 Member States of the European Union since 1995
EU-25	The 25 Member States of the European Union since 2004
EU-27	The 27 Member States of the European Union since 2007
EU-28	EU-27 plus Turkey
EUCAR	European Council for Automotive R&D
EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROMOT	European Association of Internal Combustion Engine Manufacture
EUROPIA	European Petroleum Industry Association
EUROSTAT	Statistical Office of the European Communities
FAO	Food and Agriculture Organisation of the United Nations
FC	Fuel Cell
FTM	Freight Transport Management
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTL	Gas To Liquids
GW	Gigawatt
H_2	Hydrogen
H_2O	Water
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbons
HDV	Heavy-Duty Vehicle
HFC	Hydrofluorocarbons
HST	High-speed technology
HVAC	Heating, Venting, Air Condition
HVF	Heavy Vehicle Fee
IATA	International Air Transport Association
IBIA	International Biometric Industry Association
ICAO	International Civil Aviation Organisation
ICT	Information & Communications Technology
IEA	International Energy Agency
IEEP	Institute for European Environmental Policy
IES	Institute for Environmental Studies
IGCC	Integrated Gasification Combined cycle
IIASA	International Institute for Applied Systems Analysis
IMO	International Maritime Organisation
INTERTANKO	International Association of Independent Tanker Owners
IPCC	Intergovernmental Panel on Climate Change
IPTS	Institute for Prospective Technological Studies
IRU	International Road Transport Union
ISFORT	Istituto Superiore di Formazione e Ricerca per i Trasporti
ITS	Intelligent Transport System
IWW	Inland Waterways
IWW INFRAS	Institute for Economic Policy and Economic Research (D)

JEGTE	Joint Expert Group on Transport and Environment
JRC	Joint Research Centre
KP	Kyoto Protocol
k-values	Coefficient of heat transfer
LD	Landfill Directive
LDV	Light-duty Vehicles
LEZ	Low Emission Zone
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
LTO	Landing and Take-Off
LULUCF	Land Use, Land-Use Change and Forestry
MTFR	Maximum Technical Feasible Reduction
N_2O	Nitrous Oxide
NEC	National Emission Ceiling
NH_3	Ammonia
NMS	New Member States (the 10 countries joining the EU in 2004)
NMVOCs	Non-Methane Volatile Organic Compounds
NO_2	Nitrogen oxides
Non-EU	Non-Member States of the European Union
O_3	Ozone
OECD	Organisation for Economic Cooperation and Development
OPMUS	Osservatorio sulle Politiche per la Mobilità Urbana Sostenibile
P&M	Policies and Measures Scenario
p.a.	Per Annum/ Per Year
P2W	Powered two-wheelers
PFC	Perfluorocarbons
PM_{10}	Particulate matter
$PM_{2.5}$	Fine particles with an aerodynamic diameter of less than 2.5 µm
PT	Public Transport
PV	Photo Voltaic
R&D	Research and Development
RAINS/GAINS	Regional Air Pollution Information and Simulation Model/Greenhouse Gas and Air Pollution Interactions and Synergies
RES	Renewable Energy Sources
SAVE II	Programme on Energy Efficiency
SECA	Sulphur Emission Control Area
SF_6	Sulphur Hexafluoride
SO_2	Sulphur dioxide
SUTP	Sustainable Urban Transport Plan
T&E	Transport and Environment
TDM	Transportation Demand Management
TNO	Research Institute (NL)
TREMOVE	Transport Model
UBA	German Federal Environment Agency
UHC	Unburned Hydrocarbon
UIC	International Union of Railways
UIRR	International Union of Combined Road-Rail Transport Companies
UITP	Union Internationale de Transport Publics
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNIFE	Union of the European Railway Industries

VAT	Value Added Tax
VIBAT	Visioning and Backcasting for UK Transport Policy
VOC	Volatile organic compounds
VTPI	Victoria Transport Policy Institute - Canada
WEO	World Economic Outlook
WHO	World Health Organisation
WWF	World Wide Fund for Nature

UNITS OF MEASUREMENT

€	Euro
Mt	Million tonnes
Mtoe	Million tonnes of oil equivalent
Pkm	Passenger-kilometre
Ppm	Parts Per Million
Tg	Teragrams
Vkm	Vehicle-kilometre

EXECUTIVE SUMMARY

The aim of this study was to identify economically and politically viable measures to enhance significantly energy efficiency and to reduce the negative impacts of transport activities.

The results of the study are based on an in-depth literature review covering recent statistics, studies, notes etc., which had already analysed the volume and the impacts of the emissions caused by the different transport modes and which were already assessing and recommending different way to tackle the related problems.

The review identified the most promising and cost-efficient short, medium and long-term measures, with particular attention being paid to energy and new technology developments.

The study focused in particular on atmospheric emissions (NO_X, SO_2, CO, PM_{10}, $PM_{2.5}$), greenhouse gases (GHG) and energy consumption, paying specific attention to the transport sector's dependence on non-renewable fuel sources.

Methodology

The study was divided into two parts: Part I is dedicated to the analysis of technical databases, policy documents and scientific literature and Part II is devoted to the classification of policies and the presentation of advantages and disadvantages of the measures identified.

Part I of the study is divided into four chapters: development of passenger and freight transport demand; quantification of energy consumption and pollutant emissions (GHG and air pollution); analysis of developments in vehicle technology and fuels, and review of policy documents, which in turn distinguishes between assessing the EC policy action already in place and making proposals based on the scientific literature and national experience. The main sources of information were:

EUROSTAT, UITP and DG TREN 'Keep Europe Moving' for the development of freight and passenger demand;

EUROSTAT, GHG inventories sent by EU countries to UNFCCC, PRIMES, TREMOVE and RAINS/GAINS models, EEA TERM reports and the EMEP emission database for energy consumption;

The European Automobile Manufacturers' Association (ACEA), scientific boards and research institutes (IEA, FAO, EUCAR, EC JRC, JRC-IPTS, EMPA, ACARE) for vehicle technology and fuel innovation;

Many recent EC documents and communications, as well as a series of recent studies (ECMT 2007 database, London Department for Transport 2004, Wuppertal Institute 2005, Banister 2006, TNO 2006, Joint Expert Group on Transport and Environment 2006, Stern 2006, IPCC 2007 and ERTRAC 2007) have been analysed in the review of the policy actions in place and the proposals taken from the scientific literature.

Part II of the study discusses the most promising policy measures from the point of view of cost-effectiveness, feasibility and suitability. The three chapters of Part II include the classification of measures into eight policy clusters and their analysis from different perspectives: relevance of the expected impacts; the timescale for policy implementation; the reference area where the policy applies, the relevant institutional level, the stakeholders involved, and cost-effectiveness.

Quantification of transport impacts

About one third of final energy consumption in the EU-25 is related to transport (not including maritime transport and pipelines). Road transport is by far the dominant sector, consuming nearly 83% of the energy used for transport purposes.

The transport market today is almost entirely (97%) dependent upon oil-based fuels (gasoline and diesel), with biofuels and electricity energy accounting for only 1% and 2% respectively. Transport is responsible for about 70% of the final demand for oil and oil products in the EU-25.

Emissions from the transport sector make a significant and growing contribution to the EU's overall greenhouse gas emissions: in 2005 transport contributed a total of 24% of GHG emissions (CO_2, CH_4, N_2O) in the EU-27 (including international aviation and maritime transport and excluding land-use change and forestry activities which can remove greenhouse gases or reduce emissions).

A cause for concern is not only transport's current share of total GHG emissions, but also the past and expected trends. Analysing the EU-15 trend by large key sources it can be seen that the main reason for increases in CO_2 emissions between 1990 and 2005 was growing road transport demand.

It should be noted that half of the journeys made by European citizens are less than 5 km long, and on a daily basis 60% of all kilometres travelled by car are for journeys of 30 km or less and 37% are for distances of 10 km or less. Half of the kilometres travelled by rail passengers, and 90% of journeys, are on regional and commuter rail with an aggregate average distance travelled of about 27.9 km.

About one third of CO_2 emissions in the road sector can be attributed to passenger transport (which includes cars, mopeds, motorcycles, buses and coaches). Consequently, the remaining 34% represents emissions from road freight transport (LDVs and HDVs)

Transport's contribution to air pollution is also significant, but thanks to innovations in exhaust gas treatment in road vehicles (prompted by the introduction of EU standards), improved fuel quality (especially lower sulphur concentration) and increased electrification of EU railways, emissions of harmful substances from land transport decreased significantly between 1990 and 2004.

Proposed policy measures

The many potential measures for air pollutant and GHG emissions reduction in the transport sector currently discussed in the scientific literature and policy documents have been carefully analysed in order to identify advantages and disadvantages and select economically and politically viable measures that are able to enhance energy efficiency significantly and reduce the negative impacts of transport activities. The literature review and the analysis of best practice strongly support the point of view that ***to achieve substantial reductions in transport emissions it is necessary to combine mutually supporting policies***, involving a variety of stakeholders. There seems to be general agreement that individual policies will not contribute significantly to reducing CO_2 emissions and improving air quality, and that only combined polices or a policy mix including soft measures to raise awareness can do so.

There are many examples of uncoordinated approaches to transport policy leading to poor results: important improvements in fuel efficiency achieved in the recent past, without demand

management measures and appropriate price signals, have been offset by increases in passenger and freight transport demand; the same can be said of the modest modal shift brought about by increasing supply for competitive modes (rail, short-sea shipping, inland waterways, metros, etc.), particularly for long-distance travel. The lack of accompanying measures is particularly evident in the case of new infrastructures, which take a long time to be completed and therefore results can be seen only after several years. Indeed, without proper incentives, people and goods are reluctant to abandon the road and air modes even when new or upgraded services are in place for competing modes. A combined approach is recommended not only for technology or infrastructure measures; in many cases charging policies have also suffered from a lack of acceptability that has made their application uncertain.

Combined policies might succeed were single policies have failed. A policy mix can help mitigate the negative effects of a single measure, and therefore increase acceptability, and control rebound effects, i.e. problems of reversing the initial benefit through readjustment of individual behaviour. But the key aspect is that the combination of *push and pull* policies are able simultaneously to improve different dimensions of transport emissions problems. The synergies of combining different measures are such that the effect of combining them is better than the sum of the effects of individual policies.

The literature highlighted that to be effective the integrated policies should cover all modes of transport and should include ambitious fuel-efficiency targets, improved vehicles and fuel standards, and a reduction in road and air transport activity through charging, logistics and behavioural changes.

Recommendations

1. Policy actions should ***concentrate on the most critical transport modes***; given the existing emissions levels, the road sector should be the main target, as road transport has the highest share of transport demand (passengers and freight); it is expected to continue to grow, it is almost entirely dependent on non-renewable energy sources and has the most significant environmental impacts (air and GHG emissions). Both passenger and freight demand should be addressed: passenger transport because it currently has the highest share of road transport and freight because of the expected growth (55% between 2002 and 2020 on average, with peaks of 134% for the new accession countries). For similar reasons attention should be given to air passenger transport, which shows the most dynamic development, as its modal share (now 3 to 4%) is growing very fast, and has significant environmental impacts.

2. There is little strategic reason for action everywhere and therefore the EU policy should ***focus on those parts of the system that are more critical***:

    - congested urban and metropolitan areas where the majority of passenger journeys take place;

    - key interurban corridors where domestic, intra-EU and international trade is concentrated;

    - environmentally sensitive areas (Alpine region, Baltic Sea, etc.).

3. ***Urban and metropolitan areas are particularly important*** not only because of demand density and high levels of pollution, but also because alternatives to private transport (public transport services, transport demand management, walking and cycling facilities,

and so on), are already available and therefore changes in modal shift can be more easily obtained. Consequently, in urban and metropolitan areas a combination of charging policies (congestion charging) and improvements in the public transport supply can significantly reduce emissions even in the short term, particularly if public transport service improvements are achieved through short-term measures, fleet renewal, bus priority, information technologies etc.

4. The problems stemming from the current levels of transport emissions are serious and, without coordinated intervention, will get worse in certain respects. Only a ***sophisticated policy mix*** can respond to such a demanding challenge. The literature review shows that there is general agreement to concentrate on three main areas of intervention:

   - ***Technological improvements*** concerning both vehicles (energy efficiency improvements, reduction in pollutant emissions) and fuels (development of petroleum alternatives, including first and second generation biofuels, compressed natural gas, as well as – in the long term – advanced alternatives such as hydrogen fuel cells);

   - Economic instruments (***charging and taxation***) based on the polluter-pays principle and pay-as-you-go: road vehicle taxation reform, charging on interurban road (Eurovignette scheme based on weight and emissions classes), road charging in urban areas;

   - ***Soft and eco-friendly measures***: transport demand management, logistics measures, ICT, to optimise the use of private vehicles, encourage the use of public transport and promote behavioural change.

5. Policy plans have to be designed to focus on the ***implementation times of the different types of measures***. Past experience has shown that, once shifted to road, transport demand is unwilling to go back to other transport modes. It is therefore extremely important to stop right now the modal shift to road transport and slow down the growth in energy consumption and pollutant emissions. In this respect, charging policies seem to be the most effective measures to be applied in the short term. For long-distance freight transport, truck-km charges have been shown to prompt a process of rationalisation of distribution systems and logistics organisation, and thus to reduce distances, and optimise routing, load factors and occupancy rates. Although technology improvements will produce major results in the long term, they might also deliver incremental improvements in current technologies whose market penetration could be helped by incentives and taxation. The combination of emissions taxation and congestion charging with the availability of cleaner vehicles will in the short term offer the main means to achieve the overall CO_2 emissions changes.

6. There is general agreement that innovative technology (for both vehicles and fuels) is the most promising and effective tool for reducing transport-related pollution and GHG emissions in the ***long term***. Nevertheless, technological progress is not sufficient in itself. In order to reach the ambitious EU target, it is necessary to ***support new technologies with a consistent package of accompanying measures***:

   - Amendment of the Eurovignette directive in connection with the charge related to type of vehicle (emissions and consumption) and distance travelled;

   - Promotion of congestion charging in cities and selected (congested) corridors;

- Introduction of tradable mobility credit schemes in urban and metropolitan areas;
- Incentives to increase occupancy and load factors to offset the costs of road charging to users;
- Support for captive fleet renewals (particularly for public transport, car sharing, taxis), through a system of incentives.

7. In order to be effective in the ***short term***, the use of alternative fuels (such as natural gas, biofuels, electricity and hydrogen) needs to be supported by:

- Tax reform aimed at promoting fuel-efficient cars and proposals to reduce taxes for road vehicles that emit less CO_2 and increase taxes for those with higher emissions;
- Extension of emission targets to trucks, aircraft, ships;
- Training campaigns (eco-driving) for professional and public transport drivers;
- Demarketing campaign for the car transport mode (shifting demand to the most eco-efficiency cars available).

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PART I
LITERATURE REVIEW

Part I of this document is dedicated to the analysis of technical databases, policy documents and scientific literature. It is divided into four chapters: development of passenger and freight transport demand, quantification of energy consumption and pollutant emissions, analysis of developments in vehicle technology and fuels, and review of policy documents, which in turn distinguishes between assessing the EC policy action already in place and making proposals based on the scientific literature and national experience. Part I therefore provides the key information needed to make the recommendations presented in Part II.

The text is arranged as follows:

- Chapter 1 outlines developments in freight and passenger demand in recent years and the forecasts for the next few decades. Trends and the expected evolution of transport demand are taken from EUROSTAT, UITP and from the latest policy document of DG TREN, 'Keep Europe Moving', based on the mid-term review of the 2001 White Paper.

- Chapter 2 provides energy consumption figures by sector, transport mode and fuel, and makes reference to the EUROSTAT database (whilst energy consumption projections are the output of the PRIMES model in the 'European Energy and transport – Trends to 2030' report). In the same chapter, greenhouse gas emissions and trends are taken from the national GHG inventories submitted by EU countries to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat. GHG projections by mode of transport come from the models applied on behalf of DG ENV and DG TREN (TREMOVE and RAINS/GAINS), which also provide forecasts for other selected air pollutants. Historical transport emissions of air pollutants, such as acidifying substances, ozone precursor and particulate matters, made reference to the EEA TERM reports and factsheets and to the EMEP emission database implemented under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP).

- Chapter 3 analyses the technology trends in vehicle and fuel innovation in the transport sector in terms of reducing the impact of pollutants and uptake prospects. Recent technological trends and their environmental impacts are outlined for the automotive, shipping and aviation sectors. In this regard the main sources are the Manufacturers' Associations (ACEA) and scientific boards (JRC-IPTS, ACARE). As regards alternative fuels, special attention is given to biofuels; their economical and environmental potential is briefly described in the light of studies by IEA, FAO, EUCAR-EC JRC and the EMPA research institute. An overview of other alternative fuels, such as hydrogen, is given, on the basis of technical studies produced by IEA, JRC-EC and EEA.

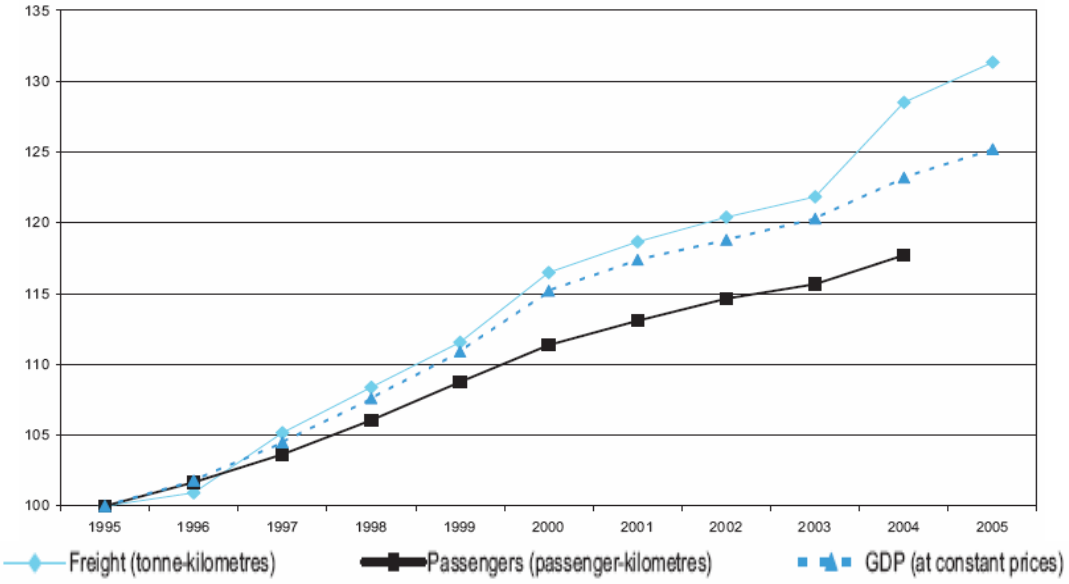
- Chapter 4 analyses the existing literature, focusing on the recommended measures for reducing pollutant emissions and energy consumption. The most recent European Commission Communications concerning the environmental impact of the transport sector provide a framework of the main recommended EU actions. Some case studies are analysed as a selection of the best measures reported in the ECMT 2007 database. Other relevant scientific contributions (London Department for Transport 2004, Wuppertal Institute 2005, Banister 2006, TNO 2006, Joint Expert Group on Transport and Environment 2006, Stern 2006, IPCC 2007, ERTRAC 2007) complete the literature review.

1. Developments in passenger and freight transport demand

1.1 Recent trends

The transport sector plays a central role in the European economy and accounts for continuous growth in terms of tonne and passenger-kilometres. Whilst goods transport grew on average by 2.8% per year between 1995 and 2005 in the EU-25, thereby surpassing the average growth in GDP (at constant prices) of 2.3%, passenger transport increased at a slower rate of 1.8% (based on data covering the 1995-2004 period)[1]. Overall, as against a 25% increase in GDP between 1995 and 2005, goods transport grew by 31%. Passenger transport went up by 18% between 1995 and 2004, as against an increase in GDP of 23% over the same period (Figure 1).

Figure 1 Evolution of freight and passenger transport compared with growth in GDP, 1995-2004/5 (1995=100)



Source: DG Energy and Transport, reported in Eurostat, *Panorama of transport* (2007).

The share for road transport accounts for about 84% of passenger transport in 2004 if passenger cars, powered two-wheelers (P2W), buses and coaches are all included. In freight, although road transport accounts for the single largest share (44%) in 2005, sea transport is not far behind with a share of 39%. The shares for rail are 6% for passenger transport and 10% for freight transport, around 9% growth on 1995 figures. With regard to rail freight, the largest increases are generally recorded in those Member States that opened up their rail markets early.

Air transport is clearly more important for passenger transport (with an 8% share), in which it also recorded the fastest growth of all transport modes (49%). By contrast, sea transport is clearly more important for freight, registering the second fastest growth (35%) after road and the only decline in passenger transport (-11%), a trend reflecting the shift from ferry transport to other transport modes. Although freight performance over inland waterways only increased

[1] Rates refer to tonne-km and passenger-km

by 10% in the EU-25, growth is much larger in some Member States (50% in Belgium and 30% in France).

It is interesting to note the importance of urban and short distance transport in general: European citizens make 1 000 journeys (per year and per capita) on average and half of these are less than 5 km long. About 75% of kilometres travelled in EU conurbations are in cars and, on a daily basis, 60% of all kilometres travelled by car are for journeys of 30 km or less and 37% are for distances of 10 km or les (CEI-CIVES based on RWE Energie).

Regional and commuter rail passengers now represent by far the biggest share of all rail journeys in Europe: they account for about 90% of the total number of rail passengers (including long-distance journeys) and 50% of the total number of passenger-kilometres per year, with an aggregate average distance travelled of about 27.9 km, as shown by the study on the 'European Suburban and Regional Railway Landscape' (ERRAC, 2006) carried out by UITP (International Association of Public Transport).

Table 1 Passenger transport performance in the EU-25, by mode of transport, 1995-2004 (in billion passenger-kilometres)

	Passenger cars	**P2W**	**Bus & Coach**	**Railways**	**Tram & Metro**	**Air***	**Sea***	**Total**
2004	4458	143	502	352	75	482	49	**6061**
2000	4196	132	492	353	71	440	49	**5734**
1995	3787	120	474	324	65	324	55	**5149**
% change 95/2004	*17.7%*	*19.7%*	*5.8%*	*8.6%*	*16.4%*	*48.8%*	*-11.1%*	***17.7%***
% annual change	*1.8%*	*2.0%*	*0.6%*	*0.9%*	*1.7%*	*4.5%*	*-1.3%*	***1.8%***

Source: DG Energy and Transport, reported in Eurostat, *Panorama of transport* (2007).
* Air and Sea: only domestic and intra-EU traffic, data under revision.

Table 2 Freight transport performance in the EU-25, by mode of transport, 1995-2005 (in billion tonne-kilometres)

	Road*	**Rail**	**Inland waterways**	**Oil pipelines**	**Sea***	**Air***	**Total**
2005	1724	392	129	131	1525	2	**3903**
2000	1487	374	130	124	1345	2	**3462**
1995	1250	358	117	112	1133	2	**2972**
% change 95/2005	*37.9%*	*9.2%*	*10.2%*	*17.5%*	*34.6%*	*31.1%*	***31.3%***
% annual change	*3.3%*	*0.9%*	*1.0%*	*1.6%*	*3.0%*	*2.7%*	***2.8%***

Source: DG Energy and Transport, reported in Eurostat, *Panorama of transport* (2007).
* Road: national and international haulage by vehicles registered in the EU-25. Air and Sea: data only include intra-EU traffic and are estimates by the Commission services based on port-to-port data collected under Council Directive 95/64/EC and on airport-to-airport data collected under Regulation (EC) 437/2003.

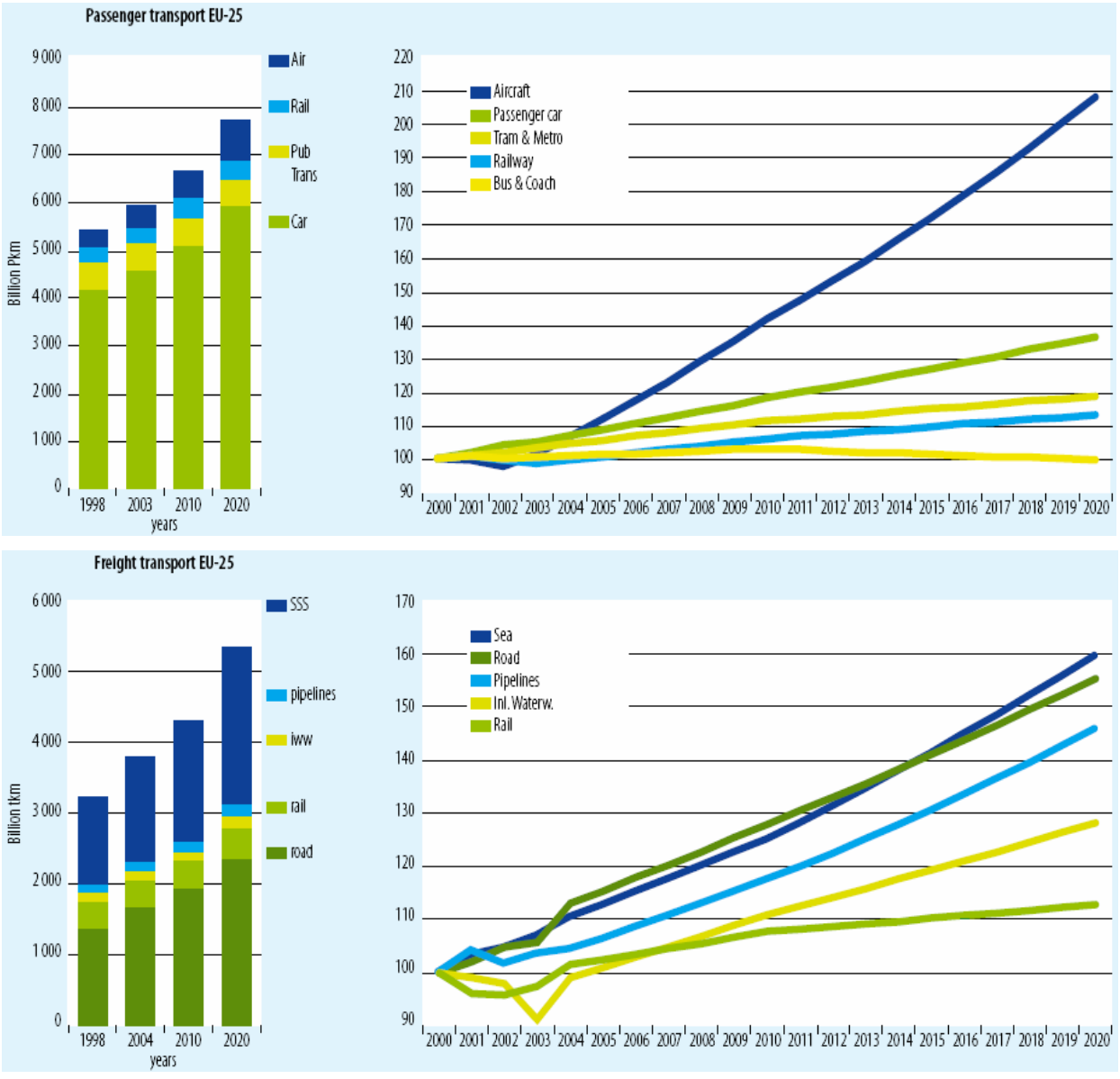
1.2 Demand forecast

The expected developments in passenger and freight transport demand in the EU are reported in the mid-term review of the 2001 Transport White Paper (European Commission, 2005). The forecast suggests that total passenger travel demand (in passenger-km) will grow by 17% in 2000-2010 and 34% in 2000-2020. This overall growth is characterised by slower percentage rises in the EU-15 (by 16% and 32% respectively for the periods 2000-2010 and 2000-2020)

and much faster increases in the new Member States (30% and 60% respectively). The modes that have significant demand growth are car (17% and 36% respectively for 2000-2010 and 2000-2020) and air (51% and 105% respectively). Train, bus and walking/cycling are expected to grow more slowly in terms of passenger-km.

According to the same document, total freight transport demand is expected to grow by 17% in the period 2000-2010 and 39% in 2000-2020. Road is expected to grow in the EU-25 by 26% by 2010 and 55% by 2020. In the EU-15, the rates will be lower, albeit from a high base: 20% and 45% respectively for 2010 and 2020. In the new EU-10 road is expected to increase by 70% and 134%.

Figure 2 Expected growth in passenger and freight transport activity by mode (2000 = 100)



Source: Mid-term review of the European Commission's 2001 Transport White Paper- *Keep Europe moving*; projections based on Assess study.

2. QUANTIFICATION OF ENERGY CONSUMPTION AND POLLUTANT EMISSIONS

2.1 Energy consumption

About one third of the final energy consumption in the EU-25 is related to transport (excluding maritime transport and pipelines), at a level of 352 million tonnes of oil equivalent (Mtoe) in 2004. Road transport is by far the dominant sector, consuming nearly 83% of the energy used for transport purposes.

As indicated by Eurostat data, the transport sector exhibited the highest energy demand growth between 1990 and 2004 (2.0% annually). Improvements in fuel efficiency were offset by increases in passenger and freight transport demand. Following the strong decline of energy needs in industry in the same decade, partly as a result of the migration of many manufacturing activities in non-EU countries, the transport sector (excluding marine bunkers) became the largest demand-side sector by 2004, accounting for 30.7% of final energy demand compared with 26.7% in 1990.

Table 3 Evolution of final energy consumption in transport, by transport mode, various years, EU-25, in Mtoe and %

	1990	1995	2000	2004	1990-2004 % change
Transport	**272**	**295**	**334**	**352**	**29**
Rail	9.1	8.8	9.2	9.3	
% share	*3.4%*	*3.0%*	*2.8%*	*2.6%*	1
Road	228.0	245.5	274.0	290.0	
% share	*83.8%*	*83.3%*	*82.1%*	*82.5%*	27
Air	28.4	33.7	45.3	47.4	
% share	*10.4%*	*11.4%*	*13.6%*	*13.5%*	67
Inland and Coastal Shipping	6.6	6.7	5.4	5.0	
% share	*2.4%*	*2.3%*	*1.6%*	*1.4%*	-23

Source: Eurostat, *Panorama of Transport*, 2007.

For many years final energy consumption by transport has been growing and current forecasts do not expect a break in this trend. The transport market today is almost entirely dependent upon oil-based fuels and is responsible for about 70% of the final demand for oil and oil products in the EU-25 (Eurostat database). The fuel mix has changed slightly in terms of the importance of renewable energy sources (RES): looking at 2005 figures, almost 1% of the final energy consumption in transport has shifted from oil-based fuels (97%) to biofuels, with electricity having a stable 2%.

Comparing the 1990 and 2005 shares of final energy consumption of oil-based fuels, it is possible to see the rapid growth of air transport, which accounted for 11% and 14% respectively, the dominant role of road transport, which absorbed 85% in 1990 and 83% in 2005 of the total consumption, and the marginal demand of rail transport and inland navigation which accounted for 1% and 2% respectively in both periods.

Table 4 Evolution of final energy consumption in transport, by type of fuel, various years, EU-25, in Mtoe

	1990	1995	2000	2004	2005*
Crude Oil and Petroleum Products	267.3	288.8	327.0	343.1	345.0
Gas (road)	0.2	0.3	0.4	0.5	0.5
Electricity (rail)	5.1	5.5	5.9	6.1	6.2
Renewables – Biofuels (road)	*0.002*	0.2	0.6	2.0	3.2
Solid fuels (rail)	0.1	*0.01*	*0.01*	*0.004*	*0.005*
Total	**272.7**	**294.8**	**333.9**	**351.7**	**354.9**

Source: Eurostat database (* Provisional values).

According to DG TREN estimates (European Energy and Transport, trends to 2030, 2005 update), the predominant role of the transport sector in final energy demand growth for the EU-25 is expected to continue under baseline assumptions up to 2010 (1.4% annually). However, beyond that period the combined effect of decoupling transport activity from economic growth (especially in passenger transport in the EU-15) and technological progress will lead to a deceleration of transport demand growth from 2010-2020 (0.6% p.a.) and even a decline in transport energy needs in 2020-2030 (-0.1% p.a.). Because of these two factors, transport in the EU is expected to account for 30% of final energy demand in 2030, still the largest demand-side sector.

In its EU Action Plan for energy efficiency (COM(2006) 545 final), the Commission estimated the energy saving potential in the transport sector to be up to 26% by 2020. The target of the Action Plan is to achieve at least 20% of cost-effective energy saving potential by 2020.

Table 5 Forecast of energy demand in transport in the EU-25 in Mtoe

	2005	2010	2015	2020	2025	2030
Public road transport	7.0	7.0	6.7	6.3	5.8	5.3
Private cars and motorcycles	169.3	170.2	164.5	168.9	166.5	159.9
Trucks	119.8	135.6	148.4	156.8	162.4	164.4
Rail Transport	8.9	8.3	7.2	6.5	6.2	6.0
Aviation	50.0	54.2	57.5	60.8	58.9	60.3
Inland Waterways	5.6	5.8	6.0	6.2	6.3	6.4
Transport sector	**360.6**	**381.1**	**390.3**	**405.5**	**406.1**	**402.3**

Source: European Energy and transport: trends to 2030 - 2005 update - PRIMES baseline scenario

2.2 Greenhouse Gas (GHG) emissions

2.2.1 The current situation

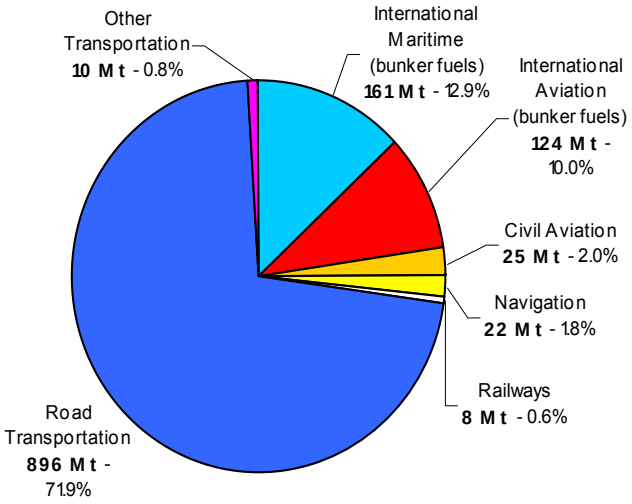
The most comprehensive public source for assessing greenhouse gas emission trends and reduction commitments in Europe is the EC GHG inventory (1990-2005), compiled on the basis of the national inventories by the EEA and the European Topic Centre on Air and Climate Change (ETC/ACC). Greenhouse gas emissions (see the annex to chapter 2) within the EU, also referred to as *domestic* emissions, are submitted annually to the UNFCCC Secretariat

and are used to track progress within the Kyoto Protocol[2] but also to implement the mechanism for monitoring Community greenhouse gas emissions[3]. Emissions from international aviation and maritime transport, so called *bunker fuels*, are not included in the national totals but are reported as memo items and are available since 1990.

In 2005 total *domestic* GHG emissions (CO_2, CH_4, N_2O) in the EU-27, excluding LULUCF[4], were 5 180 million tonnes (Mt) or teragrams (Tg) of CO_2 equivalent. Part of the largest emitting source, 'energy' (80% of total *domestic* GHG emissions), in the same year the 'transport' category accounted for 961 Mt of CO_2 equivalent (18.6% of the *domestic* total). This category includes road transportation, railways, domestic navigation, domestic civil aviation and other transportation. The memo items international aviation and maritime transport accounted for an additional 285 Mt of CO_2 equivalent in 2005.

The contribution of each single transport-related category to the sector's total (emissions from *domestic* transport and *bunker fuels)* is shown in Figure 3.

Figure 3 Transport category's contributions (in Mt of CO_2 equivalent and %) to total GHG emissions from transport in 2005.



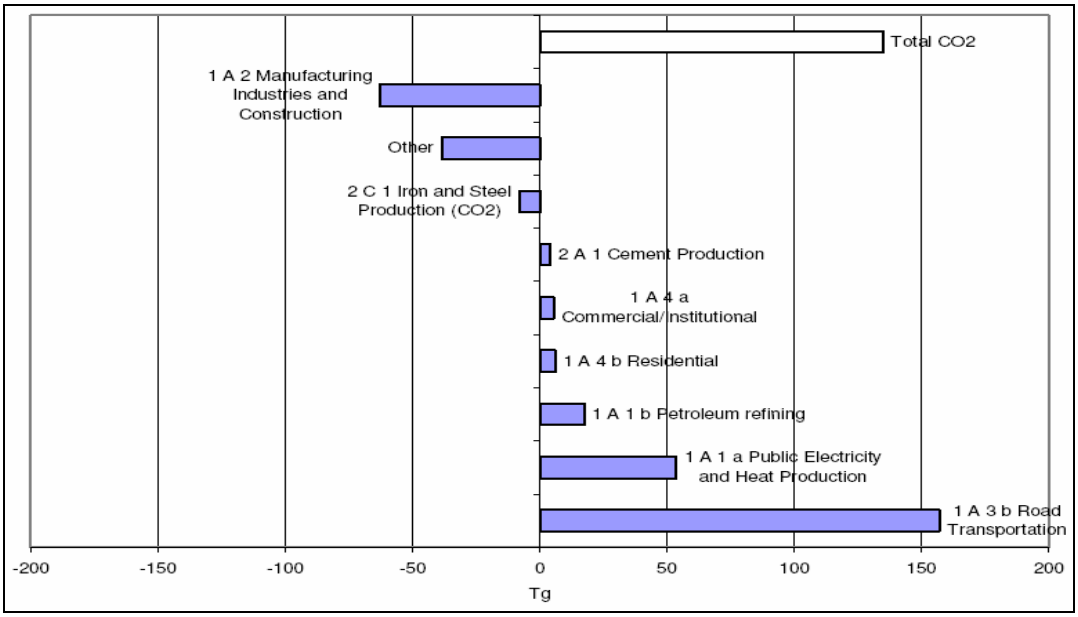
Source: based on data from EC GHG inventory 1990-2005.

