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Mitigating climate change

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Photo on cover page: public transport in Paris (photo: Kjell Ottar Sandvik, Norwegian Public Roads Administration)

Preface

The objective of task group 17 is to provide the road directors with annual reports in order to keep all CEDR's national road administrations (NRAs) informed about on-going activities concerning climate change and sustainable mobility and to exchange information about policies and strategies and their consequences for the work of the NRAs.

This report is an updated version of the 2012 annual report, with the addition of two new themes:

- long-term planning in line with greenhouse gas (GHG) objectives (Chapter 8)
- the indirect effects of speed limits (Sections 9.1.2 and 9.1.3)

The report is based on publicly accessible statistics and websites, supplemented by the responses to a questionnaire that was distributed to the members of both task group 16 (Adaptation to Climate Change) and task group 17 (Mitigating climate change). Task groups 16 and 17 have been organised as a single project group led by Norway.

The information in the report is limited to the member countries of the project group. The statistics are from all the participating countries, while the analytical part (which is based on the questionnaire) naturally covers only the countries whose representatives submitted responses.

The leader of the Project Group on Climate Change (comprising task groups 16 and 17) is Gyda Grendstad (Norway).

This report has been edited by Kjell Ottar Sandvik, leader of task group 17, and Marie Aarestrup Aasness.

Oslo, March 2013

Gyda Grendstad
Leader, Project Group on Climate Change

This report is: **FOR INFORMATION**

1 Executive summary

The mitigation of climate change is by definition any action that seeks to decrease the intensity of radioactive forcing in order to reduce the potential effects of global warming. Mitigation of climate change is distinguished from adaptation to global warming, which means acting to tolerate the effects of global warming.

International cooperation and measures

For a number of years, the European Union (EU) has been committed to tackling climate change both internally and internationally and has placed it high on the EU agenda, as reflected in European climate change policy. The 2011 EU White Paper on the Future of Transport outlines very ambitious long-term goals. A Transport 2050 roadmap has been drawn up, setting goals for different types of travel: within cities, between cities, and long distance.

Policies, targets, and research

Very few of the participating countries have a separate strategy for reducing energy use and GHG emissions in the road sector. Most countries incorporate the road sector into their overall strategy for the transport sector. All countries that responded to the survey have a national policy for mitigating climate change. Most, but not all, NRAs have a wider role in addition to their core mission of building and maintaining the national road network.

Trends and indicators for energy use and GHG emissions

The transport sector's share of GHG emissions has increased from 14% in 1990 to 20% in 2010 in the EU-27. Road transport accounts for the largest share of GHG emissions in the transport sector, with a peak in GHG emissions for some of the 12 countries participating in the Project Group on Climate Change (CEDR-12) in 2000 and 2005.

Energy efficiency increased during the 1990s; accordingly, GHG emissions and total energy use per unit of gross domestic product decreased during the decade. From 1995 to 2011, CO_2 emissions from new passenger cars were reduced by 27% within the EU-27, from 186 g/km to 136 g/km.

The potential for GHG reduction in the road transport sector

In order to meet climate objectives, an 80% reduction in GHG emissions from road transport in the EU by 2030 (with 2004 as the baseline) might be needed. Actions are needed in three different areas: development and use of more energy-efficient vehicles, replacement of fossil fuels with renewable fuels and electricity, and measures to decrease VKT (vehicle kilometres travelled). Measures to decrease VKT include sustainable urban planning, improved public transport and facilities for cycling and walking, more efficient transport of goods, increased fuel taxes, stricter parking policies, and vehicle charges (congestion charging as well as road pricing per km or restrictions on vehicles).

Sweden's experience indicates that reductions in GHG in line with the 2°-C climate target are possible for the road transport sector. The crucial element is the production of biofuel. Sufficient production of second- and third-generation biofuels is required, and this production must be sustainable.

Long-term planning is often not in line with GHG objectives

Transport system planning usually relies on predictions based on current trends. This method of planning the expansion and extension of a road system is called 'predict and provide': the road system is developed in accordance with existing trends and prognoses for traffic growth. However, the climate objectives and other needs point in a different direction.

As a basis for transport planning, the desirable future which meets political objectives must be defined first; then planners must work backwards to identify the tools and measures needed to connect the future to the present. The method is called 'back-casting'.

In rural areas, cars will continue to be the main mode of transport. It is important to design measures that do not compromise the viability of these areas. The considerable change in trend according to car use will initially involve higher costs for vehicles, fuels, and infrastructure. In the longer term, beyond 2030, costs relating to this scenario could be lower compared with a scenario based on current developments. These conclusions are also supported by a recent report by the International Energy Agency (IEA). Their conclusion, based on a scenario for the transport system that contributes to the fulfilment of the 2°-C target, is that the reduction in costs yielded by fewer vehicles and less infrastructure with reduced energy use more than compensates for early investments in technology compared with existing developments.

Traffic management can influence GHG emissions

Traffic management and ITS measures can be used to achieve better traffic flow and to reduce the emission of contaminants, in this case GHG. In urban areas, this can be done by optimising traffic lights. For highway networks, different types of measures are available. In most cases, when traffic flow is improved and travel time reduced, the volume of traffic also increases. The induced traffic could slightly reduce the environmental benefits of the traffic flow improvement.

One demand management method is congestion charging, also called congestion tax or congestion pricing. The main objective of this scheme is to reduce congestion, thereby reducing travel times and improving reliability for individual and public transport users. Large-scale congestion charging systems are in place in Singapore, London, Stockholm, and Milan. In London, traffic has been reduced by 237 million vehicle km and GHG emissions by 120,000 t.

Energy-efficient road infrastructure.

Energy use is not limited to the vehicles using the infrastructure. Infrastructure construction, maintenance, and operation also require energy. To minimise energy use, it is important to consider the life cycle of the infrastructure, including the energy consumed by the vehicles that utilise it. This methodology, which is based on Life Cycle Assessment (LCA), aggregates the emissions generated by the extraction of raw materials, the processing of these materials, construction of the infrastructure, and its use. GHG emissions should be taken into account at the earliest stage of planning, while there are still alternative solutions that may vary significantly with respect to greenhouse gas emissions.

Cooperation with other partners

NRAs must cooperate with other partners (research institutions, construction companies, municipalities, and agencies for technical standards and guidelines) in their efforts to mitigate climate change. Even though they may not have a direct influence on certain processes, the NRAs can play an important catalysing role by seeking contact with potential partners and encouraging and supporting these partners' own activities to reduce GHG emissions.

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3 Introduction

3.1 Terms of reference for task group 17

CEDR's Executive Board gave task group 17 (Mitigating Climate Change) the following terms of reference:

Goals:	To keep CEDR's members informed about on-going activities concerning climate change and sustainable mobility. CEDR shall take direct action only if clear and visible benefits from CEDR's involvement can be defined.
Strategy:	- Exchange information on government policies formulated in different countries for mitigation of climate change - Assess the possible consequences for the NRAs and for their network operations - Define targets to be reached by the transport sector and the NRAs - Exchange of views and insights - Provide regular reports about on-going activities
Expected output:	A report about on-going activities and trends shall be produced annually.

The current report is the fourth and final report.

3.2 Background: the GHG emissions trend needs to be reversed

Climate change mitigation means taking action to decrease the intensity of radiative forcing in order to reduce the potential effects of global warming. Mitigation of climate change is distinguished from adaptation to global warming, which means taking action to tolerate the effects of global warming. Most often, climate change mitigation scenarios involve reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks.[1]

According to the Intergovernmental Panel on Climate Change (IPCC), which brings together hundreds of scientific experts on climate change from across the world, the global average temperature has risen almost 0.8°C since the second half of the nineteenth century. The IPCC is more than 90% certain that human activities that release greenhouse gases are having a net warming effect on the atmosphere. The first decade of the twenty-first century was the warmest since reliable record-keeping began in 1880.[2]

Since the beginning of the industrial revolution in 1750, the concentration of CO_2 in the atmosphere has increased by 40%, mainly due to the use of fossil fuels and deforestation.[3] The UN Intergovernmental Panel on Climate Change (IPCC) has drawn up scenarios that show that by 2100, the temperature on earth is expected to rise by between 1° and 6 °C. To avoid dangerous impacts on the climate, EU member states have agreed to work to stabilise the average global temperature at a maximum 2°-C increase relative to pre-industrial times.

[1] European Commission (2011) 'A road-map for moving to a competitive low carbon economy in 2050, COM (2011) 112 final
[2] European Commission, http://ec.europa.eu/clima/policies/international/index_en.htm
[3] Global greenhouse gas warming, Anthropogenic Climate Change, http://www.global-greenhouse-warming.com/anthropogenic-climate-change.html

Consumption and transport needs are growing, and both developing and industrialised countries are using ever more energy, especially from sources such as oil and gas. Global cooperation is needed. In order to limit climate change, global emissions need to be reduced by 50–85% by 2050.

Emissions from developing countries now exceed those from developed countries, and this share will continue to rise. Projections show that by 2020, nearly two-thirds of global emissions will come from developing countries. To be effective, action to combat climate change needs to become global.

UN negotiations aimed at drawing up a global climate agreement by 2009 to replace the Kyoto Protocol at the end of its first commitment period failed. Instead, under the voluntary Copenhagen Accord, countries were invited to make pledges to limit or reduce their emissions by 2020.[4]

In its road map for a low-carbon economy, the European Commission has proposed a reduction target of 40% by 2030 and 80% by 2050 relative to 1990. Targets have also been set for the different sectors. For the transport sector, these targets are presented in the 2011White Paper on Transport. While emissions from transport continue to increase, they could be reduced to more than 60% below 1990 levels by 2050. By 2030, they could be reduced to 9% below 1990 levels.[5] The road transport sector in the EU has the potential to reduce GHG emissions by 80% by 2030. This is described in more detail in Chapter 7. Some of the targets are summarised in the table below.

The International Energy Agency stresses the urgency of starting to reduce the emissions of greenhouse gases; if this is not done, 'the door to 2° C is closing'. 'If stringent new action is not forthcoming by 2017, the energy-related infrastructure then in place will generate all the CO_2 emissions allowed in the 450 Scenario up to 2035, leaving no room for additional power plants, factories and other infrastructure unless they are zero-carbon, which would be extremely costly.' [6]

Targets for reducing GHG emissions:

Year	Sector	Target	Reference
2030	All sectors in the EU	A reduction target of 40–44% with respect to 1990	European Commission road map for a low-carbon economy
2050	All sectors in the EU	A reduction target of 79–82% with respect to 1990	European Commission road map for a low-carbon economy
2030	The transport sector in the EU	9% reduction of GHG emissions with respect to 1990	European Commission White Paper on Transport
2050	The transport sector in the EU	54–67% reduction of GHG emissions with respect to 1990	European Commission White Paper on Transport

[4] European Commission, http://ec.europa.eu/clima/policies/international/negotiations/index_en.htm
[5] European commission, http://ec.europa.eu/clima/policies/roadmap/perspective/index_en.htm
[6] International Energy Agency, World Energy Outlook 2011.

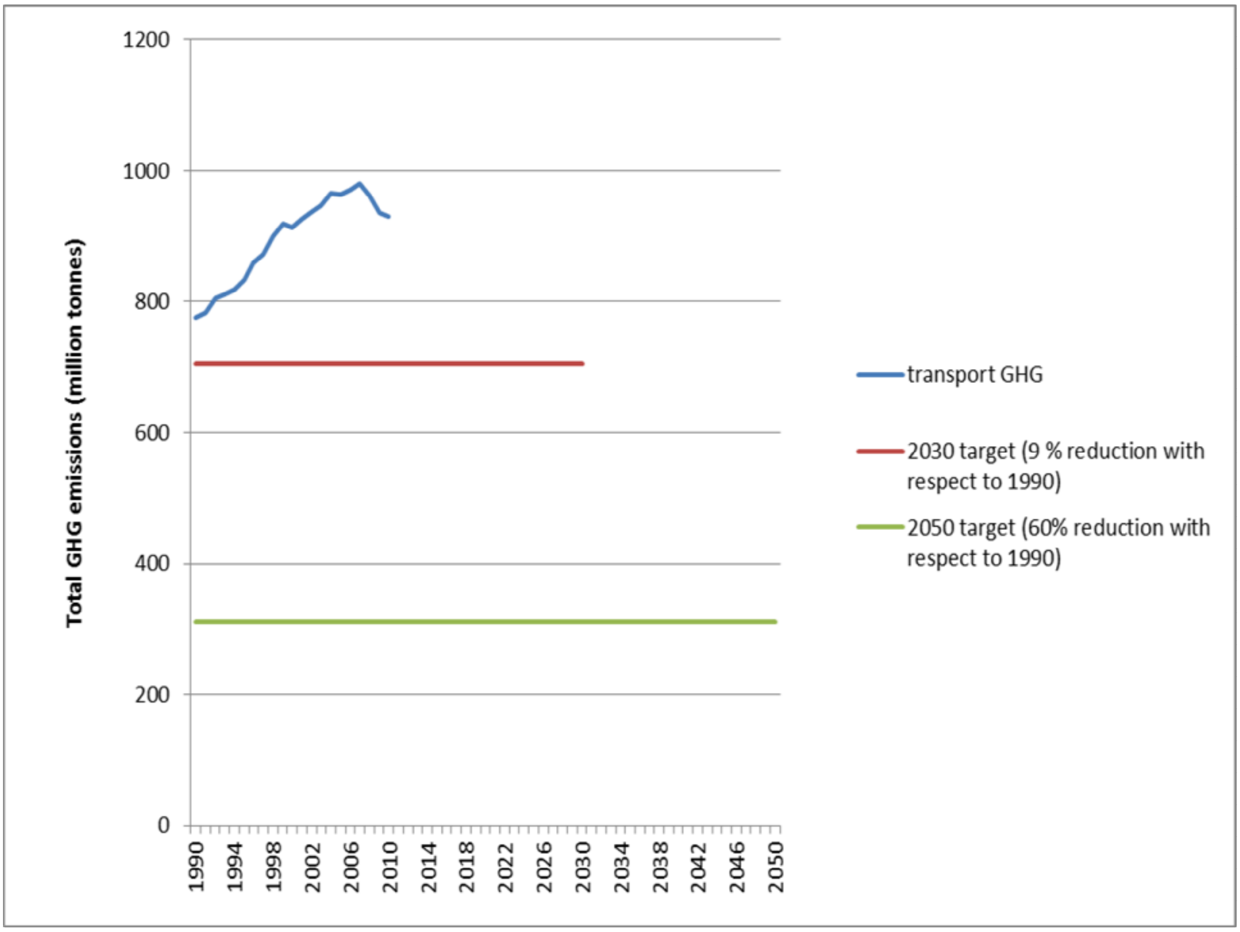

Figure 3.1: GHG emissions from transport (from civil aviation, other transport, navigation, railways, and road transport) in the EU-27 and targets for 2030 and 2050 (data source: EEA)

4 International cooperation and measures

4.1 International cooperation

To achieve the emission reductions needed to forestall a continuing cycle of global warming, a broad range of policy instruments will have to be developed, and action by all countries will be required.

The Kyoto Protocol, adopted in 1997 by countries participating in the UNFCCC, has taken a first step towards addressing the increasing GHG emissions mentioned in Chapter 3. The world's only legally binding treaty to reduce GHG emissions, it only requires action to be taken by developed countries. Under Kyoto's first commitment period, from 2008 to 2012, these countries were supposed to reduce their emissions by an average of 5% below 1990 levels by 2012. The 15 countries that were EU member states at the time that Kyoto was adopted committed to an 8-per cent cut and are on track to achieve this by a comfortable margin. In addition to not requiring developing countries to take action, the protocol's impact was further limited by the fact that it was never ratified by the United States and that Canada has since withdrawn.