The most important greenhouse gas by far is carbon dioxide, accounting for 83% of total EU-27 emissions in 2005 (including *bunker fuels*). In 2005 *domestic* EU-27 CO_2 emissions (4 269 Mt) were 3.5% below 1990 levels. At EU-15 level the same aggregate accounted for 3 482 Mt, which was, on the contrary, 3.7% above 1990 levels. The source category of *domestic* transport contributes 20% in CO_2 emissions, 0.1% in CH_4 and 0.5% in N_2O to the EU-15 national totals of GHG emissions. Between 1990 and 2005 emissions from transport increased by 26% in the fifteen old Member States, reaching 880 Mt.

2 Only the old EU-15 countries share a common target under the Kyoto Protocol and only 10 of the 12 new Member States have an individual Kyoto target (Cyprus and Malta do not).
3 Council Decisions No 1999/296/EC and 280/2004/EC.
4 Land use, land-use change and forestry activities can remove greenhouse gases from the atmosphere (e.g. tree planting or forest management) or reduce emissions (e.g. by curbing deforestation).

Analysing the trend of EU-15 key sources (Figure 4), it can be seen that the main reason for increases in CO_2 emissions between 1990 and 2005 was the growing road transport demand (with repercussions also on N_2O emissions).

Figure 4 Absolute changes of CO_2 emissions by large key source categories, 1990 to 2005, in CO_2 equivalent (Tg) for the EU-15.



Source: Annual European Community greenhouse gas inventory 1990-2005 and inventory report 2007.

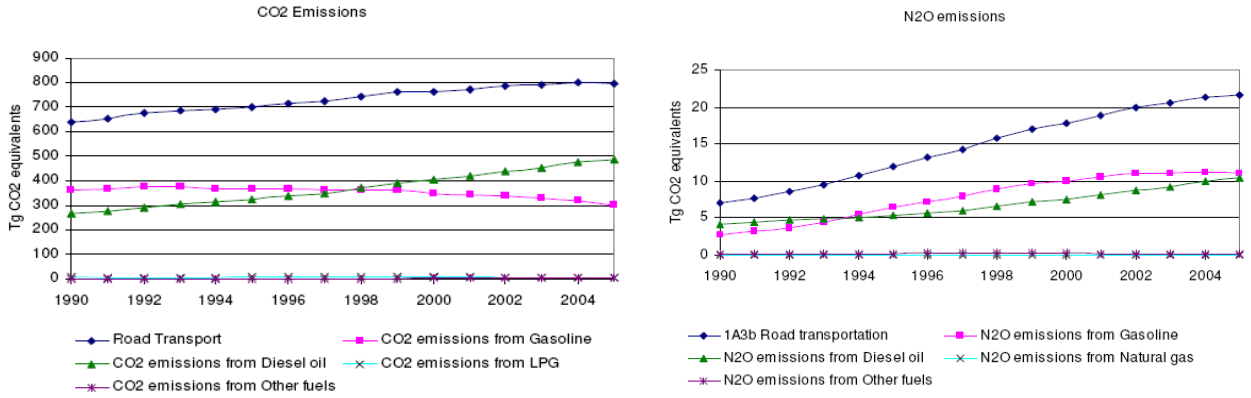
2.2.2 The contribution of different modes of transport

CO_2 emissions from **road transport** account for 72% of emissions from the transport sector. Between 1990 and 2005 CO_2 emissions increased by 25% in the EU-15. reaching 794 Mt; such growth is due to the marked escalation of diesel vehicle emissions which more than compensated for the slight decline in gasoline passenger cars in several EU-15 Member States. Because of the large increase in the number of cars equipped with catalytic converters (with larger emission factors than cars without such device), N_2O emissions rose to 21.6 Mt in 2005 (+206% compared with 1990 levels). All Member States increased emissions from road transport since the reference year 1990. Spain, France and Italy had the highest increases in absolute terms. All the Member States except for Austria, Germany, the Netherlands and Sweden had an increase higher than 100% in their N_2O emissions.

According to the baseline of the TREMOVE[5] model, about 66% of CO_2 emissions in the road sector can be attributed to passenger transport, which includes cars, mopeds, motorcycles, buses and coaches. Consequently, the remaining 34% is emitted by road freight transport (LDVs and HDVs).

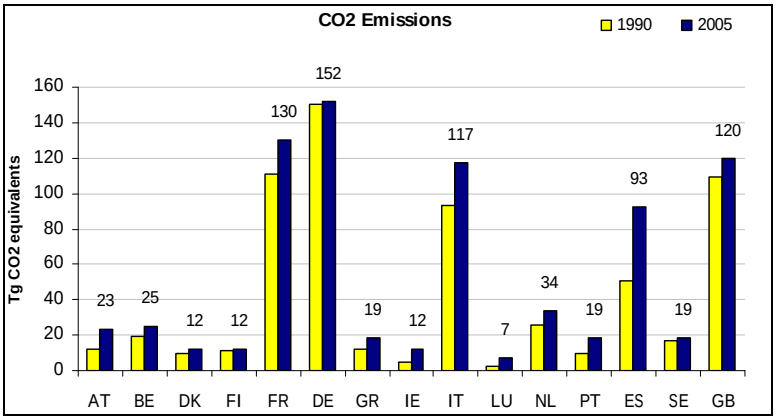
5 TREMOVE is a policy assessment model developed since 1997 to study the effects of different transport and environment policies. The model estimates transport demand, modal shifts, vehicle stock renewal, emissions of air pollutants and welfare level. TREMOVE models both passenger and freight transport, and covers the period 1995-2020.

Figure 5 EU-15 CO_2 and N_2O emission trends for road transport



Source: Annual European Community greenhouse gas inventory 1990-2005 and inventory report 2007.

Figure 6 EU-15 Member States'contributions to CO_2 emissions from road transport in 1990 and 2005



Source: based on data from EC GHG inventory 1990-2005.

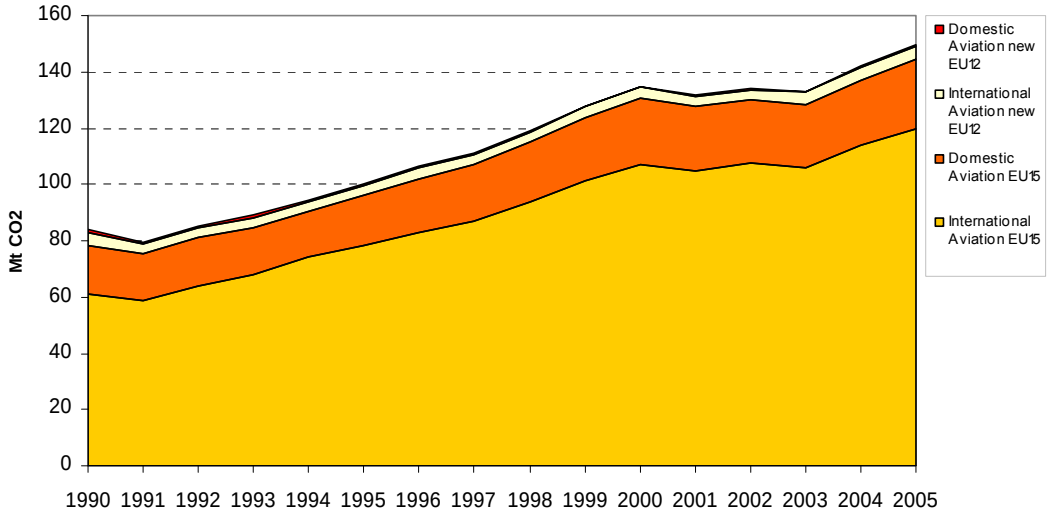
CO_2 emissions from **railways** are due to fossil fuel consumption in rail traction, which decreased in the EU-15 from 7.9 Mt of CO_2 in 1990 to 6 Mt in 2005 (-24%). Emissions from diesel rail transport decreased between 1990 and 2005 in nearly all Member States, with the exception of Ireland (+12%), the Netherlands (+16%) and the United Kingdom (+36%).

Since 1990 CO_2 emissions from the **aviation** sector in the EU-15, including mandatory domestic reporting and international emissions in the bunker fuels aggregate, have risen by 83%, reaching 145 Mt[6]. The United Kingdom, Germany, France, Spain and Italy are responsible for 82% of total emissions from this source. Despite a moderate decline after the attacks of 11 September 2001, aviation emissions resumed a rapid growth in 2003 (+6.7% in 2004 and +5.4% in 2005). Using its flights emission model based on real air traffic movements, Eurocontrol has estimated that 132 Mt of CO_2 was emitted by aircrafts departing from EU-25 airports in 2005 (T&E, 2007). This alternative figure excludes operational military flights and small aircraft, but allows a geographical assessment of emissions: almost 85% of flights departing from an EU airport remain in the EU and represent approximately 40% of

6 Aviation emissions at EU-27 level accounted for 150 Mt in 2005, but the data in the new Member States showed large annual fluctuations which might be due to incomplete or inaccurate estimates in some countries.

total CO_2 aviation emissions (20% from domestic and 20% from intra-EU flights). The remaining 60% is caused by flights leaving the EU. It should be pointed out that the total impact of aviation on climate change is estimated to be 2 to 5 times higher than the radiative forcing of its CO_2 alone because of the altitude at which airplanes fly and emissions occur (mainly as a result of NO_X emissions, sulphate aerosols and cirrus cloud formation).

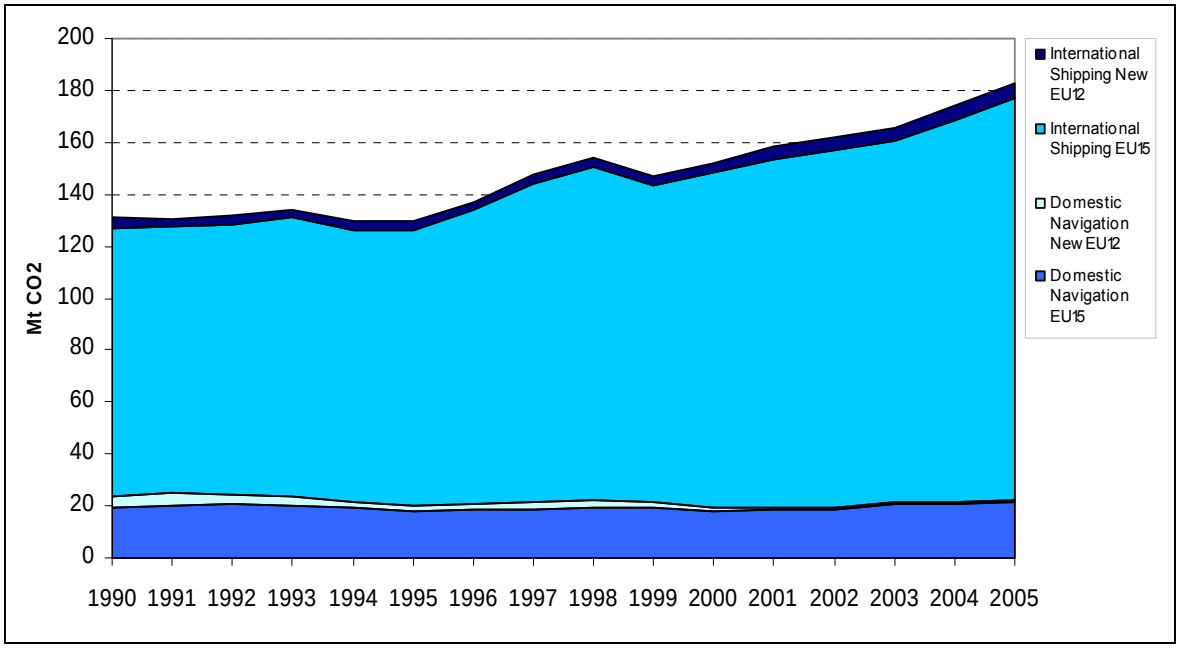
Figure 7 CO_2 emissions from aviation in the EU-15 and new EU-12 Member States 1990-2005



Source: based on data from EC GHG inventory 1990-2005.

Maritime transport is included in the national totals under the subcategory of domestic navigation (inland waterways and coastal shipping). International shipping is reported separately under the sales of marine bunker fuel. Greenhouse gas emissions from ocean-going ships, operating on both national and international seaborne trade, have risen by 39% from 1990 levels (about 2.3% annually). A comparison of emissions estimates for maritime transport with more detailed models using ship features and vessel movement data showed that figures based on reported sales of marine bunker fuel are likely to be underestimated when referred to global CO_2 emissions from shipping. At EU-27 level, official figures from the EC GHG inventory and activity-related estimates agree within a range of 5% for the sector as a whole. Shipping's contribution to global warming, according to CE Delft (2004), the only model study performed to date, is similar to the radiative forcing effect of aviation, although shipping remains the most energy-efficient mode of transport in terms of fuel burned per cargo tonne-mile or passenger-mile (90% of goods traffic to and from the EU is by sea).

Figure 8 CO_2 emissions from maritime transport in the EU-15 and new EU-12 Member States 1990-2005



Source: based on data from EC GHG inventory 1990-2005.

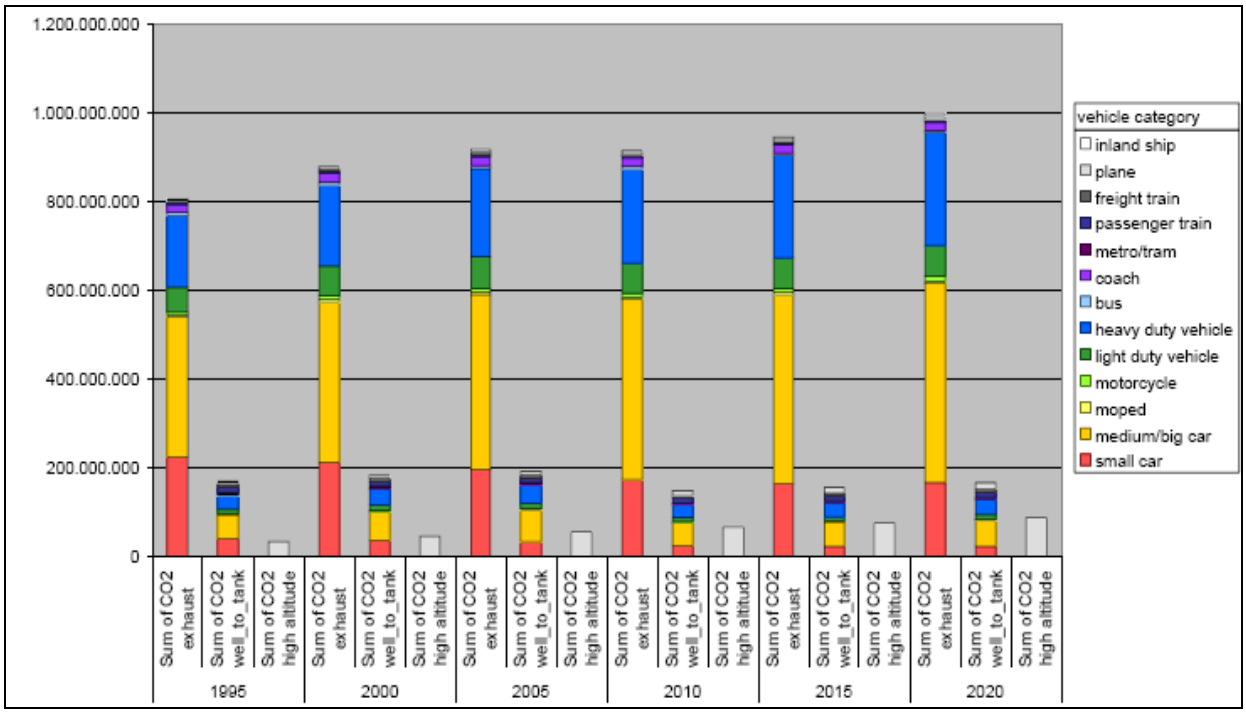
2.2.3 Expected developments

The EU Kyoto Protocol target for 2008-12 is an 8% reduction of total greenhouse gas emissions compared with 1990 levels. No overall targets for emissions of GHGs from transport have been agreed in the EU. In June 1998 EU Member States agreed a system of target sharing, which was then reaffirmed in Council Decision 2002/358/EC.

The evolution of exhaust CO_2 emissions from land transport (road, rail and inland waterways) was estimated by the TREMOVE model on behalf of DG Environment (de Ceuster, 2007). The values (see Figure 9) are expressed in tonnes of CO_2 and relate to 21 countries (EU-15, Czech Republic, Hungary, Poland, Slovenia, Norway, Switzerland) for all vehicle ages.

To some extent as a result of the partially successful voluntary agreement with the car industry to limit test-cycle CO_2 emission for cars to 140g per km in 2008/2009, according to TREMOVE projections, during the 2005-2010 period fuel efficiency improvements for road vehicles will lead to a limited downward trend in overall transport fuel consumption. The resulting decrease in specific fuel consumption offsets the increase in transport demand. After 2010 no further fuel efficiency improvements for new vehicles are modelled in TREMOVE and the replacement of old vehicles by newer fuel-efficient ones will not offset growth in transport demand.

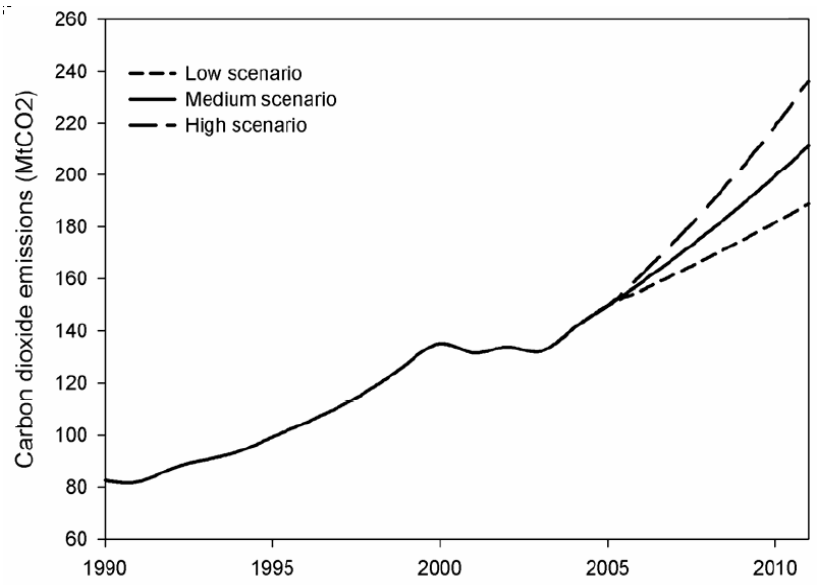
Figure 9 CO_2 emissions in the EU19+2 by mode, in tonnes



Source: TREMOVE, 2007. Maritime sector is not included

Projections and forecasts of carbon dioxide emissions from aviation are focused on the sector's impact on global warming (e.g. using climate models) and the expected growth in industry (in terms of passenger-km and freight-km). The recent report by The Tyndall Centre for Climate Change Research (Friends of the Earth, 2007) presents an assessment of both modelled and empirical baselines used in the debate in favour of the inclusion of aviation in the EU Emissions Trading Scheme (ETS). Historical and projected developments of emissions from the aviation sector are shown in Figure 10.

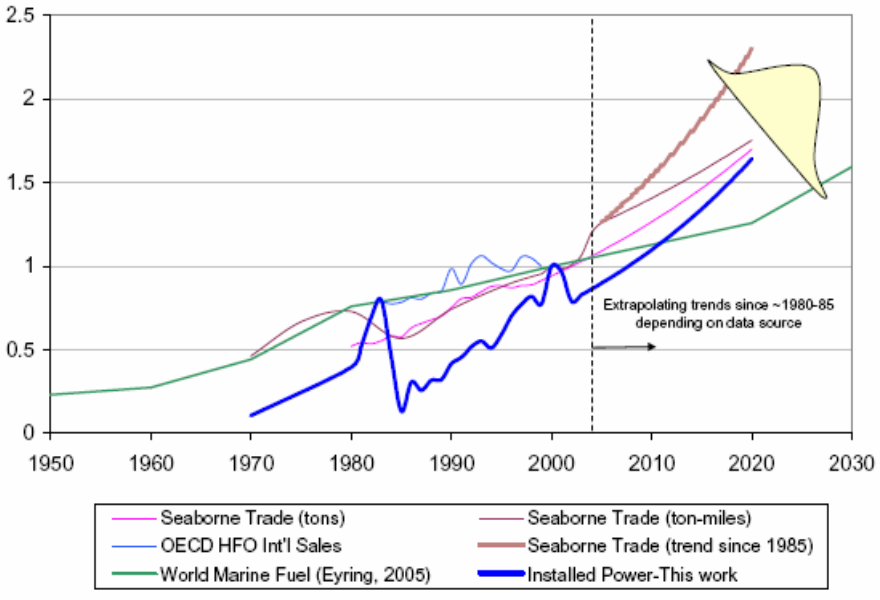
Figure 10 CO_2 emission trends and scenarios for aviation



Source: Tyndall (2007)

The development of future shipping activities, which might affect growth in GHG emissions from ships, ranges from 2.5% to 4.1% per year according to various sources (Figure 11).

Figure 11 Activity trends and scenarios for Maritime Transport



Source: Corbett *et al.*, 2007; reported in IIASA-Entec-Met.NO, 2007

2.3 Air pollutant emissions

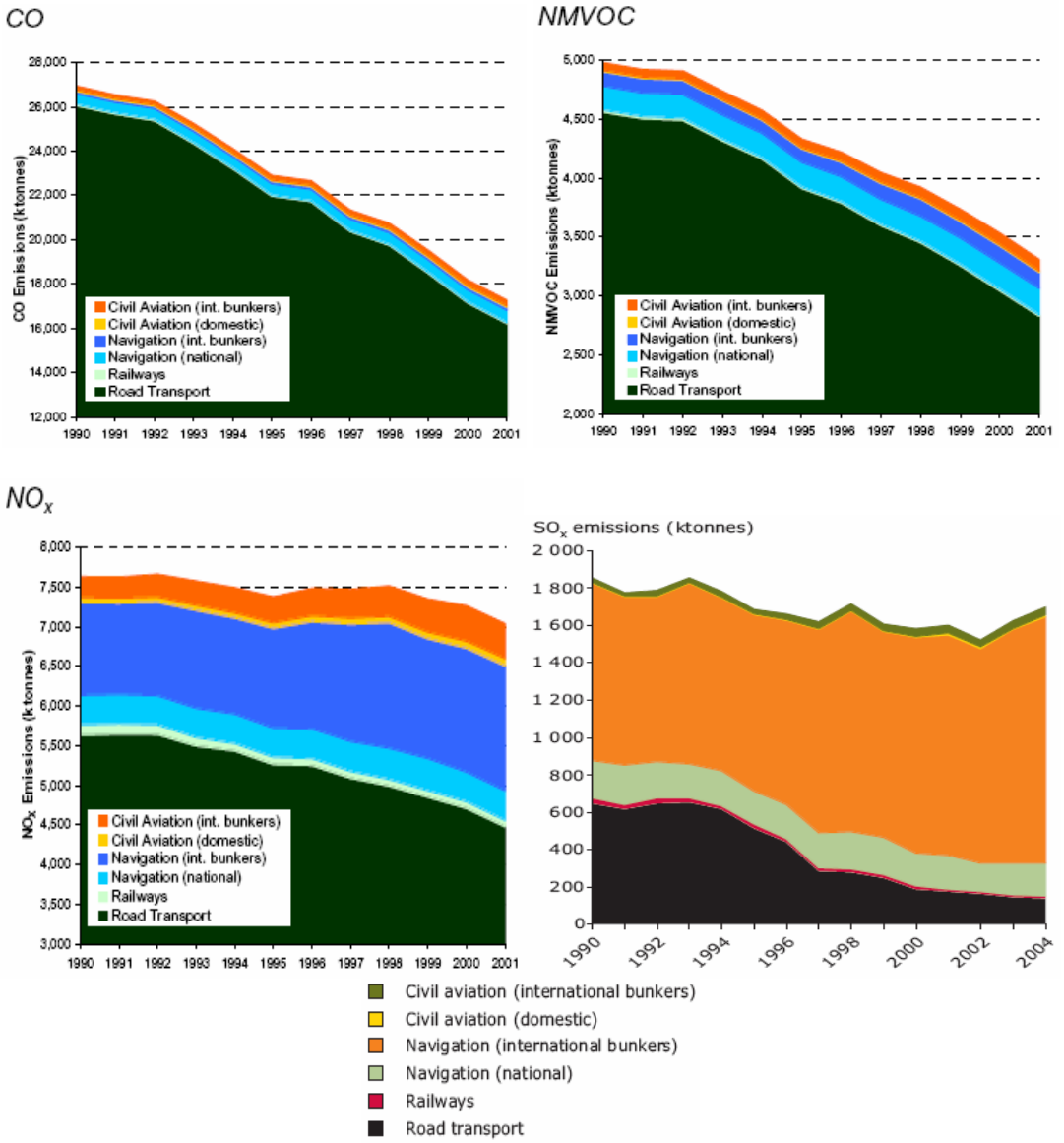
2.3.1 Recent trends

Emissions of harmful substances from land transport decreased significantly between 1990 and 2004 in EEA[7] member countries: particulate matter (PM_{10}) by 29%, acidifying substances (NO_X and NMVOCs) by 32% and ozone precursors (NO_2, SO_X, and NH_3) by 41%. This is mainly due to innovations in exhaust gas treatment in road vehicles (prompted by the introduction of EU standards) and improved fuel quality (especially reduced sulphur concentrations).

Carbon monoxide (CO) and non-methane volatile organic compound (NMVOC) emissions are dominated by road vehicles and showed a significant decrease together with rail transport (emission reductions from diesel powered stock and increased electrification of EU railways). Whilst emissions of nitrogen oxides (NO_X) and sulphur dioxides (SO_X) from road transport decreased by 37% and 84% respectively in the EU-27 between 1990 and 2004, emissions from maritime and air transport now represent the biggest contributors to the sector as a whole. SO_X emissions have shifted from land to sea rather than actually decreased.

[7] The EEA members are the EU-27 plus Turkey, Norway, Iceland and Liechtenstein.

Figure 12 Emission trends of major air pollutants in EEA member states by type of transport

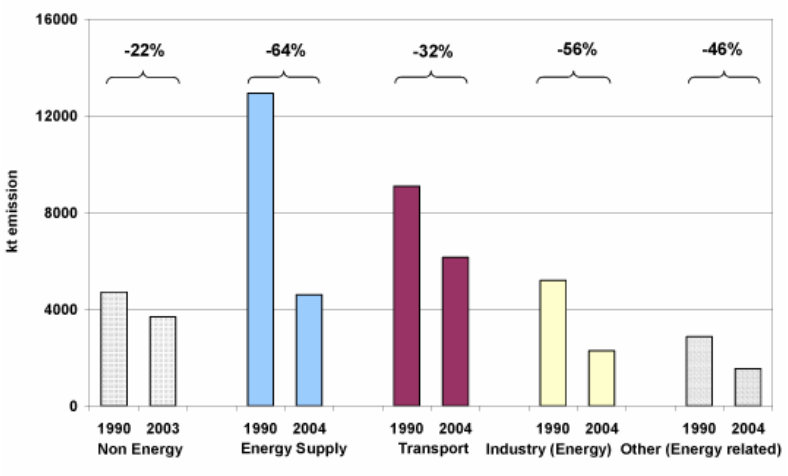


Source: TERM 03 EEA-31 indicator factsheet (2003) and TERM 2006 (2007), European Environment Agency.

Maritime transport is the major emitter of SO_X in transport. Its contribution increased from 50% in the early 1990s to 78% in 2004. Despite a sulphur limit for marine fuel of 1.5% in Sulphur Emission Control Areas (SECA –Baltic, North Sea and English Channel) and the average sulphur content of 2.7%, the general limit under Annex VI of the IMO Marpol Convention (which entered into force in May 2005) is only 4.5%. Annex VI also contains a limit for NO_X emissions of marine engines and most manufacturers have been building engines compliant with this standard since 2000. EU strategy seeks to extend the SECA concept to other European seas and to press for tighter NO_X standards. The EU has also applied the same 1.5% limit on fuel sulphur content for passenger vessels on regular services to or from EU ports.

Emissions of particulate matter from the transport sector decreased by 32% between 1990 and 2004 in the EU-25, though not at the same rates as the other sectors. The reduction was largely a result of the continued penetration of catalytic converters and the improvements in vehicle technology, reducing emissions of secondary particulate precursors.

Figure 13 Total and sectorial non-energy and energy-related emissions of primary and secondary PM_{10} particulate matter emissions, EU-25 (weighted using particle formation factors)

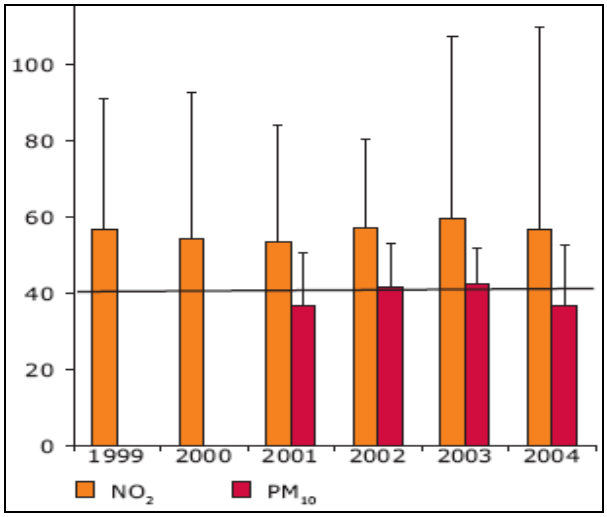


Source: EEA/ETC-ACC 2006.

In the European Union most of the population live in urban areas. About 60% of the European population live in cities with more than 10 000 inhabitants (EC GREEN PAPER, 2007 – source Eurostat) and more than 70% live in inner cities or inner suburban districts (World Bank, see the annex to chapter 1).

Data from selected measuring stations in urban agglomerations close to major traffic arteries indicate that concentrations of NO_2 (2010 limit) and PM_{10} (2005 limit) are equal to or higher than the European air quality limits at these sites (EEA TERM 2006). Air quality is affected by a combination of emission and meteorological factors. However, two elements may help to explain why the improvement still fails to appear: the increased use of diesel in urban areas and an increase of the proportion of NO_X emitted as NO_2 since 2000. Oxidation catalysts and regenerative traps in modern diesel engine have been found to cause the increase (AQEG, 2006).

Figure 14 Average annual concentrations of NO_2 and PM_{10} in urban areas ($\mu g/m^3$)

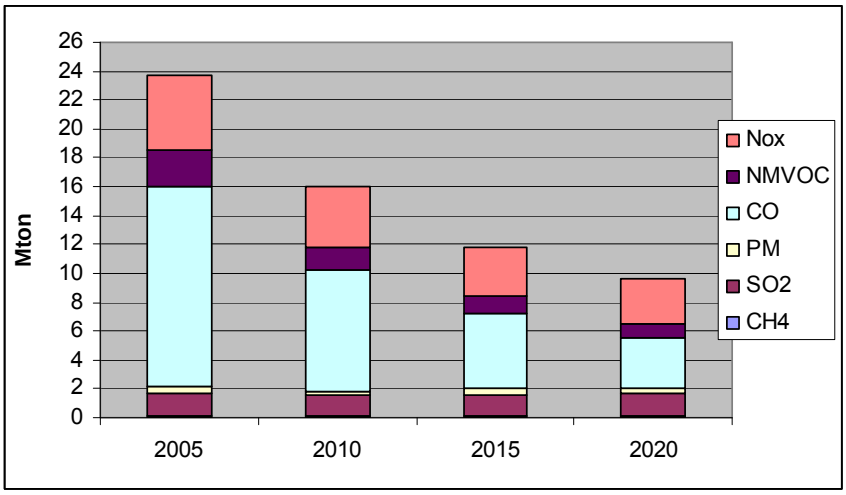


Source: EEA TERM 2006.
Note: the error bars represent maximum values. The dotted line represents the yearly limit value set for PM_{10} (2005) and NO_2 (2010).

2.3.2 Expected developments

In addition to GHG emissions, the TREMOVE model provides projections for several different pollutants (de Ceuster, 2007). Results are summarised in the figure below, which shows the emissions trend in road transport in Mt for 19 EU Member States[8] plus Switzerland and Norway. Each pollutant is calculated as the sum of exhaust and well-to-tank emissions. Emissions of CO, NO_x, NMVOC and PM show a significant decrease over the modelled time period as a result of tightening EU emission standards for road vehicles

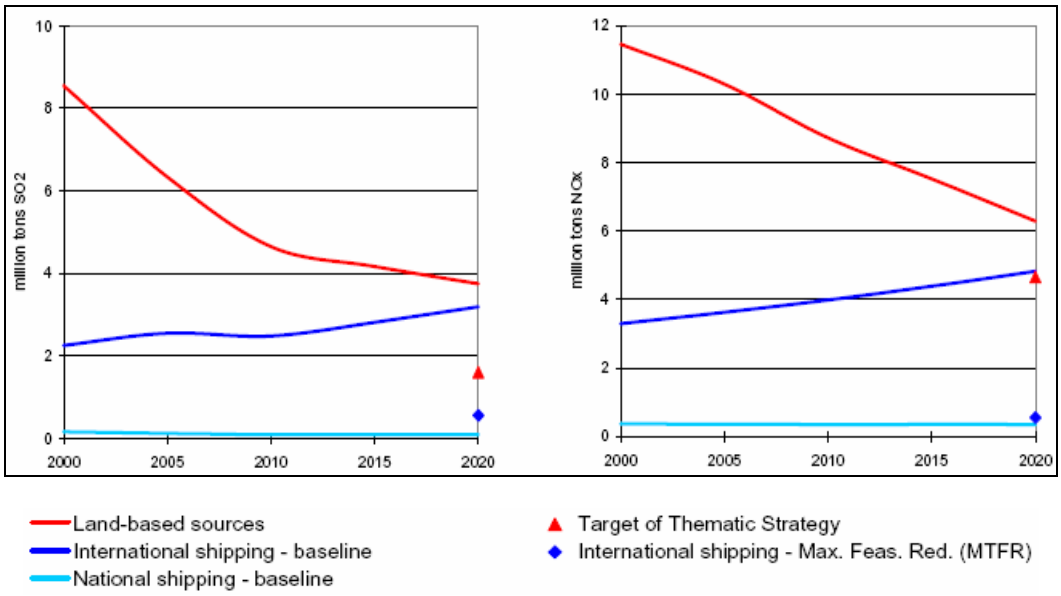
Figure 15 Road transport emissions projections for selected air pollutants, in Mt



Source: TREMOVE 2.44.c

8 EU-15, Czech Republic, Hungary, Poland, Slovenia.

Figure 16 Emissions of sulphur dioxide and nitrogen oxides in maritime transport, in Mt



Source: IIASA-ENTEC-Met.NO, 2007.

Figure 16 shows the development of baseline emissions from shipping over time (IIASA-ENTEC-Met.NO, 2007) and compares it with the NEC baseline emissions from land-based sources in the EU-25. In 2000 emissions from shipping accounted for about 28% and 32% of land-based SO_2 and NO_x emissions, respectively. Whilst emissions from land-based sources will significantly decrease until 2020, national and international shipping emissions are expected to rise up to a level of 88% of land-based emissions of SO_2 and 82% of NO_x. The graph also shows the technical potential for reducing emissions from ships (MTFR – blue diamond) and the indicative emission reduction target for land-based sources of the Thematic Strategy on Air (red triangle).

To date, environmental emissions targets exist for total emissions (including all sectors) of acidifying substances, ozone precursors and particulates as well as for air quality. Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings (NECs) sets upper limits for each Member State for total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (SO_2, NO_x, VOCs and ammonia), but leaves it largely to the Member States to decide which measures to take in order to comply (see the annex to chapter 2).

The Air Quality Framework Directive (Council Directive 96/62/EC) describes the basic principles for how air quality should be assessed and managed in the Member States. This directive sets numerical limits and thresholds and applies to specific pollutants[9] (see the annex to chapter 2).

[9] The Commission adopted a proposal for a directive on ambient air quality at the same time as it adopted the thematic strategy on air pollution (COM(2005) 447 final). In this proposal the Commission does not propose to modify the existing air quality limit values but will propose a strengthening of existing provisions so that Member States will be obliged to prepare and implement plans and programmes to eliminate non-compliance.

3. TECHNOLOGY INNOVATION

Technology innovations play an important role in reducing the ecological footprint of the transport sector. Their mitigation potential is driven mainly by four groups of relevant measures:

- changes and improvements in vehicle design, i.e. by reducing aero/hydro-dynamic resistance, vehicle weight;
- efficiency of converting fuel into energy: i.e. by improving drive train efficiency;
- substantial reductions of harmful pollutant emissions from vehicle exhaust gases and climate controls (e.g. EURO standards);
- development and use of less carbon-intensive fuels (e.g. biofuels) or their hybrid (flex) use.

Such innovative sectors focus on developments on both existing vehicles and new concept vehicles for the future. This chapter analyses these issues, giving an overview of the impact of emission reductions and other barriers to the uptake of alternative sources.

3.1 Vehicle and engine developments

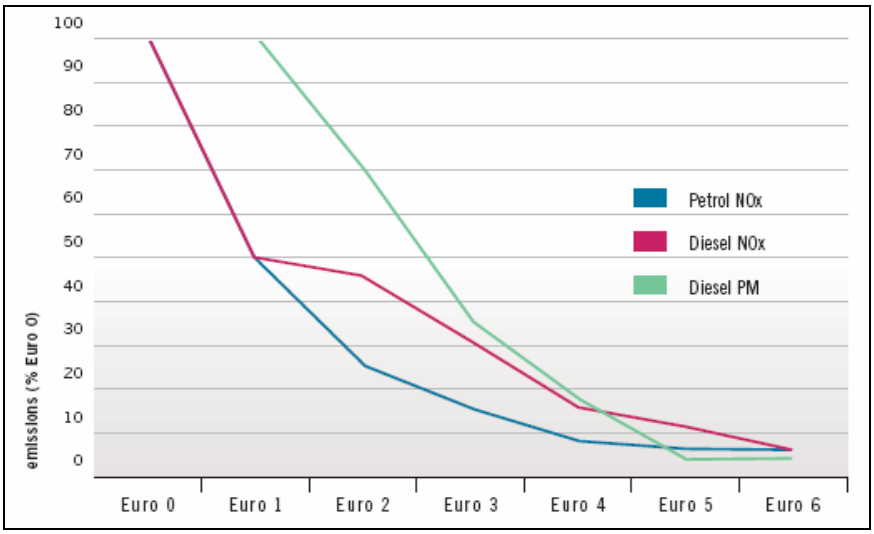
3.1.1 Automotive industry

Vehicles, engines and their systems have undergone important developments in the last thirty years. The volatility of oil prices and increasing concerns about the environment have influenced user choices and prompted government action (e.g. emission limits) in many countries. As a result, car manufacturers have had to accelerate the introduction of new engines and fuel technologies, with positive impacts in terms of the objectives of reducing emissions and fuel consumption. The main trends in vehicle and engine development, can be summarised as follows:

- Improvements in fuel economy, performance and emissions for both gasoline and diesel-fuelled LDVs, HDVs, P2Ws and buses. According to the EURO emission standards, nitrogen oxide (NO_X) and particulate matter (PM) emissions from cars and trucks have been reduced by more than 90% in the last 25 years (Figure 16);
- R&D projects looking at more efficient powertrains, improved aerodynamics, reduced rolling resistance and lighter vehicles (Figure 17), but also research activities on eco-driving, advanced traffic management using ICT and vehicle technologies;
- Introduction on the market of hybrid vehicles as well as prototypes of combustion and fuel-cell hydrogen engines;
- Introduction of new engine technologies for trucks and commercial vehicles to further decrease emission levels, such as Exhaust Gas Recirculation (EGR - in combination with a diesel particulate filter designed to reduce the NO_X emission level in the engine itself) and Selective Catalytic Reduction (SCR - an exhaust after-treatment system);

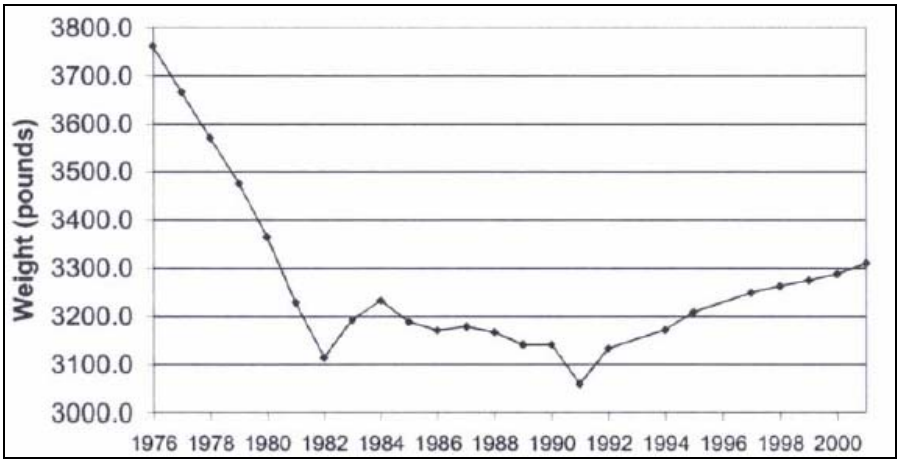
- Increasingly turning to Liquefied Petroleum Gas (LPG) and Compressed or Liquefied Natural Gas (CNG/LNG) for public transport in urban areas because of their low emissions. Other alternative fuels being tested or used on a limited basis include biodiesel, methanol and ethanol, hydrogen and electricity. Electric hybrid vehicles are also being developed, running on a silent, zero-emission electric motor in city centres and on diesel or petrol on highways.

Figure 17 Passenger cars: NO_X and PM emissions limits from Euro 0 to Euro 6



Source: ACEA, 2007a.

Figure 18 Passenger car weight trends



Source: EC JRC-IPTS, 2003.

Reducing the weight of automobiles is one of the primary means by which fuel consumption is lowered. The two basic approaches are in automotive design and in materials selection, and these are closely related. According to ACEA, in relation to the voluntary agreement (see paragraph 2.2.3), between 1995 and 2004 CO_2 emissions were reduced by 13% (ACEA, 2007b).

According to the IPCC Fourth assessment report (IPCC, 2007), carbon emissions from 'new' light-duty road vehicles could be reduced by up to 50% by 2030 compared with models

currently produced, assuming continued technological advances and strong policies to ensure that new technologies are used to increase fuel economy rather than to increase horsepower and vehicle mass. In the abovementioned report, the IPCC states that road vehicle efficiency can be improved by 5-20% through strategies such as increased load factors, improved maintenance, in-vehicle technological aids and more efficient replacement tyres.

Against these positive trends and suggested strategies, it should be noted that total transport demand has grown faster than improvements in fuel economy and emissions. In addition, changing user preferences and lifestyles coupled with the marketing policies of vehicle manufacturers have led to an increase in heavier, higher-consumption and more polluting cars: for example, the Sport Utility Vehicle's market penetration in 2006 was 8.1% of new car registrations in Western Europe (EU-15 + EFTA countries), against 2.6% in 1990.

Reducing CO_2 emissions: the position of the stakeholders

The European automobile manufacturers are committed to reducing CO_2 emissions from cars, using an integrated approach, which combines further developments in vehicle technology with an increased use of alternative fuels, intelligent traffic management, changes in driving style and car use, and CO_2-related taxation. This requires partnership between the fuel industry, policy makers, drivers and the automotive industry. There is no single technological solution to reducing CO_2 emissions from cars further. Most likely, the future will see a number of technological combinations entering the market, tailored for different use, driving circumstances and consumer preferences.

Under the European Climate Change Programme (ECCP), in 2006the independent scientific institute TNO assessed the costs and CO_2 reduction potential of different measures, including vehicle technology, biofuels and infrastructure (TNO, 2006). The costs of moving towards 120 g CO_2/km by 2012 through vehicle technology were calculated to be at about € 3600 on average per vehicle. The costs of cutting down to 130 g CO_2/km are still high with at € 2500 per vehicle.

Taking into account the price of technology and fuel savings for consumers, the TNO institute calculated societal costs of emission cuts through vehicle technology at between € 132 and € 233 per reduced tonne of CO_2, depending on the oil price. This is up to ten times more expensive than other traffic-related measures.

Eco-driving, for example, is very cost-effective compared with other transport measures. Measures aimed at existing and new drivers could lead to annual CO_2 savings of 7.8 Mt (more than half of what could be achieved by putting the entire burden of reaching 120 g/km on vehicle technology).

In order to find the most cost-effective way to achieve the maximum result in terms of reducing CO_2 emissions from cars, the automobile industry proposes combining different approaches, including changing driver behaviour, infrastructure measures, alternative fuels, CO_2-related taxation and vehicle technology.

However, the European Federation on Transport and Environment T&E, which represents the position of principal environmental organisations engaged in sustainable transport, stresses that the motor industries are unlikely to be able to honour their commitment to reach an average of 120 g for new cars in 2012. T&E agrees with ACEA in stating that '*infrastructure, driving behaviour, new fuels, public transport, physical planning, etc, are important parameters in any strategy for reducing greenhouse gas emissions from road transport, and the Council and the Commission should make all relevant stakeholders participate in an effort to stop climate change'*. However, *'the fact that others should also contribute is no reason to let the motor industry off the hook. It is rather a reason to define clearly what the obligations of the manufacturing industry are. The motor industry is clearly the only stakeholder that the Community can make responsible for the fuel efficiency of vehicles and for any onboard instruments that may be needed for assisting drivers who want to improve their driving behaviour*' (T&E, 2005).

To face the increasing preference among customers for higher performance and bigger cars, T&E proposes the introduction of economic incentives and a fuel efficiency regulation to influence strongly market preferences. '*Only a dramatic change in consumer preferences or a major technological breakthrough could significantly support the climate change policy of the European Union*' (T&E, 2005).

Source: ACEA, 2007b; T&E, 2005

3.1.2 Shipping industry

Modern shipping is one of the most technology-intensive transport activities. Besides the wide use of information and communications technologies in some specific markets (e.g. container and liner shipping, integrated logistics) the technical efficiency of ships has grown with the technical capacity of the shipbuilder who constructs the hull and the marine engineering industry which supplies machinery and equipment.

Such developments in advanced ship design have consistently reduced the industry's impact on the environment: hull shapes have been optimised to improve sea-keeping and reduce frictional resistance, the double hull has been introduced for the new generation of tankers, non-toxic and zero discharge antifouling paints are used in hull coatings to prevent marine pollution and propellers have seen significant improvements.

Modern weather forecasting and communications capacity allows for worthwhile fuel (and thus emissions) savings through optimal routing of ships, maximising the assistance given by currents, and avoiding the waves and bad weather that can slow ships down.

The integrated project HERCULES is a large-scale cooperative R&D project supported by the EC and the Swiss Federal Government. The project is coordinated by the two main groups of marine engine builders (namely MAN Diesel SE and Wärtsilä Corporation, which cover about 80% of the world's marine engine market) and comprises a large range of demonstration activities supported by major industrial partners and shipping companies. The project was launched in 2004 with the objective of drastically reducing gaseous and particulate emissions from marine engines, and increasing engine efficiency and reliability, hence reducing specific fuel consumption, CO_2 emissions and engine lifecycle costs. Table 6 presents the current Best-Available-Technology In-Service (BAT-IS) for shipboard prime movers (with at least one marine engine installation reference worldwide in 2003) and the targets of the project up to 2007, 2010 and 2020.

Table 6 Fuel consumption and emission limits and reduction targets of the HERCULES project for the years 2007, 2010, 2020

HERCULES Objectives	BAT-IS (2003)	Year 2007 Targets	Year 2010 Targets	Year 2020 Targets
Reduction of fuel consumption and CO_2 emissions	2-stroke: 170 g/kWh 4-stroke: 175 g/kWh	-1%	-3%	-5%
Reduction of NO_X (Relative to IMO 2000 standard)	IMO 2000 limits (g/kWh) 17 N<130 rpm 45 x (rpm)$^{-0.2}$ 130<N<2000 rpm 9.8 N>2000 rpm	-20%	-30%	-60%
Reduction of other emission components (PM, HC)	< No limits for marine engines > Visible smoke limit FSN 1.1 Opacity 20%	-5%	-20%	-40%

Source: www.ip-hercules.com.

Figures from the HERCULES project confirm estimates made by Marintek in its 2000 report commissioned by the International Maritime Organisation (IMO). Developments in marine propulsion and auxiliary plants on board new ships (mainly diesel engines), and also operational and after treatment abatement measures on existing ships, should raise the industry CO_2 targets to a further 20% of reduction potential for old ships and 30% for new ships.

The most promising measures are therefore a mix of operational (but technology-assisted) strategies and pure technology-based vessel/engine improvements, such as speed and routing reductions, load optimisation, practical and reliable methods for emission monitoring in-service and the use of new after-treatment methods (i.e. Plasma Assisted Catalytic Reduction and Wet Scrubbers).

3.1.3 Aviation and aerospace industries

Both aircraft and engine manufacturers are pursuing technological developments to reduce fuel consumption to a practical minimum, as a result of the steady pressure from air transport operators (around 20% of total operating costs for modern aircrafts represents fuel expenditure). The introduction of high-bypass ratio turbofan engines in the 1970s significantly reduced both aircraft fuel consumption and noise. Further reductions have been achieved by increasing cycle pressure ratio and bypass ratio and through the use of more sophisticated acoustic attenuation. Unfortunately, increasing cycle pressure ratio had a detrimental effect on combustor NO_X emissions, a situation that has now been improved through the incorporation of new-technology combustion systems. Data for IATA member airline fleets (IATA, 2006) show that fuel efficiency increased by 64% between 1970 and 2000.

Within the current air transport system, half of the CO_2 emitted is generated by flights below 1 200 nautical miles, the sector of the market that, for reasons of economy and passenger convenience, operates the least fuel-efficient aircraft, whereas for longer-range operation low fuel consumption is necessary to operate economically. However, if CO_2 production were to become a primary design consideration, the choice of design speed, range and altitude would need to be re-optimised.

The take-off weight and range of aircraft both have an effect on the amount of NO_X produced. For short-range missions, up to 15% of the NO_X is produced during the landing and take-off (LTO) cycle, with the remainder being generated during the climb and cruise phases. For long-range missions, this percentage is significantly lower. In assessing the benefits of future technology, consideration will need to be given to the relative influences of emissions during the various flight phases. Based on current figures, between 13% and 15% of fuel is consumed because of excessive holding either on the ground or in flight and through indirect routing and non-optimal flight profiles. Radical changes in air traffic management can save 5% to 10% of fuel consumption. Benefits will also be achieved for other emissions (UHC and CO) and noise.

Aircraft manufacturers have signed up to targets for future aircraft fuel efficiency. Through the Advisory Council of Aeronautical Research in Europe (ACARE), European aircraft manufacturers have set themselves voluntary targets to be reached by 2020. These include a 50% cut in CO_2 emissions per passenger-kilometre and an 80% cut in nitrogen oxide emissions for new aircraft in 2020. The targets are to be achieved in part through a 15-20% engine improvement and a 20-25% cabin improvement.

3.1.4 Rail industry

European railways use electricity as their major energy source. Both conventionally electrified and high-speed networks are expanding, and diesel-powered trains play an important function, mostly in running feeder services and shunting operations, but also for operating medium-distance rail links (for instance in the United Kingdom).

The main breakthrough in fuel economy has been brought about by direct injection technology improving the energy efficiency of diesel combustion engines by 15-20%. Further improvements have also been achieved in the sectors of regenerative braking and storage of energy to be used in transmission, therefore allowing for hybrid or diesel-electric powered trains. Reducing aerodynamic resistance and train weight (by using aluminium car bodies, lightweight bogies and lighter propulsion equipments) are other key measures implemented by the railway industry.

Apart from the energy needed for train motion, passenger trains consume energy for comfort functions. In central and northern European countries, this energy usually accounts for about one fifth of the total energy consumption of a train during service. Reduction strategies include coach insulation, smart windows, and systems for regulating ventilation according to actual occupation rather than number of seats (CO_2-sensors). A pilot project realised in NS Reizigers showed that air conditioning energy might be reduced by 20%. Correspondingly, total energy consumption can be reduced by 3-4% (UIC, 2005).

3.2 Development of alternative fuels

In road transport three potential alternative fuels ranges have been identified as promising: biofuels, natural gas (CNG/LNG/GTL) and hydrogen (fuel cell). Hydrogen is also a potential non-carbon fuel for trains and ships, but not for aviation (due to the major changes in aircraft designs and higher production of water vapour). Biofuels, and in particular biodiesel, have been suggested as promising fuels for the whole transport sector, although with different potentials for each different mode.

3.2.1 Biofuels

The capacity of biofuels to play a role in reducing greenhouse gases and EU dependency on fossil fuels has been debated in recent years. Policy actions have been launched and targets have been set (see the annex to chapter 3), even though not all the experts agree on the feasibility of biofuels uptake as a valid alternative to transport fossil fuel. The issue has been briefly analysed in the light of different aspects (technical and economic potential, GHG emissions reduction potential and other environmental impacts relating to their production) and is based on recent studies and reports, namely the World Energy Outlook 2006 (WEO), the Agricultural Outlook 2006 (OECD-FAO) and several studies carried out by the EC Joint Research Centres IES and IPTS.

Technical and economic potential

The market entry potential for biofuels depends on fuel prices and on three other variables that directly influence their profitability and environmental impact: cost and availability of feedstock, government regulation and conversion technologies.

In most parts of the world outside Brazil, biofuels cost significantly more to produce than conventional gasoline or diesel, even with crude oil prices at more than $70 per barrel (IEA, 2006). This is a commercial barrier to its development, although costs have been declining over recent years as technology has improved and economies of scale have been developed. Subsidies and fiscal measures could contribute towards higher penetration rates (see the annex to chapter 3 on current government support measures for biofuels in selected countries).

The 2006 World Energy Outlook (IEA, 2006b) estimates the current costs of conventional biodiesel production at just over $0.60 per litre of diesel equivalent (based on rapeseed) in the EU. According to the same study, production costs are projected to fall to just $0.40 per litre of diesel equivalent in Europe in 2030. This means that, aside from production subsidies, it will be competitive with diesel at crude oil prices of $50 per barrel[10]. The reference scenario in WEO 2006 predicted biofuels would supply 4% of road fuels by 2030, with greater potential of up to 7% under the Alternative Policy scenario. According to IPCC 2007, the uptake of biofuels will range from 20% to 25% of global transport road fuels by 2050 and beyond.

Environmental impact and other constraints

Biofuel is not the most effective use of biomass for CO_2 abatement. Several studies show that on a per hectare basis, woody biomass achieves the greatest CO_2 abatement when it is used in an IGCC[11] power plant to offset coal-fired generation. Nevertheless, as shown in a number of life-cycle or well-to-wheels assessments, biofuels offer significant reductions in GHG emissions compared with traditional transportation fuel sources (JRC/IES – EUCAR, 2006; EMPA, 2007; ECMT, 2007). But the results of such estimates are uncertain as they depend on the feedstock (cultivation method, fertiliser use, soil, climatic conditions) and the production process in question, as well as on particular assumptions, e.g. energy used in growing and transporting feedstock, plant conversion efficiency. According to a recent major well-to-wheels study (JRC/IES – EUCAR, 2006), the estimate ranges for CO_2 reduction (per km of vehicle travel) are as follows:

- Biodiesel: 50-80% reduction compared with fossil diesel;
- Bioethanol from grains such as wheat: 20-40% reduction compared with gasoline;
- Bioethanol from sugar beet: 30-50% reduction compared with gasoline;
- Bioethanol from cellulosic feedstock: 75-100% reduction compared with gasoline.

In the recent IEA Energy Technology Perspectives Study (IEA, 2006a), the GHG mitigation potential of alternative solutions including vehicle efficiency was assessed; the results show that the mitigation potential for biofuels by 2030 is less than for vehicle efficiency improvements.

A recent report by the EMPA research institute for the Swiss Government (EMPA, 2007), which evaluated the environmental impacts of the entire production chain of fuels made from biomass and used in Switzerland, states that it is true that GHG emissions can be reduced by more than 30% with a certain uptake of biofuels. However most of these supply paths show greater impacts than petrol for various other environmental indicators[12]. Excessive fertiliser use, acidification of soil and loss of biodiversity caused by clearcutting rainforest are the main impacts caused by the cultivation process.

It should also be noted that with conventional gasoline and diesel becoming virtually sulphur- and lead-free and with emissions norms being tightened to a more-than-90% reduction of most

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[10] Average IEA crude oil import price.

[11] IGCC (Integrated Gasification Combined Cycle) plants burn coal, biomass etc., gassifying the fuel drives a gas turbine as well as raising steam to drive a steam turbine (ECMT 2007).

[12] http://www.bfe.admin.ch/themen/00490/00496/index.html?lang=en&dossier_id=01273.

conventional emissions, biofuels will offer little, if any, emission advantage over gasoline and diesel except for the potential CO_2 reduction (EEA TERM 2003). Besides that, another issue should be taken into account: expanding agricultural energy production may lead to land use conflicts with other land uses such as food production or the conservation of natural areas.

According to the Agricultural Outlook 2006 (OECD-FAO 2006) increased demand for biofuels is causing fundamental changes to agricultural markets that could drive up world prices for many farm products. The report points out that higher commodity prices are a particular concern for net food importing countries as well as the urban poor. OECD-FAO also emphasises the environmental risks: it warns that cultivations for sustainable energy might have a negative impact if they are replacing the primary forestry, causing major carbon release.

Unlike the case of fossil fuels, these last two reports state that the environmental impacts of biofuels can be reduced by specific measures and that national and international standards and certification schemes are necessary to safeguard the land. In brief, sustainable crops and management practices can substantially reduce the negative impact of biofuels production.

In addition to environmental problems, there are concerns about the capacity of the EU to produce enough biomass feedstock to meet the demand for biofuels for the transport sector as proposed in the EU Directive. A study by the JRC Institute of Prospective and Technological Studies (JRC-IPTS, 2004), which is in line with similar studies, suggests that land area requirements vary from 6 to 25% of arable land for the EU-15, 5 to 19% for the EU-25, and 5 to 19% for the EU-28 (EU-27 plus Turkey) depending on the fuel and bio-crop type. Under these conditions, sugar beet appears to be the most suitable crop candidate, but the suitability of each crop depends on local climatic, agricultural and economic conditions. For instance, the biodiesel target for the EU-28 would need 19% of the total estimated EU-28 arable land. This corresponds to an arable land requirement of 26.7 million hectare, which is roughly the equivalent of half the territory of France and four times the UK's arable area.

The EU target of ensuring that biofuels represent 10% of all transport fuels by 2020 has been criticised in a recent study carried out by OECD (OECD, 2007). The report states that the EU policies '*place a significant bet on a single technology despite the existence of a wide variety of different fuels and power trains that have been posited as options for the future*' The report suggests switching to technology-neutral policies such as a carbon tax, since such policies will more effectively stimulate regulatory and market incentives for efficient technologies.

Moreover, the report adds that biofuels will be able to achieve only a 3% reduction in energy-related CO_2 emissions by 2050, considered the best-scenario; this small benefit would come at a huge cost, requiring the Governments to implement subsidies and tariff protection measures.

In contrast with this position, the European Bioethanol Fuel Association (eBio) underlines the efforts that EU Member States and multilateral roundtables on sustainable biofuels are currently making to set up efficient and effective actions on the sustainability of biofuels, in order to increase their use, and the consequent achievements in reducing CO_2 emissions over the next few years[13].

[13] http://www.ebio.org/home.php

3.2.2 Hydrogen

Hydrogen and fuel cell technologies for transport have been the subject of intensive research efforts in recent years. Hydrogen can fuel combustion engines and turbines, but it offers its full benefit in terms of energy efficiency, CO_2 and pollutant emissions when used in fuel cells. The use of hydrogen in fuel cell vehicles could solve the problems of both oil dependence and emissions in the transport sector.

Today, most hydrogen is produced from fossil fuels especially through steam reforming of natural gas,[14] which is the cheapest option available, but not the cleanest. In the long term, fossil-fuel-based H_2 production will require CO_2 capture and sequestration (CCS) and a large proportion of hydrogen might be produced by water electrolysis from non-carbon electricity sources such as nuclear and renewable sources. Alternative production routes like biomass gasification or direct production of hydrogen through biological processes might also become very important. Alongside low-carbon H_2 production pathways, the main challenges relate to cost reduction for fuel cells in order to compete with other vehicles (e.g. hybrids, biofuels, LPG) and increasing technological maturity (e.g. on-board H_2 storage).

Unlike biofuels, H_2/FC technologies are expected to enter the transport market in the long term (2030) but will still face major obstacles. A stable policy framework along with strong political will are essential to make the so-called 'hydrogen economy' a reality. At this stage it is recommended that hydrogen be considered as a research and development initiative only (ECMT-OECD, 2007). The IEA comes to similar conclusions in its 2005 report *Prospects for Hydrogen and Fuel Cells*. It states that development of infrastructure at this point would be premature; continued R&D activities should concentrate on niche opportunities to deploy fuel cell vehicles, for instance in public service fleets (buses and delivery vans), in order to start the process of cost reduction (ECMT-OECD, 2007).

3.2.3 Other fuels and technologies

- *Natural Gas* can be used directly in vehicles or converted into more compact fuels. It may be stored in compressed (CNG) or liquefied (LNG) form in the vehicle. The high octane ratios require dedicated CNG or LNG vehicles to benefit fully from engine efficiency, even though many vehicles are converted from gasoline or are manufactured as bifuels, with two tanks. The Commission has proposed the following targets for the introduction of natural gas as transport fuel: 2% by 2010, 5% by 2015 and 10% by 2020. The main challenge will be establishing a new distribution infrastructure.

- *Diesel fuel from natural gas* (Liquefied Petroleum Gas or LPG) is cheap and traditionally seen as environmentally friendly fuel. However, with gasoline and diesel becoming much cleaner than in the past, this advantage is rapidly diminishing.

- The *Fischer-Tropsch process* is a catalysed chemical reaction in which carbon monoxide and hydrogen are converted into liquid hydrocarbons in various forms. The main purpose of this process is to produce a synthetic petroleum substitute, typically from coal or natural gas, for use as synthetic fuel. Fischer-Tropsch Synthesis, including Gas-to-Liquids (GTL) Coal-to-Liquids (CTL) Biomass-to-Liquids (BTL), has potential but still faces major challenges (GHG emissions and land resources) aside from their high capital cost.

14 Steam methane reforming accounts for 48% of all hydrogen produced worldwide (95% in the US).

- The *hybrid car* features a small fuel-efficient engine (powered by gasoline, diesel or an alternative fuel) combined with an electric motor that assists the engine when accelerating. The electric engine is powered by batteries which are automatically recharged by the vehicle fuel engine. There are significant margins of improvement in hybrid technology that can lead to reductions of 10-20% in fuel use, particularly for diesel engines (IPCC fourth assessment report). Hybrid solutions are not particularly suitable for heavy-duty trucks and intercity buses because the driving cycle for those vehicles is characterised by long driving periods at steady speeds. The main barrier to greater market penetration by hybrid vehicles is their cost, the battery representing the biggest component.

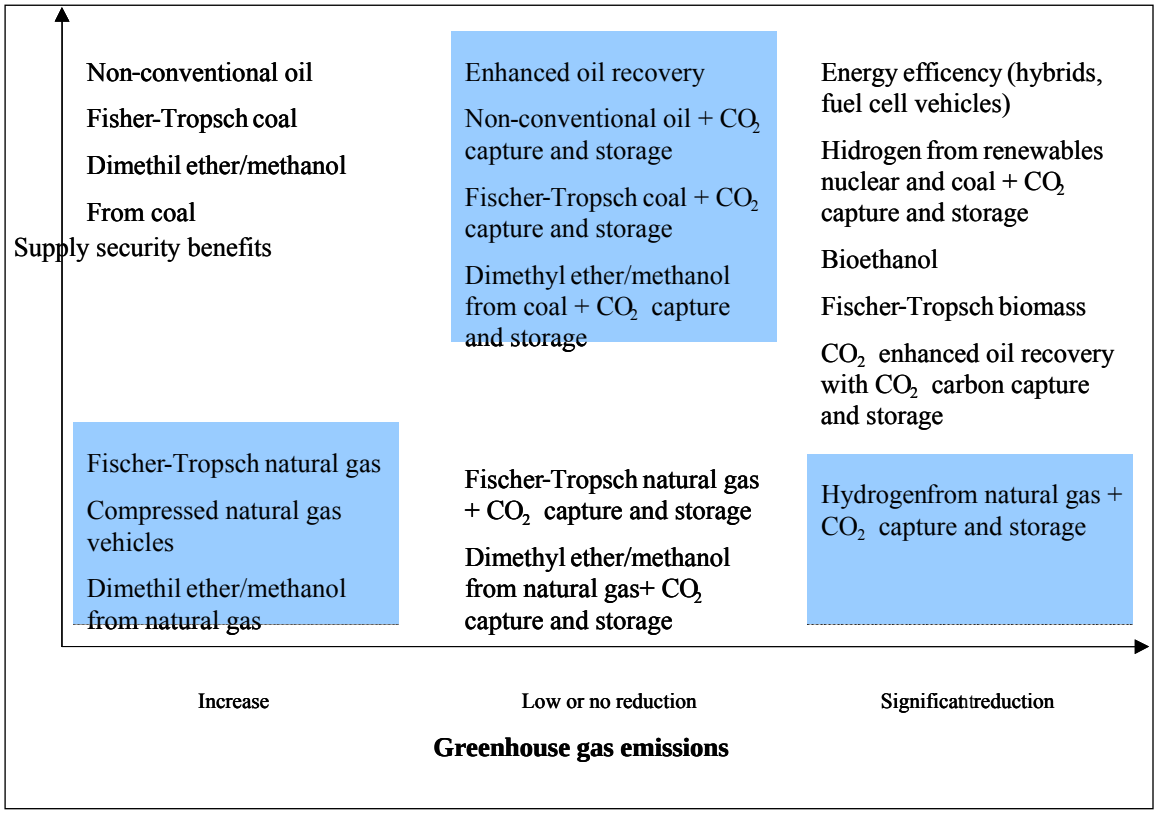
Table 7 outlines a description of the different types of alternative fuels, whilst Figure 18 categorises alternative fuels by their potential benefits in terms of supply security and CO_2 emission reductions. Certain fuels could enhance supply security but very few options could contribute towards both targets.

Table 7 Alternative fuels summary

Fuel	Description
Compressed Natural Gas (CNG)	A gaseous mixture of hydrocarbons with 80-90% methane. Colourless, odourless, non-toxic, highly flammable and compressed to improve storage capacity. Most of the CNG contains less carbon than any other fossil fuel. Main drawback is the lack of refuelling facilities
Liquid Petroleum Gas (LPG)	A mixture of gases, liquefied by compression or refrigeration. Major drawback is limited supply, ruling out any mass conversion to LPG fuel
Methanol	An alcohol. Most of the world's production of methanol is produced by a process that uses natural gas, coal, biomass or urban waste refuse
Ethanol	An alcohol less toxic and corrosive than methanol. Ethanol also has a high volumetric energy content. Can be produced by the fermentation of sugar cane or corn. One third of the 12 million cars in Brazil are ethanol-powered
Biodiesel	Produced by reacting vegetable or animal oils with methanol or ethanol to produce a lower-viscosity fuel that has similar physical characteristics to diesel
Hydrogen	Potential to be the cleanest fuel option. However, suffers from two major problems: production and storage (fuel is highly flammable and requires large storage capsules). Significant investments are needed in infrastructure for delivery, storage and dispensing of hydrogen if it is to be used as a vehicle fuel. The combustion of hydrogen produces mainly water vapour and no direct CO_2 emissions, but this depends on the nature of the energy source used to produce hydrogen
Electricity	Electricity-powered vehicles as a niche part of the market. CO_2 emissions depend on the energy source used to produce the electricity

Source: The Bartlett School of Planning and Halcrow Group Ltd, 2006.

Figure 19 Alternative fuel options and their contribution to supply security and CO_2 reduction



Source: Energy Technology Perspectives, IEA 2006.

4. REVIEW OF POLICY DOCUMENTS AND SCIENTIFIC LITERATURE

As it is responsible for about 31% of final energy consumption and about 26% of total CO_2 emissions (see chapter 2), the transport sector is considered to be a key area of action in the effort to deal with environmental problems and energy saving. Accordingly, transport policy must guarantee a transport system that, assures not only passenger and freight mobility, but also environmental sustainability. Starting from the European Commission's transport policy documents, this chapter analyses the existing literature, taking into account the main contents, as currently discussed in the scientific community. The potential emissions reduction measures suggested by the studies are listed in full in annex to chapter 4.

4.1 Key European Union documents

Many policy initiatives have been taken or proposed by the Commission to deal with environmental damage caused by transport. Some of these policies directly address the transport sector while others are consequences of a more general policy action relating to a wider context. The Commission develops its policy action in this field through by publishing guideline documents (Green Papers and White Papers) or through its common binding or non-binding acts (i.e. recommendations, proposals, regulations, directives).

4.1.1 The transport policy framework

Through the 2001 White Paper and the 2006 Keep Europe Moving communications, the EU has designed a ten-year strategy on sustainability in the transport sector. The EU is aiming to establish a common transport policy approach and to develop an integrated European transport system that is environmentally compatible. The White Paper clearly affirms that actions should be taken in order to tackle the increased contribution of transport to global warming and energy consumption. All transport policy should take account of the impact on these issues.

Underlining the importance of modal share with a view to a more environmentally friendly transport system, the White Paper and its mid-term review address the EU and the Member States' transport policy by suggesting a list of measures that should be implemented in order to discourage the use of road transport for freight transport, by making it more expensive (i.e. infrastructure charging, uniform commercial road transport fuel taxation, electronic road toll system - interoperability - and taxation of energy products and exemptions for hydrogen and biofuels). Numerous measures promote the development of the European intermodality system on the basis of the existing European infrastructure. The magnitude of the impact on freight transport of all these measures will depend on their implementation level in the European Union.

As regards urban areas, European citizens' mobility accounts for about 40% of all CO_2 emissions from road transport and up to 70% of other pollutants from transport[15], and the Commission is aware that the management of transport in these areas is a critical issue in tackling environmental externalities. After a period of public consultation, the Commission is

[15] European Commission, Green Paper on Urban Transport, 2007

about to issue a Green Paper on Urban Transport. The document, expected in autumn 2007, aims to provide a general EU policy framework for urban transport. The actions proposed are based on an analysis of new approaches for promoting more efficient use of urban transport and the possibility of introducing an award criteria scheme for clean and energy efficient vehicle procurement for public transport services.

4.1.2 Air quality

As regards human exposure to pollutants, the Commission and the Parliament are working towards the adoption in 2008 of a new directive on air quality which strengthens the existing provisions[16]. EU action has focused on improving environmental protection, integrated into the transport and energy sectors.

The EU objective is to attain *'levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment',* as affirmed in the Commission Communication on a thematic strategy on air pollution (COM(2005) 446 final). With the Proposal for a Directive by the Commission on ambient air quality and cleaner air for Europe (COM(2005) 447 final), the Commission does not propose to modify the existing air quality limit values but proposes to strength existing provisions so that Member States will be obliged to prepare and implement plans to eliminate non-compliance.

Focusing on car usage, the Commission has started a dialogue with the stakeholders concerning the future needs and challenges of the automotive industry in order to review the Community strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles (COM(2007) 19 final) and to develop a competitive automotive regulatory framework for the 21st century (COM(2007) 22 final). The Communication presents the Commission's position on the CARS 21 High Level Group Report and makes recommendations for future public policy and a regulatory framework.

4.1.3 Energy efficiency

To give a European dimension to energy policy, the Commission presented a Green Paper on an Action Plan on Energy Efficiency (COM(2006) 105 final). The challenge is to maximise the potential competitive gains for Europe while limiting potential costs. In the Communication from the Commission on an Action Plan for Energy Efficiency: realising the potential (COM(2006) 545 final), a coherent and interlinked package of measures is suggested in order to put the EU on track towards achieving at least 20% cost-effective energy savings potential by 2020.

As regards renewable energies, the Commission proposed a road map for building a more sustainable future (COM(2006) 848 final) that is an integral part of the Strategic European Energy Review and sets out a long-term vision for renewable energy sources in the EU. As main parameters for the measures to be implemented by 2020, the Commission has proposed (An energy policy for Europe, COM(2007) 1 final) achieving a 30% reduction in greenhouse

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[16] At first reading the proposal for a directive was approved by Parliament, although the Commission and the Council expressed doubts with regard to PM_{10} and $PM_{2.5}$ standards adaptation, postponed from 2010 to 2014, as suggested by the Parliament. Moreover, in the Parliament reading, the limit of the PM_{10} annual value was reduce from 40 micrograms per cubic metre to 33.

gas emissions by developed countries compared with 1990 and the need to limit the global average temperature increase to less than 2°C compared with pre-industrial levels (Communication Limiting Global Climate Change to 2 degrees Celsius COM(2007) 2 final).

In December 2005 agreement was reached on a directive on the promotion of end-use efficiency and energy services to enhance the cost-effective and efficient end-use of energy in Member States including the transport sector (Directive 2006/32/EC). Under Article 14(2) of the directive, Member States shall submit their first National Energy Efficiency Action Plan (NEEAP) to the Commission by 30 June 2007. In their NEEAPs, Member States should show how they intend to reach the 9% indicative energy savings target by 2016.

Among other measures, in line with the announcement in the Action Plan on Energy Efficiency, the European Commission has proposed a framework where market-based instruments and fiscal policies in general will play a decisive role in delivering the EU policy objectives. The Green Paper on market-based instruments for environment and related policy purposes (COM(2007) 140 final) has launched a discussion on advancing the use of market-based instruments in the Community.