Until 2020, the international climate regime will comprise—in addition to the existing provisions of the UNFCCC—new rules, institutions, and commitments that were borne of the UN climate conferences held in Copenhagen (2009), Cancún (2010), Durban (2011), and Doha (2012). These commitments include voluntary emission pledges for 2020 that have been made by more than 90 countries to date, as well as commitments by developed countries to provide financial support to help developing countries adapt to climate change and limit their emissions.

The countries at the 2012 UN Climate Conference in Doha, Qatar, extended the Kyoto Protocol to the end of 2020. The second commitment period of the Kyoto Protocol will run from 2013 to the end of 2020, when the global agreement enters into force. The EU is participating in the second period, but as several major emitters among the developed countries are not, Kyoto will cover only about 14% of global emissions.

Work is also underway at international level to raise the ambitions for global action before 2020 by identifying actions that can be taken to reduce emissions further. This work applies to all countries, whether or not they are parties to the second commitment period of the Kyoto Protocol.[7]

4.2 The EU's ambitions

For several years now, the European Union has been committed to tackling climate change both internally and internationally. This issue ranks high on the EU agenda, as reflected in European climate change policy. The EU is taking action to curb GHG emissions in all its areas of activity in a bid to achieve the following objectives:

- to consume less-polluting energy more efficiently,
- to create cleaner and more balanced transport options,
- to make companies more environmentally responsible without compromising their competitiveness,

[7] European Commission, http://ec.europa.eu/clima/policies/international/index_en.htm

- to ensure environmentally friendly land-use planning and agriculture
- to create conditions conducive to research and innovation (Europa.eu[8] (22/04-2013))

In the context of a global and comprehensive international agreement, EU heads of states and governments made a commitment in March 2007 that the EU will cut its emissions to 30% below 1990 levels by 2020 provided that other developed countries commit to making comparable reductions.

At the same time, EU leaders pledged to transform Europe into a highly energy-efficient, low-carbon economy. They underlined their determination to see the EU gain a 'first mover advantage' by committing the EU to cut emissions by at least 20% of 1990 levels by 2020, regardless of what action other countries take.

These emission targets are underpinned by three energy-related objectives, which are also to be met by 2020:

- a 20% reduction in energy use through improved energy efficiency,
- an increase in renewable energy's share of the market to 20% (from around 9% today),
- as part of the renewable energy effort, a 10% share of sustainably produced biofuels and other renewable fuels used for transport in each member state.

The targets have been individually set for each country, based on that country's policy, within the agreed targets of the EU.

Transport in Paris (photo: Kjell Ottar Sandvik, Norwegian Public Roads Administration)

[8] See website http://europa.eu/legislation_summaries/environment/tackling_climate_change/

4.3 EU legislation and policies

EU legislation on CO_2 from passenger cars is to be found in Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009, setting emission performance standards for new passenger cars as part of the community's integrated approach to reducing CO_2 emissions from light-duty vehicles. Under the Cars Regulation, the fleet average to be achieved by all new cars is 130 grams of CO_2 per kilometre (g/km) by 2015 and 95g/km by 2020. The regulation is currently undergoing amendment in order to implement the 2020 target.[9] EU directive 510/2011contains similar legislation for light commercial vehicles.

Directive 2009/30/EC, which revises the Fuel Quality Directive [Directive 98/70/EC], was adopted in April 2009. It amends a number of elements of the petrol and diesel specifications and introduces in Article 7a a requirement that fuel suppliers reduce the GHG intensity of energy supplied for road transport (Low Carbon Fuel Standard). In addition, the Directive establishes sustainability criteria that must be met by biofuels if they are to count towards the GHG intensity reduction obligation.

Under the directive promoting renewable energy, at least 10% of energy in every member state must come from renewable sources by 2020. There is an urgent need to ensure that the EU meets this goal, by using either electricity or hydrogen from renewable energy sources or first- or second-generation biofuels. The directive on renewable energy also aims to ensure that the EU expands the use of biofuels. Only sustainable biofuels are used in the EU, generating a clear and net GHG saving and with no negative impact on biodiversity and land use. The background and details of the biofuels sustainability scheme were discussed through public consultation and analysed in an impact assessment.

The European Commission adopted the Action Plan on Urban Mobility on 30 September 2009. The Action Plan proposes 20 measures to encourage and help local, regional, and national authorities to achieve their goals for sustainable urban mobility. With this action plan, the European Commission presented for the first time a comprehensive support package in the field of urban mobility. The aim is to support cities in their efforts to achieve a more sustainable and effective urban transport.

The 2011 White Paper on the Future of Transport, which was presented in the following press release, outlines very ambitious long-term goals. Following up these goals with concrete action in the short term will be of the utmost importance. The following text is copied from the Commission's press release:

> ***White paper 2011*[10]**
>
> ***Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system***
>
> *The European Commission adopted a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050.*

[9] European Commission, http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm
[10] European Commission (2011), White paper, Roadmap to a Single European Area – Towards a competitive and resource efficient transport system, http://ec.europa.eu/transport/strategies/2011_white_paper_en.htm

By 2050, key goals will include:

- *No more conventionally-fuelled cars in cities.*
- *40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions.*
- *A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.*
- *All of which will contribute to a 60% cut in transport emissions by the middle of the century.*

The Transport 2050 roadmap to a Single European Transport Area sets out to remove major barriers and bottlenecks in many key areas across the fields of: transport infrastructure and investment, innovation and the internal market. The aim is to create a Single European Transport Area with more competition and a fully integrated transport network which links the different modes and allows for a profound shift in transport patterns for passengers and freight. To this purpose, the roadmap puts forward 40 concrete initiatives for the next decade.

The Transport 2050 roadmap sets different goals for different types of journey - within cities, between cities, and long distance.

1. ***For intercity travel: 50% of all medium-distance passenger and freight transport should be shifted off the roads and onto rail and waterborne transport.***

- *By 2050, the majority of medium-distance passenger transport, about 300km and beyond, should go by rail.*
- *By 2030, 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport, and more than 50% by 2050.*
- *Deliver a fully functional and EU-wide core network of transport corridors, ensuring facilities for efficient transfer between transport modes (TEN-T core network) by 2030, with a high-quality high-capacity network by 2050 and a corresponding set of information services.*
- *By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.*
- *By 2020, establish the framework for a European multimodal transport information, management and payment system, both for passengers and freight.*
- *Move towards full application of 'user pays' and 'polluter pays' principles and private sector engagement to eliminate distortions, generate revenues and ensure financing for future transport investments.*

2. ***For long-distance travel and intercontinental freight, air travel and ships will continue to dominate. New engines, fuels and traffic management systems will increase efficiency and reduce emissions.***

- *Low-carbon fuels in aviation to reach 40% by 2050; also, by 2050, reduce EU CO_2 emissions from maritime bunker fuels by 40% (if feasible, by 50%).*
- *A complete modernisation of Europe's air traffic control system by 2020, delivering the Single European Sky: shorter and safer air journeys and more capacity. Completion of the European Common Aviation Area of 58 countries and 1 billion inhabitants by 2020.*

- *Deployment of intelligent land and waterborne transport management systems (e.g. ERTMS, ITS, RIS, SafeSeaNet and LRIT).*
- *Work with international partners and in international organisations such as ICAO and IMO to promote European competitiveness and climate goals at a global level.*

3. For urban transport, a big shift to cleaner cars and cleaner fuels. 50% shift away from conventionally fuelled cars by 2030, phasing them out in cities by 2050.

- *Halve the use of 'conventionally fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO_2-free movement of goods in major urban centres by 2030.*
- *By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. Make sure that the EU is a world leader in safety and security of transport in aviation, rail and maritime.*

The EU is also drafting a strategy to reduce GHG emissions from heavy-duty vehicles. A regulation making it mandatory to provide information about emissions from these vehicles is in the pipeline. The strategy will be finalised in 2013, and the regulation is scheduled to be adopted in 2014. In January 2013, the EU Commission launched a clean fuel strategy, proposing a package of binding targets on member states for a minimum level of infrastructure for clean fuels such as electricity, hydrogen, and natural gas, as well as common EU-wide standards for the equipment needed.

The Clean Power for Transport Package consists of a communication on a European alternative fuels strategy, a directive focusing on infrastructure and standards, and an accompanying document describing an action plan for the development of Liquefied Natural Gas (LNG) in shipping.

The main measures proposed with relevance for the road sector are:

- **Electricity:** the situation as regards electric charging points varies greatly across the EU. The aim is to put in place a critical mass of charging points so that companies will mass produce the cars at reasonable prices. A common EU-wide plug is an essential element for the roll-out of this fuel. To end uncertainty on the market, the Commission has announced the use of the 'Type 2' plug as the common standard for the whole of Europe.
- **Hydrogen:** according to this proposal, existing filling stations will be linked up to form a network with common standards, ensuring the mobility of hydrogen vehicles. This applies to the 14 member states which currently have a hydrogen network.
- **Biofuels** already account for nearly 5% of the market. A key challenge will be to ensure their sustainability.
- **LNG:** liquefied natural gas is also used for trucks, but there are only 38 filling stations in the EU. The Commission is proposing that by 2020, refuelling stations will be installed every 400 km along the roads of the Trans-European Core Network.
- **CNG:** compressed natural gas is mainly used for cars. One million vehicles currently use this fuel, representing 0.5% of the total fleet. The industry aims to increase this figure ten-fold by 2020. The Commission proposal will ensure that publically accessible refuelling points with common standards are available across Europe at maximum intervals of 150 km by 2020.

5 Survey of policies, targets, and research

5.1 Introduction

Task group 17 conducted a survey of policies, targets, and research among the countries participating in the project group. The summary of the conclusions is given in Sections 5.2–5.4; the full report is available in the appendix.

The first survey was conducted between November 2009 and January 2010. The updated survey was completed by 2012. Its main purpose is to provide a rough overview of the field as a basis for further work by task group 17.

Transport in Paris (photo: Kjell Ottar Sandvik, Norwegian Public Roads Administration)

5.2 The survey of policies

Most NRAs have a wider role in addition to their core mission of building and maintaining the national road network. Key topics for further investigation are both emissions of GHG from road building and maintenance, and cooperation with other authorities on subjects concerning climate change.

All countries that responded to the survey have a national policy for mitigating climate change. Several of the respondents commented that such a national, cross-sectoral policy must be expressed in general terms.

Sector-specific strategies appear to be in place in many of the countries that responded to this question in the survey. How specific these strategies are seems to vary. It is not clear how this approach affects the countries' concrete actions.

Very few of the participating countries have a separate strategy for reducing energy use and GHG emissions in the road sector. Most countries include the road sector in their overall strategy for the transport sector. This approach may affect their ability to take concrete action.

The general impression is that measures involving taxation, technology, and fuels are being implemented, while measures to reduce traffic have not yet been considered to the same extent.

5.3 The survey of targets

The targets for energy use are mostly formulated as a total for all sectors. Targets specified for the transport sector involve the introduction of biofuel. Only one country (Hungary) has specified a target for the road sector. One country (Norway) has no targets for energy efficiency.

Most countries have targets for total emissions (all sectors) and for the transport sector as well. Two countries have adopted targets for the road sector. Some countries have formulated targets for a projected and immeasurable future (mostly 2020).

The most common targets for the road sector are targets for the introduction of biofuels. This target is not generally specific to the road sector alone, but for the transport sector as a whole. Most countries list measures without being specific as to the scope of the measures or when they are to be implemented.

5.4 The survey of research

The survey included some questions about on-going research, focusing on two main issues in particular:

- the impact of road infrastructure construction, operation, and maintenance on GHG emissions,
- the reduction of energy use and GHG emissions in urban areas.

The survey reveals broad on-going research in the CEDR-12 in different fields, such as vehicle technology, fuels, multimodal transport systems, and methods for planning construction, maintenance, and operation. A brief summary of on-going research (main research programmes identified in the survey responses) is presented in Appendix C.

The research project 'Energy – Sustainability and Energy Efficient Management of Roads', initiated by ERA-NET ROAD, is currently addressing a number of relevant issues (see Appendix C.4.)

6 Trends and indicators

6.1 Transport trends

A key finding is that the rate of energy efficiency improvement in International Energy Agency (IEA) countries since 1990 has been less than 1% per year—much lower than in previous decades. Consequently, final energy use and CO_2 emissions have both increased significantly, with particularly large growth in the transport and service sectors. Despite some variations in the share of passenger-kilometres, cars are the main driver behind increased passenger travel in all CEDR-12. Once individuals and families own a car, two things tend to happen: firstly, they complete a greater proportion of their trips by car; secondly, their total distance travelled rises significantly. Transport sector emissions showed a slight reduction in 2008 as a result of high oil prices (which peaked at US$140 per barrel) during the first half of the year and the onset of an economic crisis in the second half of the year.

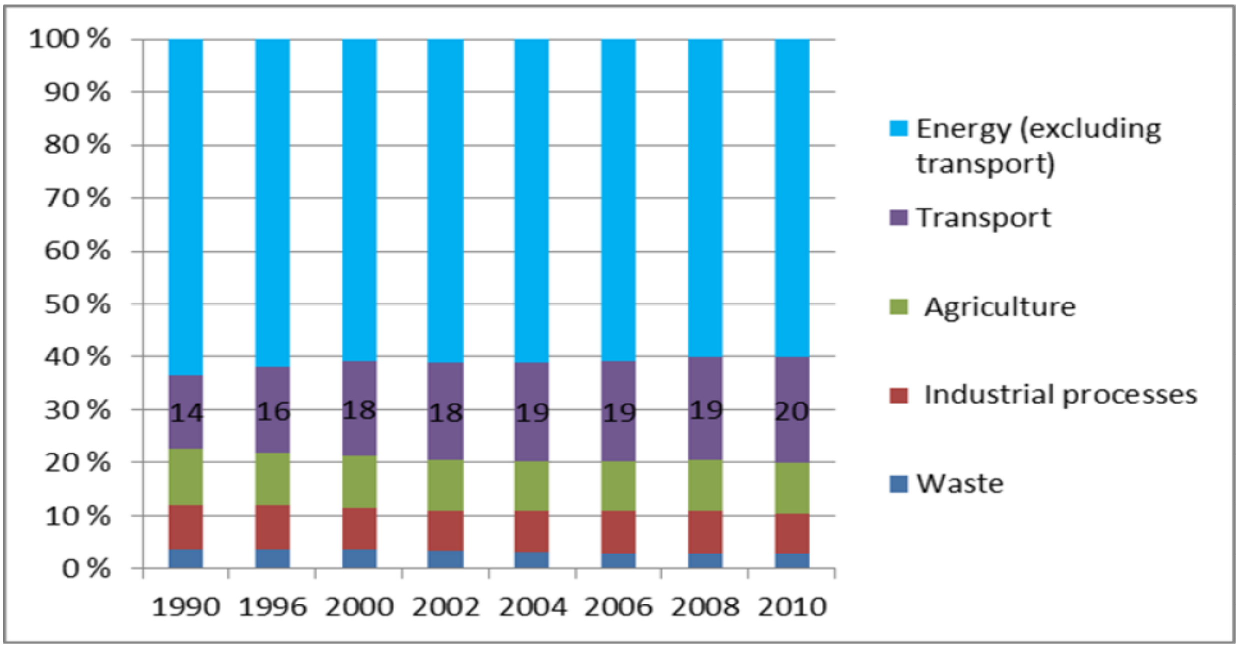

Figure 6.1: GHG emissions per sector in the EU-27 (data source: EEA)

Road transport accounts for the largest share of GHG emissions in the transport sector, with a peak in GHG emissions for some of the CEDR-12 in 2000 and 2005. Transport volumes appear to be increasing steadily as wealth increases. Figure 6.2 illustrates the emissions of GHG from road transport for 1990, 2000, 2005, and 2010. Norway is the only country where GHG emissions increased between 2005 and 2010. This is probably due to economic growth and low unemployment. Nevertheless, substantial improvements have been made to energy efficiency in vehicles.