Table 8 Specific EU actions influencing pollutant emissions and energy efficiency

Main Objective	Measures	Description	Legislative reference	Next steps
Reducing GHG emissions under the EU Kyoto Protocol (*linked to the promotion of biofuels and energy efficiency*)	*Emissions trading scheme*	No overall targets for emissions of GHGs from transport. The Commission adopted a legislative proposal to include aviation in the EU's emissions trading scheme	Directive 2003/87/EC Council Decision 2002/358/EC	ETS for Road transport in discussion (see European Parliament resolution 2005/2049(INI)) EU plans shipping emissions cap
	Voluntary commitments undertaken by car manufacturers' associations	Light-duty vehicles target of 140 g CO_2/km by 2008 or 2009	ACEA 1998 commitments	COM (2007)19 Communication from the Commission and the European Parliament (120g CO_2/km by 2012)
	Car labelling	Requires the display of a label on fuel consumption and CO_2 emissions on all cars	Directive 99/94	
	Car taxation	Re-structuring passenger car taxation systems including CO_2 emissions elements	Proposal for a directive on car taxation COM (2005) 261 Final	
	Energy efficiency	Member States should reach the 9% indicative energy savings target by 2016 (public procurement)	Directive 2006/32/EC	
Limiting SO_2, NOx, VOCs and ammonia emissions	*Setting upper limits for each Member State for total emissions in 2010*	All activities are subject to overall limits for each pollutant	Directive 2001/81/EC of the European Parliament and the Council on National Emission (NECs)	Thematic strategy on air pollution (COM(2005) 447 final). Sets pollution targets
Limiting CO, NOx, PTS emissions from vehicles	*Setting technological standard for road vehicles*	Light-duty vehicles - Euro 4 (2006) Euro 5 (2009) Euro 6 (2014) Heavy-duty vehicles - Euro IV - V (October 2008) Environmentally friendly Vehicle (EEV)	Directive 98/69/EC Regulation (EC) No 715/2007 Directive 99/96/EC Directive 2005/78/EC	Commission is currently preparing a new Euro VI stage for HDV
Air Quality (SO_2, NOx, PM_{10}, CO, C6H6, O_3, Benzene, $PM_{2.5}$	*Setting air quality thresholds*	All activities are subject to overall limits for each pollutant	Air Quality Framework Directive (Council Directive 96/62/EC)	Thematic strategy on air pollution (COM(2005) 447 final). New target sets
Fuel quality - main focus on sulphur and for petrol on lead and aromatics	*Setting fuel quality standards*	Limit on the sulphur content of petrol and diesel 50 ppm 9 ppm sulphur content is mandatory by 2009	Directive 2003/17/EC	On 31 January 2007 the European Commission proposed new standards for transport fuel

Main Objective	Measures	Description	Legislative reference	Next steps
Promoting the use of biofuels for transport	*Setting biofuels share target*	The share of biofuels should reach 2% by 2005, 5.75% by 2010 and a 10% share in transport fuels by 2020	Directive 2003/30/EC	By the end of 2007, Commission expected to present a revision of the biofuels directive.
Energy efficiency	*Car taxation*		Proposal for a Directive that would require Member States to re-structure their passenger car taxation systems.	
To cut SO_2 and particle emissions from seagoing ships	*Setting fuel quality standards for ships*	1.5% is the sulphur limit set for fuels used by passenger vessels on services between EU ports and for all ships in the Baltic Sea 0.1% sulphur limit is set on fuel used by inland vessels and by seagoing ships at berth in EU ports, from 1 January 2010	Directive 2005/33 Sulphur content of marine fuel	

Source: TRT, 2007.

4.3 Policy actions at national level

National and local governments are committed to promoting policies that affect polluting emissions behaviour over the next few years. Many European countries are pursuing actions relating to the abatement of CO_2 and various aspects of climate change, building a comprehensive strategy on that basis.

In 1997 and updated in 2007, ECMT prepared a comprehensive review of the policies adopted by the Member States with the aim of identifying the most cost-effective measures in tackling environmental problems. Table 9 shows the existing 'best national practices' in reducing CO_2 emissions, selected according to the highest effective policies described in the abovementioned study and confirmed by the OECD analysis on the capacity of European countries to meet the Kyoto Protocol targets for 2008-2012[17]. The potential CO_2 abatement of active policies is directly linked to the transport sector: for this reason, the third column of the table shows transport sector CO_2 emissions in 2002 and the final column gives an estimate of the CO_2 emissions abatement for 2020, in terms of Millions tonnes of CO_2 equivalent per year, expected to be achieved through the better policies implemented by the countries in question.

Table 9 Best practices for cutting CO_2 emissions in Europe

Country	Policy	Transport sector 2002 CO_2 emissions (kt of CO_2)*	Impact in 2020 (Mt CO_2 equivalent pa)**
United Kingdom	*Company car tax reform*	124.706	1.28 - 2.38
Sweden	*Motor fuel tax*	19.802	1.6 - 3.4
Germany	*Fuel efficiency improvements*	176.234	11

Source: * UNFCCC taken from the 2005 GHG Inventory Submissions
** ECMT database 'Cutting Transport CO_2 Emissions'

In addition to the best practices selected from the ECMT database, some other cases are presented:

- Switzerland, which has adopted many actions to protect its Alpine environment from transit traffic, introducing one of the limited number of distance-dependent and differentiated charging regimes in force in the transport sector;

- The Alpine region, considered to be a sensitive area on account of its geographical characteristics, which is trying to solve environmental problems resulting from the Alpine traffic through the Alpine Convention, as a tool for supervising transport actions;

- Japan, regarded as a best practice example due to its strong action in tackling environmental impacts resulting from the transport system and in cutting CO_2 emissions.

A short description of the selected case studies is given in the following paragraphs.

17 Greenhouse gas emissions in CO2 equivalent and Kyoto Protocol targets for 2008-2012, estimated for the EU 15 on the base year 1990 – United Nations Land Use, Land Use Change and Forestry LULUCF.

4.3.1 United Kingdom

The United Kingdom government is particularly involved in tackling environmental challenges. One of the most widely known and discussed reports concerning the effect of climate change and global warming on the world economy is the 'Stern Review on the Economics of Climate Change', published in October 2006 by the economist Nicholas Stern for the UK government. The other measures recommended by the report with a view to obtaining an effective global response including the pricing of carbon, implemented through tax, trading or regulation (Stern, 2006). This recommendation could be incorporated in a policy path already followed by UK Government, which adopted a fiscal measure to promote cost-effective reductions in emissions in April 2002. The measure is called 'company car taxation reform', as seen in the previous table: company car tax has been based on a percentage of the car's list price, which varies according to the CO_2 emissions band (of which there are 21) they fall into. This creates a significant incentive to purchase more fuel-efficient vehicles and removes the incentive to drive unnecessary extra business miles that existed under the previous system[18].

4.3.2 Sweden

Economic instruments have also become increasingly important in Sweden, the leading example of the 'greening' of the taxation system. The carbon dioxide (CO_2) tax within the energy taxation system is a key policy for reducing or stabilising CO_2 emissions, generating revenue for the national budget and serving as a model for applications internationally.

When the Swedish CO_2 taxes were first introduced in January 1991, their rates varied according to the average carbon content of different fossil fuel types, but they were applied equally across 'basic' users (households and non-manufacturing industries) and industries (mining, manufacturing and horticulture). The fiscal policy, aimed at cars, road freight and buses, established that petrol and diesel are subject to an energy tax, a CO_2 tax and VAT. The total tax rate has been pegged to the consumer price index since the late 1990s; elasticities used to model the CO_2 abatement estimate are -0.4 (petrol) and -0.1 (diesel) for the low estimate and -0.8 (petrol) and -0.2 (diesel) for the high estimate[19].

However, the CO_2 tax was accompanied by a reduction in the general energy tax, such as tax on sulphur and a value-added tax on energy, because a high CO_2 tax rate could hamper competitiveness if similar measures were not also taken abroad. For a small country like Sweden, highly dependent on international trade, special rules had to be established to safeguard the international competitiveness of Sweden's energy-intensive industries, including international aviation and shipping.

4.3.3 Germany

Germany, among numerous other policies geared to the reduction of CO_2 emissions, first of all took fiscal measures such as the introduction of the German HGV toll system in operation since January 2005[20], and has invested considerable resources in information and education actions, such as marketing and behaviour change measures. The German government has adopted an

18 Third National Communication to the UNFCCC (p. 35-37). DTI (2004) Updated emissions projections (p. 8).
19 Sweden's Fourth National Communication to the UNFCCC.
20 Economic impact of the introduction of the German HGV toll system, Claus Doll, Axel Schaffer, 2006.

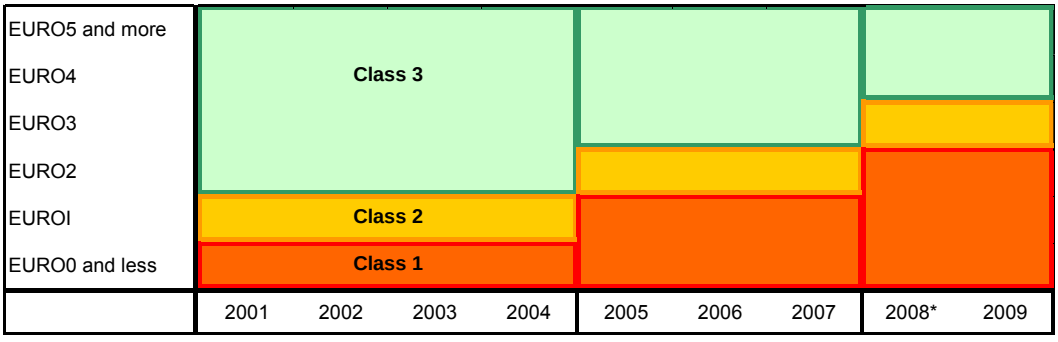
initiative in this area concerning the use of low friction oil and tyres in new cars[21], considered in the ECMT database as one of the highest potential impact measures on reducing CO_2 emissions. This action is a part of an extensive programme aimed at a very cost-effective Eco-driving programme for car drivers, that also comprises a campaign for climate protection in the transport sector, with special attention on fuel-saving driving habits, vehicle maintenance, low-viscosity oils, low-roll-resistance tyres and highly fuel-efficient vehicles (3 litre/100km)[22]. In January 2007 the European Commission approved a German State aid scheme that aims to help transport operators acquire heavy vehicles with better emission performance[23].

4.3.4 Switzerland

Due to its geographical position in the Alpine region, Switzerland has adopted many actions to protect its particular environment, above all from the negative effects of the heavy traffic crossing the Alps. The new charging regime for road freight transport came into force on 1st January 2001 and replaced the existing flat rate (FHVF). All domestic and foreign heavy vehicles and trailers for goods transport with a gross total weight of more than 3.5t are subject of the HVF. The HVF is levied on the whole Swiss road network and it is regarded as an instrument for 'getting the prices right', i.e. making users and polluters pay for the costs they cause. The user-and polluter-pays-principle was and still is well accepted among the public and in environmental policies in Switzerland. The Swiss HVF is one of the rare examples where the implementation of the basic principle of internalising external costs was successful.

The calculation of the HVF fee is based on the number of kilometres driven on all public roads in Switzerland, the gross total weight (GTW), and the emissions category of the heavy goods vehicle determined from the standardised EURO emission value of the vehicle. In order to keep the implementation and operation costs as well as the complexity of the charge at a 'justifiable' level, the extent of differentiation has been limited to three different classes. This limitation clearly represents a simplification because different emission standards belong to the same HVF class. In 2008, for example, vehicles complying with seven different emission standards will circulate in Switzerland.

Figure 20 Allocation of the different EURO standards to the HVF classes over time



Source: Different D8.2, 2007
* = The final allocation of the different EURO standards to the three classes has still to be agreed between Switzerland and the EU (situation in March 2007).

[21] 2004 Report to the EU under Directive 93/389/EEC.
[22] Third National Communication to the UNFCCC (p. 76-87).
[23] European Commission, press release IP/07/86: Commission authorises German scheme to promote environmentally friendly heavy vehicles, Brussels, 24 January 2007.

The figure shows, for example, that while in the period 2001-2004 trucks meeting the EURO2 standard belonged to the cheapest class (class 3), from January 2008, however, they will belong to the most expensive class 1 (unless another solution is agreed between Switzerland and the EU, with negotiations ongoing in 2007). The dynamics of the HVF rate have been designed to take into account the development in the emission abatement technologies of diesel engines. The figure also makes clear that from 2008 onward the rather standard technology EURO3 will be differentiated from the more advanced technologies EURO4 and 5. The revenues generated by the HVF are earmarked for the New Alpine Rail Tunnels (NART), considered to be a fundamental investment to achieve a different modal shift, the key goal of Swiss transport policy.

4.3.5 The Alpine region

Due to its geographical position, the Alpine Region demonstrates a strong commitment in addressing the environmental impact of Alpine traffic. In order to tackle the increasing environmental damage and the growth in energy consumption caused by the increased mobility in the Alpine Region, Alpine countries signed a framework agreement, the Alpine Convention, aimed the protecting the Alpine environment, harmonising the policies of the signatory countries, and reconciling the differences in the relevant economic interests in the Alps. Germany, Austria, Switzerland, France, Italy, Liechtenstein, Monaco and Slovenia, plus the European Union, signed it in November 1991. The Contracting Parties participating in the Alpine Convention are working on the implementation of the transport protocol, signed at Lucerne on 31 October 2000; it is a tool for supervising the action in the transport sector within the Alpine area. The protocol is still awaiting ratification by Italy and Switzerland, and signature by the European Union.

The overall objective of the protocol is to identify sustainable development policies for transport in the Alpine area, allowing for environmental protection of sensitive population groups and areas, whilst encouraging the development of alternative modes as opposed to road transport (in particular piggybacking and sea-river transport)[24].

4.3.6 Japan

Japan is working hard to curb greenhouse gas emissions from the transport sector according to the commitment under the Kyoto Protocol, which entered into force in February 2005, with a comprehensive strategy that involves citizens and local institutions. The cabinet endorsed the Kyoto Protocol Goal Achievement Plan in April of the same year. In recent years, the Japanese government has promoted new cross-sectional policy measures to reduce CO_2 emissions from the transport sector. The main measures concern:

- Automobile Green Taxation: in 2001 the Japanese government began implementing a so-called ‘green’ tax on automobiles to encourage people to purchase more environmentally friendly low-emission motor vehicles. The regulations levy lighter taxes on new motor vehicles deemed ‘environmentally friendly,’ whilst heavier taxes are levied on older and higher-emission motor vehicles;
- supporting local efforts by applying the energy saving law to transport businesses and through the ‘Environmentally Sustainable Transport (EST) Model Program’: to limit

24 Report on the State of the Alps – Permanent Secretariat of the Alpine Convention – 2007.

excessive dependence on passenger cars for personal use, which is a major cause of increases in carbon dioxide emissions in the passenger sector, the government is recruiting pioneering regions seeking to promote Environmentally Sustainable Transport (EST) through traffic flows improvements, introduction of low-emission vehicles, information and education, etc. Relevant ministries and agencies will work to strengthen policies for specific ambitious measures tailored to the characteristics of each single region.

Is California leading the way?

California's action to tackle environmental problems resulting from the transport sector started many years ago. California Air Resources Board (CARB) was established in 1967. Its main objectives were to attain and maintain healthy air quality, to conduct research into the causes of and solutions to air pollution and, in particular, to solve the serious problem caused by motor vehicles, which are the major causes of air pollution in the state.

In 2002, a law (AB 1493) was introduced which requires demands sharp reductions in emissions of greenhouse gases from cars and light-duty vehicles. On the basis of this law, in autumn 2004 the CARB proposed that carmakers should, in a first phase, be forced to reduce specific emissions from new cars and light-commercial vehicles by 25 and 18 per cent respectively in 2012 and in a second phase by a total of 34 and 25 per cent in 2016. The idea is to make the manufacturers comply with CO_2 emission limits, which are gradually lowered. Under these caps individual producers will be allowed to trade emissions permits with each other. At present, two actions are planned.

Nevertheless, the implementation of the legislation is running the risk of remaining inapplicable. The car industry insists that the technology required to meet the new rules is either unavailable or hugely expensive. In December 2004 the industry filed a lawsuit against CARB, contesting the California state's powers to regulate CO_2 emissions and claiming that a law limiting emissions from new vehicles pre-empts federal law setting fuel-economy standards.

Moreover, it is important to note that the CARB objectives are much less ambitious than the European ones: 2006 CARB set for 2012 a car emissions target that amounts to 233 grams of CO_2/mile, equivalent to 144.5 grams of CO_2/km (Source: An and Sauer 2004), higher than the 120 g/km EU target for the same year.

4.4 Policy recommendations in the scientific literature

This paragraph presents the relevant scientific studies that have contributed in recent years to the debate on policy measures and their capacity to reduce pollutant emissions and consumption. The potential measures for emissions reduction, recommended by the studies, are described in detail in the annex to chapter 4.

The abovementioned Report on the Economics of Climate Change (Stern, 2006) argues that the benefits of strong and early action far outweigh the economic costs of not acting. Using the results from formal economic models, the report estimates that in the event of non-action, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year. Tackling climate change is regarded as the pre-growth strategy for the longer term, and it can be done in a way that does not curb countries' aspirations for growth.

In order to assess options for mitigating climate change, it is essential to link this with development issues. The Fourth Assessment Report - 2007, produced by the IPCC Working Group III, explores these links in detail, and illustrates where climate change and sustainable development are mutually reinforcing. The concept of 'mitigation potential' was developed in this study to assess the scale of GHG reductions that could be made, relative to emission baselines, for a given level of carbon price (expressed in cost per unit of carbon dioxide equivalent emissions avoided or reduced).

In order to analyse the specific policy aimed at reducing greenhouse gas emissions, one of the main contributions comes from the Wuppertal Institute, which, on behalf of the WWF European Policy Office, carried out the research project called 'Target 2020: Policies and Measures to in the EU' in 2005. The study examines the possibility of applying an integrated policy approach to achieve a reduction in energy consumption and a contribution of renewable energy sources of about 25% of overall energy consumption by 2020, leading to a 33% cut in greenhouse gas emissions in the EU compared with 1990.

If the Wuppertal Report gives an overview of the different policies to reduce CO_2 emissions, the review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2 emissions, carried out by TNO, IEEP and LAT on behalf of the European Commission (DG-TREN) in 2006, focuses on measures to reduce CO_2 emissions from cars, in order to achieve the 2008/2009 EU target, to identify post-2008/2009 reduction scenarios and to assess their economic, environmental and social effects.

Since the road transport sector is a target for policies to reduce emissions and consumption, ERTRAC, the European Road Transport Research Advisory Council, composed of representatives from all road transport sectors, periodically develops a common vision for the sector in order to specify research needs. The last ERTRAC Research Framework suggests, as the main areas of transport and environment research, truck design and production with a view to improving fuel consumption, urban freight and passenger management to improve local air quality and the development of a second generation of biofuels to achieve sustainable energy use for road transport.

A complete analysis of policy measures to reduce energy use in transport is offered by the study Reduction of Energy Use in Transport, carried out by the Joint Expert Group on Transport and Environment (JEGTE) in 2006. The study considers all factors influencing energy use in transport over the whole chain, including transport demand, modal choice, logistics, vehicle efficiency and vehicle use. For each measure the study identifies its potential, time frame, political acceptability and synergies with other policies. To tackle climate change, reduce greenhouse gas emissions and energy consumption, transport policy is called to play a big role, due to the high negative impact on the environment.

To respond to the growing interest in a range of initiatives, which are generally described as 'soft' transport policy measures, and due to their increasing relevance, two main contributions give their suggestions for helping people reduce their car use whilst enhancing the attractiveness of alternatives:

- The report 'Smarter Choices - Changing the Way We Travel' (London Department for Transport, 2004) considers the soft measures which are sufficiently effective in facilitating choices to reduce car use and offer sufficiently good value for money, in order to attribute them serious consideration for an expanded role in local and national transport strategy.

- The study 'Assessing the ICT sector - Contribution to the Millennium' (Wuppertal Institute, 2006) presents an analysis of stakeholder-driven demand for a solid information base about ICT and sustainable development and a status-quo analysis of available sustainability information in the ICT sector.

Nevertheless, the achievement of the environmental target can be realised only with a correct combination of policies. This kind of approach is suggested in particular by the project entitled 'Visioning and Backcasting for UK Transport Policy (VIBAT)', carried out by R. Hickman and D. Banister for the UK Department for Transport on January 2006. This project examined the

possibility of reducing UK transport CO_2 emissions by 60 per cent by 2030, testing combinations of policy measures and assessing their contribution to the CO_2 emissions reduction target. The main characteristic of the study is the approach, defined as 'backcasting', aimed at the assembly of individual policy measures into packages and consistent groupings in order to implement them in a manner that may generate complementary benefits. The packages are clustered together to obtain the maximum effectiveness in contributing to the 60% CO_2 reduction target, and they are placed in a time sequencing process for implementation, as a policy path.

The transport measures recommended by the EU policy documents analysed and the scientific contributions are listed in a summary table reproduced in the annex to chapter 4.

PART II

COST-EFFICIENT AND VIABLE MEASURES

A number of different policy documents which analyse ways to reduce pollutant emissions and energy consumption in the transport sector and which have recently been produced by the EU institutions and other relevant scientific bodies were reported in the first part of the study.

Starting from the list of measures recommended by the literature (see the summary table of the transport measures recommended by the European Commission and the scientific literature reproduced in the annex to chapter 4), Part II discusses the clusters of selected policy measures, with the objective of identifying the most promising actions from the point of view of cost-effectiveness, viability and suitability.

Part II is arranged as follows way.

- The different measures are grouped into policy clusters that are described in chapter 5. Key reference documents for this chapter are: Banister et al, 2006, IPCC, 2007, OECD 2007, The Bartlett School of Planning and Halcrow Group 2006, JEGTE 2006; COM (2007) 19 final, (2007), ASSESS Final Report 2005, Litman 2007.

- Chapter 6 looks at each policy cluster and each measure from different perspectives: the expected type and the relevance of the impacts for GHG reduction and air quality improvement; the time scale for policy implementation; the reference area where the policy applies, the institutional level concerned (local, national or European), the stakeholders involved, and cost-effectiveness.

- The policy recommendations in chapter 7 place the emphasis on the need to implement a consistent mix of measures, where synergies might be achieved and side-effects might be minimised. In addition to describing the main actions, the chapter also includes recommendations by transport mode.

5. POLICY CLUSTERS

5.1 Overview

In order to analyse their impacts, suitability and effectiveness, the measures recommended in the literature and promoted by the policy documents analysed in chapter 4 have been selected and grouped into homogeneous policy clusters, as shown in Table 10. This chapter will investigate the clusters. In particular, the analysis will focus on non-technological measures, since technological measures have already been discussed extensively in chapter 3.

Table 10 Policy clusters and measures

Policy clusters	Measures	Descriptions
Technological improvement (vehicles and fuels)	Reduction of CO_2 emissions and fuel consumption	Compulsory targets for CO_2 emissions from cars (120g/km) and vans (175 g/km) by 2012, including through Emissions Trading Schemes for car manufacturers
	Increased efficiency in the automotive sector	Reduction of vehicle weight and resistance factors; efficiency requirements for automobile air conditioning systems
	Labelling scheme for tyres	Standards to measure tyre rolling resistance 2008
	Labelling scheme for car fuels	New CO_2 labelling scheme for amended car fuels efficiency directive (1999/94EC)
	R&D on efficient vehicles	Support for project to develop more efficient vehicles
	Improved fuels	Development of the second generation of biofuels and alternative fuels able to reduce CO_2 and air pollution emissions
Charging and taxation	Road vehicle taxation reform	Passenger car taxes linked to CO_2 emission levels
		Fiscal incentives to encourage the cleanest LDV classes
		Inclusion of land transport in CO_2 emissions trading
	Charging for Interurban Roads	Application of 'Eurovignette' Directive (1999/62) and its amended version (Directive 2006/38/EC)
		Attention to congested corridor and sensitive areas (i.e. Alpine region)
		Internalisation of external costs of transport
	Road charging in urban areas	Congestion charging, value pricing, road tolls and HOV lanes
	Tradable mobility credits	Tradable permit schemes among car drivers in urban areas
Long-distance travel (passengers and freight)	Rail interoperability	Improving the seamless movement of trains across Europe, on both high-speed and conventional rail networks
	Harmonised regulation systems	Providing fair competition for rail operators across the EU
	Rail efficiency	Increasing technical unit efficiency of rail travel
	Rail passenger services quality	Stimulating rail usage by increasing quality (rolling stock, ICT, ticketing, etc.)
	Intermodal facility for passengers	Developing service integration by mode (train, air, maritime, road) and journey (long/short-distance)
	Intermodal facility for freight	Intermodal loading units and freight integrators. Freight facility incentives to offset the capital costs of providing rail freight handling and operating facilities
	Rail capacity	Improving rail capacity by using advantage technology in key corridors (metropolitan areas) and rail bottlenecks

Policy clusters	Measures	Descriptions
Liveable cities	Improved public transport services	Systems providing high-quality PT service and convenient light-rail transit on urban corridors
	Regulation, incentive effectiveness	Policy changes to encourage transport service competition, innovation and efficiency
	Park and Ride facilities and access to PT	Providing convenient parking at transit and rideshare stations
	Walking and cycling facilities	Strategies for improving bicycle transport and walking conditions
	Transport Demand Management	Developing car sharing and car pooling services as a substitute for private vehicle ownership and encouraging ridesharing
		Commuting and school travel planning that encourage more efficient transport modes (shift from car to public transport and environmental modes)
	Integrated planning	Land use, environmental and transport integration, reduction of urban sprawl, encouraging LEZ (Low Emission Zones)
ICT (Information and Communications Technology)	Real-time and pre-journey information	Real-time road traffic and PT travel information; travel planning systems to optimise use of combined modes of transport
	Teleworking/teleconferencing	Use of telecommunications as a substitute for business and commuter travel
	Telebanking/teleshopping	Use of telecommunications as a substitute for physical travel
	Research and Development	Application and technology including Galileo programme
Eco-friendly behaviour	Eco-driving	Strategies for improving driving behaviour, energy efficiency and traffic safety among drivers
	Demarketing of cars	Campaign to demarket cars to change public attitudes and develop environmental certification (ecolabels)
Logistics	Logistics management (integrated supply chain)	Strategies to improve the efficiency of freight transport and storage
	City logistics (freight distribution centres and regulation)	Strategies to improve the efficiency of freight distribution in urban areas
	Increased load factor	Strategies to optimise the load capacity of freight vehicles
Air and Maritime	Operation rules for ports	Rules on pilotage, cargo handling, stevedoring
	Marco Polo Programme	Modal shift, catalyst and common learning actions
	Vessel traffic monitoring	Monitoring System to prevent illegal discharges at sea and help in identify ships and their environmental performance
	Single European Sky	Management of air traffic, thereby facilitating further cost reductions and demand growth
	Environmentally differentiated charges at terminals	Differentiating terminal fees and charges according to the level of pollutants emitted/discharged and noise produced, mainly by ships and aircrafts

Source: TRT, 2007.

5.2 Technological improvement: Low-emission vehicles and better fuels

This policy cluster, the main components of which have already been presented in chapters 2 and 3, aims substantially to improve the efficiency of vehicles and engines by reducing fuel consumption and by introducing innovative design based on current technologies. The package also includes the development of alternative fuels capable of reducing harmful emissions.

This in turn will have a major impact on CO_2 emissions. The Commission has recently (COM (2007)19) launched a new strategy to reduce CO_2 emissions from passenger cars and light-

commercial vehicles through an integrated approach. A key element of such a strategy is the proposal of a legislative framework to achieve the target of 120 g CO_2/km by the year 2020, focusing on mandatory reductions in CO_2 emissions to reach the target of 130 g CO_2/km for the average new car fleet by making improvements in vehicle motor technology, and a further reduction of 10 g CO_2/km, or equivalent if technically necessary, by other technological improvements and by an increased use of biofuels. The new CO_2 emissions target for light-commercial vehicles (vans) are: 175 g/km by 2012 and 160 g/km to 2015.

The EU move to introduce legally binding fuel efficiency targets responds to the fact that most of the car industries will not meet the target fixed in previous voluntary agreements. At present, the EU's voluntary regime offers carmakers no incentives to comply with the targets. Even though the current generation of hybrid petrol vehicles' emissions levels are around 100g/km of CO_2, on the market there are a number of larger and heavier models that emit higher levels of CO_2, reaching peaks of more than 350 g/km[25].

The other main measures of the EU strategy are related to regulation, such as car fuel efficiency labelling actions, already provided for by the labelling directive (1999/94 EC), which requires a label on fuel consumption and CO_2 emissions to be shown on all new cars, national guides to be published on the fuel efficiency of new cars, posters to be displayed at dealerships and fuel efficiency information to be included in printed promotional literature. The directive is considered to be a useful tool in raising awareness but its impact has not been visible, with labels of strongly varying quality in different Member States. For these reasons actions along these lines are strengthened by the Commission in the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles (COM2007 19 final).

Mandatory limits for CO_2 emissions for new vehicles term could also be achieved in the medium through the adoption of an emissions trading system between car manufactures. The European Parliament resolution on 'Winning the battle against global climate change' (2005/2049(INI)): i) underlines that developments within the transport sector are critical as it contributes to roughly 30% of the Community's CO_2 equivalent emissions, approximately 85% of which is represented by road transport; ii) regrets the fact that the automobile industry is unlikely to meet the target of 140 g/Km within the time-limit laid down under the current voluntary agreement; iii) therefore calls for a policy of strong measures to reduce emissions from transport, including mandatory limits for CO_2 emissions in the order of 80-100 g/km for new vehicles in the medium term to be achieved through emissions trading between car manufactures. The European Parliament Report (2007/9/24) on the Community strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles (2007/2119(INI)) proposes the introduction on 1 January 2011 of a new closed market mechanism, the Carbon Allowance Reduction System (CARS), under which manufacturers and importers will pay financial penalties in proportion to any exceedance of emissions limits. These penalties may be offset by redeemable credits awarded to newly registered passenger cars of the same manufacturer with emissions below the limit value curve.

[25] Some examples: Porsche Cayenne S (380 g/km), BMW 3-Series E46 (229 g/km), SUV-Lexus RX 400h (192 g/km), Skoda Octavia 1.6 (184 g/km), Ford Focus 1.6 (161 g/km).

Technological aspects also deal with the increased unit efficiency of the other transport modes: rail, air, shipping and public transport (coaches and buses). The technological development package includes the measures to promote alternative fuels which are described in the following table.

Table 11 Alternative fuels: advantages and disadvantages

Fuel	Advantages	Technical Disadvantages	Note
Natural Gas	Very low particulate emissions compared with diesel Low NO_X emissions compared with advanced diesel engine Zero sulphate and SO_2 emissions	More complex refuelling system 4 times larger tank size requirement Engine efficiency in bus operation 20% lower than diesel engine	The Commission has proposed the following targets for the introduction of natural gas as transport fuel: 2% by 2010, 5% by 2015 and 10% by 2020. The main challenge will be to establish new distribution infrastructure.
Ethanol (Biofuel)	Miscible with gasoline High octane number Low NO_X emissions Large potential to reduce CO_2	Cold start problems More corrosive than hydrocarbons Causes emission of aldehydes	Environmental concerns due to cultivation phase of biofuels Land use conflicts with other land uses such as food production Concerns about the EU's capacity to produce enough biomass feedstock
Dimethyl ether (Biofuel)	Very low PM Zero sulphate and SO_2 emission Low NO_X levels without after-treatment	Lower viscosity Injection system needs to be developed	
Biodiesel (Biofuel)	Higher cetan number Good lubricity Zero sulphate and SO_2 emissions Particulates of lower toxicity	Corrosion properties Lower heating value Higher freezing point Increased NO_X emissions Increased odour	
LPG	Cheap and traditionally seen as environmentally friendly	With gasoline and diesel becoming much cleaner than in the past, this advantage is rapidly diminishing.	
Electricity	Less local problems related to air pollution (health) and produces less noise in urban areas	Size and costs of batteries; recharging issues make them suitable for short-distance motoring only, still very expensive.	Full benefits exist if the electricity is produced by renewable sources
Hydrogen Fuel Cell	Full benefits in terms of energy efficiency, CO_2 and pollutant emissions	Most hydrogen technologies are much more costly than conventional ones	At this stage it is recommended that hydrogen be considered as a research and development initiative only

Source: TRT, 2007.

5.3 Charging and taxation

Charging and taxation measures are key elements in any strategy aimed at reducing energy consumption and polluting emissions in the transport sector. Charging measures include a broad range of instruments, some of them used widely all over Europe, such vehicle ownership taxes, fuel taxes, public transport fares, and others that have only recently entered the transport policy agenda, like road charging.

5.3.1 Road vehicle taxation reform

The reform of road vehicle taxation is aimed at promoting fuel-efficient cars and proposes to reduce taxes for road vehicles that emit less CO_2 and increase them for those that emit more. In July 2005 the Commission presented a proposal for a directive (COM/2005/261/Final) that would require Member States to restructure their passenger car taxation system (registration tax and annual circulation tax) so as to include elements directly related to carbon dioxide emissions, to internalise externalities and to apply the 'polluter-pays' principle. The proposal also sought to remove distortions and inefficiencies which impede a proper reduction in transport energy use in the European Internal Market as a whole. One example of fiscal measures to promote cost-effective reductions in emissions is the measure adopted by UK Government, called 'company car taxation reform', as mentioned in paragraph 4.3.1.

Others approaches used to control pollution by providing economic incentives for achieving reductions in the emissions level include the emissions trading scheme (ETS). The EU ETS directive (Directive 2003/87/EC) lists transport as one of the sectors that should be considered when assessing whether to expand the scheme. Emissions trading could offer a cost-effective way for transport to reduce its climate change impact. The European Commission is working to develop robust evidence based on the costs and benefits of including surface transport in CO_2 emissions trading at a EU level.

The EU explored the possibility of manufactures and importers paying financial penalties in proportion to any exceedance of emissions limits in January 2007 in COM (2007)1, where the Commission emphasised that 'further measures to tackle CO_2 emission for cars will be outlined in the forthcoming Communication in order to reach through a comprehensive and consistent approach the target of 120 g/km CO_2 by 2012' and in the COM (2007)19, where the Commission underlines that its long-term vision will support research into 'improvements in vehicle efficiency that will deliver as much as a 40% reduction in CO2 emission passenger cars for the new vehicle fleet in 2020' (see also paragraph 5.2).

5.3.2 Charging for interurban roads

With reference to interurban road transport, the most recent version of the European rules (Eurovignette Directive 1999/62) on lorry charges was agreed by the European Parliament in December 2005 and came into force upon publication of Directive 2006/38/EC in June 2006. A year on from the entry into force of the new rules, a few Member States (Germany 2005, Austria 2004, Czech Republic 2007 and Switzerland 2001 outside the EU) operate nationwide distance-based charging schemes for lorries and many more are creating such schemes or investigating possibilities. An impact analysis of the Swiss, Austrian and German systems draws the following conclusions:

- ***Reduced vehicle-kilometres***. After a steady increase in HGV vehicle-km for over 30 years, this trend has clearly been reversed in Switzerland since the introduction of the heavy vehicle fee (see paragraph 4.3.4). In the first two years after the introduction of the fee, vehicle-kilometres fell by 5% per year (ARE, 2004). The heavy vehicle fee plays a central role in Swiss transport policy, which also includes promotion of the transfer of goods to railways and has led to a stable reduction in the total number of lorries crossing the Swiss Alps.

- ***Innovation in road freight transport and logistics***. In Switzerland the transport and logistics sector has evolved its operations to achieve productivity gains. To avoid empty journeys, some companies are now cooperating. The transport sector was already replacing old vehicles with less polluting ones even before the scheme had been introduced. This effect is not evident in Austria, as there the fee does not depend on emission class.

- ***Traffic diversion***. In Austria and Germany parts of the secondary road network have seen an increase in the number of lorries following the introduction of motorway charging schemes. However, in Germany, after a few months of the kilometre charge for heavy-duty vehicles on motorways only, this temporary shift on regional roads did not take hold and now just three sections of the federal road network are included in the charging system to prevent traffic shifts. Apparently, in this case the underlying network is not a valid alternative to motorways. Consequently, there is not always clear evidence that heavy goods traffic is diverting to the other, parallel roads. This effect cannot be analysed in Switzerland, where all roads are subject to charges.

Table 12 Recent experience with nationwide distance-based toll systems

Characteristics	Austria	Germany	Switzerland	Czech Republic
Introduction	2004	2005	2001	2007
Vehicles	>3.5 tonnes	>12 tonnes	>3.5 tonnes	>3.5 tonnes
Network	Motorways and few expressways	Motorways + 3 national highways	All roads within the country	All state-run motorways and expressways
Differentiation	Axles	Axle and emission class	Maximum laden weight and emission classes	Axle and emission class
Max fee level €/km (40t/4+axles)	0.325	Euro 0-II= 0.155 Euro III-IV= 0.13 Euro V= 0.11	Euro 0-I= 0.69 Euro II= 0.61 Euro III-V= 0.52	Euro 0-II= 0.19 Euro III-V= 0.15

Source: T&E, 2007.

Now, under Directive 2006/38/EC, Member States will be able to charge lorries for using their entire road network, not just motorways; in addition, Member States operating lorry charges are obliged to include all vehicles over 3.5 tonnes only after 2012, but they may do so before that date. After 2010 Member States must differentiate tolls according to the environmental performance of vehicles. Finally, in mountain areas a mark-up may be added on top of the average toll to finance priority Trans-European Transport Network projects in the same corridor.

Moreover, in June 2008 the Commission will present a model for the assessment of the external costs of all modes of transport; the model will serve as a basis for future calculations of infrastructure charges and will be accompanied by a strategy for the ***internalisation of the external costs*** that requires further differentiation of taxes and charges according to parameters that are good proxies for the external cost (such as type of location, time of the day, Euro-standard or noise standard). In general, km-based charges will allow a more differentiated charging scheme than fuel excise duties can provide. For this reason, the Commission is working towards a shift from fuel-based infrastructure financing to infrastructure charges based on marginal cost and it regards scarcity, safety and environmental issues as an appropriate way to achieve internalisation, in particular for road transport.

5.3.3 Road charging in urban areas

In urban areas, road charging can be implemented by a congestion charging scheme as a way to encourage more efficient use of the transport system, and address congestion and pollution problems, providing net benefits to society.

In recent years a few cities have implemented various forms of congestion charging, including Singapore, Orange County (California State Route 91) and the cities of Trondheim, Oslo, and Bergen in Norway, but proponents have been frustrated by the existing citizens' resistance to congestion charging. Best practices in this field, including as regards public acceptance of the measure, are London and Stockholm. Since February 2003 the city of London has charged a fee for driving private automobiles in its central area during weekdays as a way to reduce traffic congestion and raise revenue to fund transport improvements. This has significantly reduced traffic congestion, improved bus and taxi services, and generated substantial revenue. Public acceptance has grown and there is now support to expand the program to other parts of London and other cities in the UK. Stockholm has a congestion charging system, Stockholm congestion tax, in use on a permanent basis since 1 August 2007, after having had a seven month trial period from 3 January to 31 July 2006. The city centre is within the congestion charge zone. All entrances and exits to and from this area have unmanned control points operating with automatic number plate recognition. All vehicles entering or exiting the congestion charge area, with a few exceptions, have to pay SEK 10-20 (EUR 1.09-2.18), depending on the time of day, between 06:30 and 18:29. The maximum charge per vehicle per day is SEK 60 (EUR 6.53). The primary purpose of the congestion charge is to reduce traffic congestion and improve the environmental situation in central Stockholm. As in London, the funds collected will be used for new road construction in and around the city.