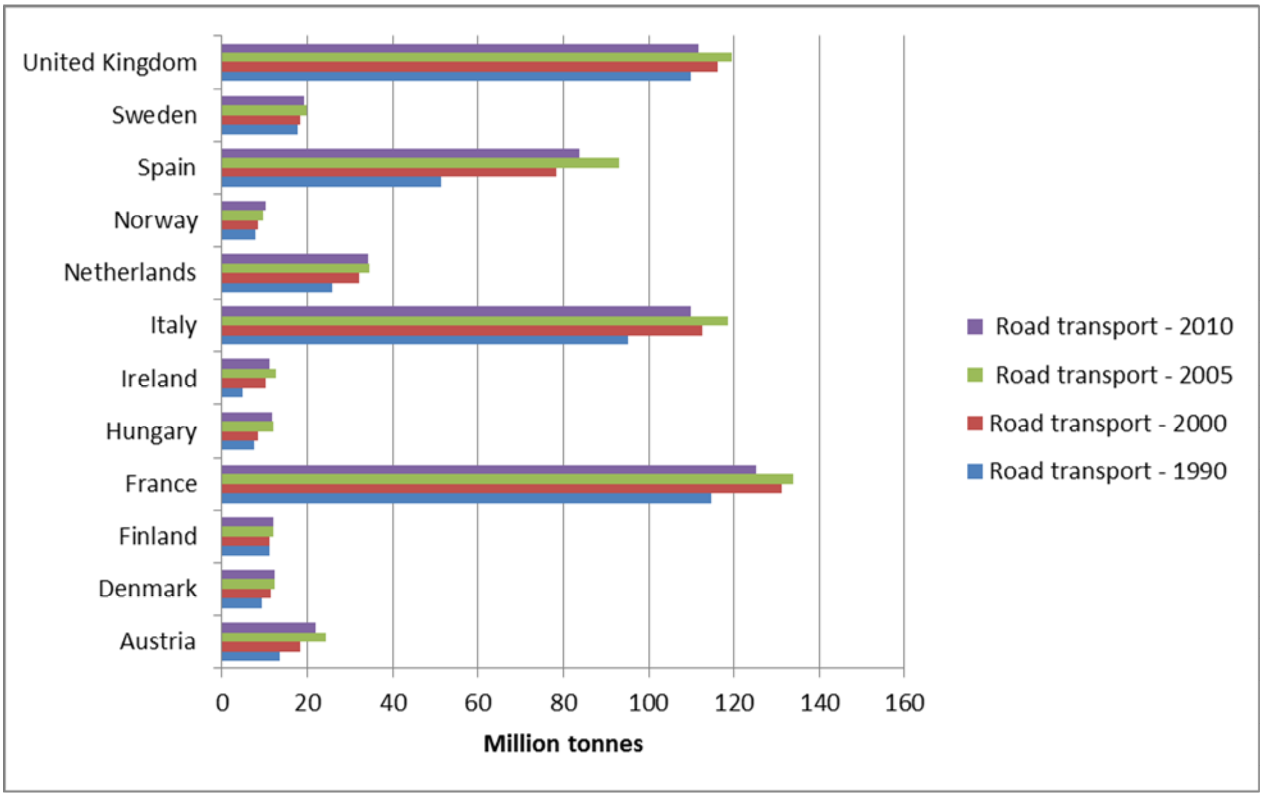

Figure 6.2: GHG from road transport in 1990, 2000, 2005, 2010 (source EEA)

Energy efficiency increased during the 1990s; accordingly, GHG emissions and total energy use per unit of gross domestic product decreased during the decade. In contrast, final energy use per capita increased in most countries. This increase was linked to growing wealth, which means greater per capita demand for energy-consuming goods and services. From 1995 to 2011, CO_2 emissions from new passenger cars were reduced by 27% within the EU-27, from 186 g/km to 136 g/km.

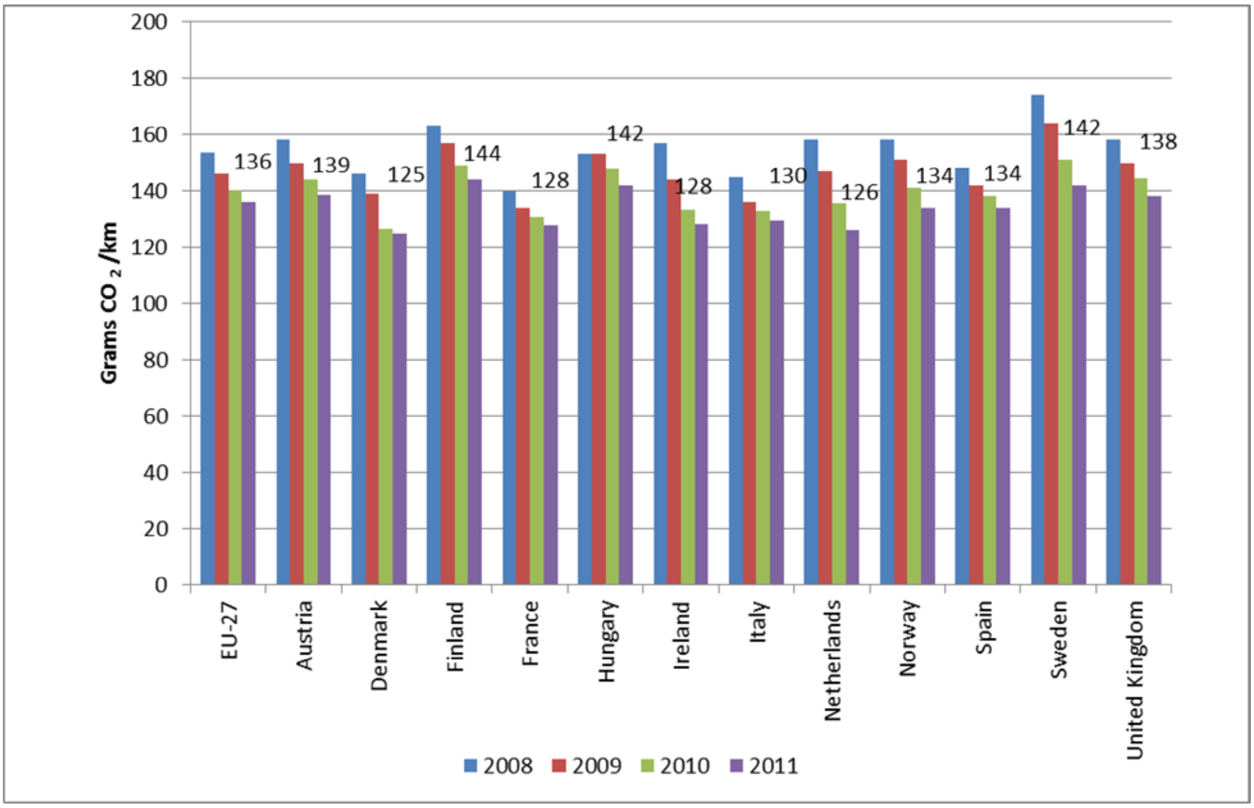

Figure 6.3: CO_2 emissions from new passenger cars (data sources: EU DG Environment, Transport and Environment and the Norwegian Public Roads Administration)

Biofuels have also been introduced and accounted for 4.3% of the energy use in the road transport sector in the EU-27 (2009).

Figure 6.4 below shows changes in emissions from freight transport and passenger transport for seven of the CEDR-12 from 1990 to 2010. The general picture is that the total level of emissions from freight transport on roads has been steadily increasing for all seven countries, and its share of the total emissions from road transport is growing. Emissions from passenger transport on roads have been increasing since 1990 for Denmark and Norway and have declined slightly in Sweden and Hungary. Corresponding emissions peaked in France, the United Kingdom, and Italy between 1990 and 2010.

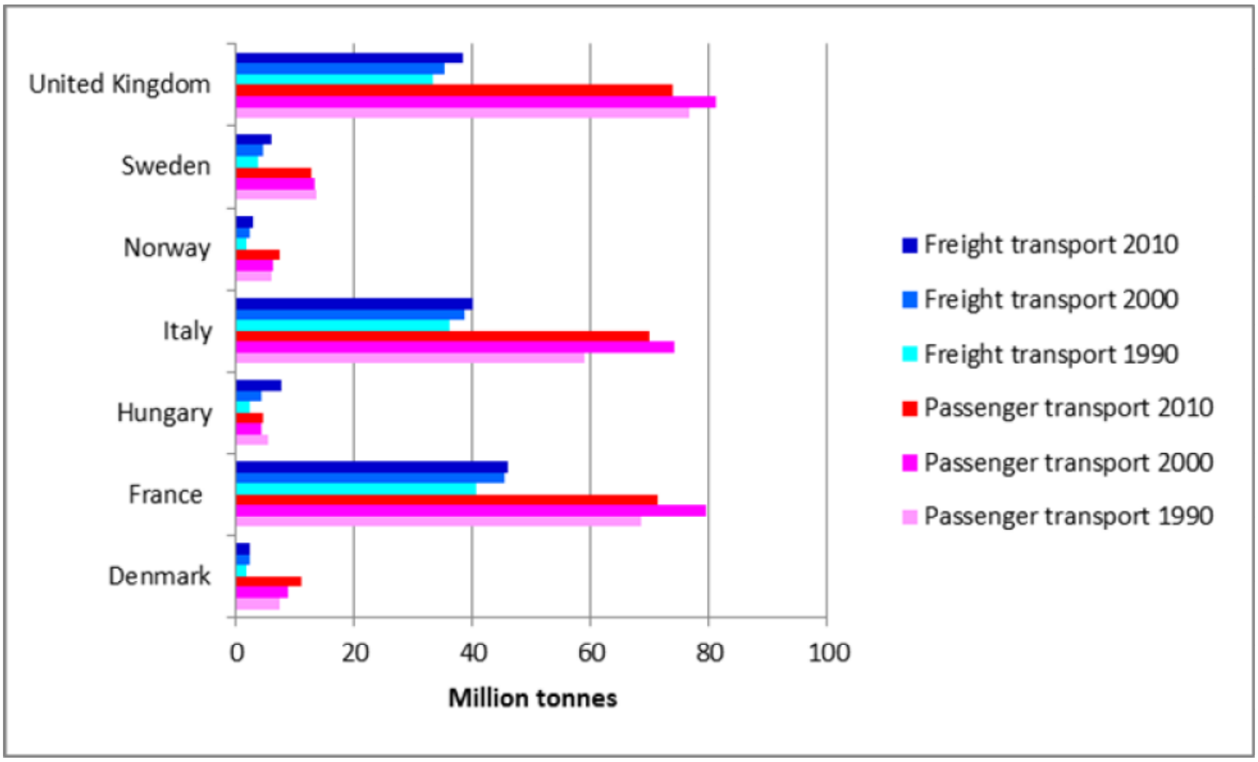

Figure 6.4: Total GHG emissions from freight transport and passenger transport from 1990 to 2010 in CO_2 (equivalents).[11]

6.2 Targets and emissions according to the Kyoto Protocol

The Kyoto Protocol is an international agreement that includes legally binding GHG emissions targets for industrialised countries. The EU-15 agreed to an 8% reduction of their collective GHG emissions by 2008–2012 compared with a Kyoto base year (mostly 1990).

Between the Kyoto base year and 2009, Spain recorded the highest increase in GHG emissions, followed by Ireland. In contrast, significant decreases were observed in Hungary, the United Kingdom, and Sweden. It must be noted that 2009 showed a sharp decline in emissions—largely due to the effects of the economic crisis—with EU-27 emissions falling 7 times faster from 2008 to 2009 than the annual average rate of decrease over the whole period. The Kyoto Protocol sets binding targets for developed countries to limit or reduce their GHG emissions. It has established innovative mechanisms to assist these countries in meeting their emissions commitments. The Kyoto Protocol sets a specific time period for achieving emissions reduction and limitation commitments, commencing in 2008 and ending in 2012.[12]

11 For France and Sweden, the unit is CO_2, instead of CO_2 (equivalents).The figures from France and Hungary are from 2009.
12 Eurostat, European Commission, Energy, transport and environment indicators, 2011 edition.

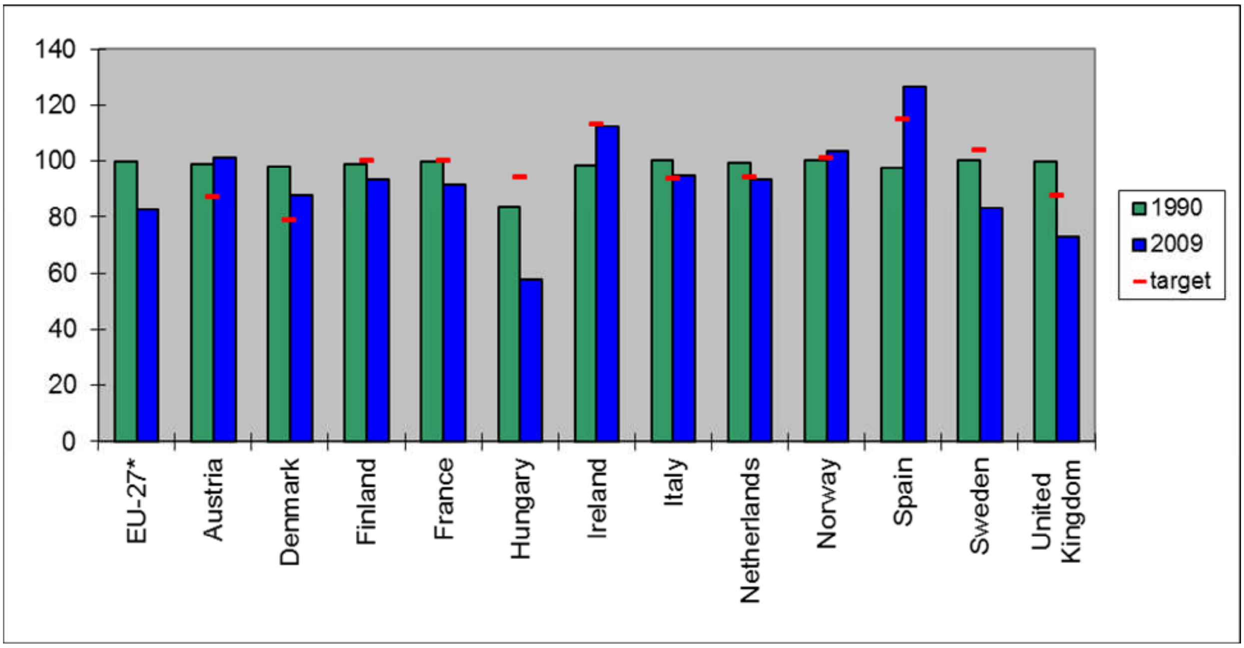

Figure 6.5: Index of GHG emissions and targets, according to the Kyoto Protocol for 2008–2012. Index 100 = Kyoto base year emissions EU-27 (1990)[13] (data source: Eurostat)

More than two-thirds of the CEDR-12 have reduced their emissions over the last 19 years. The United Kingdom, Finland, France, Sweden, and Hungary have already met their targets.

6.3 Road transport the largest source of GHG emissions in the transport sector

In Europe, transport accounts for approximately one-quarter of all GHG output, and its emissions are growing, especially in the road sector. Road transport is the largest contributor to the increase in overall transport energy use. As a result, national and international authorities are making substantial efforts to identify ways of reducing the transport sector's GHG emissions. The technology exists to tackle the transport sector's impact on the environment in Europe.. Clear, measurable, realistic, and time-bound targets are essential for reducing GHG emissions, air pollutants, and transport noise.

[13] The base value for Hungary is the average yearly emission from the years 1985–1987.

Transport in Trondheim, Norway (photo: Knut Opeide, Norwegian Public Roads Administration)

Figure 6.6 illustrates how GHG emissions from the road transport sector are much greater than those from other transport modes per capita. Norway has low population density and a long coastline, which explains why a greater share of transport is by sea and air. Hungary has the lowest per capita emissions from transport. The reductions can be explained by more efficient vehicles, greater use of biofuels, and a slowdown in traffic growth due to the financial crisis.

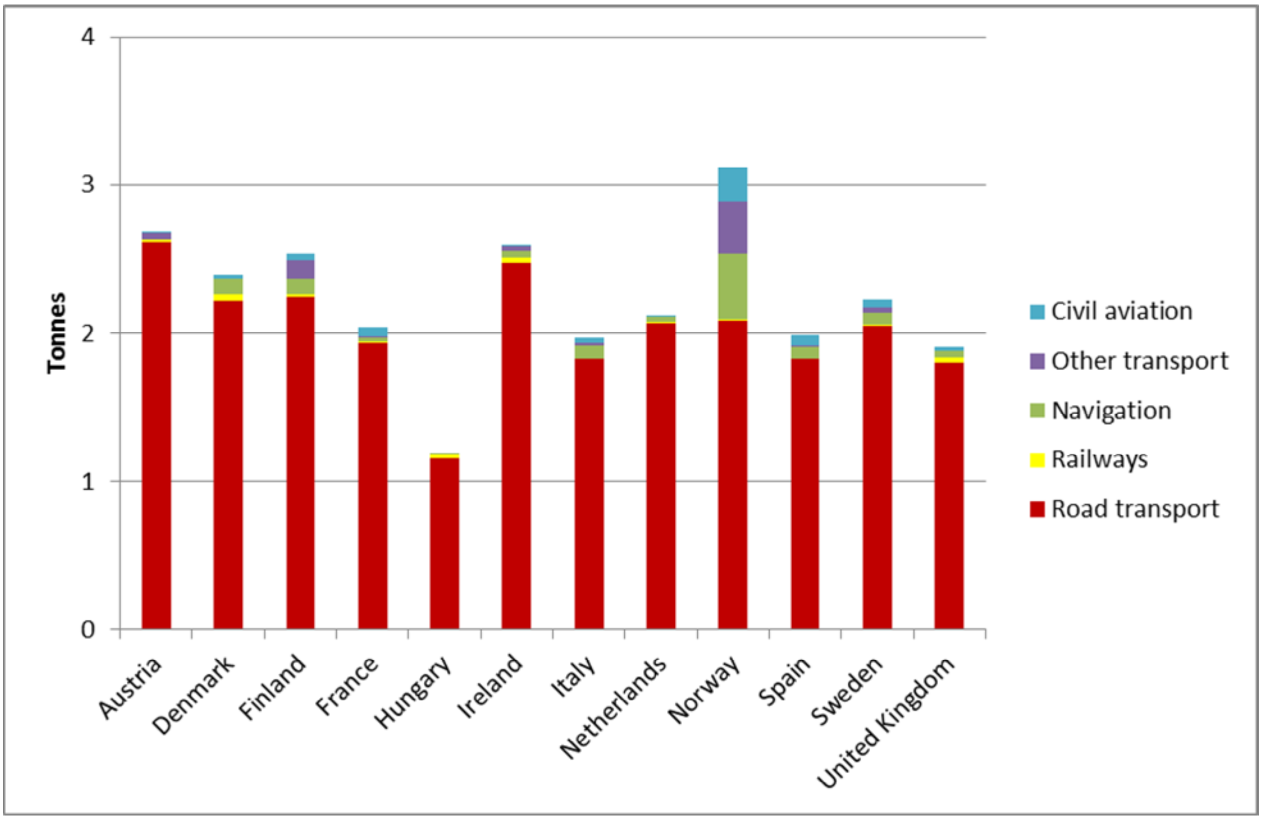

Figure 6.6: GHG emissions from transport per capita 2010 (data source: EEA)

Between 1995 and 2007, the freight transport volume on roads in the EU-27 grew by 49%. At the same time, the passenger transport volume grew by 22%. As a result, GHG emissions from road transport in the EU-27 increased by 29% between 1990 and 2007. Figures 6.7 and 6.8 show how dominant road transport is.

Since the middle of the last decade, growth in passenger car travel has slowed and even declined in some European countries.[14] This can be explained in part by the recession. However, in some cases, the decrease actually began before the economic crisis. Sales of new vehicles in Europe have also decreased every year since 2007.[15] In many countries, there have also been active programmes that invest in and promote non-motorised alternatives and public transport. If the plateau in passenger car travel that we are now experiencing continues, or if the volume even starts to decline, it would mean that the effect of improved energy efficiency in vehicles and the increased proportion of biofuels will have taken full effect.

[14] EU Commission (2012), EU transport in figures, Statistical pocket book 2012
[15] ICCT (2012), European Vehicle Market Statistics Pocketbook 2012

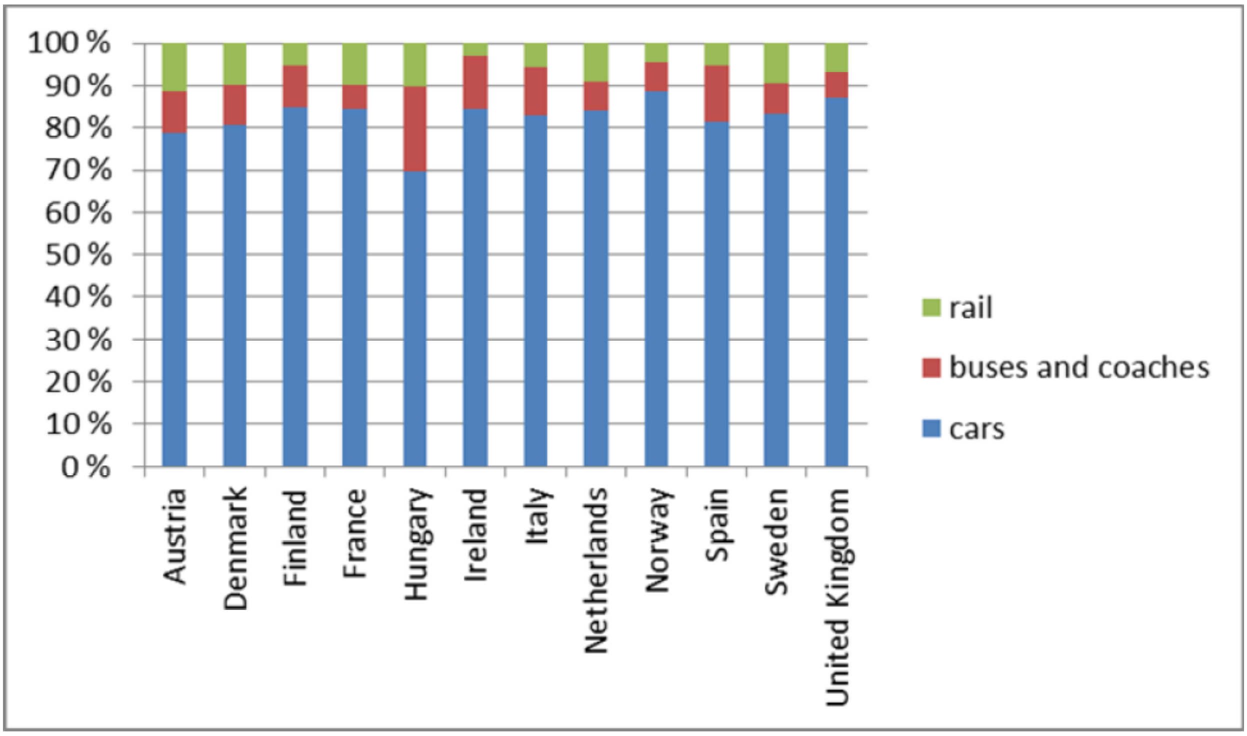

Figure 6.7: Modal split of passenger inland transport 2010 (cars, trains, buses, and coaches) (data source: Term 2012)

In 2010, on average 83% of passenger transport within the CEDR-12 was car transport. High levels of car ownership and the relatively low modal share of public transport continue to have a negative environmental, social, and economic impact. Moreover, congestion in urban areas is a problem throughout Europe.

(photo: Göran Fält, Swedish Transport Administration)

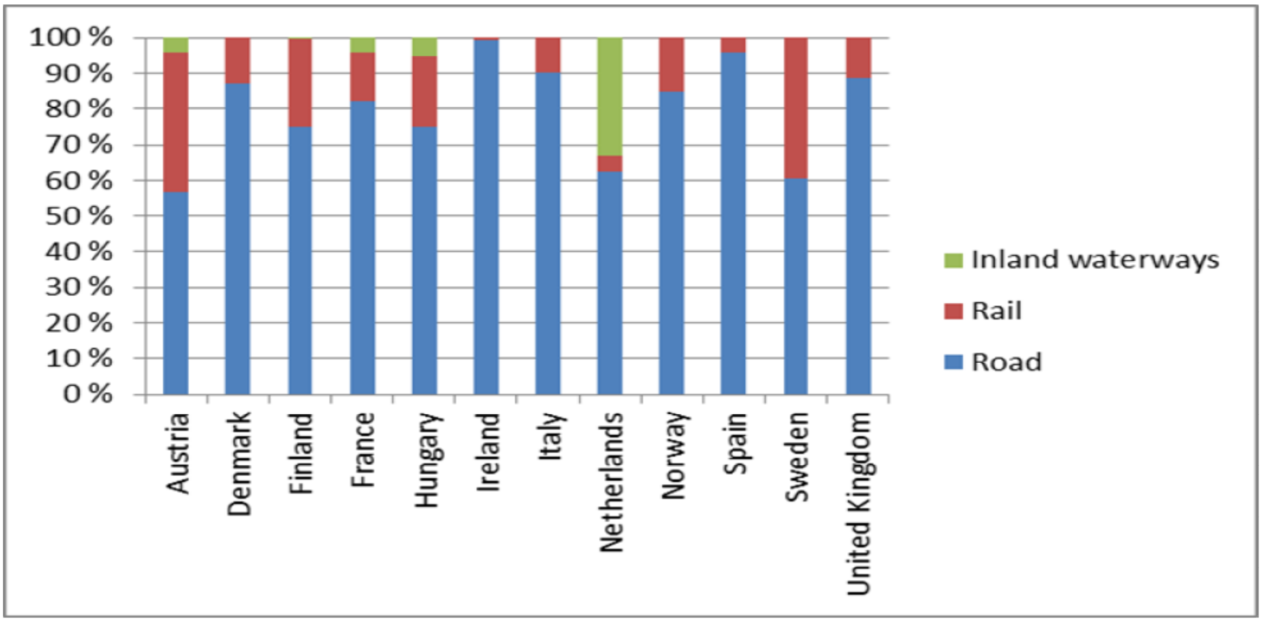

Figure 6.8: Modal split for freight transport in 2010 (percentage of total inland freight tkm) - excl. pipelines (data source: Term 2012)

In 2010, 80% of all inland freight was transported by road, which was the main mode of transport for all the CEDR-12.

Two main ways of reducing transport can be distinguished:

- changes that seek to reduce the volume/weight transported and
- changes that seek to reduce distances.

Taking GHG emissions into consideration at an early stage of spatial planning can reduce emissions in the road transport sector. High-grade public transport, well-developed cycling and walking facilities, and shortening the distance between home, work, and other facilities are examples of relevant measures. Other measures include the concentration of activities within a company or an industrial area, the extraction of air and/or water from products to decrease volume and weight, and the combination of the logistical networks of different companies (Oranjewoud[16]). In addition to the above-mentioned measures, continuous efforts should be made to alter attitudes within the population in order to achieve more sustainable transport trends. In order to achieve a significant change in the modal split towards more walking and cycling and the greater use of public transport in cities, these measures must be combined with restrictions on the use of private cars, e.g. fewer and more costly parking spaces or congestion charging.

[16] Oranjewoud (2008) Traffic measures for air and climate, http://www.luftkvalitet.info/Libraries/Rapporter/080523-164111-rap-DVS-Air_Climate_Measures_getekend.sflb.ashx

7 Potential for GHG reduction in the road sector

7.1 Sustainable impact on climate

An 80% reduction in GHG emissions generated by road transport in the EU by 2030 on 2004 emission levels might be needed to be in line with the adopted climate objectives. Reducing emissions by such a considerable amount within such a short space of time is an immense task. It is possible, but it requires immediate, powerful action to be taken. Actions are needed in three different areas: the increased production and use of energy-efficient vehicles, the replacement of fossil fuels with renewable fuels and electricity, and the introduction of measures to decrease VKT (vehicle kilometres travelled). Measures to decrease VKT include sustainable urban planning, improved public transport and facilities for cycling and walking, more efficient transportation of goods, increased fuel taxes, stricter parking policies, and new or increased car charges (congestion charging as well as restrictions on cars or road pricing per km).

7.2 Trends

As described in Chapter 6, improved energy efficiency in vehicles and an increased proportion of renewable energy have not been enough to curb the emissions generated by a growing road transport sector. Looking to the future, EU regulation of CO_2 from passenger cars and light-duty trucks, combined with binding targets for EU member states on the proportion of renewable energy used in the transport sector will influence the size of emissions. However, even with these ambitious measures, it will barely be possible to compensate for the growth in traffic volumes and might only be possible to stabilise emissions at current levels.

7.3 Reducing VKT through sustainable planning, efficient public transport, walking, and cycling

If VKT is decreased to meet the climate target, how can society and its infrastructure develop without a decline in accessibility? People still need to get to their workplaces; children still need to get to school, and food still needs to be transported from the farm to the table. By focusing on compact development in urban planning and making a powerful and long-term investment in public transport and facilities for walking and cycling, accessibility need not decrease. In fact, it will probably be improved since more people will have access to the transport system, and not just those with (access to) private cars.

Urban planning for a reduction of car VKT is about creating reasonable settlement density with a mix of different functions, a proximity to a good public transport service, and streets that promote cycling and walking. Shops and other services should be located in city and local centres. External shopping centres or large urban shopping centres should be avoided. These are all principles of smart growth and compact development.

In the future, cars will be more expensive; in a more sustainable city, the need for cars will be reduced. This will make car-sharing a better choice than car ownership. Studies of existing car-sharing schemes also point out that this reduces mileage.

Telework and online shopping have the potential to reduce mileage, for example by giving employees the opportunity to work from home one or several days a week, by having a teleconference instead of a meeting at the workplace, or by consumers buying things online that they would otherwise have bought by driving to the shop.

In cities, the number of parking spaces should be restricted to encourage use of other modes of transport. The first priority should be to reduce street parking in order to create more space for cycling, walking, and public transport. Parking prices should be market based and not included in housing rental or salary etc. In existing residential areas, there should be a strategy for reducing the number of parking spaces. Road pricing or road tolls with congestion charging are other ways of encouraging the use of other modes of transport. Good results have been achieved in London, Stockholm, Milan, and Trondheim, as mentioned in Chapter 9.

(photo: Colourbox.com)

Speed limits affect the emission level both directly and indirectly by influencing the modal split. Lowering the speed limit for car traffic will make public transport, walking, and cycling more attractive. At the same time, traffic safety and air quality are improved and noise levels reduced.

The planning of the transport system should be based on realistic traffic scenarios that also take into account climate objectives and other goals such as air quality, noise abatement, health, social integration, etc. These areas would all benefit from a society and a transport system with less car traffic. For developed countries, such planning will mean a new focus on what is needed in future transport systems: more public transport and cycling facilities.