Another widely used charging measure is parking charges, which is a traditional strategy to deal with parking problems that can also be implemented for transport demand management in areas where other road charging policies are considered too difficult to apply.

As has already been said, one argument often raised against road charging is that imposing an additional cost on car users unfairly affects different population groups, e.g. low-income individuals who have no alternative to using car. Technologies now allow for more sophisticated 'push and pull' approaches to be introduced, with a view to more sustainable urban mobility based on a mix of 'pay as you go' and rationing policies with the possibility of trading the external costs of transport.

A first step in this direction is to couple road charging with a mechanism based on mobility vouchers. An initial endowment of vouchers would guarantee every citizen free use of car. The cost of additional vouchers could be differentiated according to several aspects, such as the quality of public transport from the area of residence, the presence of modal alternatives, the vehicle type (size, emission class) or the time of the day. Every citizen has the possibility to choose between private car and public transport alternatives, according to his personal mobility needs. The municipality of Genoa (Italy) is currently studying the feasibility of such a scheme (TRT, 2006), assessing the impact of the system in terms of reduced demand, modal shift, lower emissions and economic distribution of costs among different population groups.

5.4 Long-distance travel substitution (passengers and freight)

The package is intended to reduce the impacts of long-distance passenger and freight travel by substituting highly energy-intensive modes (road and air) with less energy-intensive modes (rail, maritime). In fact, the increase in long-distance travel – particularly air travel and freight transport – causes particular concern in terms of CO_2 emissions: the modal share of air transport is still low but growth rates are much higher than those of all other modes; air transport operates with a type of 'extraterritorial' status, being exempted from taxes that in national contexts are charged to all other modes.

Rail has the potential to offer an attractive alternative to air travel over distances of around 300-500 km. The considerable improvements brought to HST in a limited number of countries, together with faster services on existing infrastructure (e.g. tilting technology, signalling, technical harmonisation, organisational cooperation and improved competition conditions) including technical and organisation harmonisation measures to improve the competitiveness of rail. Measures to support railway interoperability (infrastructure, energy, signalling and rolling stock), integrated transport and interchange facilities could be a way to increase rail demand.

Obstacles for interoperability on the European Transport Network

At the macro level, obstacles concerns three main subsystems:

- infrastructure: in particular, the preference for non-standard gauges in some national networks (i.e. Spain, Portugal, Finland);
- energy: presence of different power systems (AC systems and DC systems);
- signalling: presence of different signalling and train control system (in general, one or more system per national network).

Investments on the infrastructure side are relevant and cannot be performed if not through the construction of the new lines: it is the case, for example, of the new HST lines in Spain, which in turn imply interoperability problems at national level which will last for long periods. Consequently, non-standard gauges will be present in the European network for decades.

Source: European Parliament, DG-Internal Policies of the Union, Interoperability of the community railway system, April 2007.

Maritime transport (including inland waterways) could offer an environmentally friendly alternative to the increase in road freight transport demand. The new concept of 'motorway of the sea', but also the wider and long established network of short-sea shipping links, combined with ICT applications and renewed ferry fleets, may divert medium/long-distance freight traffic from the European motorways to the sea. Also, unitised freight traffic (primarily containers) should use rail services through intermodal connections between ports and inland terminals, and also by developing IWW services.

5.5 Liveable cities

One of the major challenges to be faced by policymakers at all institutional levels is to integrate transport and land use planning strictly. More than a quarter of the European Union's territory has now been directly affected by urban land use; by 2020 approximately 80% of Europeans will be living in urban areas, whilst in seven countries the proportion will be 90% or more. The expected 'car-dominated' growth in passenger transport demand will therefore be concentrated in urban areas, which are also facing unplanned incremental development characterised by lower densities, individual housing preferences for detached houses and commercial investment in

low-price agricultural land (i.e. shopping malls). This *urban sprawl* can be also seen as a consequence of new road infrastructure investment planned and realised without a proper strategy for implementing the public transport alternative.

This package aims to make cities more attractive by using strategic and local urban design to reduce car dependence (by reducing urban sprawl). Measures are targeted at commuting, leisure and shopping trips and include: public-transport-oriented development, local land-use planning in favour of mixed-use areas, better conditions for walking, cycling and public transport, less space for cars and parking; better access to Information Technology plays an important supporting role within this package.

The promotion of high-quality public transport systems could be a very effective way to reduce GHG emissions and energy consumption. The EEA states that environmental tax measures and road charges in urban areas and the associated revenue must rebalance costs and achieve a more sustainable transport system, in order to shift towards public transport (EEA report 3, 2004). An example is London where the revenue from of the congestion charging scheme was used mainly to invest in the urban bus system.

Transport demand management could be considered the best measure to address urban road congestion, focusing on the management of road systems in urban areas in ways that optimise the capacity of existing infrastructure and provide new capacity to handle current traffic demand and the expected future demand. In order to tackle congestion impacts such as queuing, slower speeds and increased travel time, in addition to the external impacts, the recent study on 'Managing urban traffic congestion' (ECMT, 2007) requires an integrated congestion management strategy that works to improve traffic operations, shifts urban traffic to public transport, seeks to increase the capacity of existing infrastructure and, as a last resort, tries to provide new infrastructures.

Measures such as workplace and school travel plans also form part of this package: a recent study (Cairns et al, 2004) estimates that implementation of these measures could lead to a reduction in peak urban traffic of around 20%, with significant benefits for congestion, fuel consumption and air pollution.

Mobility plans at metropolitan level (encompassing the city and the surrounding areas) are indispensable for efficient urban mobility planning for both passengers and freight. Integrated land-use and transport and environmental planning is the key instrument in pursuing this objective and improving, developing and implementing Sustainable Urban Transport Plans (SUTPs). The guidance from SUTPs will be coordinated with the Green Paper and the wide-ranging discussion on urban transport as part of the Action Plan on urban mobility which will be presented in early autumn 2008.

Green Paper: towards a new culture for urban mobility

Experience from stakeholders shows that there is no single solution to reduce environmental impacts and negative social economics of urban congestion effects. Alternatives to private car use, such as walking, cycling and collective transport, should be made attractive and safe. Citizens should be able to optimise their travel through efficient links between different modes of transport. Authorities should promote co-mobility and reallocate space that becomes available after congestion mitigation measures. The main environmental issues in town and cities are related to the predominance of oil as a transport fuel, which generates CO_2 pollutant emissions and noise. The options are:

- new technologies (environmental performance of the existing vehicle fleet could be further improved by setting harmonised minimum performance standards for vehicle operation). There are opportunities to promote the

exchange of best practices in the field of clean urban transport beyond European's boundaries and to capitalise on the knowledge and experience gained in EU initiatives such as CIVITAS (www.civitas-initiative.eu);

- internalisation of external costs by using life-time cost for energy consumption, CO_2 emissions, and pollutant emissions linked to the operation of vehicles to be procured as award criteria, in addition to vehicle price. This would give a competitive advantage to the cleanest and most energy-efficient vehicles and at the same time minimise the overall cost. The public sector could set an example for 'sustainable economics', to be taken up by other market actors. In addition, public procurement could give preference to new Euro standards. The early use of cleaner vehicles could also improve air quality in urban areas. The Commission intends to present a revised proposal before the end of 2007;
- some authorities have improved the environmental performance of their public transport fleet and taxis by procuring cleaner vehicles and offering economic incentives to private operators. Public financing supports new infrastructure for the distribution of alternative fuels. Joint procurement of clean and energy-efficient vehicles by public authorities could accelerate the building of a market for new technologies and ensure their economic viability;
- eco-driving, which reduces energy consumption through a change of driving habits should be encouraged, in particular by driving schools and through the training of professional drivers. Electronic driver support systems could help to improve driving behaviour. Improved infrastructure and traffic management systems and more 'intelligent' cars will also have an important contribution to make;
- smart charging systems as an effective method of managing demand. In public transport, the use of ITS (Intelligent Transport System) or ICT (Information and Communications Technology) ensure better management of operations and new services (fleet management, traveller information systems, ticketing systems, etc.).

Source: Commission of the European Communities, COM (2007) 551 Draft.

5.6 ICT (Information and Communications Technology)

The package combines several measures to reduce the need for travel by providing an (ICT) alternative to physical travel with real-time information and travel services and facilities, including multi-modal travel so that journeys can be planned in advance and modified as circumstances arise. This requires cooperation between all public transport providers for journeys from door to door. The intention would be to encourage multi-modal journeys which are flexible and convenient. The ICT (also Intelligent Transport System) applications are currently underused for efficient management of urban mobility, or are developed without due attention being paid to interoperability. Traffic and travel data processing can provide information, assistance and dynamic control of transport, travellers, drivers, fleet operators and network managers. A number of applications are already available for road, rail or transport waterways. In the next few years the applications will be further enhanced by the Galileo satellite system.

5.7 Eco-friendly behaviour

Eco-driving is about driving in a style suited to modern engine technology: smart, smooth and safe driving techniques that lead to average fuel savings of 5-10%[26]. Several European countries have implemented successful eco-driving programmes. With support from the European Commission in the 'Intelligent Energy Europe' programme, under the project umbrella called ECODRIVEN, a Europe-wide campaign for improving driving behaviour, energy-efficiency and traffic safety among drivers has been organised during 2006 and 2008.

[26] www.ecodrive.org

Among others eco-driving behaviours, maintaining an optimum speed of 60-80 km/h makes vehicles some 20% more efficient than when they travel at faster speeds (more than 110 km/h). Today's cars are designed to be able to break speed limits and the tendency is towards faster vehicles: in the next three years the market share of Sport Utility Vehicles is expected increase from 7% to 9.6% in the EU (Dudenhoffer F, 2007). Even though the highest speed limits in Europe are 130km/h, apart from a few derestricted stretches of Autobahn in Germany, a typical family car has a maximum speed in excess of 200 km/h. Such speed requires cars to have over-sized engines, brakes, tyres, etc. A recent simulation shows that designing a car for a 160 km/h top speed instead of over 200 km/h can cause a one-third reduction in emissions (T&E, July 2007) and that intelligent speed adaptation systems can ensure that cars go no faster than 150 km/h[27].

Demarketing of cars, which includes various actions aimed at discouraging customers from buying cars with a high impact on the environment, could be promoted as a programme to incentivise the use of environmentally friendly transport modes (cycling, walking) in urban areas and to steer preferences towards 'cleaner' cars.

5.8 Logistics

Freight transport is considered to be a critical area of action due to the important role played by the transport mode in comparison with other modes (such as rail, maritime and IWW), the continuous growth of the road sector[28] (especially after enlargement) and the presence of bottlenecks on the main corridors and also in the urban and sensitive areas (such as the Alpine region and the Pyrenees).

Strategies aimed at reducing the environmental impact of freight transport include numerous measures, ranging from technological improvements to the reform of vehicle taxation, as well as actions to be implemented in the long term and already described under the long-distance travel cluster.

The mid-term review of the 2001 White Paper (COM (2006) 314) stresses the key role of logistics in ensuring sustainable and competitive mobility in Europe and in contributing to meeting other objectives, such as a clean environment, security of energy supply, transport safety and security. According to the Communication from the Commission presented on 18 October 2007 on the 'Freight Transport Logistics Action Plan', the logistics cluster includes a number of short to medium-term actions.

Freight transport logistics focuses on the planning, organisation, management, control and execution of freight transport operations in the supply chain. The main measures selected for the logistics cluster are:

- Integration of supply chain management;
- Information and Communications Technology;

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[27] 150 km/h is still 15% faster than the highest enforceable or recommended speed limits in any EU Member State.

[28] According to the EU White Paper (2001) freight transport demand is expected to increase by 38% in terms of tonne-km from 2000 to 2010

- Urban logistics measures.

Integration of supply chain management in terms of increasing the efficiency of intermodal terminals, including seaports, airports, inland waterway ports and better interconnectivity of companies is a crucial point for logistics performance. Multimodal freight transport is still underutilised. This may be due to lack of knowledge of the benefits of modal alternatives, integration between transport modes or the additional costs of transhipment. Adequate logistics management, in particular towards full integration of the supply chain, could support the rationalisation of freight transport and the improvement of logistics services. Better integration of the supply chain, through advanced logistics information systems, opens the way for the introduction of collaborative planning and execution of logistics operations. Connectivity and transparency in transport and warehouse management are enabling improvements to be made in planning and scheduling of operations and in real-time adjustments to changed circumstances.

Advanced *Information and Communications Technologies* (ICT) can contribute greatly towards co-mobility by improving infrastructure, traffic fleet management, facilitating better tracking and tracing of goods across transport networks and better linking of transit points and intermodal services. This will be made more practical and affordable by emerging technologies such as Radio Frequency Identification (RFID) and the use of the Galileo satellite positioning system.

Urban logistics. Freight transport logistics has an essential urban dimension. Distribution in urban conurbations requires efficient interfaces between trunk deliveries over longer distances and distribution to the final destination over shorter distances. In addition, the distribution process between production centres and customers within an urban area needs to be efficient and clean. A holistic vision should cover freight transport and pay attention to aspects of land-use planning, environmental impacts (air emissions) and traffic management (see the relationship between congestion, fuel consumption and air pollution).

Green logistics measures such as ICT (loading and journey management), regulation and restriction of access to urban areas, low-emission vehicles and toll systems for LDVs and HDVs could optimise logistics chains for long and short journeys.

5.9 Air and maritime

This study is focused mainly on the land transport. Policies suggested in this cluster summarise the main EU actions for the economic regulation of aviation and maritime sectors and for the provision of measures to shift freight and passenger movements to more energy-efficient modes, e.g. from air and truck to rail and maritime or inland waterway.

The Commission has proposed a new legislative framework for ports with a view to laying down new, clearer rules on pilotage, cargo handling and stevedoring. Furthermore, the new framework will simplify the rules governing the operation of ports themselves and bring together all the links in the logistics chain. The Marco Polo programme can improve the environmental performance of the whole transport system (and reduce road congestion) by shifting freight from ‘road only’ transport to short-sea, rail and inland waterway transport. The programme has three types of activities: modal shift, catalyst measures and common learning actions. Because the average energy consumption of non-road modes of transport is lower, it is likely that the predicted types of actions would lead to a reduction in energy use.

Together with vessel-related developments (see 3.1.2), further emissions reductions in the maritime sector could be linked to a better relationship between ships and EU visiting ports and terminals. Vessel traffic monitoring strategies (implemented through a proper, common Vessel Monitoring System) should prevent illegal discharges at sea and help recognise ships and their environmental performance (in terms of certified equipment, fuel used, and speed) when cruising in the territorial waters of a country or in Exclusive Economic Zones (e.g. 200 nautical miles from the coast) and also when ships are at ports (i.e. by using shore-side power facilities and turning off auxiliary engines).

The package of measures on air traffic management proposed by the European Commission – Single European Sky (issued in 2004) – have recently been discussed and incorporated in the EU emissions trading regime. Air transport has been growing at around 6% per year and its CO_2 emission and energy use have been growing by 4.4% per year. The measures in progress to create the Single European Sky will reduce inefficiencies in the management of air traffic and thereby facilitate further cost reductions and demand growth. In contrast, inclusion of aviation in the EU ETS will lead to a slight increase in cost for aviation but is not predicted to have any significant impact on demand.

6. IMPACTS, SCALE AND TIMING OF POLICY MEASURES AND PACKAGES

6.1 Introduction

In order to assess the impacts as well as the feasibility and suitability of the policy measures, these have been analysed under different dimensions:

- What are the main effects expected in terms of reduction of carbon intensity and atmospheric emissions (NO_X, SO_2, CO, PM_{10}, $PM_{2.5}$)?
- What are the timings for policy implementation and for the expected impacts (short, medium and long-term)?
- Which are the areas concerned (local/regional, European, global)?
- What are the institutional levels involved in the implementation phase (urban/regional, national, European)?
- What are the main stakeholders (positively/negatively) affected?
- What is the cost-effectiveness of the policy clusters?

Table 13 gives a synthetic score for each policy cluster in relation to the capacity to reduce GHG emissions and pollutant emissions. In the same table, the assessment of implementation timing and the territorial area of interest is given for each measure. All policy clusters have positive impacts on GHG and air quality but their performance is extremely variable. According to the IPCC (2007), improved energy efficiency offers an excellent opportunity for transport GHG and air pollution mitigation in the medium term. Carbon emissions, fuel consumption and air pollution could be reduced (-50% of GHG by 2030 compared with currently produced models) assuming continuous technological advances and strong policies, such as charging measures, tax incentives to encourage the purchase of clean vehicles and tax disincentives to purchase vehicles with high CO_2 emissions. These policies might be coupled with soft measures, public facilities in urban areas and regulatory actions, as well as mandatory standards for new engines and fuel emissions.

Table 13 Expected effects of policy packages

Policy packages	Impact on CO_2	Impact on air quality	Measures	Timescale	Territorial area
Technological improvements (vehicles and fuels)	+++/++	+++	Reduction of CO_2 emissions and fuel consumption	Medium	EU
			Increased efficiency in the automotive sector	Medium	EU
			Labelling scheme for tyres	Short	EU
			Labelling scheme for car fuels	Short	EU
			R&D on efficient vehicles	Medium	EU
			Improved fuels	Long	EU
Charging and taxation	++	++	Road vehicle taxation reform	Short/Medium	EU
			Charging for Interurban Roads	Short/Medium	EU
			Road charging in urban areas	Short	Local
			Tradable mobility credits	Short	Local
Long-distance travel (passengers and freight)	+	++	Rail interoperability	Short	EU
			Harmonised regulation systems	Short	EU
			Rail efficiency	Medium	EU
			Rail passenger services quality	Medium	Country
			Intermodal facility for passengers	Medium	Country
			Intermodal facility for freight	Medium/Long	EU
			Rail capacity	Long	EU
Liveable cities	+	++	Improved public transport services	Short/Medium	Local
			Regulation, incentive, effectiveness	Short	Local
			Park and Ride facilities and access to PT	Short/Medium	Local
			Walking and cycling facilities	Short	Local
			Transport Demand Management	Short	Local
			Integrated planning	Long	Local
ICT (Information and Communications Technology)	= / +	= / +	Real-time and pre-journey information	Short	Country
			Teleworking/teleconferencing	Medium	Country
			Telebanking/teleshopping	Short	Country
			Research and Development	Medium	EU
Eco-friendly behaviour	= / +	+ / ++	Eco-driving	Short	EU
			Demarketing of cars	Medium	EU
Logistics	+	++	Logistics management (integrated supply chain)	Medium	Country
			Urban logistics (freight distribution centres and regulation)	Medium	Local
			Increased load factor	Medium	Country
Air and Maritime	+	++	Operation rules for ports	Medium	EU
			Marco Polo Programme	Short	EU
			Vessel traffic monitoring	Medium	EU
			Single European Sky	Short	EU
			Environmentally differentiated charges at terminals	Medium	EU

Note: positive: low (+), medium (++), high (+++), neutral (=).

6.2 Policy Measures and reduction of carbon intensity

The tables below show two different estimates of the policy clusters' impacts on carbon intensity, as reported in the scientific literature. Although the two tables come from different studies, they are useful to highlight the ranking of the policy clusters' effectiveness in reducing CO_2 emissions in different time frames.

An estimate of the policy clusters' effectiveness in the short term is illustrated by Table 14, based on the ECMT study (ECMT, 2007), which provides – for more than one hundred countries – a measure of expected potential CO_2 emissions abatement in million tonnes for the year 2010 in comparison with 2002 (see also the annex to chapter 6). With reference to the values reported in the table, the ECMT analysis underlines the following aspects:

- the more effective policy approach in the reduction of CO_2 emissions is the fiscal one (charging and taxation), actually introduced in numerous countries (51);
- logistics measures, liveable cities policies (public grants and facilities), actions relating to information/education, including ICT and measures to change citizens' behaviour show a medium impact, verified by wide diffusion;
- technological improvements that fix mandatory standards and regulatory reform seem to have less influence within the relevant time frame.

Table 14 CO_2 emissions, expected savings of policy clusters at 2010

Policy clusters	CO_2 expected savings in 2010 (%)	Number of Countries with Active Policies*
Technological improvements (Vehicles and fuels)	12%	19
Charging and taxation	46%	51
Liveable cities (urban policy)	19%	33
ICT (Information and Communications Technology)		
Eco-friendly behaviour		
Logistics	23%	37
Total	100%	140

Source: TRT on the basis of ECMT 2007

* The EU is included as if it were a single country where the policy was introduced across Member States through an EU Directive

Table 15 is based on a UK Department for Transport study (VIBAT, 2007) and gives a measure of the policy clusters' effectiveness in terms of the contribution to achieve the UK 60% CO_2 reduction target (-25.7 MtC) by 2030. The table offers useful insights in understanding the policy impacts in the longer term (more than twenty years). Indeed, the ranking of the policy clusters is now different and, therefore, the more effective policy is technological improvements (where vehicle improvements score better than fuel improvements), whilst charging measures and ICT for passengers seem to be much less effective.

Table 15 Contribution to the UK CO_2 emission reduction target in 2030

Policy clusters		Contribution to CO_2 reduction target at 2030 (%) - Passenger	Contribution to CO_2 reduction target at 2030 (%) - Freight
Technological improvements	Vehicles	-46% +	-25%
	Fuels	-14%	
Charging and taxation		-4%	
Liveable cities (urban policy)		-2%	
ICT (Information and Communications Technology)		-4%	-2.5%
Logistics		-2.5%	
Total		100%	

Source: TRT on the basis of high impact scenario of VIBAT 2006

The two estimates confirm that technological advances and charging measures are the best policies clusters for reducing CO_2 emissions, highlighting the importance of soft and logistics measures as supporting actions. However, if technological improvements demonstrate their high effectiveness in the long period, the charging and taxation policy cluster seems to be the most effective in the short term.

6.3 Policy measures and implementation timescale

Although all measures might be implemented in the near future, their impacts might appear only in the medium to long term: that is the case for instance with some innovation technology measures, many modal shift measures and generally all the investment policies for building new infrastructures (i.e. increasing capacity). The main factors considered are:

- the maturity of technologies (the availability of commercial products)
- the complexity of the decision-making process for the regulatory actions (institutional levels involved, number of stakeholders, public acceptability and barriers);
- the completion time for major transport projects, such as the TEN-T network;
- the flexibility of the solutions and their capacity to adapt.

Many measures which, from the point of view of implementation, belong to the short-term (such as charging measures and information technology actions), have proven in the past to be more uncertain in their application. The main problems concerning charging measures are:

- the lack of harmonisation that still exists among European countries' fiscal policies, added to the long processes for the adoption of economic regulation, both in European institutions and in Member States (i.e. legislative path for marginal cost road charging, public services, freight transport charging, etc.);
- the acceptability of measures, due to the potential impact on the European economy of the increase in passenger and freight transport costs after the prospective external costs internalisation. This process could be anticipated by the introduction of economic measures such as tradable mobility credits valid for passenger and freight transport.

In the case of information and communications technology (ICT), i.e. teleworking, teleconferencing, telebanking, their effectiveness – in terms of significant travel reductions – will depend on the ICT network's capacity to reach a wide range of European citizens in a short time, and the economic convenience of supplying services remotely (see the development of telebanking and the convenience for telephone operators to create new areas of business, such as links between the network and road freight operators).

6.4 Policy measures and territorial areas

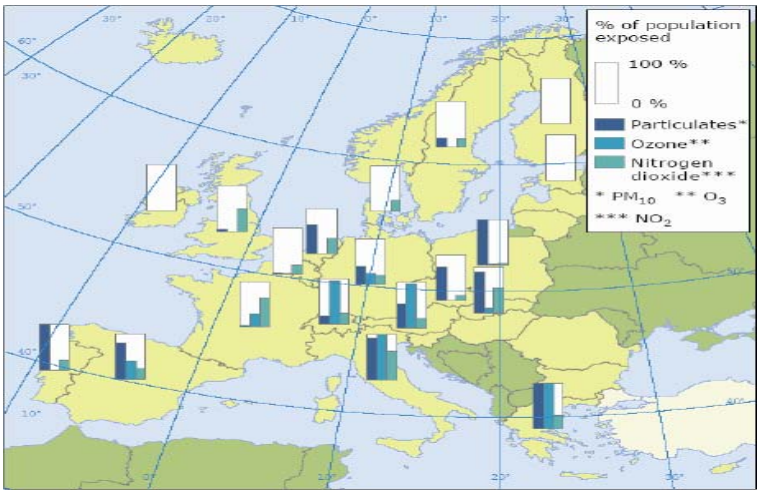
The territorial analysis is an important input to be considered in selecting the most appropriate measures. With the exception of the measures concerning technological innovations in vehicles and fuels, ICT and fiscal policies, which have an EU and global relevance, many of the policies analysed are designed for urban and metropolitan areas and heavily use part of the network. Two fundamental considerations support this focus on the local dimension:

- the concentration of transport activities, the majority of the passenger journeys are concentrated in European conurbations and catchment areas, freight logistics is located mainly along corridors near or within the urban and metropolitan areas, and consequently,

- the concentration of emissions sources in urban areas, as well as congestion and other environmental effects (i.e. $PM_{2.5}$ concentration). Examples of the urban areas suffering most in Europe are the cities of northern Italy, Germany and eastern Europe, including Poland and Hungary[29].

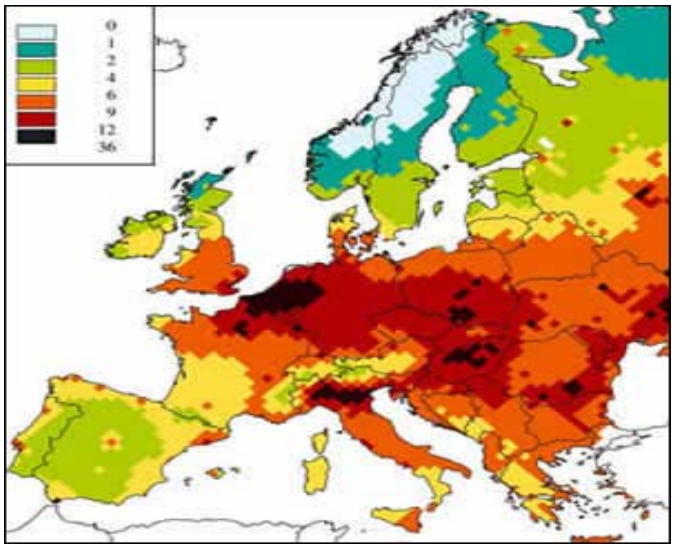
29 The EEA estimates that in 2004 the number of European people exposed to daily limit values for PM_{10} was 117 million (Exceedance of air quality limit values in urban areas, EEA, 2006).

Figure 21 % of urban population located in areas with pollution values higher than daily (PM_{10}, O_3) or annual (NO_2) limits - 2004



Source: European Environment Agency, 2006.

Figure 22 PM_{10} values in the EU (2004)



Source: European Environment Agency, 2006.

6.5 Policy measures and institutional level

A policy action with global impacts may also involve national and local partners in order to generate the required consensus, and overlaps of decision-making levels is inevitable. Whereas policies require a shared definition at higher institutional levels (i.e. the harmonisation of regulatory frameworks or funding activities), practical measures frequently require the involvement of local bodies for their correct implementation. At the same time, the normative apparatus and the financial resources available for policy implementation often require the support of higher institutional levels. Furthermore, for many policies the research and development component is relevant. In this regard, two different sets of policies can be identified:

- ***Technologies, regulatory and market-based policies***; these are characterised by the presence of normative EU or national provisions. In this regard, the improvements recently seen appear to be modest and slow. The ten years taken to build the European framework seem to be inconsistent with the objectives and targets set by the EU and implemented at national level. This is also due to weak use of sanction measures.

- ***Transport Demand Management policies***; in this case, and especially in the implementation stage, the action at local level is predominant. Nevertheless, these measures demand financial resources for process/product development which involves a higher spatial detail. From this point of view, the biggest problem experienced in the last ten years is the small amount of financial resources used, their temporal discontinuity and the demonstrative perspective rather than their being structural measures. Integrated and strategic planning (land-use-transport-and environmental) would play a crucial role in overcoming these weaknesses; in this regard, not only the local government levels but also the national and international levels would be very important in supporting innovation (guidelines for planning), addressing resources and intended use, and promoting the spread of best practice with the aim of building a sustainable mobility model.

6.6 Policy packages and stakeholders

The implementation of policy packages has a relevant impact on different stakeholders. This section takes a closer look at the stakeholder groups, their positions, interests and the conflicts arising between them due to the implementation of the policy package measures.

Transport policies in terms of measures for reducing the environmental impacts of human activities require great attention by both policy and decision-makers because of their significant implications for people's attitudes and lifestyles (i.e. changes in mobility patterns), industry production (vehicle, engine and component manufacturers, energy utilities) and public services (public transport, freight facilities). The awareness raised over the non-sustainability of a business-as-usual scenario (growing passenger and freight demand, dependence on fossil fuels and non-renewable energy sources, large contribution of the transport sector to climate change and air pollution) calls for full agreement on policies capable of radically changing the present mobility and transport situation.

It is important to stress that in order to be successful the policy for energy consumption, GHG and air pollutants reduction requires significant changes in people's lifestyle and mobility patterns, in production (i.e. car industry, technology, energy sector) and in the provision of transport services (public transport operators, freight transport operators) etc. These changes will also involve the economic and the social spheres as well as public attitudes. The issue is extremely complex and reaching a consensus on the policies and measures to be implemented in order to modify the existing mobility patterns and transport supply is a '*conditio sine qua non*' for their success. It is therefore important to look in more detail at the position of the main stakeholder groups affected by the recommended policies.

A public consultation[30] on the review of the EU strategy to reduce CO_2 emissions and to improve fuel efficiency from cars was held from June to August 2006. A total of 1 215 responses were received. The largest number of respondents lived in the UK, France and Germany. 77% of respondents owned a car and 23% did not. There was a large degree of

[30] European Commission, DG Environment, Report on the public consultation, June-August 2006, Brussels, 2006.

agreement that road transport should make a further efforts to mitigate climate change and to improve energy security and supply, but also that the responsibility for reducing CO_2 emissions from cars should be shared by various stakeholders (i.e. not only the car industry, but also the fuel industry, consumers, public authorities). Particularly strong support was voiced for the inclusion of light-commercial vehicles in efforts to reduce CO_2 emissions, as well as for efforts to raise consumer awareness about CO_2 emissions from cars.

In terms of approaches to reduce CO_2 emissions from cars, the questionnaire asked about the degree of support for seven different approaches: improving car technology, fiscal measures to support low CO_2 emissions, better consumer information on fuel efficiency of cars, etc. A majority of respondents considered all these approaches, the improvement of car technology coming out top, followed by tax differentiation, consumer information about cars and the promotion of alternative fuels.

The European Automobile Manufacturers' Association (ACEA) supports the EU objective of further reducing average car emissions to 120 g carbon dioxide (CO_2) per kilometre. Crucial, however, is that this target is achieved in a cost-effective, comprehensive way, involving all relevant actors. The European car manufacturers advocate a cost-effective approach combining further vehicle technology improvements, including the fuel industry. ACEA underlines the complexity of the car product, whose development – from design to production logistics – takes up to 5 years and whose product cycle – or the time they are kept in production – lasts up to 7 years. Given that vehicle and engine adjustments are hugely complicated and capital-intensive operations, manufacturers and their suppliers plan and allocate production capacity well ahead to accommodate production and the renewal of their car portfolio. The message is then that, in order to adjust automobiles to new legal requirements, the car industry needs sufficient lead time ahead of implementation of such new rules. Recently (Frankfurt Motor Show, 12/09/07) the president of the European Automobile Manufacturers' Association (ACEA) said 'The EU objective to bring carbon emissions from cars down to 120 g per kilometre is achievable through an integrated approach and we fully support that route'. The key elements of such a comprehensive approach are improved car technology, infrastructure changes, a more efficient driving style, CO_2-related taxation and greater use of biofuels.

The IRU (International Road Transport Union) promotes a three 'i' strategy for achieving sustainable development:

- Innovation: reduction of fuel consumption and thus CO_2 emissions from commercial vehicles; eco-driving training helps to reduce fuel consumption and emission by up to 10% and priority is given to reducing toxic emissions (NOx).

- Incentives: encouraging faster introduction by transport operators of best available technology and practices, which help to reduce CO_2 emissions. Good examples of effective incentives are the Fleet Smart Programme in Canada, which is a government initiative to help transport operators purchase clean and environmentally friendly vehicles and the SELA initiatives in the Netherlands, which is a tax incentive for clean and safe vehicles.

- Infrastructure: removing bottlenecks and missing links, best use of existing infrastructure.

Table 16 Impacts on Stakeholders

Policy packages	User Groups	Private and public sectors	Impacts on stakeholders
Technological improvements(Vehicles and Fuels)	Autoclubs and their federations (ARC Europe) Federations of transport operators (IRU, AEA, EFTA, IATA, ECSA, UIC, etc.) Environmental non-profit organisations and communities etc.	Vehicle and engine manufacturers and their federations, by mode EUROMOT Road: ACEA, IAMA, KAMA Trains: UNIFE Aircraft: Airbus, Rolls-Royce, AECMA Ships: CESA Oil companies, federations, groups IBIA, EUROPIA, CONCAWE, EBB, EREF, etc.	Vehicles: An increase of transport-related costs for people and firms operating polluting vehicles. Strong impacts in urban areas, LEZ (Low Emission Zones) and in new Member States (less vehicle-efficient). Impacts on professional drivers (commercial, bus, taxi, etc.), it may be possible to provide incentives for fuel-efficient and safe driving Fuels: Few changes here for end users (drivers), with the exception of encouraging them to use different fuels (mixed fuels) for their vehicles. For commercial vehicles (taxi, buses, vans, etc.) there are substantial environmental and cost benefits from switching fuels. Biofuels and gas sources (LPG and GPL) also offer benefits.
Charging and taxation	Autoclubs Citizens Urban economic sectors	EU/National Regional Local Authority	Congestion charging is a difficult concept that needs a clear message to be sent to the users. According to The Bartlett School analysis (2006) 'you pay less, you must pollute less, either by driving less in distance, or by using a cleaner vehicle, or by making best use of available space'. The same argument applies to commercial vehicles, taxis and buses as they would all pay the charge according to their emissions profile.
Long-distance Travel (passengers and freight)	Citizens Employees (Trade unions) Shipping companies, intermodal operators, road hauliers and their federations (i.e. UIRR) Forwarding agents (EFFA) Logistics operators Manufacturing industries	Rail and Short-Sea Shipping operators Freight platforms, road terminals, sea and inland ports and terminals, airports and their associations Handling equipment manufacturers ICT operators National/regional and local government	Stakeholders involved in air transport may oppose this policy package, but air transport calls for solutions according to the industry's expected fast growth. There will be a strong pressure and encouragement to railway operators to reform their structures (not only operational but also commercial) and then to offer faster and more customer-friendly services. The charging measures could balance modal shift from truck to rail and to intermodal services

Policy packages	Users Groups	Private and Public sectors	Impacts on stakeholders
Liveable cities (urban policy)	Associations of European citizens (sustainable communities) Environmental NGOs	Public transport operators Urban economic sectors Regional and Local Authority ICT operators	Urban citizens will benefit hugely from a safer, quieter and cleaner environment. The improved accessibility of everyday services (ICT, soft measures) arising from changes in urban planning and land-use regulations will reduce travel costs and time.
ICT (Information and Communications Technology)	Citizens Employees	Public transport operators Local Authorities Chambers of Commerce High-tech industry Telecommunication Industry	Much of the potential of the ICT impacts has yet to be supported by high quality empirical data. The market suggests that rational choices should be made in order to enhance individual welfare, but the implication for travel is less clear. On its own, there may be minimal effect, but when combined with other measures that reflect full environmental costs and emissions levels, the impact may be greater.
Eco-friendly behaviour	Citizens Employees	Public Transport operators Local Authorities	The package involves extensive participation from individuals and businesses. Its main intention is to be holistic as all travel contributes to traffic demand management (workplace and school travel plans). Most of the actions here can be taken locally and it would depend on the local authority pressure and incentive to reduce car travel demand.
Logistics	Forwarding agents (EFFA) Logistics operators Industries Employees (Trade unions)	Chambers of Commerce EFFA European Freight Forwarders Association Local Authorities Intermodal operators, road hauliers	The sector is constantly affected by problems of strong competition and fragmentation. Operating costs will rise not only as a consequence of more stringent measures for reducing the impacts on the environment (i.e. fuel and labour costs), so that the overall approach has to be more focused on distribution platforms (especially in urban areas) and company concentration (including through commercial agreements). Further attention has to be paid to the effects of new technologies and supply-chain management on new Member States' operators.
Air and maritime	Passengers Cities near port or airport infrastructures and their citizens Employees and their unions	EUROCONTROL IATA ESPO and Port Authorities Shipping companies	Ship owners will have to resolve their strategy for calling at European seaports and sailing in SECAs (i.e. by abandoning fuel switching and adopting marine distillates) depending on the level of international regulation (IMO level) and EU mandatory schemes. Major effects will be on refineries and seaports, due to the higher costs of production for bunker fuels and strong competition among ports. Also airport duties should be more environment-oriented, depending on the level of transparency of charges and subsidies to the airline companies.