Table 7.1 shows how much key measures can contribute to reducing VKT. The reductions should be related to the predicted level of travel in 2030 without any new measures (business as usual). For example, if 33% growth by 2030 is predicted without any new measures, a 40% reduction of growth will result in a volume of travel in 2030 that is 20% lower than today (1.33 × 0.6 = 0.80). For a country with a growing population, the increase without the implementation of new measures could be higher, resulting in a lower reduction or even an increase despite these new measures.

Table 7.1: **Potential to reduce VKT growth by 2030 and 2050**

	Potential by 2030 (reduction of VKT growth)	**Potential by 2050 (reduction of VKT growth)**
Urban planning for reduction of car VKT	-10%	-15%
Improved public transport (x2/x3 frequency)	-6%	-10%
Improved facilities for walking and cycling	-2%	-3%
Car-sharing	-5%	-10%
Telework and online shopping	-3%	-5%
Parking policies and road pricing	-5%	-5%
Generally reduced speed limits	-3%	-3%
Fuel tax (fuel price + 50%)*	-15%	-15%
Total	**-40%***	**-50%**

According to the Urban Land Institute US (Growing cooler, 2008), the potential for reducing VKT growth by 2030 through urban planning is 7.7% as a result of increasing population density, and another 11.4% from reduced highway building. The IEA (Transport Energy and CO_2, 2009) estimates a potential of 10%. We used 10% here to calculate the potential of various measures to reduce VKT growth by 2030. The figures for 2050 are based on the potential for 2030 and assume a continuing compact development.

Improved public transport represents a potential for 100% growth in public transport by 2030, using 0.4 elasticity of demand with respect to service frequency. This results in a 5% decrease in passenger car use when service frequency is doubled. Reduced travelling time combined with increasing reliability and comfort can mean even less passenger car use. Here, a total potential of 6% is estimated. This is also in line with the ULI study (Growing cooler, 2008), which reports a potential of 4.6%, and that of the IEA (Transport Energy and CO_2, 2009), which indicates a potential of 5%. Our 2050 figures are in line with 2030 but assume 200% growth in public transport.

According to the IEA (Transport Energy and CO_2, 2009), cycling has the potential to account for another 5% of travel in urban areas. If we assume that this increase in cycling comes from passenger cars and that 30% of travel by car is in urban areas, the reduction potential is 1.5%. We assume here that the potential is 2% for 2030 and that it could be stretched to 3% by 2050.

The IEA (Transport Energy and CO_2, 2009) reports potential for a 50% reduction in kilometres driven for former car owners who switch to car-sharing. Studies show that 10–25% of car owners are interested in car sharing, which results in a potential reduction of 5–12.5%.

The Swedish Road Administration (Klimatstrategi för vägtransportsektorn, 2004 – in Swedish) estimates a reduction potential due to teleworking including Internet/video meetings at work. To this can be added the potential of Internet shopping. We use a potential of 3% by 2030 and 5% by 2050.

In Transport Energy and CO_2 (2009), the IEA reports a reduction potential of 5% for 'parking policy and road pricing'. According to the Swedish Road Administration (Klimatstrategi för vägtransportsektorn, 2004), congestion charging could mean a 3% reduction of total VKT. In the city where the congestion charge is implemented, the effect is much larger.

Reducing speed also indirectly effects VKT. According to the Swedish Road Administration (Klimatstrategi för vägtransportsektorn, 2004), a general reduction of speed limits by 10 km/h on rural roads could reduce the VKT by 3%. This is assumed to be implemented by 2030 and yields no further reduction by 2050.

In order to reach the goal of reducing traffic by 15%, fuel prices would have to increase by 50% (elasticity 0.3). This is assumed to be implemented by 2030 and yields no further reduction by 2050. Fuel price increases can be a result of either higher taxes or higher market prices on oil products or both.

The total is not a sum of the figures above, since the combined effect would be lower that of the individual measures. Percentage reductions cannot be added, but should be multiplied instead, as has been done here.

7.4 More efficient transportation of goods through modal shift and improved logistics

The amount of goods transported by truck can be reduced using more efficient logistics or by shifting transportation to other modes. The volume of goods also has a direct effect on the volume of transport.

Transporting goods by ship or train usually means higher energy efficiency than transportation by truck, although transportation by truck is often needed at the beginning and the end of a logistics chain. In its White Paper on Transport, the European Commission set a goal of shifting 30% of road freight transportation over 300 km to other modes such as rail and waterborne transport by 2030, and 50% by 2050. This would require new economic incentives (with pricing to charge the different modes for their external costs), international harmonisation of technical as well as administrative standards for intermodal transport, a general update of the rail infrastructure to increase capacity, including longer, heavier, and wider trains throughout the network, and improvement of intermodal hubs.

City logistics can be improved considerably; well-designed projects have resulted in a reduction of vehicle movements by 30–70%. However, the share of the total goods transportation that takes place in cities is limited, which means that this area has much less overall potential. Measures such as fewer trucks driving without cargo (empty running) and better route-planning mostly impact on the goods transport volume. The use of longer and heavier trucks has been a matter of considerable debate. Competition with rail services also needs to be considered.[17]

Behind the increase in goods transport are the general trends of increasing consumerism and structural changes in industry, with more specialised production and increasing transport distances. If these trends could be changed in a more sustainable direction, the problem of GHG emissions from goods transport would be less considerable.

Table 7.2 provides estimates for the potential of key measures for reducing the growth of goods transport volumes. The reductions should be related to the predicted level of transport in 2030 without any new measures (business as usual). For example, if an increase of 33% by 2030 is predicted without any new measures, a reduction in growth by 25% will result in a level of goods transport in 2030 that is the same as today.[18]

[17] Norwegian Public Roads Administration (2010), Climate Cure 2020, Chapter 10: The transport sector analysis.
[18] 1.33 × 0.75 = 1.0

Table 7.2: **Potential reduction of tonne kilometre growth by 2030 and 2050**

	Potential by 2030 (reduction of tonne kilometre growth)	**Potential by 2050 (reduction of tonne kilometre growth)**
Modal shift to rail and waterborne	-15%	-25%
Improved city logistics	-3%	-5%
Less empty running	-3%	-4%
Route planning	-5%	-7%
Longer vehicles	-1%	-5%
Consumer and production patterns	Not available	Not available
Total	**-25%**	**-40%**

The potential represented by a modal shift assumes that 30% of truck transport over 300 km could be shifted to rail or waterborne transport by 2030 and 50% by 2050. This is in line with the objectives outlined in the EU commission 2011 White Paper on Transport. It is estimated that truck transportation over distances longer than 300 km accounts for 50% of all truck transportation, based on Eurostat 2009 data for the 29 countries of the European Economic Area (http://epp.eurostat.ec.europa.eu/portal/page/portal/transport/data/database). Our calculations show 0.5 × 0.3 = 0.15 by 2030 and 0.5 × 0.5 = 0.25 by 2050.

In projects, improved city logistics have been shown to reduce truck movement by 30–70%. We have chosen to use the assumption of a 30% reduction by 2030 and a 55% reduction by 2050. According to Eurostat, truck transportation over distances of less than 50 km accounts for 9% of truck freight transportation (tonne kilometre), which would lead to results of 0.09 × 0.30 = 0.03 by 2030, or 0.09 × 0.55 = 0.05 by 2050.

According to the IEA, Transport Energy and CO_2 (2009), empty running could be reduced by 5%. The share of transport involved accounts for 91% (in city logistics, 9%), and a large share of these will be reduced by 30% due to modal shift. Our calculations show 0.91 × 0.7 × 0.05 = 0.03 by 2030. It assumed that this could be stretched to 4% by 2050.

The UK Department for Transport (Computerised Vehicle Routing and Scheduling for Efficient Logistics, Freight Best Practice Programme, 2005) estimates that route planning could yield fuel reductions of 5% to 8%. Here we assume that the total potential for city logistics and route planning is 8%, of which route planning accounts for 5% and city logistics 3%. By 2050, the potential for route planning is projected to stretch to 7%.

As far as the potential for longer vehicles is concerned, we assume that exemptions for longer vehicles are granted only for restricted routes where shifting from rail to road does not represent a risk, e.g. as an incentive for intermodal transport for the first and last part of a logistic chain. Assuming that this accounts for 2% of goods transport volume and that the increase in length and weight improves efficiency by 50%, this would mean 0.02 × 0,5 = 0.01 by 2030. If the share of trips that can be carried out using longer vehicles could be increased to 10% by 2050, then the reduction potential would increase to 5%.

The total is not a sum of the figures above, since the combined effect will be lower that of the individual measures. Percentage reductions cannot be added, but should be multiplied instead, as has been done here.

(photo: Colourbox.com)

7.5 More efficient passenger cars and light-duty trucks

There is substantial potential for improved energy efficiency in passenger cars and light-duty trucks. It may be possible to reduce energy usage per kilometre for passenger cars by half by 2030. In the EU regulations on CO_2 emissions from new vehicles, a target of 130 g/km[19] has been set for manufacturers by 2015, with a phase-in period from 2012. A mid-term goal of 95 g/km has also been set for 2020.[20] These targets, together with national incentives, will govern the development of energy-efficient vehicles for the European market in the coming decade.

However, this is not enough to reach the targets for 2030. The limits must be lowered further in stages, to 70 g/km by 2025 and 50 g/km by 2030.[21] This cannot be achieved solely by improving diesel and petrol engines; an increasing share of the drive train must be electrified. Setting long-term limits and standards will increase the possibilities of reaching the climate targets by creating long-term regulations and stability for the car industry. To reach the objectives for 2050, further reductions are needed. Such reductions are possible through an increasing share of electric propulsion and other improvements that reduce driving resistance.

7.6 Electric propulsion

Drive trains that consist partly or totally of electric components are a prerequisite for achieving a sustainable road transport system. Despite innovations and improvements, batteries remain a very costly component. Reducing the need for battery capacity will be a key issue. Even so, the battery electric vehicle (BEV) will not be a long-distance car. With limited battery capacity, slow charging will make travel too time consuming.

[19] 130 g/km is equivalent to 5.5 l petrol/100 km or 43 mpg.
[20] 95 g/km is equivalent to 4.0 l petrol/100 km or 59 mpg.
[21] 50 g/km is equivalent to 2.1 l petrol/100 km or 112 mpg. This is only the fuel used, excluding use of electricity.

It is more likely that most electric cars will be plug-in hybrids. One extreme is the traditional car with some support from a battery and electric motor. The other extreme is a battery EV with a small-range extender, a concept radically different from traditional design. Will the latter be accepted by consumers? Areas of interest will be the conditioning of and fast charging of batteries, and optimisation of cooperation between the ICE[22] and the electric motor. We assume that by 2030, 20% of the kilometres driven by passenger cars could be electric, increasing to 60% by 2050.

BEVs are limited to two wheelers, passenger cars, and small distribution goods vehicles. Battery weight is too great and battery capacity insufficient for long-distance heavy-duty trucks. Still, there are some possibilities for electrification of heavy-duty trucks. Trolley buses have existed for a long time. Supplying heavy-duty vehicles with electricity on the main road network and using batteries or a combustion engine for transition from these roads to the destination could be possible. In cities, where trips are characterised by short distances between stops, it would be possible to charge buses at their end station, at stops, or along roads that are shared by many bus lines. Similar thinking could be applied to goods distribution. This would be one way of achieving 'CO_2-free city logistics in major cities', as called for by the European Commission in its 2011 White Paper on Transport.[23] In the long run, especially after 2030, highways and other major roads between cities could have an infrastructure for directly supplying electric heavy-duty trucks with energy. Preferably, this infrastructure would be designed so that other vehicle types, including electric passenger cars, could also use this direct energy supply.

7.7 More efficient heavy-duty vehicles

The energy efficiency of heavy-duty vehicles could be improved by improving aerodynamics, lowering rolling resistance, and increasing engine and transmission efficiency. Hybridisation would contribute to energy efficiency. Electrification could contribute even more, initially for urban buses and city logistics. By 2030, there is a potential for a 24% efficiency improvement in long haulage and coach transport. Further improvements after 2030, combined with electrification, could increase this potential to 44% by 2050. All electric urban buses and urban trucks could reach an efficiency improvement of 67% by 2030. One important step towards achieving this is a standard for measuring and presenting CO_2 emissions and fuel consumption for a complete vehicle. CO_2 regulation and incentives are needed for a functioning market.

7.8 Ecodriving and speed reduction

Besides improvements to the vehicles, it is also possible to reduce emissions by driving in a more energy-efficient manner, including driving at lower speeds. The potential for reducing fuel consumption—and thereby emissions of GHG—by ecodriving is generally estimated at 10%.

[22] internal combustion engine

[23] European Commission (2011) White Paper, Roadmap to a Single European Area – Towards a competitive and resource efficient transport system.

Lower speeds due to lower speed limits and improved speed surveillance could mean another 5%. Acquiring skills in ecodriving as a part of driver training is one way of implementing an energy-efficient driving style in the long term. Instruments for supporting ecodriving and speed surveillance should also be standard in future vehicles. Moreover, the road design should support ecodriving, for instance with traffic-calming measures designed to ensure a smoother driving style. Lower speed limits are generally a part of a more sustainable road transport system, resulting in both lower emissions per kilometre and slower traffic growth (see above).

(photo: Colourbox.com)

7.9 <u>Total potential for efficiency improvements</u>

Table 7.3 summarises the potential for energy efficiency improvements in the road transport sector.

This includes more energy-efficient passenger cars, light-duty trucks, and heavy-duty vehicles. The effect is given with and without electrification (in brackets). The table also shows the potential that could be achieved by a more efficient use of vehicles, including driving at lower speeds and ecodriving (this includes the direct effects of lower speed limits). The indirect effects of lower speed limits on car VKT are shown in Table 7.1.

Table 7.3: **Efficiency improvements**

Vehicle type	Potential for entire vehicle fleet by 2030	Potential for entire vehicle fleet by 2050
Passenger cars and light-duty trucks (excl. electric drive)	54% (42%)	68% (65%)
Long haulage and coaches (excl. electric drive)	24%	47% (40%)
Urban buses and urban trucks (all-electric)	67%	67%
Other improvements (ecodriving, lower speeds)		
Passenger cars and light-duty trucks	15%	15%
Heavy-duty (trucks and buses)	15%	15%

The potential for passenger cars and light-duty trucks was calculated using EU regulations that are already in place, with new vehicles on average emitting 130 g/km by 2015 and 95 g/km by 2020. New regulations are expected to be implemented, requiring further reductions to 70 g/km by 2025 and to 50 g/km by 2030. Petrol and diesel vehicles are expected to reach the 95-g/km target by 2020, with further improvements as a result of electrification, which is expected to yield a 21% share of electric driving by 2030 and a 53% share by 2050. With electric driving, the improvement by 2030 for the vehicle stock would be 54% (compared with 2006). For combustion engines only, the corresponding figure is 42%. The corresponding figures for 2050 are 68% and 65%.

The potential for long haulage and coaches assumes that new vehicles will be 20% more efficient by 2020 and 30% more efficient by 2030 (compared with efficiency levels in 2006). This results in an improvement in fleet efficiency of 24% by 2030. By 2050, it is assumed that heavy-duty trucks with conventional drive trains could be 40% more efficient. This is based on IEA figures (Energy Technology Perspectives, 2010), which predict a potential increase in efficiency of 40–50% by 2050. In addition it is assumed that 25% of the kilometres driven would be electric following an electrification of the major goods road network.

It is assumed that all-electric urban buses and urban trucks would provide an energy efficiency improvement of 67% by 2030.Other improvements include ecodriving and speed surveillance. Lowering speed limits would also have a direct effect on the efficiency of passenger cars and light-duty trucks (see Table 7.1).

7.10 Low-carbon fuels

The EU regulation on CO_2 emissions from new passenger cars and light-duty trucks results in electrification and an increased share of diesel cars in Europe. Jet fuel depends on the same components as diesel, and heavy oils in marine applications will probably be substituted by lighter fractions. The current imbalance between petrol and diesel in refineries will increase. Thus substitutes for fossil diesel are crucial. Two options are possible. One of them is to substitute crude oil-based diesel oil with a synthetic fuel such as F-T diesel or HVO (hydro-treated vegetable oils). Another option is to modify heavy engines to enable use of fuels such as ethanol, DME, or methane (biogas or natural gas). Obstacles include the production process, available feedstock, the infrastructure, and engine design.

The most promising options include the commercialisation of the gasification of biomass, using methane in heavy engines, and finding viable processes for synthetic diesel oil (mainly HVO, but F-T might also be possible). Methane can also be used in spark-ignited engines, not only in passenger cars but in heavy-duty vehicles as well. Compared with use in diesel engines, this results in a somewhat lower efficiency and, consequently, a shorter range. Range can be improved by using methane in the more efficient diesel engine, using a dual-fuel technique where the gas is ignited with a small amount of diesel. Another way to improve range is to use liquefied biogas (LBG) or liquefied natural gas (LNG). Using both dual fuel and liquefied gas gives a range acceptable for long haulage.

Commercialising cellulosic ethanol would dramatically increase potential volumes, but the Swedish attempt to make ethanol from wood chips seems to be far from market introduction.

Other issues concerning the use of ethanol in cars are the ability to use greater proportions than 10% in 'low blends' and market forecasts for dedicated E-85 flex fuel cars. These vehicles have to meet stringent exhaust regulations even in cold starts and be competitive with highly efficient diesel engines and direct-injection gasoline engines.

7.11 More efficient infrastructure

Energy use is not limited to the vehicles using the infrastructure. Construction, maintenance, and operation of the infrastructure also require energy. To minimise energy use, it is important to consider the life cycle of the infrastructure, including the energy consumed by the vehicles that utilise it.

Chapter 10 deals with methods to calculate and measures to reduce energy use and GHG emissions in the context of infrastructure.

Transport in Trondheim, Norway (photo: Knut Opeide, Norwegian Public Roads Administration)

7.12 Taking Sweden as an example

Sweden can be taken as an example of how GHG generated by road transport can potentially be reduced. The figures are mainly taken from the text above.[24] The energy efficiency improvement in passenger cars can be expected to be somewhat greater in Sweden (since Sweden currently has almost the highest energy use in new vehicles in the EU-27). By combining more energy-efficient vehicles and use with measures to reduce VKT and goods transport volume, the road transport sector could reduce its energy use by 57%, from 77 TWh in 2004 to 33 TWh by 2030, and by 66% (to 26 TWh) by 2050. Electrification would account for 4 TWh of this reduction by 2030 and 10 TWh by 2050. Here, it is assumed that the generation of electricity will not generate net GHG emissions. In order to reach the 2-°C climate target, electricity generation must dramatically reduce its GHG emissions. According to the road map for a low-carbon economy,[25] the power sector is the sector that will make the fastest reduction of GHG emissions in the scenario that meets the climate objective. According to this scenario, the reduction in GHG emissions is 70% for the power sector by 2030 when compared with levels in 1990. By 2050, this reduction will increase to 99%.

[24] See also Målbild för ett transportsystem som uppfyller klimatmål och vägen dit, Trafikverket 2010:105 (in Swedish) http://publikationswebbutik.vv.se/shopping/ShowItem____5664.aspx

[25] European Commission (2011), Communication from the Commission to the European Parliament, the Council the European Economic and Social Committee and the Committee of the Regions, A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final

In the section on biofuels above, no figures were given for the potential in Europe. For Sweden, it is estimated that 14 TWh of biofuels could be produced and a certain amount could be imported by 2030. By 2050, production of biofuels is expected to grow to 16 TWh, making Sweden a net exporter of biofuels and biomass. Swedish biofuel production was a mere 1.7 TWh in 2004—a figure that has grown to nearly 6 TWh today (2011). On the basis of these assumptions, the use of fossil fuels could be reduced from 77 TWh in 2004 to 15 TWh by 2030, a reduction of 80%. Given that biofuels can be produced in a sustainable manner, this means that GHG emissions could be reduced accordingly. By 2050 the road transport sector could be fossil free, in line with Sweden's national objective of no net GHG emissions.

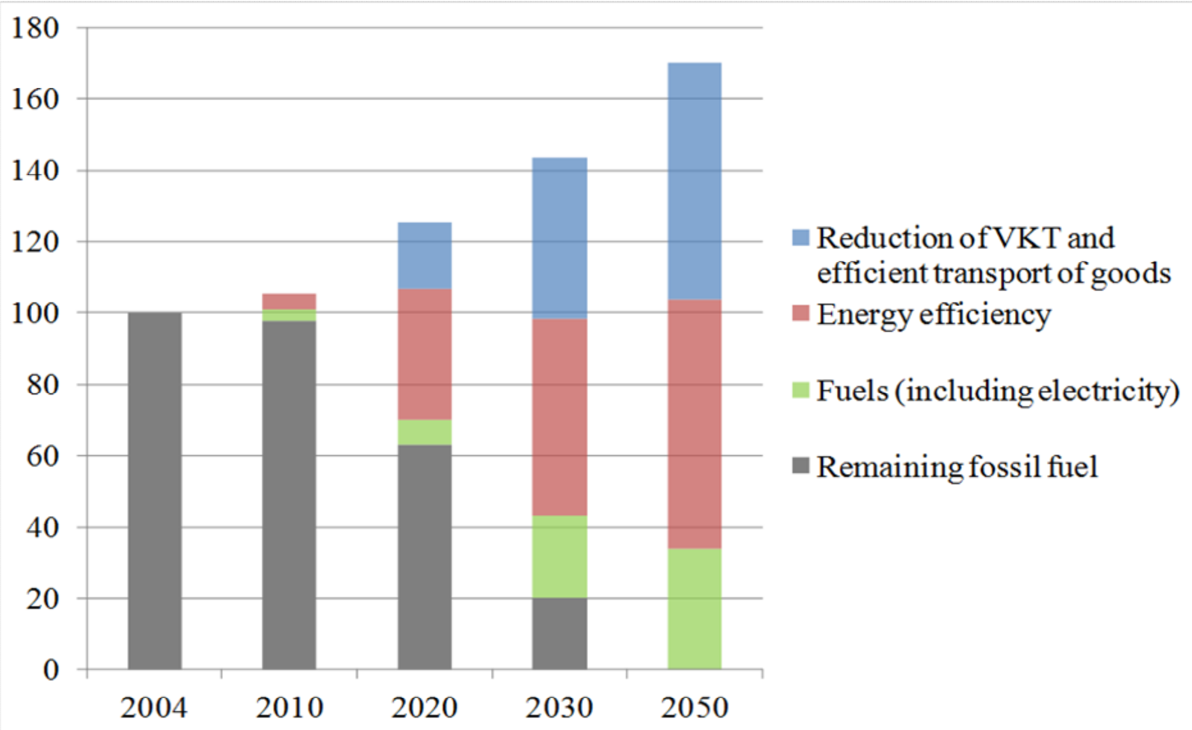

Figure 7.1: Use of fossil fuels for road transport in Sweden, with and without new measures (index 2004=100)

The bar for 2004 shows the situation without the implementation of new measures. The grey part of the bar shows the use of fossil fuels after implementation of targeted measures. From the bars, it is possible to see the contribution of the three different types of measures.

The example from Sweden indicates that reductions in GHG in line with the 2-°C climate target are possible for the road transport sector. The crucial element is the production of biofuel. Sufficient production of second- and third-generation biofuels is required, and this production must be sustainable, as has become very clear in recent debates.[26] It is essential that the production generates zero or at least low net GHG emissions and that biofuels are not produced on land needed for food production. If there are problems producing these quantities of biofuels in a sustainable manner, further efficiency improvements would be possible by electrifying heavy-duty vehicles. Research projects that seek to make this feasible are currently underway in Europe. This potential, which is significant, has not been considered in this example from Sweden. There might also be greater possibilities for reducing VKT in more densely populated areas of the EU than in Sweden.

[26] European Environmental Bureau, Europe's biofuels plans driving social and environmental destruction. http://www.eeb.org/EEB/index.cfm/news-events/news/europee28099s-biofuels-plans-driving-social-and-environmental-destruction/

This chapter has described targeted measures and a scenario for Sweden that meets the climate objective and makes the transport sector less dependent on fossil fuels. A large number of scenarios for meeting these goals are developed every year. The European Commission's White Paper on Transport was presented in 2011;[27] the IEA regularly presents scenarios. In 2012, the IEA presented a new version of the Energy Technology Perspectives.[28] This shows that in the long run, the total cost for vehicles, energy, and infrastructure will be much lower for a scenario that meets the 2-°C climate objective than for a scenario that follows current developments. This is still the case even when the benefits of reduced GHG emissions, lower VKT, and increased accessibility are not included.

The CEDR-12 countries have also developed scenarios and strategies. The Norwegian Climate Cure[29] and the Danish government's Energy Strategy 2050[30] are examples from the CEDR-12. The appendix contains more references, including the measures mentioned above. In the White Paper and most of the national strategies, the conclusion is also that technical measures will not be enough to reach climate objectives. The need for transport will also have to be reduced using smarter planning of society and transport systems and using the most efficient combination of different modes of transport.

[27] European Commission (2011), White Paper, Roadmap to a Single European Area – Towards a competitive and resource efficient transport system, http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm

[28] International Energy Agency, Energy Technology Perspectives 2012 - how to secure a clean energy future, http://www.iea.org/etp/

[29] Climate Cure 2020: The Transport Sector Analysis, http://www.klif.no/no/Publikasjoner/Publikasjoner/2010/November/Climate-Cure-2020-The-Transport-Sector-Analysis/

[30] The Danish government, Energy strategy 2050. http://denmark.dk/en/green-living/strategies-and-policies/the-impact-of-the-energy-strategy-2050-on-the-danish-consumer/

8 Long-term planning in line with GHG objectives

8.1 Looking beyond prevailing trends

Transport system planning is usually based on predictions made from current trends in a society, using more or less sophisticated models. Both prevailing trends and the models in use indicate further growth of transport and traffic volumes. Based on this future scenario, measures are planned—which often means new roads. This approach to planning the expansion and extension of a road system is called 'predict and provide'; in other words, the road system is developed in accordance with trends and prognoses for traffic growth.

Climate objectives and other needs point in a different direction. When the goal is less growth or zero growth in passenger car traffic, this should form the basis for planning rather than the prevailing trend, which is continuous growth. This is especially relevant in cities, where it is possible to provide other means of transport at a reasonable cost. If the ambition is to increase public transport, walking, and cycling much more than the current trend indicates, this will have a significant impact on what infrastructure is needed. If there is no room for these modes of transport within existing traffic infrastructure, this space will have to be taken from passenger cars, meaning less street parking and fewer lanes. This has already been done in many European cities.

Cyclist in Trondheim, Norway (photo: Knut Opeide, Norwegian Public Roads Administration)

Planning and investment in infrastructure are long-term processes. It takes between five and ten years from the time planning starts until a new project is opened to traffic. It is essential to incorporate climate goals into planning, not only when setting priorities. Most roads built today will be in use in 2050; some of them even at the end of the century. Will these roads be technically compatible with the society and road transport system needed in the future? Do they allow room for public transport, walking, and cycling facilities? Can they provide electricity for vehicles with electric propulsion? Can they withstand expected climate changes? Expansions and other improvements can sometimes be made after the roads have been built, but it is often easier and more economical to take future needs into account during the planning stage. The scenario in Chapter 7 includes electric heavy-duty vehicles using trolley or other systems for the continuous transfer of electricity to the vehicles. In many cases, this can be implemented after the road has been built, but in some circumstances it may be very difficult. Has space been set aside for this in the new tunnels that are being planned and built today? Have bridges and other infrastructure been designed for heavier and longer trucks? Probably not, and these changes may be difficult and costly to implement after completion of construction. It is recommended that future needs be taken into account in long-term planning.

As a basis for transport planning, a desirable future that meets political objectives should be defined. This will make it possible to work backwards and identify the tools and measures needed to connect the future to the present. This method, which is called 'back-casting', is often required when the objective (the desired future) is long term and deviates significantly from the current trend. The traffic models that road administrations use are often not suitable if the scenario diverges substantially from what they have been calibrated for.

The difference between traditional planning and planning based on political goals for the future (on the basis of back-casting) is illustrated in the figure below. In traditional planning, forecasts of traffic are used to assess the need for action within the transport system. The first approach is to meet these needs by taking measures other than the reconstruction of existing infrastructure or even the construction of new roads (the first steps in the four-step principle – see Chapter 11.3), but if problems are extensive, it is often impossible to avoid new infrastructure.

If, however, the definition of needs is based on the desired future, different conclusions will be reached. Technical measures alone will not be sufficient to attain the prescribed objectives. Moreover, in order to make the required changes in society and the transport system, planners need other measures and tools. A plan based on the objectives and the desired future must be developed using the back-casting technique. This approach should permeate all decisions made in the short- and long-term planning of the transport system, not only within the transport sector but also in urban planning.

Figure 8.1 illustrates the technique of back-casting. Instead of planning based on the current trend, or business as usual (BAU, the red line), back-casting begins with a scenario based on the desired future. The technique of back-casting can be used to identify the tools and measures needed to connect the desired future with the present (the green dots).

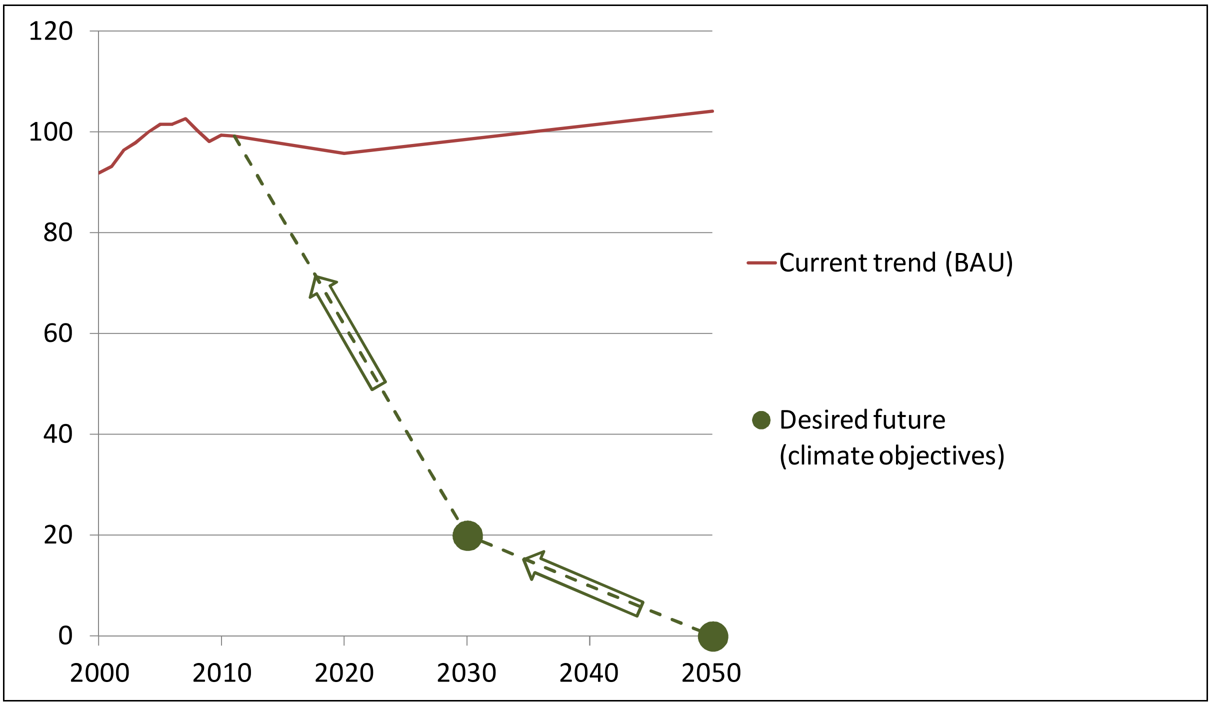

Figure 8.1: Illustration of the back-casting technique

A future with compact urban development, more efficient transport, and less dependency on fossil fuels, as described in the scenario in Chapter 7, has other benefits in addition to reducing the emissions of GHG. The reduced use of energy and increased share of renewables means that the transport system is less vulnerable to decreasing oil supplies and high fuel prices. There are different scenarios for the future availability of oil resources. The IEA predicts that world oil supply, including unconventional oil (light tight, oil sands, coal and gas to liquid), may increase until 2035.[31] This would mean a long-term global temperature increase of 3.6 ºC. Other sources[32] say that there is not even oil enough for the scenario that shows a maximum temperature increase of 2 ºC.