Source: TRT, 2007

Two main points are addressed by the IRU: traffic congestion increases CO_2 emissions: '*If a 40 tonne lorry is driving at 50 km/h, it will use around 28 l/100km. If it has to stop once per one km it will already consume 52 litres and if it has to stop two times during a stretch of one km the fuel consumption will increase considerably to 84 litres',* and road transport taxes should go to roads to reduce CO_2 emissions: '*Every year road users in the EU pay about € 350 billion through taxes from the transport sector, yet the public spending amounts to only € 100 billion per year. The IRU fully supports the principle that each mode of transport should cover its own costs but revenues collected from road users should be put back, first and foremost, into the improvement of road infrastructure, its maintenance and amortisation since adapting road infrastructure is essential to be able to meet the increasing demand for the mobility of persons and goods, as requested by citizens day after day, while simultaneously improving fuel savings and reducing CO_2 emissions'.*

In its strategy to address climate change, IATA has a proper industry-wide position on emissions trading for aviation, which is preferred on a voluntary basis over increases in (fuel/airport) taxes and charges, but underlines some key elements for a fair and accepted system: the preservation of the ICAO's global leadership and authority for implementing policies to reduce GHG emissions from international aviation, the opposition to unilateral inclusion of flights to/from third countries, open access to trading (allowances) markets by airlines, an initial free-of-charge distribution of emission allowances, the limitation of the scheme only to CO_2 emissions and the choice of targets and baselines which have to take into consideration existing infrastructure inefficiencies.

6.7 Cost-effectiveness of policy packages

Cost-effectiveness is one of the most consistent approaches to evaluating the efficacy of the measures adopted or to be adopted. The lack of ex post evaluation for many of the policies discussed makes it difficult to infer strong evidence on cost-effectiveness from past performance. Nevertheless, some general indications can be inferred from the review.

There is general agreement on the fact that technological developments or improvement of currently available technologies are most promising from a cost-effectiveness point of view. Past experience, in fact, has shown that the cost of new technologies can fall significantly over the time, whilst their effectiveness rapidly increases due to different learning mechanism (learning by searching, learning by doing, learning by using, etc).

A recent publication from ECCP[31] concludes that the costs of lowering average CO_2 emissions from 140g/km to 120g/km through vehicle technology would translate into a retail price increase of € 2.450 per vehicle. This is *in addition to* a retail price increase of € 1200 from reaching 140g/km in 2008. It has been calculated that societal costs (taking into account all relevant factors such as vehicle technology and cost savings as a result of reduced fuel consumption) are € 132 - € 233/t CO_2 abated for going from 140g/km to 120g/km.

The results on the cost-effectiveness of biofuels differ strongly depending on production pathways. Some biofuels are highly cost-effective. As a 1% increase in biofuels leads to annual CO_2 savings of 3.1-4 Mt per year in 2012, an increase of 5% would lead to savings of 15.5-

[31] Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2 emissions from passenger cars, Final Report, 31 October 2006.

20 Mt per year. Hydrogen, while not an effective tool in the short term, may have a role to play in the very long term.

The most cost-effective abatement policies come from initiatives to improve fuel efficiency. Significant cost-effective savings could also be made through efforts to promote fuel-efficient driving. ECCP data shows that eco-driving is not only cost-effective compared with other transport measures – it actually leads to cost savings for society (in all scenarios studied). Measures on existing and new drivers could lead to annual CO_2 savings of 7.6 Mt – more than half of which could be achieved by placing the full burden of reaching 120 g/km on vehicle technology.

Economic measures, in particular reform of vehicle taxation based on a vehicle's specific CO_2 and air pollution emissions and road charging policies, are less cost-effective than technological improvements; their impact on emission reduction is not so high but on the other hand they have the advantage of being more easily implemented and giving immediate results. Technology development may contribute to reducing further implementation costs of charging policies, and increase the feasibility of tradable mobility credits. It is important to underline that while the impacts of charging and taxation policies might be lower than the impacts of low-emission vehicles and innovative fuels they will enhance the effectiveness of many abatement measures.

Modal shift policies in general show a low cost-effectiveness in terms of the quantity of CO_2 and air emissions abated per amount invested and appear to offer only very limited potential. This low performance is due to a number of factors: first of all, the capacity of the alternative modes to absorb the diverted demand might be very limited and the level of service significantly lower than the dominant road modes, and require huge investments, and huge amount of resources while at the same time the impacts will come only in the long medium term, with the exception of urban areas where, given the high densities of well-targeted modal shift policies toward public transport, cycling and walking appear to offer reasonable potential, in terms of cost-effectiveness. Nevertheless, as infrastructure use is site-specific and therefore their use and success is highly dependent on local condition (demand, modal alternatives etc.) it is extremely difficult to generalise.

ICT and soft measures are unlikely to be very effective, at least in the short term but they might have significant impact in the medium to long term, particularly as they can prompt relevant changes in market and behaviour and should be included as important complementary measures.

7. POLICY RECOMMENDATIONS

7.1 The need for a consistent mix of policy measures

The problems resulting from the current levels of transport emissions are serious and, without a coordinated approach, will get worse in some respects. Only a sophisticated policy mix can respond to such a demanding challenge.

The literature review and the analysis of a number of practical actions strongly support the point of view that ***to achieve substantial reductions in transport emissions it is necessary to combine mutually supporting policies***, involving a variety of stakeholders.

There seems to be general agreement that individual policies will not contribute significantly to reducing CO_2 emissions and improving air quality, and that only combined polices or a policy mix including soft measures to raise awareness can do so. A policy mix can help mitigate the negative effects of a single measure, and therefore increase acceptability, and control rebound effects, i.e. problems of reversing the initial benefit gained through readjustment of individual behaviour. But the key aspect is that the combination of *push and pull* policies are able simultaneously to improve different dimensions of transport emissions problems. The synergies of combining different measures are such that the effect of combining them is better than the sum of the effects of individual policies.

Up to now, modal shift brought about by increasing the supply of competitive modes (rail, short-sea shipping, inland waterways, public transport, etc.) has proven to be weak in terms of CO_2 and emissions abatement, in particular for long-distance travel and non-urban areas. The reasons for this are manifold: investments in new infrastructure take a long time to be completed and therefore results can be seen only after several years, but the main one is that in general the shift of demand has shown to be much lower than expected. Indeed, people and goods are reluctant to abandon the road and air modes even when new or upgraded infrastructures for competing modes are in place unless they are pushed by demand management and pulled by integrated policies.

To be effective the integrated policies should cover all modes of transport and should include ambitious fuel-efficiency targets, improved standards for vehicles and fuels, reduction in road and air transport activity through charging, logistics and behavioural changes. The three main thrusts of the mix of mutually supporting policies are:

- Technological improvement (use of new vehicle technologies and alternative fuels),
- Charging and taxation (reform of road vehicle taxation, road charging, Eurovignette),
- Soft and eco-friendly measures (ICT, transport demand management, logistics measures) to optimise the use of private vehicles, improve the use of public transport and promote behavioural changes.

7.2 The relevance of focusing on selected policy actions

There is little strategic reason for action everywhere and therefore the EU policy should focus on those parts of the system that are more critical:

(i) congested urban and metropolitan areas, where the majority of passenger journeys take p place;

(ii) key interurban corridors where domestic, intra-EU and international trade are concentrated;

(iii) environmentally sensitive areas (Alpine region, Baltic Sea, etc.).

The approaches to CO_2 emissions and air quality impacts on the transport sector are in many cases overlapping and this means that there are significant synergies to be achieved in tackling the two problems in a coordinated way. Air pollution policies should concentrate on urban and metropolitan areas as well as on environmentally sensitive areas, where the impacts are particularly high. CO_2 and GHG emissions in general are a function of total transport demand and therefore urban areas and key interurban corridors are priority areas of intervention.

(a) ***Increase fuel efficiency for all modes of transport***. There is general agreement that technology is the most promising and effective tool for reducing transport-related pollution and GHG emissions. Nevertheless, technology progress is not sufficient in itself, while the severity of the problem also requires policies to be implemented that produce results in the short term, including incremental improvements of the current technologies, use of electric and hybrid vehicles, train and ships. The focus should be on increasing fuel efficiency for all modes of transport, especially air and road transport including vehicles in the Eco-design Directive and the planned Energy End-Use Efficiency Directive and on reducing the emissions target for the passenger car fleet to 120 g CO_2 per vehicle-kilometre by 2012 and to 100 by 2020 and extending such an approach to cover trucks, aircraft and ships. COM (2007) 19 underlines that in a long-term vision the Commission will support research into '*improvements in vehicle efficiency that will deliver as much a 40% reduction in CO_2 emission passenger cars for the new vehicle fleet in 2020. This would correspond to a new car fleet average of 95g CO_2/km*'. To reach this target, a system of emission credits has been proposed. See also the Carbon Allowance Reduction System (CARS) recently proposed in the European Parliament Report (point c).

(b) ***Get the prices right so that passengers and freight face the full cost of travel and feel the consequences of their decisions***. A general reform of taxation in the transport sector, clearly based on CO_2 emissions and other environmental emissions, appears to be a fundamental instrument for maximising the abatement of emissions. The policy should be designed to provide strong incentives to shift towards better performing vehicles in all transport modes: tax levels linked to vehicle energy and emissions efficiency (lower for more energy-efficiency, higher for less energy-efficiency), to congestion charging on roads and to environmental charging across modes.

(c) ***Introduce innovative measures based on the 'emissions trading' approach***. One argument often raised against road charging is that imposing an additional cost on car

users unfairly affects different population groups, e.g. low-income individuals who have no alternative to using the car. Technologies now allow more sophisticated *push and pull* approaches to be introduced with a view to more sustainable urban mobility based on a mix of 'pay as you go' and rationing policies with the possibility of trading the external costs of transport. A first step in this direction is to couple road charging with a mechanism based on ***tradable mobility credits***. Mobility credits would guarantee to everyone the freedom to move and will be differentiated according to several aspects such as vehicle type (size, emission class), but also the supply of alternative modes. The same closed market mechanism applied on the car manufacturing side, the Carbon Allowance Reduction System (CARS), might help in obtaining substantial reductions in CO_2 emission levels (see point a): manufacturers and importers will be required to pay financial penalties in proportion to any exceedance per car sold of the emissions limits. These penalties may be offset by redeemable credits awarded to newly registered passenger cars of the same manufacturer with emissions below the limit value curve.

(d) ***Support a modal shift from individual car to public transport, walking and cycling, in urban areas and from road to rail freight transport through charging policies and soft measures***. As stated before, urban and metropolitan areas suffer of high levels of pollution and at the same time alternatives to private transport are already available. A combination of charging policies (congestion charging) and improvements in public transport supply can significantly reduce emissions, particularly if public transport service enhancements are achieved through short-term measures, such as fleet renewal, bus priority, information technologies etc.

(e) ***Prompt a more efficient organisation of road freight transport***. For long-distance freight transport, truck-km charges have proved to induce a process of rationalisation of distribution systems and logistics organisation, and thus to reduce distances and optimise routing, load factors and occupancy rates. There is general agreement that the freight distribution sector as well as logistics still have scope for optimisation and this might be exploited by strongly differentiated taxation and charging policies in order to encourage more efficient use of the existing fleets.

(f) ***Promote more responsible behaviour to road users***. Develop eco-drive procedures in the road transport sector (freight and passenger) to reduce emissions and fuel consumption. Demarketing of cars, support for car sharing and car pooling initiatives, support to green logistics, and promoting an eco-drive ITS are all soft measures that might play a highly positive role in strengthening the positive impacts of other hard measures and in some cases in mitigating negative impacts.

(g) ***Encourage integrated land use and transport planning***. Spatial planning at urban and regional level might play an important role in the medium and long term both in slowing down the increase in distance travelled for goods and passengers and in increasing the attractiveness of alternative modes by concentrating new developments on rail or metro or near ports or intermodal nodes.

The actions will inevitably have to be adapted for specific countries, regions, and urban areas whose needs and problems vary widely. As a consequence, the 'weight' of each package or measure in the policy mix has to be carefully chosen in order better to exploit their potential positive impacts.

7.3 Policy recommendations by transport mode

The recommended policy process for **road transport** should start from technological measures to improve fuel quality and energy efficiency coupled with price signals, based on the internalisation of external transport costs and including taxation reform and differentiated charging schemes in interurban areas, as well as tradable mobility credits in urban areas. A further component of such a process is the soft measures to influence the time of journey or the need to travel and to increase the attractiveness of more environmentally friendly modes of transport (public transport, walking and cycling, speed limits, information technology, etc.), with a particular focus on high densely populated areas.

Rail transport should reduce its impact on the environment using two main levers: efficiency in passenger and freight services (e.g. increased load factors and cost-effectiveness of all transport activity) and integration in the intermodal chain. To maximise benefits, interoperability should be defined and pushed on High Speed Trains and conventional lines (including track access to terminals and main port facilities in accordance with Directive 2004/50/EC) on the basis of the same rationale, the same regimes and the same technical and administrative requirements.

Public transport in urban areas should be improved using a complete mix of policies, where economic measures concerning supply are supported by proper TDM policies for managing demand in a sustainable way, with specific attention being paid to measures which are capable of reducing car use (as in the Green Paper of Urban Transport being prepared).

Aviation's ecological footprint has grown steadily in the past due to the increasing demand for air traffic and despite efficiency increases achieved through technological improvements and operational measures. There is a lack of political action to reduce environmental impacts from aviation at international level, despite the upward trend foreseen for the next few decades. In addition to further technological advancements, the economic regulatory lever mixed with a price policy, including emissions trading (as proposed in Directive EC 2006), is suggested as the best instrument to re-align the sector to more sustainable growth.

Maritime transport (deep-sea, short-sea and inland shipping) has a wide range of measures available to reduce its polluting effects, such as technological innovations (advanced vessel/hull design concepts, low-sulphur marine bunker fuels, marine engine improvements), economic instruments (environmentally differentiated port fees and charges, fleet renewal incentives) and economic or operational measures for promoting intermodal transport (rail links connecting ports and inland terminals, bonus to shift lorries from road to sea).

7.4 The importance of accompanying measures to support new technologies development

It might be counterproductive to call for action to be taken on all measures; priority should be given to measures that can also produce benefits in the short term, and this includes the option to make the best use of existing transport networks, to sustain the effectiveness of long-term benefits.

There is general agreement that innovation technology (both for vehicles and for fuels) is the most promising and effective tool for reducing transport-related pollution and GHG emissions in the ***long term***. Nevertheless, technological progress is not sufficient in itself. In order to reach the ambitious EU target, it is necessary to ***support new technologies with a consistent package of accompanying measures***:

- Amendment of the Eurovignette directive charge related to type of vehicle (emissions and consumption) and distance travelled;
- Promotion of congestion charging in cities and selected (congested) corridors;
- Introduction of tradable mobility credit schemes in urban and metropolitan areas;
- Incentives to increase occupancy and load factors to offset the costs of road charging to users;
- Support for captive fleets renewal (particularly for public transport, car sharing fleets, taxis) through a system of incentives.

In order to be effective in the ***short term***, the use of alternative fuels (such as natural gas, biofuels, electricity and hydrogen) needs to be supported by:

- Tax reform aimed at promoting fuel-efficient cars and proposals to reduce taxes for road vehicles that emit less CO_2 and increase them for those with higher emissions;
- Extension of emissions targets to trucks, aircraft, ships;
- Training campaigns (eco-driving) for professional and public transport drivers;
- Demarketing campaign for the car transport mode (shifting demand to the most eco-efficiency cars available).

The following table reports the main recommendations, showing how the EU can contribute to the implementation of the measures.

Table 17 Recommended measures

Measures	Best level to act	How can EU contribute?	Goals/actions/instruments
Technological improvement			
Compulsory targets for CO_2 emissions of cars and vans	EU	Reviewing the Community strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles. Supporting improvements in vehicle efficiency that will deliver a 40% reduction in CO_2 emissions by passenger cars for the new vehicle fleet in 2020.	Cars: 120g/km by 2012 and 95g CO_2/km by 2015 Van: 175 g/km by 2012 and 160 g/km
Improving alternative fuels and energy efficiency	EU Member States	Promoting energy efficiency in all transport modes and achieving energy savings by promoting the increase of alternative fuels (such as second generation biofuels).	9% reduction in energy consumption by 2016 New EU Directive by the end of 2007 to achieve 10% use of renewable energies by 2020
Charging and taxation			
Reform of road taxation	EU Member States	Re-structuring road registration tax and annual circulation tax by linking taxation to CO_2 emissions and energy consumption	New directive by 2012
Charging for long-distance freight	EU Member States	Introducing into the new directive a toll differentiation according to vehicle weight and environmental performance and extending it to the entire interurban road network.	Amended Eurovignette Directive by 2008 Harmonising EU charges by 2010 Appling the Eurovignette to all vehicles over 3.5 tonnes by 2012
Charging for interurban roads and sensitive areas	EU Member States Regional	Promoting the introduction of congestion charging on interurban roads Promoting emissions charging in sensitive areas	New directive based on the model for the internalisation of marginal cost pricing by 2010
Charging for urban and metropolitan areas	EU Local/regional Level	Promoting congestion charging Introducing innovative measures based on 'tradable mobility credits'	Action plan in Green paper for urban mobility by 2008
Other supporting measures			
Information and Communications Technology	EU Member States	Promoting research and development applications on passenger and freight transport services and infrastructure management in order further to develop ITC	New roadmap for Information Transport System by 2008
Improving public transport services	EU Member States Local	Harmonising regulation of public transport services on rail and road	New directive on regulation of public transport services by rail and road by 2008

Transport demand management	EU Local	Developing car sharing and car pooling systems to integrate public transport services Developing walking and cycling facilities	Action plan in Green paper for urban mobility by 2008
Improving efficiency in city logistics	EU Local	Supporting city logistics schemes (delivery regulation in the city centre)	Freight Transport Logistics Action plan by 2008
Eco-driving	EU Member States	Promoting European strategy for improving driving behaviour for energy efficiency and traffic safety	Eco-drive Campaign
Integrated land use and transport planning	EU Local	Promoting the follow-up of sustainable urban transport plans (SUTPs)	Action plan in Green paper for urban mobility by 2008
Demarketing of cars	EU Member States	Promoting eco-friendly behaviour among car trade/brand and customers	New directive on environmental certification of vehicles based CO_2 emissions and consumption by 2008-2010

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ANNEX TO CHAPTER 1

Urbanisation 1990-2004

Our society is constantly changing. There are a number of major societal trends that have a clear impact on demand for transport and on the way urban transport influences citizens' daily life.

It is of strategic importance to have a good understanding of the impact of global trends on urban transport, both short-term and long-term, and both on the supply and on the demand side.

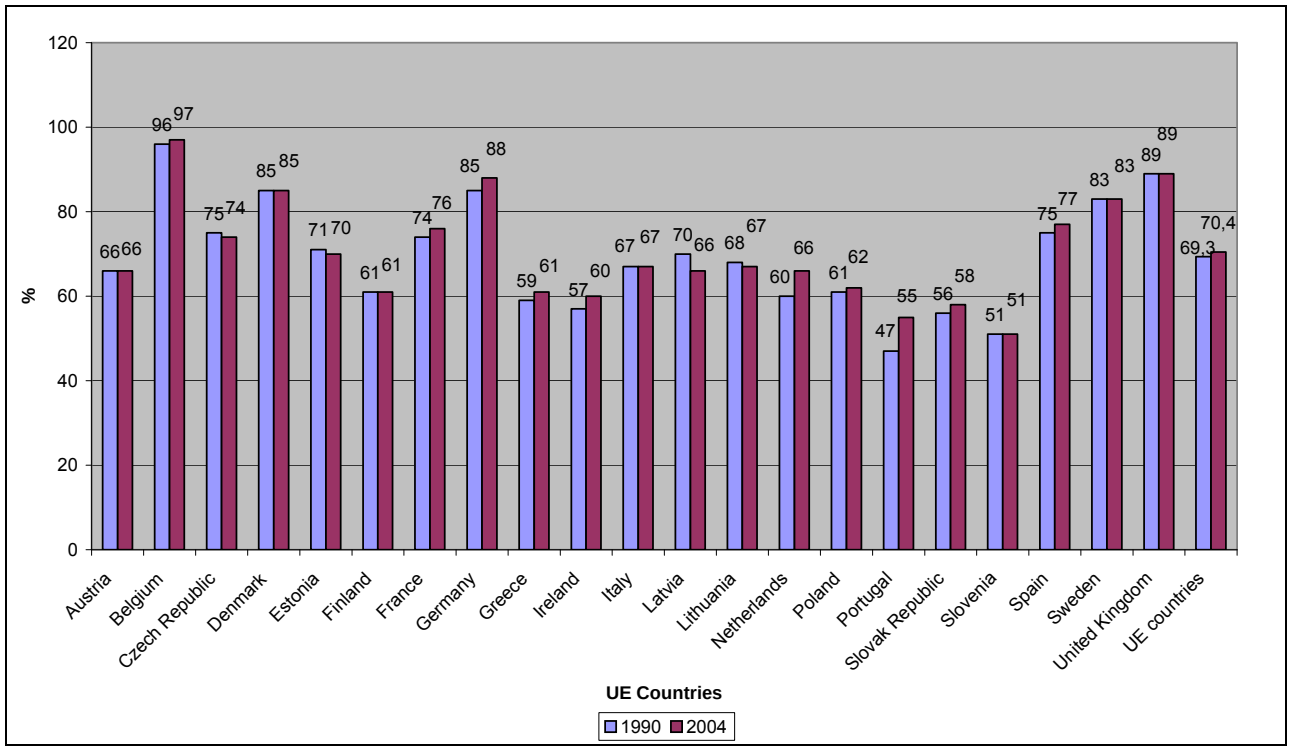
Demographic trends have a direct impact on the demand side. But changes in demand might in the longer term lead to changes in supply.

Consequently, special attention should be given to transport in urban areas. In fact, more than anyone else, city dwellers directly experience the growth of traffic and the consequent negative effects on their own mobility.

As shown in Figure 1, 70.4% of Europeans live in an urban environment. Public transport, cars, lorries, cyclists and pedestrians all share the same infrastructures.

Belgium, the United Kingdom and Germany have the highest percentages of urban population as a proportion of the total population.

Figure 23 Urban population - % of total population in EU countries (1990-2004)



Source: World Bank – 2006 World Development Indicators

However, the constant trend of the urbanisation of European society resulting from influxes from rural or less prosperous areas and from migration, especially from third countries, only gives a general picture. In fact, there are major cities that are experiencing exactly the opposite pattern: they are losing significant numbers of inhabitants.

Between 1990 and 2004 the population of the EU-25 cities or metropolitan areas did not increase substantially, with an urban population growth percentage of 6.7% (Table 18).

The positive growth of the 15 EU countries urban population (7.8%) is not confirmed by the data concerning the cities of the new European Union Member States which show a decline in their urban population (-1%).

These demographic trends will have a huge impact on the overall demand for transport, and the characteristics of the solutions that are offered.

Table 18 Urban population, comparison between the EU-15 and the EU-25, 1990-2004

		urban population				
		millions		% of total population		% growth
		1990	2004	1990	2004	1990-2004
EU-15	Austria	5,1	5,4	66	66	5,9%
	Belgium	9,6	10,1	96	97	5,2%
	United Kingdom	51,1	53,4	89	89	4,5%
	Sweden	7,1	7,5	83	83	5,6%
	Denmark	4,4	4,6	85	85	4,5%
	Spain	29,3	32,7	75	77	11,6%
	Finland	3,1	3,2	61	61	3,2%
	France	42	46,2	74	76	10,0%
	Germany	67,8	72,9	85	88	7,5%
	Greece	6	6,8	59	61	13,3%
	Ireland	2	2,4	57	60	20,0%
	Italy	37,8	38,8	67	67	2,6%
	Netherlands	9	10,8	60	66	20,0%
	Luxembourg	/	/	/	/	/
	Portugal	4,6	5,8	47	55	26,1%
EU-15 Total		278,9	300,6			7,8%
EU-10 new countries	Malta	/	/	/	/	/
	Lithuania	2,5	2,3	68	67	-8,0%
	Poland	23,2	23,7	61	62	2,2%
	Slovak Republic	3	3,1	56	58	3,3%
	Slovenia	1	1	51	51	0,0%
	Latvia	1,9	1,5	70	66	-21,1%
	Estonia	1,1	0,9	71	70	-18,2%
	Czech Republic	7,8	7,6	75	74	-2,6%
	Unghery	/	/	/	/	/
	Cyprus	/	/	/	/	/
EU-10 total		40,5	40,1			-1,0%
EU-25 total		319,4	340,7			6,7%

Source: World Bank – 2006 World Development Indicators

ANNEX TO CHAPTER 2

Main transport pollutants and greenhouse gases

CO_2

Description	**Carbon dioxide** is a colourless, odourless gas, denser than air that occurs naturally in the earth's atmosphere. It is slightly soluble in water, forming carbonic acid
Impact on environment	The main environmental concern with carbon dioxide is the role this compound plays as a greenhouse gas influencing climate change
Cause	Man-made carbon dioxide is produced by combustion processes and released into the atmosphere in chimney emissions from power stations, motor vehicles and other processes where fuels containing carbon are burnt. The concentration of carbon dioxide has increased by around 30% since the industrial revolution, mainly as a result of the combustion of fossil fuels.

CH_4

Description	**Methane** is a colourless gas, odourless at low concentrations, but with a sweetish chloroform-like odour at high concentration. It is highly combustible, and mixtures of about 5 to 15 per cent in air are explosive. Upon release into the atmosphere methane is destroyed by reactions with other chemicals in the atmosphere, giving a lifetime of about 10 years.
Impact on environment	The main environmental concern with methane is the role it plays as a greenhouse gas influencing climate change. The concept of global warming potential has been developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. Carbon dioxide has a global warming potential (GWP) of 1 (over 100 years). Although less methane is emitted into the environment the global warming potential of methane is 21 times that of carbon dioxide (over 100 years).
Cause	Methane occurs naturally in the environment. On a global scale, the human activities that result in the most methane emission, in descending order of importance, are livestock farming, production of fossil fuels, wet rice cultivation, biomass burning, landfill and domestic sewage.

N_2O

Description	Under normal environmental conditions dinitrogen oxide (more commonly known as **nitrous oxide**) is a colourless gas with a slightly sweet taste and odour. It is non-flammable itself but will support combustion and is only slightly soluble in water.
Impact on environment	The main impact of nitrous oxide on the global environment is as a greenhouse gas, leading to global warming. Nitrous oxide is for many countries the third most important greenhouse gas, after carbon dioxide and methane. Although emissions of nitrous oxide to the environment are lower, its global warming potential is 310 times that of carbon dioxide. The concept of global warming potential has been developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. Nitrous oxide is also an ozone-depleting substance causing damage to the ozone layer when it reaches the upper atmosphere.
Cause	Lower-level emissions arise from combustion processes in the power-generation sector and from road transport. Emissions from road transport are increasing as a result of the growing number of petrol-driven cars fitted with 3-way catalytic converters, as the converters produce significantly larger emissions of nitrous oxide. The contribution of road transport is minor but important because it is steadily growing in contrast with the other sectors which are declining.

NO_x

Description	The term **'nitrogen oxides'** (NOx) is usually used to refer to two gases, nitric oxide (NO), which is a colourless, odourless gas, and nitrogen dioxide (NO_2), which is a reddish-brown gas with a pungent odour. Nitric oxide reacts with oxygen or ozone in the air to form nitrogen dioxide. Inhalation of the pure gases is rapidly fatal.
Impact on environment	Nitrogen dioxide is one of the gases that contribute to acid rain-causing damage to vegetation, buildings and to the acidification of lakes and streams. Ground-level ozone is formed by a chemical reaction between oxygen, nitrogen dioxide and volatile organic compounds (VOCs) in the presence of sunlight. High concentrations of ozone can also damage crops and other plant life as well as materials such as rubber. Nitrogen dioxide can react with organic peroxy radicals (formed from the breakdown of volatile organic compounds (VOCs) in the air) to form PANs (peroxyacetyl nitrates), which can serve as a temporary reservoir for reactive nitrogen and may be transported long distances.
Cause	Major man-made releases of nitrogen oxides are primarily from fuel combustion, biomass burning and some production processes. Combustion processes emit (among many other releases) a mixture of nitric oxide (90%) and nitrogen dioxide (10%). The nitric oxide reacts with other chemicals in the air to become nitrogen dioxide.

SO_x

Description	The most common **sulphur oxide** is sulphur dioxide (SO_2). Sulphur trioxide (SO_3) is an intermediate product formed during the manufacture of sulphuric acid (contact process). Sulphur dioxide is a colourless gas with a penetrating, choking odour. It dissolves readily in water to form an acidic solution (sulphurous acid).
Impact on environment	Sulphur dioxide emitted in sufficient quantities at low or ground level can combine with air moisture to cause gradual damage to some building materials (such as limestone) by forming an acid solution that gradually dissolves the stonework if it is constantly exposed. Sulphur dioxide gas dissolves in the water droplets in clouds causing the rain to be more acidic than usual. Pollutants can be transported thousands of kilometres as a result of the introduction of tall chimneys, dispersing pollutants high in the atmosphere. Acid rain affects the natural balance of rivers, lakes and soils, resulting in damage to wildlife and vegetation.
Cause	The main emission source of sulphur dioxide is the burning of fossil fuels. Power stations, oil refineries and other large industrial plants contribute the majority of the total mass released. Motor vehicles and domestic boilers, as well as natural sources such as active volcanoes and forest fires, release sulphur dioxide. Oxidation of other sulphur compounds (such as hydrogen sulphide) released into the atmosphere by natural and man-made processes provide another emission source. From 1970 to 1998 the amount of sulphur dioxide being released into the atmosphere annually was reduced by 75%. This reduction was largely a result of the decreasing use of coal for power generation and its replacement by natural gas.

NMVOCs

Description	The **Non-Methane Volatile Organic Compounds** are a group of chemicals (methane is excluded) that contain the element carbon in their molecular structure - i.e. are 'organic'. They easily vaporise at room temperature and most of them have no colour or smell. NMVOCs include in general the following chemical groups: alcohols, aldehydes, alkanes, aromatics, ketones and halogenated derivatives of these substances.
Impact on environment	Many NMVOCs are involved in reactions that form ground-level ozone, which can damage crops and many materials as well as have potential effects on human health.
Cause	NMVOCs are released from the burning of fossil fuels, in particular the burning of petrol in road transport. NMVOCs are often present in solvents, for example in paints and aerosol sprays. Trees and other plants also produce NMVOC naturally.

CO

Description	**Carbon monoxide** is a colourless, odourless, poisonous gas. It is formed when fuels containing carbon are burnt in conditions where oxygen is limited. It is slightly lighter than air. Carbon monoxide can form explosive mixtures with air.
Impact on environment	Carbon monoxide reacts with other pollutants to produce ground-level ozone, which can harm human health and damage buildings and plants.
Cause	Carbon monoxide is produced when fuels containing carbon are burnt in conditions where oxygen is limited. Petrol engines are the main source of carbon monoxide. However, emissions are much lower from modern vehicles fitted with catalytic converters. Carbon monoxide concentrations in urban areas are closely related to motor traffic density and to weather conditions. Concentrations can vary greatly during the day, reflecting traffic levels and speed. Vehicles produce most carbon monoxide when idling or decelerating. Other minor sources are power stations and waste incinerators.

PM_{10} - Particulate matter less than 10 µm

Description	**PM_{10} particles** are made up of a complex mixture of many different species including soot (carbon), sulphate particles, metals and inorganic salts such as sea salt. The particles vary in size and shape, up to 10 microns diameter.
Impact on environment	Particles can stick to the surfaces of buildings resulting in blackening of the facades. Research is currently underway to elucidate the role particulates play in climate change.
Cause	Soot particles are released into the air from combustion processes like coal burning, road transport, waste incineration and other industrial processes. Sulphate particles can arise from combustion of fuel containing sulphur, either directly or by subsequent chemical reactions of sulphur dioxide with other air-borne species.

GHG: Proposed caps by Member State

The European Union Greenhouse Gas Emissions Trading Scheme (EU ETS) is based on Directive 2003/87/EC, which entered into force on 25 October 2003. For the second trading period, running from 2008 to 2012, the Commission is now adopting the decision on individual national allocations. The table below shows the approved allowances for 2005-2007 and the proposed and the approved caps for 2008-2012 in the EU.

Member State	1st period cap	2005 verified emissions	Proposed cap 2008-2012	Cap allowed 2008-2012 (in relation to proposed)	Additional emissions in 2008-2012	JI/CDM limit 2008-2012 in %
Austria	33.0	33.4	32.8	30.7 (93.6%)	0.35	10
Belgium	62.1	55.58	63.3	58.5 (92.4%)	5.0	8.4
Cyprus	5.7	5.1	7.12	5.48 (77%)	n.a.	10
Czech Rep.	97.6	82.5	101.9	86.8 (85.2%)	n.a.	10
Estonia	19	12.62	24.38	12.72 (52.2%)	0.31	0
Finland	45.5	33.1	39.6	37.6 (94.8%)	0.4	10
France	156.5	131.3	132.8	132.8 (100%)	5.1	13.5
Hungary	31.3	26.0	30.7	26.9 (87.6%)	1.43	10
Germany	499	474	482	453.1 (94%)	11.0	12
Greece	74.4	71.3	75.5	69.1 (91.5%)	n.a.	9
Ireland	22.3	22.4	22.6	22.3 (98.6%)	n.a.	10
Italy	223.1	225.5	209	195.8 (93.7%)	n.k.	14.99
Latvia	4.6	2.9	7.7	3.43 (44.5%)	n.a.	10
Lithuania	12.3	6.6	16.6	8.8 (53%)	0.05	20
Luxembourg	3.4	2.6	3.95	2.5 (63%)	n.a.	10
Malta	2.9	1.98	2.96	2.1 (71%)	n.a.	t.b.d.
Netherlands	95.3	80.35	90.4	85.8 (94.9%)	4.0	10
Poland	239.1	203.1	284.6	208.5 (73.3%)	6.3	10
Slovakia	30.5	25.2	41.3	30.9 (74.8%)	1.7	7
Slovenia	8.8	8.7	8.3	8.3 (100%)	n.a.	15.76
Spain	174.4	182.9	152.7	152.3 (99.7%)	6.7	ca. 20
Sweden	22.9	19.3	25.2	22.8 (90.5%)	2.0	10
UK	245.3	242.4	246.2	246.2 (100%)	9.5	8
Total	**2109**	**1947.86**	**2101.64**	**1903.43 (90.5%)**	**53.84**	**-**

National emission ceilings for SO_2, NOx, VOC and NH3, to be attained by 2010 (1)

Country	SO_2	NOx	VOC	NH3
	Kilotonnes	Kilotonnes	Kilotonnes	Kilotonnes
Austria	39	103	159	66
Belgium	99	176	139	74
Bulgaria (3)	836	247	175	108
Cyprus (2)	39	23	14	9
Czech Republic (2)	265	286	220	80
Denmark	55	127	85	69
Estonia (2)	100	60	49	29
Finland	110	170	130	31
France	375	810	1050	780
Germany	520	1051	995	550
Greece	523	344	261	73
Hungary (2)	500	198	137	90
Ireland	42	65	55	116
Italy	475	990	1159	419
Latvia (2)	101	61	136	44
Lithuania (2)	145	110	92	84
Luxembourg	4	11	9	7
Malta (2)	9	8	12	3
Netherlands	50	260	185	128
Poland (2)	1397	879	800	468
Portugal	160	250	180	90
Romania (3)	918	437	523	210
Slovakia (2)	110	130	140	39
Slovenia (2)	27	45	40	20
Spain	746	847	662	353
Sweden	67	148	241	57
United Kingdom	585	1167	1200	297
EC27	**8297**	**9003**	**8848**	**4294**

(1) These national emission ceilings are designed with the aim of broadly meeting the interim environmental objectives set out in Article 5. Meeting those objectives is expected to result in a reduction of soil eutrophication to such an extent that the Community area with depositions of nutrient nitrogen in excess of the critical loads will be reduced by about 30% compared with the situation in 1990.

(2) These national emission ceilings are temporary and are without prejudice to the review under Article 10 of the Directive.

(3) Provisional information based on accession treaty

Pollutant concentration limits as established by EU legislation

Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes health-based standards and objectives for a number of pollutants. These standards and objectives are summarised in the table below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times. The Air Quality Framework Directive (Council Directive 96/62/EC) on ambient air quality assessment and management describes the basic principles as to how air quality should be assessed and managed in the Member States. The individual EU directives mentioned in the table below are the daughter directives of the Framework Directive; they set numerical limits and thresholds and apply to specific pollutants.