Less traffic means less congestion, better air quality, and lower noise levels. Lower speeds and a higher share of electric vehicles further reduce noise levels. Lower speeds and reduced truck traffic also improve road safety. Use of green space on the outskirts of urban areas is curbed by denser settlement and reduced use of biomass for biofuels.

Significant increases in cycling and walking contribute to improved public health. Accessibility for all is enhanced by improving public transport. There is also evidence that compact urban development increases gender equality, reduces social exclusion, and curtails the number of violent crimes due to more people out walking. In general, compact cities are attractive for people to live in.

[31] IEA (2012) World Energy Outlook
[32] E.g. Aleklett (2012) Peeking at peak oil, www.springer.com

The compact city concept is suited to meet many objectives and needs, as has recently been highlighted by a number of organisations, including the IEA (2012),[33] the OECD (2010, 2012),[34] UN Habitat 2009,[35] UNEP (2011),[36] the World Bank (2010),[37] and the World Health Organisation (2011).[38]

Needless to say, challenges remain. Most people in industrialised countries have long been accustomed to cars and the flexibility they afford in societies that have to a large extent been built around them. Denser cities, with mixed use and proximity, efficient public transport and good facilities for walking and cycling, provide increased accessibility and reduce the need for car use. Another challenge is to change the focus of community planning, making it more consistent with compact development. Denser cities may result in more exposure to noise and air pollution if this risk is not taken into account in the planning phase. Emissions, however, are lower. Accidents among pedestrians and cyclists may increase if these modes of transport increase sharply without appropriate measures to prevent this happening. International experience shows that this can be avoided altogether by providing suitable facilities and ensuring sufficient operational and maintenance standards.

In the countryside, cars will continue to be the main mode of transport. It is important to design measures that do not compromise the viability of these areas. The scenario will initially involve higher costs for vehicles, fuels, and infrastructure compared with the current situation. In the longer term, beyond 2030, costs can be lower compared with a scenario based on current trends. These conclusions are also supported in a recent report by the IEA, which maintains that the reduced costs for fewer vehicles combined with the need for less infrastructure due to curtailed energy use more than compensates for early investments in technology.

8.2 Copenhagen as a carbon neutral city in 2025

The municipality of Copenhagen has adopted a vision of being carbon neutral by 2025.[39] The plan for that vision involves a number of measures for curtailing the use of coal and fossil fuels.

The carbon emitted in Copenhagen comes from three major contributors: energy production, energy use, and mobility.

[33] IEA (2012) Energy Technology Perspectives
[34] OECD (2012) Compact city policies, OECD green growth studies, OECD (2010), Cities and Climate Change
[35] United Nations Human Settlements Programme (UN HABITAT) (2009), Planning Sustainable Cities: Policy Directions, Global Report on Human Settlements 2009
[36] United Nations Environment Programme (UNEP) (2011), Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication
[37] World Bank (2010), Cities and Climate Change: An Urgent Agenda
[38] WHO (World Health Organization) (2011), Health Co-benefits of Climate Change Mitigation: Transport Sector: Health in the Green Economy
[39] Danish government, http://www.kk.dk/da/om-kommunen/indsatsomraader-og-politikker/natur-miljoe-og-affald/klima/co2-neutral-hovedstad, http://www.europolitics.info/sectoral-policies/copenhagen-first-carbon-neutral-city-by-2025-art329782-19.html

Transport accounted for 22% of the CO_2 emissions in Copenhagen in 2010. The city has set its sights on making it preferable to cycle, walk, or take public transport for getting around in the city. The vision is that any car used in the city should be electric, a hybrid, or hydrogen-fuelled. Heavier vehicles are to run on new fuels, such as biogas.

Copenhagen is already a known as a city for cyclists. The vision is to get even more people to cycle.

- A PLUSnet of cycle tracks with three lanes will be established.
- A Cycle Super Highway will be built. The plan is to build 26 super highways for bicycles, with a total length of 300 km. One such super highway has already been built and is in operation.
- Copenhagen business life will be involved in identifying the need for an infrastructure for electric bikes and in promoting bicycles as the preferred means of transport to work.

Pedestrians and cyclists in Copenhagen, Denmark (photo: Danish Road Directorate)

Copenhagen will promote the use of electric vehicles, hydrogen-electric vehicles, and heavy vehicles running on biofuels. As 96% of all car trips in Denmark are shorter than 50 km, there should be a large market for electric cars. A nationwide and differentiated infrastructure will allow electric cars to meet the less frequent need of driving longer distances.

In Copenhagen, about 750,000 people use buses, the underground, or S-trains (suburban trains) every day. The vision is that even more will travel by public transport and that public buses will be carbon neutral by 2025. If this vision is achieved, it will mean less noise and cleaner air.

Technology has been developing rapidly in recent years, providing opportunities for traffic planning and traffic management to improve traffic flow and reduce CO_2 emissions. The vision for Copenhagen is to create a traffic management plan that optimises bicycle, bus, and car traffic in order to attain the greatest possible reduction in CO_2 emissions in the city.

9 The effect of traffic management on GHG emissions

9.1 Speed limits and speed control

Speed has a considerable impact on GHG emissions, air pollution, noise levels, and traffic safety. The effects of speed can be divided into

- direct effects resulting from individual vehicles changing their speed;
- indirect effects resulting from changed travel time;
- indirect effects resulting from a changed local environment.

9.1.1 Direct effects

Fuel consumption and corresponding GHG emissions from a vehicle are linked to the engine load. The higher the load (*not* necessarily the same as speed), the higher the emissions. The forces slowing the car can be divided into four subcategories: rolling, air, acceleration, and incline resistance.

$$F_{total} = F_{roll} + F_{air} + F_{acc} + F_{inc}$$

F_{roll} is related to rolling drag and is almost independent of vehicle speed; F_{air} is related to the second power of speed and other factors that can be regarded as fixed for a car and the actual conditions; F_{acc} is a force generated by increasing the speed of a car; F_{incl} is a force of the same type as F_{acc} but related to inclination.

The practical implications for fuel consumption and GHG emissions are that in steady-state activities (constant speed) only $F_{roll} + F_{air}$ act on the car. In the real world, speed is not steady—especially not in urban traffic. Speed will vary as a result of interaction with surrounding traffic, stops, and turns at intersections etc. This can mean numerous accelerations. In the real world, therefore, F_{acc} will be added to $F_{roll} + F_{air}$, meaning an increase in fuel consumption and GHG emissions compared with steady-state activities.

Combustion engines demonstrate low efficiency at low engine loads, which explains why conventional cars have high fuel consumption at low constant speeds (below 30 km/h). F_{acc} and low engine efficiency are the dominant reasons for poor performance by conventional combustion vehicles in congested traffic. At low speeds and during congestion, by comparison, electric drive and hybrid vehicles show high energy efficiency. The energy used is the resistance times the distance. That means acceleration over a longer distance, to reach a higher speed, will use more energy.

For conventional combustion engine vehicles driving at constant speed, the CO_2 emissions are lowest in the range of 50–70 km/h. At speeds above 100 km/h, the wind drag makes GHG emissions increase sharply, particularly for real-world activities above 120 km/h. In urban areas, the increase in energy use for acceleration means different intervals with lowest CO_2 emissions than in rural areas. For example, on a local city street, the speed with lowest emissions is 30 km/h or even less.[40]

[40] Swedish Road Administration and Swedish Association of Local Authorities and Regions, Rätt fart i Staden, Handbok för hastighetsnivåer i en attraktiv stad, 2008, Vägverket publikation 2008:54.

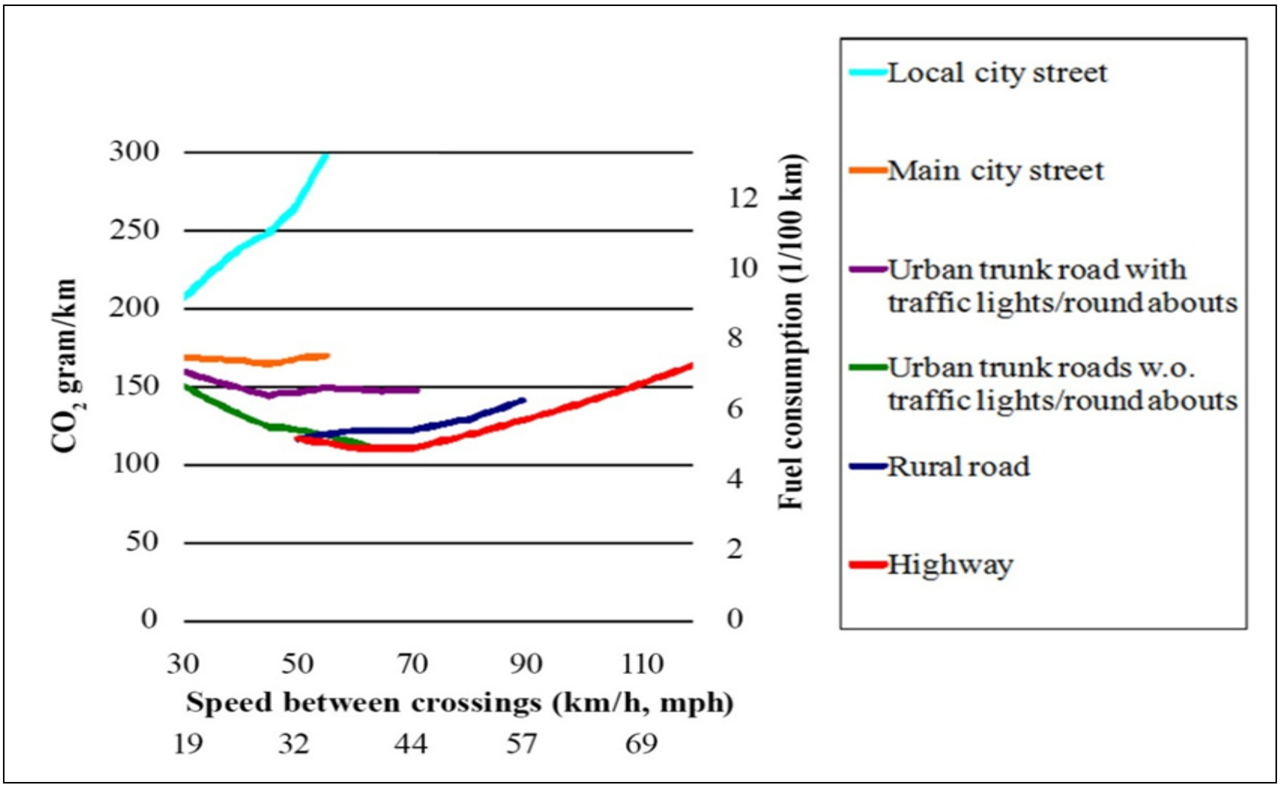

Figure 9.1: GHG emissions generated by driving in rural and urban areas

Some studies[41, 42] show that for GHG reduction, it is important to introduce measures that not only reduce the average speed, but also promote more constant speeds. Automatic speed control reduces the average speed; single point speed control yields less reduction of GHG emissions than section speed control.

Road administrations can also work to reduce speeds in other ways. They can install systems for speed adaption in the vehicles that their employees use (the Swedish Transport Administration requires such equipment in all vehicles that the administration owns or leases for more than 6 months). Another approach that has been used is to work together with hauliers, bus operators, and other companies to measure speed, influence attitudes, and implement relevant measures. One such measure may be to lower the set speed of the speed regulator for trucks (to less than 89 km/h). Of course, it is even more effective to install a more intelligent speed adaption system that works at lower speed limits as well.

[41] L. Int Panis, et al., PM, NOx and CO_2 emission reductions from speed management policies in Europe. Transport Policy, 2010.
[42] Fergusson, M., The effect of vehicle speeds on emissions. Energy policy, 1994. 22(2): p. 3.

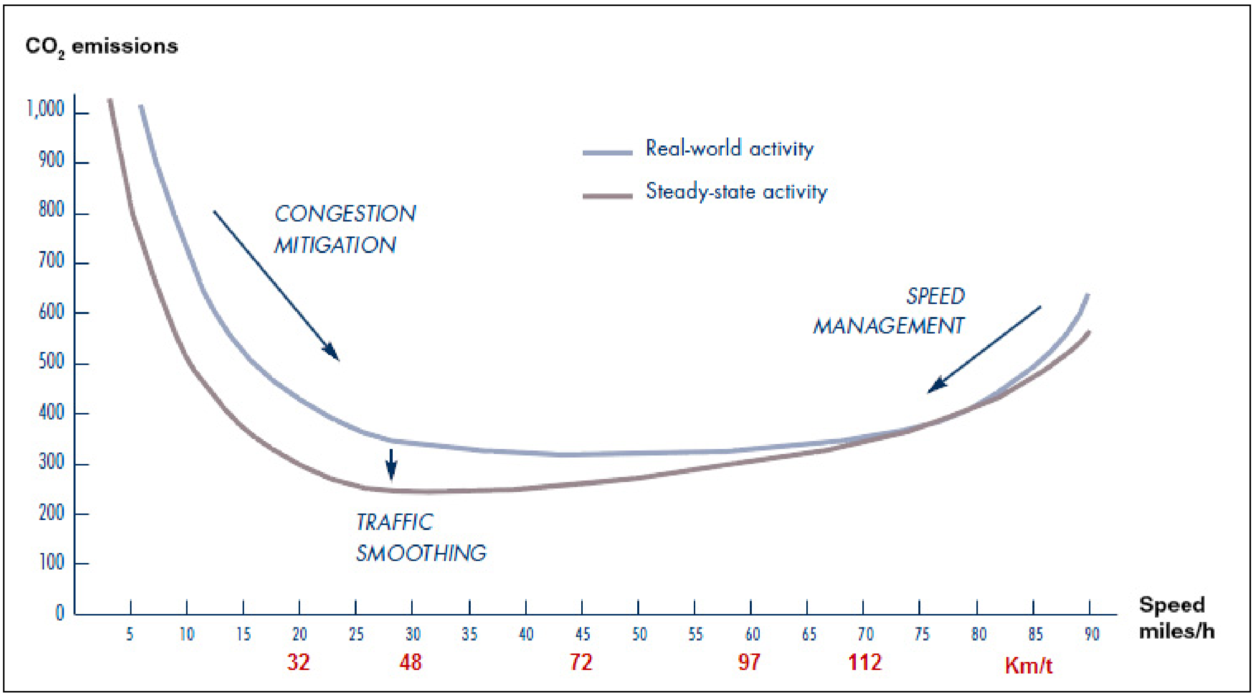

Figure 9.2: GHG emissions generated by steady-state and real-world activities[43]

9.1.2 Indirect effects as a result of changed travel time

The reason for increasing speed limits and improving the road network is often the political interest in supporting regional development. The drawback is that increased traffic also means increased emissions and other unwanted environmental impacts. There are, however, alternatives in the form of more compact urban development and increased accessibility to more energy-efficient modes such as public transport and freight transport on rail. Changed speed limits and changed travel time by car have several indirect effects, as listed below:[44]

- choice of route
- when trips are made
- how often trips are made
- choice of transport mode
- possibilities of coordinating trips with other individuals
- localisation of homes and businesses

The possibilities for incorporating these effects into the traffic models currently in use by road administrations varies. The time that elapses before these effects emerge and become pronounced also differs. Changing a route can be done almost immediately, but changing localisation can take many years.