Pollutant	Concentration threshold ($\mu g/m^3$)	Legal nature	EU reference
SO_2	human health (average 1h ≤ 350 + 120 not more than 24 times/year)	Limit value enters into force 1.1.2005	Council Directive 1999/30/EC
	human health (average 24h ≤ 125 not more than 3 times/year)		
	ecosystem health (yearly/winter average ≤ 20)		
NO_2	human health (average 1 h ≤ 200+90 not more than 18 times/year)	Limit value enters into force 1.1.2010	Council Directive 85/203/EEC
	human health (yearly average ≤ 40+18)		
NO_X	ecosystem health (yearly and winter average ≤ 30)	Limit value enters into force 1.1.2010	Council Directive 1999/30/EC
PM_{10}	human health (average 24h ≤ 50+20 not more than 35 times/year) human health (yearly average ≤ 40+6.4)	Limit value enters into force 1.1.2005	Council Directive 1999/30/EC
CO	human health (max average 8h ≤ 10+6)	Limit value enters into force 1.1.2005	Directive 2000/69/EC
C_6H_6	human health (yearly average ≤ 5+5)		
O_3	human health (max average 8h ≤ 120 not more than 20 days/year[(1)])	Target value enters into force 1.1.2010	Directive 2002/3/EC
	vegetation health (AOT40 May-July ≤ 18[(2)])	Target value enters into force 1.1.2010	Directive 2002/3/EC
Benzene	0.5 µg/m3 - 1 year of averaging period	Limit value enters into force 1.1.2010	Directive 2000/69/EC
$PM_{2.5}$	only establishes monitoring requirements		Council Directive 1999/30/EC

Source: Council Directive 96/62/EC

ANNEX TO CHAPTER 3

Summary of current government support measures for biofuels in selected countries/regions

Country	Official targets*	Production incentives	Consumption incentives
Brazil	40% rise in production, 2005-2010 (ethanol)	Tax incentives for oil-seed production Loan assistance Reduced levels of industrial tax	Tax exemptions for vehicles able to use E blends, and flex-fuel vehicles Fuel tax advantage over petrol Price controls
US	2.78% for 2006 (ethanol)	Tax credits Producer payments Grant and loan programmes	Vehicle tax credits and fuel tax exemptions Subsidies on flex-fuel vehicles Government fleet requirement Loan assistance
Canada	3.5% by 2010 (ethanol)	Some provinces exempt ethanol from road tax	Exemption excise tax (CA$ 0.085/litre)
Sweden	3% in 2005 (biofuels by energy content)	Tax incentives for new plants Access to EU Common Agricultural Policy (CAP) provisions Capital grants	Exemption from fuel excise duty
France	5.75% in 2008 7% in 2010; 10% in 2015 (biofuels)	Tax credits on equipment using renewable energy Tax penalty on refiners not using Biofuels Access to EU CAP provisions Capital grants	Capped fuel tax exemptions Quotas
Germany	2% in 2005 (biofuels)	Access to EU CAP provisions	Fuel tax exemptions for both pure and Capital grants for blended biofuels
UK	5% by 2020 (biofuels by energy content)	Access to EU CAP provisions Capital grants	Part fuel excise exemption
Japan	500 million litres by 2010	None (imports are expected to cover most ethanol needs)	None
China	15% by 2020 (total renewables)	$200 million research and development budget Loan assistance Various direct subsidies, including tax exemptions	

Sources: IEA databases; ACG (2005).

ANNEX TO CHAPTER 4

Policy documents and literature fiches

Thematic Strategy on Air Pollution, COM(2005) 446 final

Title		Communication from the Commission to the Council and the European Parliament, *Thematic Strategy on Air Pollution*, COM(2005) 446 final
Author(s)		Commission of the European Communities
Year		2005
Keyword		**Air Pollution**
Methodology	Assumptions	Air pollution damages human health and the environment. EU action has focused on establishing minimum quality standards for ambient air and tackling the problems of acid rain and ground level ozone. Fuel quality has improved and environmental protection requirements were integrated into the transport and energy sectors. Despite significant improvements, serious air pollution impacts persist.
	Approach	Extensive analysis was done to determine the costs and benefits of different levels of ambition with a view to finding the most cost-effective level consistent with the Community's Lisbon and sustainable development strategies. The analysis and the different scenarios are described in detail in the Impact Assessment accompanying this Communication. The chosen strategy sets health and environmental objectives and emission reduction targets for the main pollutants. These objectives will be delivered in stages.
	Parameters	By setting objectives to be attained by 2020, EU citizens will be protected from exposure to particulate matter and ozone in air and European ecosystems will be better protected from acid rain, excess nutrient nitrogen and ozone. This implies that: ▪ the concentration of $PM_{2.5}$ would be reduced by 75% and ground level ozone by 60% from what is technically feasible by 2020; ▪ the threat to the natural environment from both acidification and eutrophication will be reduced by 55% from what is technically possible; ▪ SO_2 emissions will need to decrease by 82%, NOx emissions by 60%, VOCs by 51%, ammonia by 27% and primary $PM_{2.5}$ by 59% relative to emissions in 2000.
Main Contents	Objective	Against the persistent pollution impacts, the Community's Sixth Environmental Action Programme called for the development of a thematic strategy on air pollution with the objective to attain *'levels of air quality that do not give rise to significant negative impacts on, and risks to human health and the environment'*.
	Conclusions	The thematic strategy on air pollution will be implemented through: ▪ a revision of the current ambient air quality legislation, which will be better focused on the most serious pollutants and integrated with other existing provisions; ▪ the introduction of new air quality standards for fine particulate matter ($PM_{2.5}$) in air; ▪ the revision of the national emission ceilings directive (NECD) to ensure reduced emissions of nitrogen oxides, sulphur dioxide, volatile organic compounds, ammonia and primary particulate matter. The national emission ceilings directive (***NECD***) will also be revised to ensure reduced emissions of nitrogen oxides, sulphur dioxide, volatile organic compounds, ammonia and primary particulate matter consistent with the interim objectives proposed for 2020.

Recommended measures	▪ Simplification of air quality legislation with a legislative proposal of a Directive (see COM(2005) 447) that clarifies and simplifies, repeals obsolete provisions, modernises reporting requirements and introduces new provisions on fine particulates; ▪ Integrating air quality concerns into other policy areas: - Energy: more efficient use of energy and better use of natural resources; - Transport: to encourage shifts towards less polluting modes of transport, alternative fuels, reduced congestion and the internalisation of externalities into transport costs. To make a proposals regarding a common framework of infrastructure charging for all modes ▪ Road transport: guidelines for differentiated charging according to air pollution damage and impacts in environmentally sensitive areas, obligations and recommendations on public authorities to implement minimum annual procurement quotas of new cleaner and energy efficient vehicles, establishing a common framework for designating low-emission zones; ▪ Aviation: use of economic instruments to reduce the climate change impact of aircraft; ▪ Shipping: to strengthen current air emission standards; to consider a proposal for tighter NOx standards by the end of 2006; to promote shore-side electricity for ships in port; to ensure low-emission operation is effectively applied as a criterion for EU funding programmes.

Proposal for a Directive of the European Parliament and of the Council presented by the Commission *on ambient air quality and cleaner air for Europe*, COM(2005) 447 final

Title		Proposal for a Directive of the European Parliament and of the Council presented by the Commission *on ambient air quality and cleaner air for Europe*, COM(2005) 447 final
Author(s)		Commission of the European Communities
Year		2005
Keyword		**Air Pollution**
Methodology	Assumptions	In the year 2000, exposure to particulate matter was estimated to reduce average statistical life expectancy by approximately nine months in the EU-25. This equates to approximately 3.6 million life years lost or 348 000 premature mortalities per annum. In addition, it has been estimated that there were some 21 400 cases of hastened death due to ozone.
	Approach	This proposal is consistent with Article 175 of the Treaty establishing the European Community and aims to provide a high level of protection for human health the environment. Numerous subjects have been consulted in developing this proposal: the interested stakeholders including industry groups, Member States, NGOs and scientific experts. All reports from experts have been routinely uploaded to the internet for public dissemination.
	Parameters	The Commission suggests the following options in respect of controlling human exposure to $PM_{2.5}$. Each option assumes that the existing limit values for PM_{10} remain in force: ▪ introduce an exposure reduction target for $PM_{2.5}$ to be attained by 2020, to reduce annual average urban background concentrations of $PM_{2.5}$ by a defined percentage rate of the Member State measured average over 2008-2010. This target to be achieved as far as possible but is not legally binding. ▪ replace the indicative limit values for PM_{10} for the year 2010 by a legally binding 'cap' for the annual average concentrations of $PM_{2.5}$ of 25μgm^{-3} to be attained by 2010. Such a 'cap' or ceiling would be designed to limit unduly high risks to the population; The benefits of the preferred combination have been estimated at EUR 37 to 120 billion per annum with costs of around EUR 5 billion per annum.

Main Contents	Objective	In 1996 the Air Quality Framework Directive was adopted which established a Community framework for the assessment and management of ambient air quality in the EU. The Framework Directive also provided a list of priority pollutants for which air quality objectives would be established in daughter legislation. There have subsequently been four daughter directives in respect of particular pollutants and a Council Decision to bring about the reciprocal exchange of air quality monitoring information. The current proposal aims to merge the provisions of five separate legal instruments into a single directive with the intention of simplifying, streamlining and reducing the volume of existing legislation: ▪ Council Directive 96/62/EC on ambient air quality assessment and management ('Framework Directive'), OJ L 296, 21.11.1996, p. 55. ▪ Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air, OJ L 163, 29.6.1999, p. 41 ('First Daughter Directive'). ▪ Directive 2000/69/EC of the European Parliament and of the Council relating to limit values for benzene and carbon monoxide in ambient air, OJ L 313, 13.12.2000, p. 12 ('Second Daughter Directive'). ▪ Directive 2002/3/EC of the European Parliament and of the Council relating to ozone in ambient air, OJ L 67, 9.3.2002, p. 14 ('Third Daughter Directive'). ▪ Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the member States, OJ L 35, 5.2.1997, p. 14 ('Exchange of Information Decision'). Due to the aim of simplifying existing directives and given that the existing legislation sets Community objectives but leaves the choice of measures for compliance to the Member States, then the best instrument is a directive.
	Conclusions	The Commission does not propose to modify the existing air quality limit values but will propose a strengthening of existing provisions so that Member States will be obliged to prepare and implement plans and programmes to remove non-compliances. However, where Member States have taken all reasonable measures the Commission will propose that Member States be allowed to delay the attainment date in affected zones where limit values are not yet complied with, if certain objective criteria are met.
Recommended measures		The proposed approach to control $PM_{2.5}$ would establish: ▪ a concentration cap for $PM_{2.5}$ in ambient air set to prevent unduly high risks to the population and to be attained by 2010; ▪ a non-binding target to reduce human exposure generally to $PM_{2.5}$ between 2010 and 2020 in each Member State, based upon measurement data; ▪ a more comprehensive monitoring of certain pollutants such as $PM_{2.5}$ that will permit a greater understanding of this pollutant and lead to better policy development in the future; ▪ a greater use of modelling and objective estimation techniques to assess the extent of air pollution that should allow less use of more expensive monitoring.

Green Paper, A European Strategy for Sustainable, Competitive and Secure Energy, COM(2006) 105 final

Title		Green Paper, *A European Strategy for Sustainable, Competitive and Secure Energy*, COM(2006) 105 final
Author(s)		Commission of the European Communities
Year		2006
Keyword		**Energy**
Methodology	Assumptions	There is an urgent need for investment. In Europe alone, to meet expected energy demand, our import dependency is rising. Reserves are concentrated in a few countries. Global demand for energy is increasing. Oil and gas prices are rising. Our climate is getting warmer. Europe has not yet developed fully competitive internal energy markets. Europe must act urgently: it takes many years to bring innovation on stream in the energy sector.
	Approach	The Green Paper puts forward suggestions and options that could form the basis for a new comprehensive European energy policy.
	Parameters	Europe needs to deal with the challenges of climate change in a manner compatible with its Lisbon objectives: ▪ in order to limit the forthcoming rise of global temperatures at the agreed target of maximum of 2 degrees above pre-industrial levels, global greenhouse gas emissions should peak no later than 2025, and then be reduced by at least 15%, but perhaps as much as 50% compared with 1990 levels; ▪ a clear goal to prioritise energy efficiency is the goal of saving 20% of the energy that the EU would otherwise use by 2020.
Main Contents	Objective	▪ Sustainability: developing competitive renewable sources of energy and other low-carbon energy sources and carriers, particularly alternative transport fuels, curbing energy demand within Europe, and leading global efforts to halt climate change and improve local air quality. ▪ Competitiveness: ensuring that energy market opening brings benefits to consumers and to the economy as a whole, while stimulating investment in clean energy production and energy efficiency, mitigating the impact of higher international energy prices on the EU economy and its citizens and keeping Europe at the cutting edge of energy technologies. ▪ Security of supply: tackling the EU's rising dependence on imported energy through an integrated approach – reducing demand, diversifying the EU's energy mix with greater use of competitive indigenous and renewable energy, and diversifying sources and routes of supply of imported energy, creating the framework which will stimulate adequate investments to meet growing energy demand, better equipping the EU to cope with emergencies, improving the conditions for European companies seeking access to global resources, and making sure that all citizens and businesses have access to energy.
	Conclusions	The Green Paper has set out the new energy realities facing Europe, outlined questions for debate and suggested possible actions at the European level. In taking the debate forward, it is essential to act in an integrated way. Each Member State will make choices based on its own national preferences. However, in a world of global interdependence, energy policy necessarily has a European dimension. For these reasons, the Commission proposes an Action Plan on Energy Efficiency to realise this potential.

Recommended measures	▪ Efficiency campaigns; ▪ Harnessing financial instruments and mechanisms to stimulate investment; ▪ A renewed effort for transport; ▪ A Europe-wide 'white certificates' trading system; ▪ Better information on the energy performance of vehicles and possibly minimum performance standards; ▪ A strategic energy technology plan, to develop leading markets for energy innovation; ▪ The full review of the EU Emissions Trading Scheme.

Action Plan for Energy Efficiency: realising the potential, COM(2006) 545 final

Title		Communication from the Commission, *Action Plan for Energy Efficiency: realising the potential*, COM(2006) 545 final
Author(s)		Commission of the European Communities
Year		2006
Keyword		**Energy**
Methodology	Assumptions	The transport sector plays a central role in the European economy and as such accounts for almost 20% of total primary energy consumption. 98% of the energy consumed in this sector is fossil fuel. As transport is also the fastest growing sector in terms of energy use, it is a major source of greenhouse gases and of import dependency on fossil fuels. It is therefore essential to realise the potential for energy efficiency gains in this sector.
	Approach	The actions set forth in the Action Plan represent a coherent and interlinked package of measures that will put the EU on track towards achieving at least the 20% cost-effective energy savings potential by 2020. For the transport sector, a comprehensive and consistent approach targeting different actors, including motor and tyre manufacturers, drivers, oil/fuel suppliers and infrastructural planners, is necessary.
	Parameters	The 2006 Spring European Council called for the adoption as a matter of urgency of an ambitious and realistic Action Plan for Energy Efficiency, bearing in mind the EU energy saving potential of more than 20% by 2020. Realising the 20% potential for 2020, equivalent to some 390 Mtoe, will result in large energy and environmental benefits. CO_2 emissions should be reduced by 780 Mt CO_2 with respect to the baseline scenario, more than twice the EU reductions needed under the Kyoto Protocol by 2012. Additional investment expenditure in more efficient and innovative technologies will be more than compensated by the more than € 100 billion annual fuel savings. For transport, a full savings potential of 26% is estimated, a figure which includes a significant impact from shifting to other modes of traffic, in line with the Mid-term review of the White Paper on transport.
Main Contents	Objective	The Action Plan is intended to mobilise the general public and policy-makers at all levels of government, together with market actors, and to transform the internal energy market in a way that provides EU citizens with the globally most energy-efficient infrastructure, buildings, appliances, processes, transport means and energy systems. Given the importance of the human factor in reducing energy consumption, this action plan also encourages citizens to use energy in the most rational manner possible.
	Conclusions	The car industry has made voluntary commitments to reach 140 g CO_2/km by 2008/2009. If it is not honoured, the Commission will not hesitate to propose legislation, aimed at reaching the Community objective of 120 g CO_2/km by 2012 through a comprehensive and consistent approach, involving other relevant stakeholders and authorities and other instruments.

Recommended measures	The Plan lists a range of cost-effective measures, proposing priority actions to be initiated immediately, and others to be initiated gradually over the Plan's six-year period. The actions in the transport sector are: ▪ measures, including legislation if necessary, to meet, through a comprehensive and consistent approach, a 120 g CO_2/km target by 2012. This target should be met based on the achievement of a 140 g CO_2/km target through a voluntary agreement by 2008-2009; ▪ strengthen efforts to develop markets for cleaner, smarter, more energy-efficient and safer vehicles, following a Commission proposal for a Directive on the promotion of clean road transport vehicles (COM(2005)634) (2007-2012); ▪ strengthen EU-wide real-time traffic and travel information (RTTI) systems and traffic management (2007-2012); ▪ encourage financing for market introduction of efficient vehicles (2007); ▪ propose an amended Car Fuel Efficiency Labelling Directive (1999/94/EC) (2007); ▪ issue a mandate for a recognised European Norm and international standard to measure tyre rolling resistance (2008); ▪ work towards minimum efficiency requirements for automobile air-conditioning systems (2007-2008); ▪ propose a labelling scheme for tyres (2008); ▪ facilitate voluntary agreements and propose other measures on accurate tyre pressure monitoring schemes (2008-2009); ▪ consider compulsory fitting of tyre pressure monitoring systems on new vehicles (2008-2009); ▪ submit a Green Paper on urban transport putting forward joint solutions based on concrete measures that have been successfully tested, including, if appropriate, infrastructure use and road and congestion charges (2007); ▪ propose legislation to harmonise requirements to promote fuel efficiency in drivers education curricula and support projects (2008); ▪ promote energy efficiency in the aviation sector through SESAR (2007-2012); ▪ propose legislation to include the aviation sector in the EU Emissions Trading Scheme (end of 2006); ▪ exploit the potential for optimising hull cleaning of ships (2007-2008) ▪ realise savings benefits of shore-side electricity for harboured ships by proposing legislation (2008-2009); ▪ promote short-sea shipping and the motorways of the sea (2007-2012); ▪ implement the legal framework for rail transport (2007).

Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future, COM(2006) 848 final

Title		Communication from the Commission to the Council and the European Parliament, *Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future*, COM(2006) 848 final
Author(s)		Commission of the European Communities
Year		2006
Keyword		**Energy**
Methodology	Assumptions	In the complex picture of energy policy, the renewable energy sector is the one energy sector which stands out in terms of ability to reduce greenhouse gas emissions and pollution, exploit local and decentralised energy sources, and stimulate world-class high-tech industries. In 1997 the European Union started working towards a target of a 12% share of renewable energy in gross inland consumption by 2010. However, the EU looks unlikely to reach a contribution from renewable energy sources exceeding 10% by 2010 because at the current stage of energy market development renewable sources will often not be the short-term least-cost options and because national policies have been inadequate for achieving the EU target.
	Approach	This Road Map is an integral part of the Strategic European Energy Review and sets out a long-term vision for renewable energy sources in the EU. The objectives can only be achieved by significantly increasing the contribution from renewable energy sources in *all* Member States at all levels of government assuming the energy industry plays its full part in the undertaking.
	Parameters	The Road Map proposes that the EU establish a mandatory (legally binding) target of 20% for renewable energy's share of energy consumption in the EU by 2020. In 2003 the EU adopted the biofuels directive (2003/30/EC), with the objective of boosting both production and consumption of biofuels in the EU, which are the only available large scale substitute for petrol and diesel in transport. The biofuels directive established a reference value of a 2% share for biofuels in petrol and diesel consumption in 2005 and 5.75% in 2010. Member States are due to adopt national indicative targets for 2010 in 2007. Some have already done so. Most of these have followed the reference value set in the directive (a 5.75% share).
Main Contents	Objective	For renewables to become the 'stepping stone' to reaching the objective of increased security of supply and reduced greenhouse gas emissions, it is clear that a change in the way in which the EU promotes renewables is needed. Strengthening and expansion of the current EU regulatory framework is necessary. It is, in particular, important to ensure that all Member States take the necessary measures to increase the share of renewables in their energy mix.

	Conclusions	The 12% target for the contribution from renewables to overall EU energy consumption by 2010 is unlikely to be met. Based on current trends, the EU will not exceed 10% by 2010. In transport biofuels, there has been some progress, particularly since the adoption of the directive, but not enough to reach the targets adopted. The Commission is convinced that a legally binding target for the overall contribution of renewables to the EU's energy mix plus mandatory minimum targets for biofuels are now called for. Reaching this target is technically and economically feasible. Additional average costs compared with conventional supply options will depend on future innovation rates and conventional energy prices and would range between €10.6 and €18 billion per year. The additional renewable energy deployment needed to achieve the 20% target will reduce annual CO_2 emission by approximately 700 Mt in 2020. The value of this significant reduction in greenhouse gas emissions would nearly cover the total additional cost under high energy prices. At the same time the EU will strengthen its position on security of supply reducing fossil fuel demand by more than 250 Mtoe in 2020. Until this new legislation enters into force, the current legislative framework, notably for electricity and biofuels, will be vigorously enforced.
Recommended measures		Given the largely national basis for support measures in renewable energy, the overall EU target will need to be reflected in mandatory national targets: ▪ National Action Plans that should contain sectoral targets and measures consistent with achieving the agreed overall national targets, demonstrating substantial progress compared with the agreed 2010 renewable energy targets

An energy policy for Europe, COM(2007) 1 final

Title		Communication from the Commission to the Council and the European Parliament, *An energy policy for Europe*, COM(2007) 1 final
Author(s)		Commission of the European Communities
Year		2007
Keyword		**Energy**
Methodology	Assumptions	Energy accounts for 80% of all greenhouse gas (GHG) emissions in the EU; it is at the root of climate change and most air pollution. With current energy and transport policies, EU CO_2 emissions would increase by around 5% by 2030 and global emissions would rise by 55%. The present energy policies within the EU are not sustainable. Europe is becoming increasingly dependent on imported hydrocarbons. With 'business as usual' the EU's energy import dependence will jump from 50% of total EU energy consumption today to 65% in 2030. Reliance on imports of gas is expected to increase from 57% to 84% by 2030, of oil from 82% to 93%. The EU is becoming increasingly exposed to the effects of price volatility and price rises on international energy markets and the consequences of the progressive concentration of hydrocarbons reserves in few hands.
	Approach	Member States have to endorse a strategic vision and an Action Plan for the next three years: with the explicit aim of moving towards an international alliance of developed countries at least with a view of reducing global greenhouse gas emissions and making a significant contribution to reducing the EU's greenhouse gas emissions. This will be backed up with careful monitoring and reporting of progress, as well as the effective exchange of best practice and continued transparency through the regular presentation by the Commission of an updated Strategic Energy Review.
	Parameters	The Communication suggests the following points as the main parameters for the choice of measures to be implemented: ▪ the international achievement of a 30% reduction in greenhouse gas emissions by developed countries by 2020 compared with 1990. In addition, 2050 global GHG emissions must be reduced by up to 50% compared with 1990, meaning reductions in industrialised countries of 60-80% by 2050; ▪ the EU commitment in order to achieve at least a 20% reduction of greenhouse gases by 2020 compared with 1990.
Main Contents	Objective	Europe's main energy challenges are: ▪ reducing CO_2 emissions, which that means using less energy and using more clean, locally produced energy; ▪ limiting the EU's growing exposure to increased volatility and prices for oil and gas; ▪ potentially bringing about a more competitive EU energy market, stimulating innovation technology and jobs.
	Conclusions	Europe needs to act now to deliver sustainable, secure and competitive energy. To achieve the strategic energy objective set out above means transforming Europe into a highly energy efficient and low CO_2 energy economy, catalysing a new industrial revolution, accelerating the change to low carbon growth and, over a period of years, dramatically increasing the amount of local, low emission energy that we produce and use. The challenge is maximise the potential competitiveness gains for Europe, and limits the potential costs.

Recommended measures	▪ to create internal electricity and gas markets for all EU citizens and businesses ▪ ensuring solidarity between Member States in the event of an energy crisis or a disruption in supplies (the Commission intends to present in 2007 a Communication on strategic stocks with reinforced measures); ▪ to step up efforts to establish global action to combat climate change and to reduce greenhouse gases with the EU Emissions Trading System; ▪ to endorse an EU energy consumption programme in a cost-efficient manner by 2020; ▪ to focus on renewable energies in the EU as a whole with 10% minimum biofuels (the Commission intends to table a new directive to put this into practice during 2007, developing National Action Plans); ▪ to promote a European Strategic Energy Technology Plan (the Commission intends formally to propose such a Plan in 2007); ▪ to provide a clear perspective when coal- and gas-fired plants will need to install CO_2 capture and storage and to establish a mechanism to encourage the construction and operation by 2015 of up to 12 large-scale demonstrations of sustainable fossil fuels technologies in commercial power generation in the EU; ▪ to establish an EU High Level Group on Nuclear Safety and Security with the mandate of developing European rules on nuclear security and safety to support the efforts of Member States; ▪ to confirm the importance of 'speaking with one voice' on international energy issues and of the international negotiations to encourage sustainable methods of production; ▪ to put forward a new Strategic Energy Review every two years and to propose in 2007 a formal legal base for financing the work of an Office of the Energy Observatory within the Commission to coordinate and improve transparency on EU energy markets.

Limiting Global Climate Change to 2 degrees Celsius. The way ahead for 2020 and beyond, COM(2007) 2 final

Title		Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions *Limiting Global Climate Change to 2 degrees Celsius. The way ahead for 2020 and beyond*, COM(2007) 2 final
Author(s)		Commission of the European Communities
Year		2007
Keyword		**Air Pollution**
Methodology	Assumptions	Urgent action to tackle climate change is imperative. There are enormous costs in the event of a failure to act. These costs are economic, but also social and environmental, and will especially fall on the poor, in both developing and developed countries. A failure to act will have serious local and global security implications. The costs of inaction, estimated by the Stern Review at 5 to 20% of global GDP, would fall disproportionately on the poorest with the least capacity to adapt, exacerbating the social impacts of climate change.
	Approach	This Communication, addressed to the European Council, held during spring 2007, decided on an integrated and comprehensive approach to the EU's energy and climate change policies, starting from an impact assessment and a costs-benefits analysis.
	Parameters	The Communication suggests the following points as the main parameters for the choice of measures to be implemented: ▪ EU has to pursue in the context of international negotiations the objective of a 30% reduction in greenhouse gas (GHG) emissions by developed countries by 2020 (compared with 1990 levels). This is necessary to ensure that the world stays within the 2ºC limit. ▪ The EU should even now make a firm independent commitment to achieve at least a 20% reduction of GHG emissions by 2020, through the EU emissions trading scheme (EU ETS), other climate change policies and actions in the context of the energy policy. ▪ After 2020 developing country emissions will overtake those of the developed world. Effective action on climate change therefore requires reduced growth in the GHG emissions of developing countries and reversing emissions from deforestation. ▪ By 2050 global emissions must be reduced by up to 50% compared with 1990, meaning reductions in developed countries of 60-80% by 2050. Many developing countries will also need to reduce their emissions significantly.
Main Contents	Objective	The EU's objective concerning the need to limit global average temperature increase to less than 2°C compared with pre-industrial levels will require atmospheric concentrations of GHG to remain well below 550 ppmv CO_2 eq. By stabilising long-term concentrations at around 450 ppmv CO_2 eq. there is a 50% chance of doing so. This will require global GHG emissions to peak before 2025 and then fall by up to 50% by 2050 compared with 1990 levels.
	Conclusions	This Communication identifies options for realistic and effective measures in the EU and globally that will allow the 2ºC objective to be met, increasing overall resource use efficiency: A global action on climate change is fully compatible with sustaining global growth. Investment in a low-carbon economy will require around 0.5% of total global GDP over the period 2013-2030. This would reduce global GDP growth by only 0.19% per year up to 2030, a fraction of the expected annual GDP growth rate of 2.8%. This is an insurance premium to pay in order to reduce the risk of irreversible damages resulting from climate change, with associated health benefits, greater energy security and reduced damages from avoided climate change.

Recommended measures	Action in the EU: ▪ define emissions reduction targets through the EU ETS, other climate change policies and actions in the context of the energy policy; ▪ improve the EU's energy efficiency by 20% by 2020; ▪ increase the share of renewable energy to 20% by 2020; ▪ increase the EU's CO_2 emissions quota covered by the EU ETS, up to more than 45% from 2013; ▪ include aviation in the EU ETS; ▪ link taxes on passenger cars to CO_2 emission levels; ▪ define the target of 120 g CO_2/km by 2012 with further reductions after 2012; ▪ demand-oriented measures; ▪ limit GHG emissions from road freight transport and shipping; ▪ reduce the life-cycle emissions of CO_2 in transport fuels, accelerating the development of sustainable biofuels and, in particular, second generation biofuels; ▪ promote the development of clean energy and transport technologies; ▪ promote sustainable transport and energy as well as environmental technologies and eco-innovations through financial assistance under the Structural Funds and the Cohesion Fund. International action: ▪ promote an international agreement to reach the 2ºC objective as an international priority; ▪ expand the Kyoto Protocol's Clean Development Mechanism, which now generates credits for investments in emissions reduction projects in developing countries (which can be used by developed countries to meet their targets, generating considerable flows of capital and technology) and tomorrow could cover entire national sectors, generating emissions credits if the whole national sector exceeds a pre-defined emission standard; ▪ improve access to finance; ▪ introduce sector-wide company-level emissions trading for energy-intensive sectors; ▪ reduce commitments in accordance with the country's level of development; ▪ no commitments for least developed countries. ▪ promote a future international agreement on international research and technology cooperation

Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles, COM(2007) 19 final

Title		Communication from the Commission to the Council and the European Parliament, *Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles*, COM(2007) 19 final
Author(s)		Commission of the European Communities
Year		2007
Keyword		**Air Pollution**
Methodology	Assumptions	Car usage has significant impacts on climate change, with about 12% of the overall EU emissions of carbon dioxide (CO_2), the main greenhouse gas, coming from fuel consumed by passenger cars. Even though there have been significant improvements in vehicle technology – in particular in fuel efficiency which also means lower CO_2 emissions - this has not been enough to neutralise the effect of increased traffic and car size. While the EU as a whole has reduced its emissions of greenhouse gases (GHG) by just under 5% over the 1990-2004 period, the CO_2 emissions from road transport have increased by 26%.
	Approach	The High Level Group was convened in order to enhance the dialogue with stakeholders concerning the future needs and challenges of the automotive industry.
	Parameters	The Community strategy has until now been based on three pillars: ▪ the car industry's voluntary commitments; ▪ consumer information, a useful tool in raising citizen's awareness; ▪ the promotion of fuel-efficient cars via fiscal measures.
Main Contents	Objective	In line with the EU strategy on CO_2 emissions from light-duty vehicles, the average new car fleet should achieve CO_2 emissions of 140 g CO_2/km (2008/09) and 120 g CO_2/km (2012)
	Conclusions	The progress achieved so far goes some way towards the 140 g CO_2/km target by 2008/2009, but in the absence of additional measures, the EU objective of 120 g CO_2/km will not be met at a 2012 horizon. This Communication provides the basis for exchanges with other European Institutions and all interested parties on implementing a next stage in the Community strategy to reduce CO_2 emissions and improve fuel efficiency from light-duty vehicles with a view to reaching the EU objective of 120 g CO_2/km by 2012 The Commission will propose, if possible in 2007 and at the latest by mid-2008, a legislative framework to the Council and European Parliament in order to achieve this objective. It will be accompanied by a thorough impact assessment further reflecting the extent to which Member States can facilitate compliance with mandatory targets by car manufacturers through the adoption of measures to address demand, notably in the field of taxation.

Recommended measures	Supply oriented measures to reach the objective of 130 g CO_2/km for the average new car fleet by means of improvements in vehicle motor technology, and a further reduction of 10 g CO_2/km, or equivalent if technically necessary, by other technological improvements and by an increased use of biofuels, specifically: ▪ setting minimum efficiency requirements for air-conditioning systems; ▪ compulsory fitting of accurate tyre pressure monitoring systems; ▪ setting maximum tyre rolling resistance limits in the EU for tyres fitted on passenger cars and light-commercial vehicles; ▪ use of gear-shift indicators, taking into account the extent to which such devices are used by consumers in real driving conditions; ▪ fuel efficiency progress in light-commercial vehicles (vans) with the objective of reaching 175 g/km CO_2 by 2012 and 160 g/km CO_2 by 2015; ▪ increased use of biofuels maximising environmental performance. Demand/behaviour oriented measures: ▪ the Commission has made a proposal for a Council Directive on passenger car taxation which is currently before the Council and Parliament; ▪ Fiscal incentives as a powerful way of encouraging the cleanest light-duty vehicle classes into the market; ▪ the Commission will adopt in 2007 an amending proposal to improve the effectiveness of the fuel efficiency labelling directive 1999/94/EC; ▪ Car manufacturers are invited to sign up before mid-2007 to a voluntary agreement on an EU-wide code of good practice regarding car marketing and advertising aimed at the promotion of sustainable consumption patterns. Long-term measure: ▪ The Commission will support research efforts towards reaching the European Road Transport Research Advisory Council (ERTRAC) target of 'improvements in vehicle efficiency that will deliver as much as a 40% reduction in CO_2 emissions for passenger cars for the new vehicle fleet in 2020'. This would correspond to a new car fleet average of 95 g CO_2/km.

A Competitive Automotive Regulatory Framework for the 21st Century, Commission's position on the CARS 21 High Level Group Final Report. A contribution to the EU's Growth and Jobs Strategy, COM(2007) 22 final

Title		Communication from the Commission to the Council and the European Parliament, *A Competitive Automotive Regulatory Framework for the 21st Century, Commission's position on the CARS 21 High Level Group Final Report. A contribution to the EU's Growth and Jobs Strategy*, COM(2007) 22 final
Author(s)		Commission of the European Communities
Year		2007
Keyword		**Air Pollution**
Methodology	Assumptions	Cars are responsible for 12% of Europe's greenhouse gas emissions and a significant part of pollutant emissions. The need to protect the natural environment, safeguard human health and lives, and operate in a high oil price environment have created a situation where car industries have to face new challenges, responsibilities and opportunities which could alter both the industry and its products. CARS 21 is a High Level Group which was established in 2005 and brought together the main stakeholders (Member States, industry, NGOs and MEPs) to examine the main policy areas impacting the European automotive industry and to make recommendations for future public policy and a regulatory framework.
	Approach	In the field of the environment, the Communication describes the key elements of the future Commission strategy to reduce CO_2 emissions from cars that is based on an integrated approach to achieving the EU objective. This Communication reflects extensive stakeholder consultation and dialogue on automotive issues and the Commission hopes that it will contribute to the policy-making culture and methodology in the future.
	Parameters	The Commission will pursue its integrated approach with a view to reaching the EU objective of 120 g/km CO_2 by 2012, in the following way: ▪ the objective of 130 g/km for the average new car fleet by means of improvements in vehicle motor technology; ▪ the further reduction of 10 g/km of CO_2, or equivalent if technically necessary, by other technological improvements and by an increased use of biofuels.
Main Contents	Objective	This Communication outlines the direction of future automotive policy. It presents the Commission's position on the CARS 21. The achievement of the EU objective of 120 g/km CO_2 by 2012 will be possible through a combination of EU and national action. The Commission will propose a legislative framework, if possible in 2007 and at latest by mid-2008, to achieve the EU objective.
	Conclusions	The legislative framework will be compatible with the overall objective of reaching the EU's Kyoto targets and will be based on a thorough impact assessment. Beyond the legislative framework, the Commission strategy to reduce CO_2 should encourage additional efforts by other means of road transport (heavy-duty vehicles, etc.), by the Member States (CO_2-related taxation and other fiscal incentives, use of public procurement, traffic management, infrastructure, etc.) and by consumers (informed choice as a buyer, responsible driving behaviour).

Recommended measures	▪ proposal for **Euro VI** emission limits to achieve further significant pollutant emissions reduction from heavy-duty vehicles; ▪ proposal for global technical regulations on heavy-duty vehicles' emission test cycles, off-cycle emissions and on-board diagnostic systems, so that real-life emissions conditions are better reflected; ▪ options to ensure that the emissions testing process for passenger cars also takes better account of real-life emissions; ▪ setting minimum efficiency requirements for air-conditioning systems; ▪ compulsory fitting of accurate tyre pressure monitoring systems; ▪ setting maximum tyre rolling resistance limits in the EU for tyres fitted on passenger cars and light-commercial vehicles; ▪ use of gear-shift indicators, taking into account the extent to which such devices are used by consumers in real driving conditions; ▪ fuel efficiency progress in light-commercial vehicles (vans) with the objective of reaching 175 g/km CO_2 by 2012 and 160 g/km CO_2 by 2015; ▪ increased use of biofuels maximising environmental performance; ▪ explore the possibility of including the road transport sector in the EU Emissions Trading Scheme for the third allocation period starting in 2013; ▪ proposal to revise Directive 2003/30/EC on the use of biofuels or other renewable transport fuels in 2007; ▪ support for R&D efforts into second generation biofuels; ▪ proposal for a regulation on motor vehicles using hydrogen as a fuel to ensure the safe use of this technology; ▪ pursuing the research and development of Information and Communications Technologies' (ICT)-based technologies and applications, ▪ putting intelligent transport systems, including Galileo, at the heart of its forthcoming action plan on logistics and the green paper on urban transport with a view to optimising transport operations and achieving safe and sustainable mobility for Europe ▪ encouraging the European Investment Bank to support the Community policy on CO_2 reductions by contributing to the financing of economically viable projects in the fields of fuel efficiency and renewable fuels

Green Paper on market-based instruments for environment and related policy purposes, COM(2007) 140 final

Title		*Green Paper on market-based instruments for environment and related policy purposes*, COM(2007) 140 final
Author(s)		Commission of the European Communities
Year		2007
Keywords		**Environmental Policy**
Methodology	Assumptions	Transport is a major contributor to air pollution and CO_2 emissions and the trend in emissions is increasing. There has been some use of Market-Based Instruments (MBI) at EU level to address the negative environmental impacts of the different modes of transport, substantial as they are. This contrasts with the national and local levels where several different types and designs of MBI have been used and are in the process of being developed.
	Approach	The paper launches a discussion on advancing the use of market-based instruments in the Community. In line with the announcement in the Action Plan on Energy Efficiency, the paper fits into the framework set by the new integrated energy and climate change agenda where market-based instruments and fiscal policies in general will play a decisive role in delivering the EU's policy objectives.
	Parameters	At EU level, the most commonly used market-based instruments are: ▪ taxes and charges: provide security regarding the cost or the price of the policy objective, tend to be easier to administer and they also generate revenue; ▪ tradable permit systems: they are a quantitative system, such as tradable permit schemes, that provide more certainty as regards reaching specific policy objectives, e.g. emission limits, and can generate revenue if the allowances are auctioned by public authorities.
Main Contents	Objective	The EU commitment to addressing climate change internally and on an international scale, to promoting environmental sustainability, to reducing dependence on external resources and to ensuring the competitiveness of European economies, could be easier achieved with 'MBI' because they provide a flexible and cost-effective means for reaching given policy objectives.
	Conclusions	The Commission believes that together with regulation and other instruments, there should be increased use of MBI, including trading schemes, taxation measures and subsidies, as a cost-effective tool to achieve environmental and other policy objectives, both at Community and national levels. This would be in keeping with the Sustainable Development, Lisbon and Better Regulation Agendas

Recommended measures	▪ an environmental tax reform (ETR) shifting the tax burden from welfare-negative taxes, (e.g. on labour), to welfare-positive taxes, (e.g. on environmentally-damaging activities, such as resource use or pollution); ▪ an MBI Forum, as a structured exchange of information between Member States on their best practices in the area of MBI in general and environmental tax reform in particular; ▪ reforming environmentally-harmful subsidies, both at Community and national levels, to remove those that are not economically, socially, environmentally and human-health-efficient; ▪ the review of the Energy Taxation Directive according to the fuel energy content and reflecting the environmental aspects of energy (by differentiating between greenhouse gas and non-greenhouse gas emissions); ▪ the exclusion of the environmental impacts addressed by the EU Emissions Trading Scheme from the scope of the Energy Taxation Directive, as a viable solution to resolve the problem of potential overlap between the two instruments; ▪ the introduction of a CO_2-dependent element in the tax base of both annual circulation and registration taxes for passenger car related taxes to tackle road transport emissions; ▪ to consider a possible extension of the scope of the ETS to a number of other sectors, including surface and aviation transport; ▪ infrastructure charging systems integrating differentiation of environmental damage (SO_2, NO_X and PM emissions) in the overall costs, which would lead to more efficient infrastructure use.

2001 White Paper

Title		*White Paper - European Transport Policy for 2010: time to decide*	
Author(s)		European Union	
Year		2001	
Keywords		**Policy**, European Transport Policy, common transport system, sustainability	
Methodology	Assumptions	The European Union aims, through this document, to set a common transport policy approach and to develop an integrated European transport system According to the document the system should be developed, being not only social, economic sustainable but also environmental compatible. The White Paper clearly affirms that actions should be taken to tackle the increased contribution of transport to global warming and energy consumption. All transport policy should take account of its impact on these issues.	
	Approach	The White Paper's approach mainly consists in identifying four action priorities to deal with: ▪ Shifting the balance between modes of transport ▪ Eliminating bottlenecks ▪ Placing users at the heart of transport policy ▪ Managing the effects of globalisation Each of these action priorities is articulated in a set of policies (twelve policies have been identified) to be developed. Then, policies are implemented by a set of 78 measures which are regulated through common European Union legislative acts (regulations, directives, etc)	
	Parameters	The White Paper fixes some quantitative and qualitative targets to be reached within 2010-2020: the following are the most relevant as regards transport environmental impacts:	
		Transport volume	▪ Breaking the link between the growth of car transport and economic growth: road haulage +35% instead of the predicted 50%. ▪ Passenger car transport +21% against a rise in GDP of 43%. ▪ Maintain and improve the competitive position of Europe's air industry by creating the Single European Sky and regulating the unavoidable expansion of airport infrastructure. *(White Paper p. 37)*
		Modal share	▪ Maintaining the rail freight market share in central and eastern European countries (35%). *(White Paper p. 89)* ▪ Raising the modal share of short-sea shipping by linking up waterways on sea with an inland traffic. *(White Paper p. 12, 27, 41-42)* ▪ Raising the modal share of inland waterway transport by establishing 'waterways branches' and transhipment facilities. *(White Paper p. 12, 41-42)* ▪ Improving the organisation of intermodal transport. ▪ Realising a modal shift from road and air to rail and water by providing fair competition between modes and link-up modes for successful intermodality. *(White Paper p. 45-46, 104)* ▪ Increase rail market share of passenger traffic (6% → 10%) and goods traffic (8% → 15%) *(White Paper p. 25, 27)* ▪ Stimulating rail usage by improving quality (*White Paper p. 30)* ▪ Better use of public transport and rational use of the car.
	Parameters	Energy consumption	▪ Raising the share of substitute fuels (6% biofuel penetration rate by 2010) *(White Paper p. 83)* ▪ Replacement of 20% of conventional fuels with substitute fuels by 2020 *(White Paper p. 83)*
Methodology		Climate change	▪ No quantitative targets

		Air quality	▪ No quantitative targets ▪ Everyone should enjoy a transport system that meets their needs and expectations, in terms of safety and costs, ▪ user rights and obligations and clean (public) transport accessibility.
		Noise exposure	No quantitative targets
Main Contents	Objective	Besides aiming at developing a European transport system capable of assuring mobility for passengers and freight, cohesion, accessibility and of boosting socio-economic development, the White Paper sets a ten-year strategy on environmental sustainability of the transport sector. This mainly consists in: ▪ promoting co-modality (e.g. through Marco Polo programmes) ▪ reinforcing the role of rail transport (e.g. through three rail liberalisation packages) ▪ boosting maritime transport (e.g. by implementing sea motorways) ▪ revitalising inland waterway transport ▪ developing infrastructure charging systems based on the polluter-pays principle ▪ speeding up TEN-T infrastructure, seen as offering real possibilities of reducing environmental impact of transport	
	Conclusions	A mid-term review of the White Paper pointed out that, among the policies implemented, the ones with a direct effect in terms of tackling environmental impacts of transport system are lagging behind. More legislative actions from the European Union, cooperation from all Member States, financial resources invested in these policies and more concrete aid to research into new technologies should be the priorities for the near future.	

2006 Keep Europe Moving

Title		Communication from the Commission to the Council and the European Parliament *'Keep Europe moving - Sustainable mobility for our continent. Mid-term review of the European Commission's 2001 Transport White Paper'* COM(2006) 314 final
Author(s)		Commission of the European Communities
Year		2006
Keywords		**European Transport Policy, common transport system, sustainability**
Methodology	Assumptions	From a slow start, the European Union's transport policy has developed rapidly over the past 15 years. The objectives of EU transport policy, from the Transport White Paper of 1992, via the White Paper of 2001 to the Communication, remain valid: to help provide Europeans with efficient, effective transportation systems.
	Approach	The policy directions outlined in the Communication are refined on the basis of public consultation and in-depth assessments before deciding on specific measures Extensive consultation have highlighted the central role of transport in economic growth and the need to re-adjust the policy measures.
Main Contents	Objective	The overall objective of transport policy is competitive, secure, safe, and environmentally friendly mobility, fully in line with the revised Lisbon agenda for jobs and growth and with the revised Sustainable Development Strategy.
	Conclusions	The mid-term review argues for a comprehensive, holistic approach to transport policy. Whereas future policies will continue to be based on the White Papers of 1992 and 2001, in many areas European action will not suffice. Mutually complementary action will be needed at national, regional and local levels of government as well as by citizens and industry themselves. That is why a permanent dialogue with all stakeholders concerned is essential.
Recommended measures		**Long-term actions:** ▪ Internal market: assure the functioning of EU rules in all modes ▪ Energy use in transport: improve energy efficiency and accelerate the development and deployment of alternative fuels ▪ Employment and working conditions: promote social dialogue; promote transport professions and training ▪ Safety: promote road safety through vehicle design, research and technology, infrastructure and behaviour, and continue the Intelligent Car and e-Safety initiatives ▪ Infrastructure: ensure a balanced approach to land-use planning; mobilise all sources of financing ▪ Technology: RTD and support to dissemination, exploitation and market penetration ▪ Galileo: build up the Galileo Supervisory Authority ▪ Global dimension: develop external relations through bilateral agreements and in multilateral forms; deploy a common aviation area in Europe ▪ Governance: consolidate the European transport safety agencies and develop their terms of reference

Green Paper on urban transport

Title		Green Paper on urban transport
Author(s)		European Commission – DG TREN – Directorate G
Year		2007
Keyword		**Urban transport policy**
Methodology	Assumptions	The preparation of the new Green Paper follows the Citizen's Network Green Paper and its 'Implementation' Communication presented by the Commission in the mid-1990s. A number of recent Commission documents, proposals and initiatives have substantially addressed urban transport issues and helped to build up momentum for the new Green Paper on urban transport. In its mid-term review of the 2001 Transport White Paper the Commission announced the publication of a Green Paper on Urban Transport in 2007 to identify potential European added value to action that is taken at the local level.
	Approach	The Green Paper is characterised by an **integrated approach**, despite the fact that urban transport has often been considered as a too controversial issue: ▪ the preparation of the Green Paper took place in partnership with the stakeholders concerned and the relevant European institutions (an Internet consultation took place during the preparatory phase; the Green Paper will include a series of questions that could be the basis for a large debate to which all stakeholders will be invited to participate); ▪ there is a general consensus on the need for a joint approach, in a wider context of other European policies, first of all land-use policies; ▪ the Green paper on urban transport will address all transport modes, including walking, cycling, motorcycles and motor vehicles, and cover both urban freight-logistics and passenger transport.
Main Contents	Objective	The challenge that urban areas have to face, in the context of sustainable development, is to reconcile the economic development of towns and cities and accessibility with improving quality of life and environmental protection. The Commission has decided to present a Green Paper on urban mobility in order to explore if and how it can add value to action already taken at local level. The European Union must play a facilitating role in helping bring about this change, but without imposing top-down solutions which may not necessarily be appropriate for the diverse local situations.
	Conclusions	The Commission wishes to continue to incorporate the views of stakeholders in its further work. The Green Paper launches the second intensive consultation that will last until 15 March 2008**.** It is important that this Green Paper rapidly leads to concrete action. The Commission believes that, after the consultation exercise, a concrete Action Plan should be drawn up. This will be published in early autumn 2008. The plan will include possible actions at EU, national, regional, and local levels and at the level of the industry and citizens.

Recommended measures	Measures to address the congestion challenge: ▪ Promotion of walking and cycling initiatives; ▪ Promotion of car-sharing, car-pooling; ▪ Parking policies; ▪ Urban charging schemes; ▪ ITS; ▪ Mobility management; ▪ Public logistics. Measures to address the environmental challenge: ▪ Promotion of new technologies; ▪ Joint green procurement schemes; ▪ Eco-driving; ▪ Promotion of urban green zones (pedestrianisation, restricted access, speed limits, urban charging) Measures to promote ITS applications: ▪ Promotion of interoperable smart-charging systems; ▪ Promotion of multi-modal journey information systems. Measures to face the accessibility challenge: ▪ Promotion of services for passenger with reduced mobility; ▪ Promotion of less costly collective transport solutions; ▪ Integration between land use and urban mobility policies. Measures to face the safety challenge: ▪ Promotion of educational and information campaigns; ▪ Improving the quality of infrastructures; ▪ Promotion of safer vehicles.

Stern Review

Title		Stern Review Report on the Economics of Climate Change
Author		Nicholas Stern
Year		2006
Keyword		**Policy**
Methodology	Assumptions	Using the results from formal economic models, the review estimates that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach double its pre-industrial level as early as 2035, virtually committing us to a global average temperature rise of more than 2°C. In the longer term, there would be more than a 50% chance that the temperature rise would exceed 5°C In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.
	Approach	The review emphasises a number of key themes, which have the following features: ▪ a consistent approach towards uncertainty about when and where particular impacts will occur. Uncertainty about impacts strengthens the argument for mitigation: the review is about the economics of the management of very large risks. ▪ the focus on a quantitative understanding of risk; ▪ a systematic approach to the treatment of inter/intra-generational equity in the analysis, informed by a consideration that inaction now risks great damage to the prospects of future generations, and particularly to the poorest amongst them. ▪ a coherent economic analysis of policy that is explicit about the effects. The review takes an international perspective. Climate change is global in its causes and consequences, and the response requires international collective action.
	Parameters	The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilised between 450 and 550ppm CO_2 equivalent (CO_2e). The current level is 430ppm CO_2e, and it is rising at more than 2ppm each year. Stabilisation in this range would require emissions to be at least 25% below current levels by 2050, and requires that annual emissions be brought down to more than 80% below current levels. Central estimates of the annual costs of achieving stabilisation between 500 and 550ppm CO_2e are around 1% of global GDP if we start to take strong action now.
Main Contents	Objective	The review assesses a wide range of evidence on the impacts of climate change and on the economic costs, and uses a number of different techniques to assess costs and risks. From all these perspectives, the review demonstrates that the benefits of strong and early action far outweigh the economic costs of not acting. Moreover, it is essential to create a shared international vision of long-term goals, and to build the international frameworks that will help each country to play its part in meeting these common goals. Countries facing diverse circumstances will use different approaches to make their contribution to tackling climate change. But action by individual countries is not enough. Each country, however large, is just part of the problem.
	Conclusions	The world does not need to choose between averting climate change and promoting growth and development. Changes in energy technologies and in the structure of economies have created opportunities to decouple growth from greenhouse gas emissions. Indeed, ignoring climate change will eventually damage economic growth. Tackling climate change is the pro-growth strategy for the longer term, and it can be done in a way that does not cap the aspirations for growth of rich or poor countries.

Recommended measures	Three elements of policy are required for an effective global response. ▪ The first is the pricing of carbon, implemented through tax, trading or regulation: expanding and linking the growing number of emissions trading schemes around the world is a powerful way to promote cost-effective reductions in emissions and to bring forward action in developing countries. Strong targets in rich countries could drive flows amounting to tens of billions of dollars each year to support the transition to low-carbon development paths ▪ The second is policy to support innovation and the deployment of low-carbon technologies: support for energy R&D should at least double, and support for the deployment of new low-carbon technologies should increase up to five-fold. International cooperation on product standards is a powerful way to boost energy efficiency. ▪ The third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change and how they can adapt themselves: the poorest countries are most vulnerable to climate change. It is essential that climate change be fully integrated into development policy, and that rich countries honour their pledges to increase support through overseas development assistance.

Mitigation of Climate Change 2007

Title		Climate Change 2007- the IPCC Fourth Assessment Report
Author		IPCC - Intergovernmental Panel on Climate Change – Working Group III
Year		2007
Keyword		**Policy**
Methodology	Assumptions	Global greenhouse gas (GHG) emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. The largest growth in global GHG emissions between 1970 and 2004 came from the energy supply sector (an increase of 145%). The growth in direct emissions in this period from transport was 120%. In 2004 transport was responsible for 23% of world energy-related GHG emissions with about three quarters coming from road vehicles. With current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.
	Approach	The Working Group III contribution to the IPCC Fourth Assessment Report (AR4) focuses on new literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change. Although this report has a global focus, an attempt is made to differentiate the assessment of scientific and technical findings for the various regions. Given that mitigation options vary significantly between economic sectors, it was decided to use the economic sectors to organise the material on short- to medium-term mitigation options.
	Parameters	The concept of 'mitigation potential' was developed in this study to assess the scale of GHG reductions that could be made, relative to emission baselines, for a given level of carbon price (expressed in cost per unit of carbon dioxide equivalent emissions avoided or reduced). Mitigation potential is further differentiated in terms of 'market potential' and 'economic potential': ▪ market potential is the mitigation potential based on private costs and private discount rates which might be expected to occur under forecast market conditions, including policies and measures currently in place, noting that barriers limit actual uptake; ▪ economic potential is the mitigation potential which takes into account social costs and benefits and social discount rates, assuming that market efficiency is improved by policies and measures and barriers are removed. Studies of market potential can be used to inform policy-makers about mitigation potential with existing policies and barriers, while studies of economic potentials show what might be achieved if appropriate new and additional policies were put into place to remove barriers and include social costs and benefits. The economic potential is therefore generally greater than the market potential.
Main Contents	Objective	The main aim of the report is to assess options for mitigating climate change. Several aspects link climate change with development issues. The report explores these links in detail, and illustrates where climate change and sustainable development are mutually reinforcing.
	Conclusions	Properly designed climate change policies can be part and parcel of sustainable development and the two can be mutually reinforcing. Sustainable development paths can reduce GHG emissions and reduce vulnerability to climate change. Projected climate changes can exacerbate poverty and undermine sustainable development, especially in least-developed countries. Hence global mitigation efforts can enhance sustainable development prospects in part by reducing the risk of adverse impacts of climate change. Mitigation can also provide positive co-benefits, such as improved health outcomes. Mainstreaming climate change mitigation is thus an integral part of sustainable development

Recommended measures	A range of policies, including those on climate change, energy security, and sustainable development, have been effective in reducing GHG emissions in different sectors and in many countries. The scale of such measures, however, has not yet been large enough to counteract the global growth in emissions. Their applicability depends on national circumstances and an understanding of their interactions. The main policies, measures and instruments that have proven to be environmentally effective in the energy and transport fields are: <u>Energy supply</u> ▪ Reduction of fossil fuel subsidies ▪ Taxes or carbon charges on fossil fuels ▪ Feed-in tariffs for renewable energy technologies ▪ Renewable energy obligations ▪ Producer subsidies <u>Transport</u> ▪ Mandatory fuel economy, biofuel blending and CO_2 standards for road transport ▪ Taxes on vehicle purchase, registration, use and motor fuels, road and parking charging ▪ Influence mobility needs through land use regulations, and infrastructure planning ▪ Investment in attractive public transport facilities and non-motorised forms of transport

Target 2020

Title		Target 2020: Policies and Measures to reduce greenhouse gas emissions in the EU
Author		Wuppertal Institute on behalf of the WWF European Policy Office
Year		2005
Keyword		**Policy to reduce GHG emissions**
Methodology	Assumptions	Among the other policies taken into consideration, the document focuses on the transport sector, as the fastest-growing sector in the EU in terms of CO_2 emissions.
	Approach	The study examines the possibility of applying an integrated policy approach to achieve cost-effectiveness and improvements in energy efficiency, a reduction in energy consumption and a contribution by renewable energy sources.
	Parameters	Reduction of energy consumption and a contribution by renewable energy sources of about 25% of overall energy consumption by 2020, leading to a 33% cut in greenhouse gas emissions in the EU compared with 1990.
Main Contents	Objective	The study aims to formulate, describe and evaluate strategies and a path for the EU to achieve significant reductions in its domestic greenhouse gas emissions by 2020.
	Conclusions	To reduce GHG emissions in the European transport sector a policy mix is needed, comprising ambitious fuel-efficiency improvements and the creation of standards to reduce road and air transport activity and to increase the consumer base for biofuels.
Recommended measures		The key policy measures to meet the emission reduction target are: ▪ increasing fuel efficiency for all modes of transport; ▪ enhancing agreement between the European Commission and automobile manufacturing associations (ACEA/JAMA/KAMA), with obligatory measures and a timetable; ▪ modal shift measures; ▪ improving traffic management systems and optimisation of freight logistics; ▪ achieving a biofuel share of 14.3% in 2020 of all fuels sold for road transport; ▪ establishing the emissions trading scheme in the aviation sector combined with an air traffic management system; ▪ increasing tax levels for the least energy-efficient cars and reducing them for the most efficient cars.

Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2 emissions from passenger cars

Title		Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2 emissions from passenger cars
Author		TNO, IEEP and LAT on behalf of the European Commission (DG-ENTR)
Year		2006
Keyword		**Policy to reduce CO_2 emissions from cars**
Methodology	Assumptions	The study analyses measures useful to the European Commission in its preparation of a new strategy to reduce CO_2 emissions by light-duty vehicles to a level of 120 g/km in 2012
	Approach	The approach of the study is based on the calculation of the costs of the measures in question. In particular, three main cost definitions are identified: manufacturer costs, costs to society and consumer costs. The essence of this approach is to identify a package of measures that achieves a certain level of CO_2 emissions reduction for the lowest costs.
	Parameters	The study follows three main steps: ▪ review of technical and non-technical options; ▪ scenario development; ▪ contribution to the assessment activity.
Main Contents	Objective	The project is a review of technical and non-technical measures and their costs for reducing CO_2 emissions from passenger cars, in order to: ▪ achieve the 2008/2009 EU target; ▪ identify post-2008/2009 reduction scenarios; ▪ assess the economic, environmental and social effects of the measures.
	Conclusions	There is a final comparison of all options presented by this study with respect to abatement costs for CO_2 reduction and overall reduction potential. This study allowed a subject project, '*Service contact in support of the extended impact assessment of various policy scenarios to reduce CO_2 emissions from passenger cars*'(carried out by ZEW and B&Dforecast), to conduct a macro-economic analysis of the impact on industry, global competition and promotion of innovation.
Recommended measures		The review of options suggested the following measures: <u>Technical measures:</u> ▪ Technical options to reduce fuel consumption at vehicle level; ▪ Application of fuel-efficient air conditioning systems; ▪ Options to reduce vehicle and engine resistance factors; ▪ Options for application of alternative fuels based on fossil energy; ▪ Increased application of biofuels; ▪ Possibilities to include N1 vehicles into the commitments. <u>Non-technical measures</u>: ▪ Fuel-efficient driving; ▪ CO_2-based taxation schemes for passenger cars; ▪ Options for improved energy or CO_2 labelling; ▪ Public procurement proposals

ERTRAC Strategic Research Agenda

Title		Strategic Research Framework
Author		ERTRAC (European Road Transport Research Advisory Council) members
Year		2007
Keyword		**Stakeholders vision for the road sector**
Methodology	Assumptions	The research challenge is to deliver low emissions whilst also meeting individual and societal demands for mobility, vehicle performance, reductions in greenhouse gas (GHG) emissions, and improvements in energy efficiency. The evaluation of future fuel and vehicle options and the choice of the most promising pathways need to be based on strategic studies, including the established well-to-wheel analyses.
	Approach	The approach used for the strategic analysis quantifies the benefit and the costs for each transport option.
	Parameters	In the report it is stated that for the period up to 2020, vehicles powered by ICE will continue to be the propulsion backbone, as powertrains for passenger cars, light-duty vehicles and heavy-duty trucks and buses.
Main Contents	Objective	To identify the research priorities leading to a cleaner and more energy-efficient transport system
	Conclusions	The study presents a wide spectrum of new technologies for many innovative solutions. But a sustained investment is required for the implementation phase from both public and private sectors.
Recommended measures		To realise the potential for lower emissions and increased efficiency research should address in particular the following topics: ▪ new advanced combustion processes, including hybridisation, together with optimum fuel formulations (including CNG, synthetic and bio components); ▪ improved components including new materials and design; ▪ road engineering and design (it can contribute to reducing energy use and emissions); ▪ mobility management and enhanced communication systems, especially for heavy transport

Reduction of Energy Use in Transport

Title		Reduction of Energy Use in Transport
Author		Joint Expert Group on Transport and Environment (JEGTE), carried out for the European Commission
Year		2006
Keyword		**Policy to reduce energy use**
Methodology	Assumptions	There is a need to consider all factors influencing energy use in transport over the whole chain, including transport demand, modal choice, logistics, vehicle efficiency and vehicle use.
	Approach	The assessment of measures to reduce energy use covers their technical and potential, economic and environmental implications as well as policy implementation issues.
	Parameters	For each measure its potential, time frame, political acceptability and synergy with other policies is identified.
Main Contents	Objective	The study seeks to give suggestions on reductions of energy use in transport, as an input to the discussions on the Green Paper on energy efficiency presented by the European Commission in June 2005.
	Conclusions	The general key conclusions which the study highlights are: ▪ the GHG emissions reduction policy is the most appropriate means of reducing energy use in the transport sector; ▪ there is no coherent European strategy on the reduction on energy in the transport sector; ▪ the identification of a large number of technical and non-technical measures potentially able to reduce energy consumption, useful as an input to the discussions on the Green Paper on energy efficiency presented by the European Commission in June 2005.

Recommended measures	The recommendations for desirable action at Community level are: ▪ National energy consumption targets for the transport sector; ▪ EU-wide energy efficiency benchmarks/targets for individual modes or means of transport; ▪ Use of the 'enhanced cooperation' mechanism; ▪ Establishment of a European Mobility Agency; ▪ Re-shaping of fuel taxes for motorised transport; ▪ Energy tax escalator; ▪ Subsequent application of the Extended Impact Assessment; ▪ Reduction of urban sprawl; ▪ Mobility management for businesses; ▪ Internalisation of external costs; ▪ Improvement of boundary conditions for energy-efficient public transport (PT); ▪ Improvement of boundary conditions for railways; ▪ Improvement of boundary conditions for TEN projects; ▪ Enabling EU-wide urban tolls or access restriction zones; ▪ Improvement of cycling infrastructure; ▪ Cargo centres in support of MARCO POLO; ▪ EU minimum standards for road signage and traveller information; ▪ Support for the application of IT-systems based on 'GALILEO'; ▪ CO_2 emissions trading for appropriate well-defined commercial transport sectors; ▪ Increase of technical unit efficiency of coaches and buses; ▪ Integrated transport and land-use planning for regional development; ▪ Increase of technical unit efficiency of railways; ▪ Increase of technical unit efficiency of passenger cars; ▪ Increase of technical unit efficiency of two wheelers (TW); downsizing of power and performance levels; ▪ Increase of technical unit efficiency of light-duty vehicles: CO_2-based vehicle tax; ▪ Usage of low-friction lubricants for engines; ▪ Efficient tyres; ▪ Energy-efficiency based EEV standards for all road vehicles and for buses used for public transport; ▪ Increase of R&D support; ▪ Increase of technical unit efficiency by public procurement measures; ▪ Regional Marketing Strategies; ▪ Ecodriving programs (road); ▪ Introducing standards in car driver feedback and assistance systems [onboard computer, cruise control, gearshift indicator]; ▪ Ecodriving standard in driving school curricula and driving license tests; ▪ Public information campaigns; ▪ Lower highway speed limits and improved enforcement; ▪ Improved traffic flow management; ▪ International information exchange; ▪ Mobility Management Centres; ▪ Mobile air conditioning; ▪ Vehicle efficiency labelling; ▪ Ecodriving training (including rail), improving corporate practises.

Smarter Choices – Changing the Way We Travel

Title		Smarter Choices – Changing the Way We Travel
Author		Sally Cairns, Lynn Sloman, Carey Newson, Jillian Anable, Alistair Kirkbride and Phil Goodwin, for the London Department for Transport
Year		2004
Keyword		**Soft policy to improve modal shift**
Methodology	Assumptions	Much of the experience of implementing soft factors is recent, and the evidence is of variable quality. Therefore there are inevitably uncertainties in the results. The study has the objective of testing their effectiveness.
	Approach	Each of the soft factors is analysed separately, followed by an assessment of their combined potential impact.
	Parameters	The assessment focuses on two different policy scenarios for the next ten years: ▪ the 'high intensity' scenario identifies the potential provided by a significant expansion of activity to a much more widespread implementation of present good practice, albeit to a realistic level which still recognises the constraints of money and other resources, and variation in the suitability and effectiveness of soft factors according to local circumstances; ▪ the 'low intensity' scenario is broadly defined as a projection of the present (2003-4) levels of local and national activity on soft measures.
Main Contents	Objective	The study responds to the recent growing interest in a range of initiatives which are now widely described as 'soft' transport policy measures. These seek to give better information and opportunities, to help people reduce their car use while enhancing the attractiveness of alternatives.
	Conclusions	The main conclusion is that, provided they are implemented within a supportive policy context, soft measures can be sufficiently effective in facilitating choices to reduce car use, and offer sufficiently good value for money, that they merit serious consideration for an expanded role in local and national transport strategy.
Recommended measures		The main soft transport policy measures are: ▪ Workplace and school travel plans; ▪ Personalised travel planning, travel awareness campaigns, and public transport information and marketing; ▪ Car clubs and car sharing schemes; ▪ Teleworking, teleconferencing and home shopping.

Assessing the ICT Sector. Contribution to the Millennium Development goals

Title		Assessing the ICT sector. Contribution to the Millennium Development goals.
Author		Michael Kuhndt, Justus von Geibler, Martin Herrndorf for Wuppertal Institute for Climate, Environment and Energy on behalf of the UNEP DTIE
Year		2006
Keyword		**ICT Policy for sustainable development**
Methodology	Assumptions	There is an increased use of ICT applications that has many benefits, but it also entails critical aspects regarding their adverse environmental impacts, such as a huge energy consumption during the use phase.
	Approach	The project presents the analysis of stakeholder-driven demand for a solid information base on ICT and sustainable development and a status-quo analysis of available sustainability information in the ICT sector. Furthermore, there is a comprehensive approach for assessing the ICT contribution to the UN Millennium Development Goals (MDG)
	Parameters	Among the other MDG aspects analysed in the report, the MDG7 concerns ensuring environmental sustainability
Main Contents	Objective	This project assesses sustainability risks and opportunities for the Information and Communications Technology sector and ICT applications, including aspects of climate protection.
	Conclusions	ICT is a relatively new field, which touches on and affects a wider range of economic activities. Policies to reduce possible effects (energy use, GHG emissions, land use, material consumption, air emissions, biodiversity impacts) are suggested.
Recommended measures		Using technologies and communications networks, the measures to ensure environmental sustainability are: ▪ Improved design processes; ▪ Improved logistics; ▪ Reduced land use for infrastructure.

VIBAT 2006

Title		Visioning and Backcasting for UK Transport Policy (VIBAT) Project
Author		Robin Hickman from the Halcrow Group and David Banister at the Bartlett School of Planning for the Department for Transport
Year		2006
Keyword		**Policy to reduce CO_2 emissions**
Methodology	Assumptions	The UK has a target for carbon emissions of a '60% reduction on 1990 levels by 2050'. The UK Government forecast (source: Greenhouse gas emissions from UK transport from 'Climate Change - The UK Programme 2006', DEFRA), based on current policies, is that transport will fail to meet this target, even excluding air travel. In fact, there are no specific interim targets for transport to guide policymaking, only a range of estimates from 2005 to 2020 based on current policy aspirations. The project examined the possibility of reducing UK transport CO_2 emissions by 60 per cent by 2030, testing combinations of policy measures and assessing how they can be implemented to achieve the CO_2 emissions reduction target.
	Approach	The main characteristic of the study is the approach, defined as 'backcasting', aimed at the assembly of individual policy measures into packages and suitably consistent groupings. The packages are clustered together to obtain the maximum effectiveness in contributing to the 60% CO_2 reduction target, and they are placed in a time sequencing process for implementation, as a policy path.
	Parameters	There have been three main stages in this innovative research project: ▪ the first was to set targets for 2030 and to forecast the business-as-usual situation for all forms of transport in the UK over that period so that the scale of change can be assessed in terms of achieving the emissions reductions; ▪ the second was to describe the transport system in 2030 that will meet the reduction target. This took the form of two alternative visions of the future: for the first image of the future, the 'New Market Economy', it is impossible to reach the target due to the expected growth in travel over the next 25 years; the second image, the 'Smart Social Policy' allows the of target to be achieved by means of a correct combination of policies; ▪ the third stage was the backcasting process, where alternative policy packages were assembled to lead to the image of the future, together with their sequencing in terms of when implementation should take place.

Main Contents	Objective	The two main objectives of the VIBAT project are: 1. to test the visioning and backcasting methodologies as a means of assessing challenging new environmental targets for UK transport policy – this is the methodological objective; 2. to produce a set of images of the future that represent different alternative visions for the year 2030, and to determine alternative policy packages that must be introduced to realise these images, together with the policy paths that highlight when change has to take place – this is the policy objective.
	Conclusions	The conclusions of the study suggest that a 60% emissions reduction in the transport sector could be met with a radical policy package to achieve the required level of change.
Recommended measures		Policy Packages suggested: ▪ Low-Emission Vehicles; ▪ Alternative Fuels; ▪ Charging Regimes; ▪ Liveable Cities; ▪ ICT and Travel; ▪ Soft Measures; ▪ Ecological Driving; ▪ Long-Distance Travel Substitution; ▪ Freight Transport; ▪ Carbon Credits; ▪ Oil Pricing.

Summary of the transport measures recommended by the European Commission and scientific literature

Policy clusters	Measures	Thematic strategy on air pollution, Com(2005)446	Green Paper, A European strategy for sustainable, competitive and secure energy, Com (2006)105	Action Plan for energy efficiency, Com (2006) 545	Limiting Global Climate Change to 2 degrees Celsius, Com (2007) 2 final	Results of the review of the Community strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles, Com (2007) 19 final	Green paper on market-based instruments for environment and related policy purposes, Com (2007) 140 final	White paper, European Transport Policy for 2010: time to decide (2006)	2006 Keep Europe Moving (2006)	Green paper on urban transport (draft 2007)	Stern review, Report on the Economics of Climate change (2006)	Climate change 2007, the IPCC Fourth Assessment report	Target 2000: policies and measures to reduce GHG in the EU (2005)	Review and analysis of the reduction potential and costs of technological..., TNO (2006)	ERTRAC Strategic Research Agenda (2007)	Reduction of energy use in transport (JEGTE, 2006)	Starter choices-changing the way we travel (LIT, 2004)	Assessing the ICT sector (Wuppertal institute, 2006)	Vision and backcasting for UK transport policy (Bartlett, school of planning, 2006)
Technological improvements (vehicles and fuel)	new emissions reduction target (CO_2 120g/km-2012)			X	X	X							X	X					
	target for light-commercial vehicles (vans) 175 g/km by 2012 and 160 g/km by 2015 of CO_2					X	X												
	market development for energy-efficient vehicles			X	X											X			X
	amended car fuel efficiency labelling directive (1999/94EC) (2007) - CO_2 labelling			X		X								X		X			
	norms and standards to measure tyre rolling resistance 2008			X		X	X									X			
	labelling scheme for tyres (2008)			X		X													
	efficiency requirements and air conditioning systems for automobiles (2007-08)			X		X	X							X					
	options to reduce vehicle and engine resistance factors (car design)													X	X			X	X
	support (ERTRAC project) to improve vehicles 95 /km CO_2 = 40% reduction 2020					X													
	energy efficiency in transport use (speed limits, development and research)		X						X		X	X	X	X	X	X			X
	financial instruments to stimulate investment		X																X
	renewed effort for transport		X																
	'white certificates' - trading system		X																
	better information on energy performance		X		X														
	energy innovation (alternative fuel, second generation biofuel)	X	X		X	X	X	X				X	X	X	X				X
	proposal for a regulation on motor vehicles using hydrogen as a fuel						X							X	X				X
	full review of the EU emissions trading scheme		X																
	obligation/recommendation, Public Authority, clean vehicles	X																	
Charging and taxation	reduce congestion (internalising external cost) - congestion charges	X		X				X		X						X			
	common framework for infrastructure charging	X						X											
	differential road charging, air pollution (tolls zone)	X						X				X				X			
	link taxes on passenger car to CO_2 emission levels				X	X		X						X		X			X
	fiscal incentive to encourage the cleanest light-duty vehicles classes					X						X	X			X			X
	explore possibility of ETS for road transport, starting 2013						X	X			X								
	CO_2 emissions trading for commercial transport															X			
	re-shaping of fuel taxes for motorised transport															X			
Long-distance travel (passengers and freight)	implement the legal framework for rail transport (2007)			X				X											
	increase rail market share by providing fair competition between modes							X											
	improve the organisation of intermodal transport							X					X						
	stimulating rail usage by increasing quality							X					X						

Policy clusters	Measures	Thematic strategy on air pollution, Com(2005)446	Green Paper, A European strategy for sustainable, competitive and secure energy, Com (2006)105	Action Plan for energy efficiency, Com (2006) 545	Limiting Global Climate Change to 2 degrees Celsius, Com (2007) 2 final	Results of the review of the Community strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles, Com (2007) 19 final	Green paper on market-based instruments for environment and related policy purposes, Com (2007) 140 final	White paper, European Transport Policy for 2010: time to decide (2006)	2006 Keep Europe Moving (2006)	Green paper on urban transport (draft 2007)	Stern review, Report on the Economics of Climate change (2006)	Climate change 2007, the IPCC Fourth Assessment report	Target 2000: policies and measures to reduce GHG in the EU (2005)	Review and analysis of the reduction potential and costs of technological..., TNO (2006)	ERTRAC Strategic Research Agenda (2007)	Reduction of energy use in transport (JEGTE, 2006)	Starter choices-changing the way we travel (LIT, 2004)	Assessing the ICT sector (Wuppertal institute, 2006)	Vision and backcasting for UK transport policy (Bartlett, school of planning, 2006)
	increase technical unit efficiency of railways															X			
	eco-driving training (including rail), improving corporate practices															X			
Liveable cities	framework for designating LEZ	X																	X
	better use of public transport and rational use of the car							X		X		X				X			X
	land-use planning (integrated transport, reduction of urban sprawl)								X	X		X				X		X	X
	transport demand management measures				X					X		X	X		X	X	X		X
	walking/bicycle infrastructure									X						X			X
ICT (Information and Communications Technology)	real-time traffic and travel information			X					X	X	X						X	X	X
	research and development into technology and applications including Galileo						X	X	X							X		X	X
	teleworking, teleconferencing and home shopping																X	X	
Eco-friendly behaviour	legislation to harmonise fuel efficiency in driving education curricula /2008)			X		X										X			
	eco-driving device (real time consumption indicator)						X			X				X	X	X			X
	lower speed limits and improved enforcement															X			X
	demarketing (car manufacturers' promotion of sustainable consumption pattern)					X													X
	car sharing schemes									X							X		X
Logistics	urban freight logistics									X			X						X
Air and maritime	economic instruments to reduce CO_2																		
	emissions trading scheme (end of 2006)			X	X								X						
	promote energy efficiency trough SESAR			X															
	air traffic management system												X						
	air pollution (emission) standard	X																	
	new standard NOx 2006	X																	
	potential of optimising hull cleaning of ships (2007-2008)			X															
	shore-side electricity for ships in port (2008-2009)	X		X															
	promote short-sea shipping and motorways of the sea (2007-2012)			X				X											
	transhipment facilities							X											
	limit GHG emissions of CO_2				X														

Annex to chapter 6

CO_2 emissions reduction – effect of policy packages – million tonnes by 2010

Policy packages	CO_2 savings from policies in 2010 (million tonnes)	Number of Countries with Active Policies*
Technological improvements (Vehicles and fuels)	55,8	19
Charging and taxation	217	51
Liveable cities (urban policy)	89	33
ICT (Information and Communications Technology)		
Eco-friendly behaviour		
Logistics	110,9	37
Total	472,7	140

Source: TRT on the basis of ECMT 2007

*The EU is included as if it were a single country where the policy was introduced across Member States through an EU Directive