[43] Barth, M. and K. Boriboonsomsin, Real-World Carbon Dioxide Impacts of Traffic Congestion. Journal of the Transportation Research Board, 2008. 2058: p. 8.
[44] Godwin P. B. (1998) Extra traffic induced by road construction: Empirical evidence, economic effects and policy implication, Round table 105 Infrastructure induced mobility, ECMT

For short-term effects, the elasticity may be 0.5, which means that half the time saved from increased speeds will be used for new trips. In the long term, the elasticity may be around 1: in other words, all the time saved will be used for new trips. The latter is in line with the theory that the amount of time per day spent travelling is constant, at around 70–80 minutes. Using an elasticity of 1.0 for the indirect effect means that the sum of the direct effect and indirect effect as result of changed travel time is at least a 1.5% decrease in emissions when the actual speed is lowered by 1 km/h. For urban streets with numerous stops, the effects can be even greater, since the direct effect then is larger (less negative).

Figure 9.3 illustrates the percentage change in emissions when the actual speed is lowered by 1 km/h. When the actual speed is changed from 50 km/h to 49 km/h, the direct effect is an increase in emissions by approximately 0.5%. The indirect effect will be a reduction in emissions of about 2%. The total effect will decrease emissions by around 1.5%. Adding the direct effects and the indirect effects when the actual speed is lowered by 1 km/h will always entail a decrease in emissions.

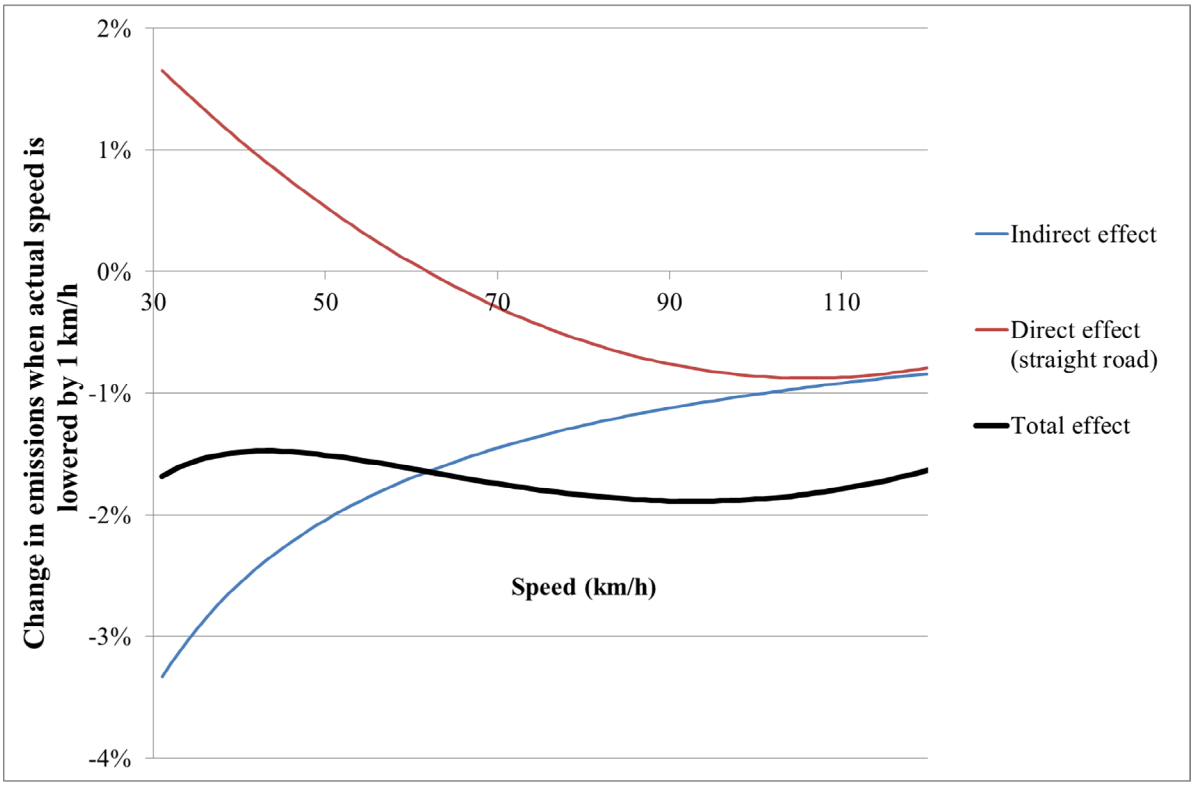

Figure 9.3: Change in emissions when the actual speed is lowered by 1 km/h

9.1.3 Indirect effects as result of effects on urban quality

Residents, shops, cafés, etc. do not like high speeds on city streets because they generate noise, poor air quality, and an inhospitable environment. Lower speeds in the city make for a more attractive city that is better able to retain its population and attract new residents and visitors, which in turn is good for the economy. High speeds also result in a hostile environment for pedestrians and cyclists moving along or crossing the street.

This means that less people choose to walk or cycle; they take their car instead, making the environment even more hostile and creating a negative spiral. This is also true of those people who would otherwise use public transport, since that involves walking to and from the bus stop. Adding these effects[45] to the direct effects and the indirect effects on travel time further strengthens the arguments for low speed in urban areas.

9.2 Traffic flow improvement

Traffic management and ITS measures can be used to achieve better traffic flow and to reduce the emission of contaminants, in this case GHG. In urban areas, this can be done by optimising traffic lights. For highway networks, different types of measures are available:

- traffic light management
- ramp metering
- 'keep your lane'
- overtaking prohibition
- dynamic maximum speed
- route information
- hard shoulder running (peak hour lane)[46]

These traffic management measures can be implemented using ITS (intelligent transport systems). ITS can improve the efficiency of passenger and goods transport, reduce the time spent in traffic congestion, and help make public transport more reliable, effective, and attractive, thereby increasing its use. ITS can also provide better information on schedules and connections, and keep traffic flowing on urban freeways, on toll roads, at commercial vehicle check-points, and elsewhere. Reducing delays caused by congestion or traffic incidents means that wasted energy, wear-and-tear, and pollution caused by stop-and-go driving are also reduced. In addition, ITS can help vehicles operate more efficiently, and provide location-specific information about weather and road conditions, helping drivers to plan efficient routes and guiding them along these routes. This helps to reduce fuel consumption and emissions.

In 2008, the Infrastructure Commission in Denmark recommended increased dissemination and integration of ITS and traffic management systems in infrastructure planning in the early planning stages and when building congestion lanes. The Infrastructure Commission has estimated that the capacity of the existing road network can be increased by 5% to 10%. Wide deployment of ITS represents a large savings potential.

In Denmark, the government has allocated €80 million for the period 2009–2014 for the development and implementation of different ITS systems. The Netherlands has estimated a potential reduction in CO_2 emissions of up to 15%, depending on the local traffic situation and the chosen measures.

[45] Sources for this section include Nozzi, D (2008), Speed size and the destruction of cities, in Tigran, H (2008), New Urbanism and beyond, Rizzoli International Publications, New York.
[46] Oranjewoud (2008) Traffic measures for air and climate, http://www.luftkvalitet.info/Libraries/Rapporter/080523-164111-rap-DVS-Air_Climate_Measures_getekend.sflb.ashx

Better traffic flow will have a positive synergy effect on air and noise pollution and improve traffic safety. When traffic flow is improved and travel time reduced, the volume of traffic usually increases. The induced traffic could slightly reduce the environmental benefits of the traffic flow improvement. In some cases, the negative effect can be minimised by combining traffic flow improvements with reduced speed limits so that travel time does not change or decrease too much. Concentrating on improving traffic flow for public transport is another way of maximising the benefits.

9.3 Improved accessibility for buses

Measures to improve the competitiveness and passenger comfort of public transport in cities:

- Tram tracks that are separate from car traffic lanes (rails are lower or higher than road pavement, or lined with protruding concrete elements on both sides) to prevent cars from disturbing the tram traffic.
- Only buses are allowed to use the tram lane during rush hours to overtake passenger cars.
- The outer or centre lane is reserved for buses on certain busy streets that have at least two or three lanes in each direction.
- A green light for buses precedes the green light for passenger cars by up to 60 seconds to ensure that buses can stop for passengers and have unhindered access to proceed.
- Audio-visual passenger information is posted at stops (giving information about the distance and arrival time of the next vehicle).
- Free rides for all on a municipally operated bus that circles the city, stopping at universities and shopping centres (every day from morning to the afternoon, at 15–30 minute intervals).
- Free buses operated by supermarkets to collect customers (these buses can be used not only between terminals but between the various stops along the way as well).

Budapest, Hungary: buses are allowed to use the tram lane if the traffic situation calls for it (photo: Zsidákovits József, Hungarian Transport Administration)

9.4 Congestion charging and GHG emissions

The traditional approach to managing congestion has been to increase supply by building new and larger roads with greater capacity. However, it is only a question of time before the reduction of congestion and travel time by increasing capacity leads to more traffic and new congestion. An alternative to this supply management is demand management. One demand management method is congestion charging, also called congestion tax or congestion pricing. Variable pricing makes it possible to regulate demand and manage congestion without increasing supply. The main objective of pricing is to reduce congestion, thereby reducing travel times and improving reliability for individual and public transport users. It can also help make goods delivery operations more efficient. Other objectives are to raise revenue (for example to pay for specific infrastructure), to encourage modal shifts to public transport, to reduce emissions of GHG, and to reduce noise and pollution in city centres.

Left: **Stockholm, Sweden (photo: Mats Halldin),** ***right*** **(photo: Kyrre Wedvik, Norwegian Public Roads Administration)**

Existing congestion charging systems cover a defined city centre area. To enter this area, vehicle owners have to pay either at specific times or daily. Usually the price is higher during peak hours and at times of likely congestion and lower during off-peak traffic and free flow.

The major congestion charging systems are in Singapore, London, Stockholm, and Milan. Singapore implemented the first congestion charging system in the world in 1975. The charge zone in Singapore is 7 km^2; the charge is time-dependent and ranges from €0 to €1.50.

London was the first city in Europe to implement a congestion charge. The system was launched in 2003. The congestion charge area is 40 km^2, and a flat rate of £10 (approx. €11.90) is charged during daytime hours. Traffic has been reduced by 237 million vehicle km and GHG emissions by 120,000 tonnes as a result of the congestion charge.

The Stockholm congestion charge was implemented in 2007 after a trial period in 2006. The area measures 35 km^2, with the charge (tax) varying during the day from €1 to €2. During the congestion charge trial period in Stockholm in 2006, the traffic volume in the charging zone was reduced by 22% (85 million vehicle km). GHG emissions were reduced by 10% to 14% (43,000 t), and concentrations of particulate air pollution were reduced by 8% to 14%. Since then, there has been a growth in traffic, and in 2008 the volume was 18% lower than before the trial. It is impossible to say how high the volume would have been in 2008 without the charge.

The congestion charge for the city centre of Milan was introduced in January 2012. The main objectives of the system in Milan are to decrease traffic in the city centre, to improve public transport networks, to raise funds for soft mobility infrastructures (cycle lanes, pedestrian zones, 30 km/h zones), and to improve the quality of life by reducing the number of accidents, uncontrolled parking, noise, and air pollution. Access to the city centre is restricted to drivers who purchase the €5 ticket valid for all vehicles. Special terms apply for residents and duty vehicles. Euro 0 petrol vehicles and diesel fuelled vehicles Euro 1, 2, and 3 no longer have access to the city centre. Incoming traffic has been reduced by approximately 30% on the same period in 2011. The expected reduction of CO_2 emissions is 20%.

Road tolls with congestion charging were introduced in Trondheim (Norway) in 2010, after upgrading public transport in 2009. An inter-municipal plan is being developed. Phase 1 has resulted in an 11% decrease in car traffic passing the toll collection points, and a 30% increase in public transport. Phase 2 is currently being planned. An environmental package for transport in Trondheim will mean better main roads, improved public transport services, and improved conditions for those who walk and cycle. Thanks to a series of measures, the city will have lower emissions, fewer traffic jams, and less traffic noise.

The environmental package is a collaborative effort between the City of Trondheim and the Norwegian Public Roads Administration. According to the plan, greenhouse gas emissions from transport should be reduced by at least 20% on 2008 levels by 2018. Half of the money in the package is allocated to completing the main roads bypassing the central suburbs to the South. The other half will be used to improve public transport, footpaths, cycle paths, traffic calming, and noise abatement.[47]

Besides these major systems, a number of other cities have implemented congestion charges, including Durham in England, Znojmo in the Czech Republic, Riga in Latvia, and Valletta in Malta. Gothenburg in Sweden will introduce a congestion charge in 2013.

9.5 Infrastructure charging

Fuel tax as an energy and carbon tax is a way of taking into account the marginal cost that the use of the infrastructure entails for road maintenance and repair, as well as the external effects on health and the environment. In a long-term perspective, a tax based on the fuel used will be a problem when a large share of the vehicles are electric. It will be difficult to distinguish the electricity that is used within the road transport sector from that which is used in households, industry, etc. One way to tackle this might be to use infrastructure charging instead. Intelligent infrastructure charging systems have the advantage that it is possible to vary fees depending on conditions such as location, time of day, and traffic conditions. In such a future scenario, the distinction between infrastructure charging and congestion charging will disappear.

[47] Miljøpakken - åpner nye muligheter, http://miljøpakken.no/

10 Energy-efficient road infrastructure

10.1 Introduction

Energy use is not limited to the vehicles driving on the infrastructure. Construction, maintenance, and operation of the infrastructure also require energy. To minimise energy use, it is important to consider the life cycle of the infrastructure, including the energy used by the vehicles that utilise it. Using more energy during construction may reduce energy usage by the vehicles that make use of the infrastructure, thus lowering total energy use. As far as we know, there are not many countries that have developed a complete method of calculating GHG emissions from these 3 phases: (1) construction, (2) maintenance, and (3) transport. Calculations can be performed at every stage of road planning. In the early phases, the calculations will be more general. The following list shows the stages of a normal project in which calculation methods can be used:

- the feasibility study
- the study plan (choice of alternatives)
- detail planning (one alternative has been selected)
- procurement
- construction
- operation and maintenance

GHG emissions should be taken into account at the earliest stage of planning, while there are still alternative solutions that may vary significantly with respect to greenhouse gas emissions. The methodology could be harmonised with the rail sector so that it is applicable when multimodality is being considered. In procurement, the choice of materials can significantly impact the amount of GHG emissions from a road during its lifetime. Section 10.2 briefly describes how this calculation is made in the early planning phase in Norway.

Figure 10.1 shows a typical difference in energy use during the life cycle of different types of roads. The Southern Link in Stockholm is 6 km long and includes a 4.7-km tunnel. One of the longest urban motorway tunnels in Europe, it has 4 lanes in each direction at its widest point (a total of 8 lanes). The traffic volume is 70,000 vehicles per day. For a country road with one lane in each direction, the traffic volume is 1,000 vehicles per day. The maximum speed limit on both roads is 70km/h.

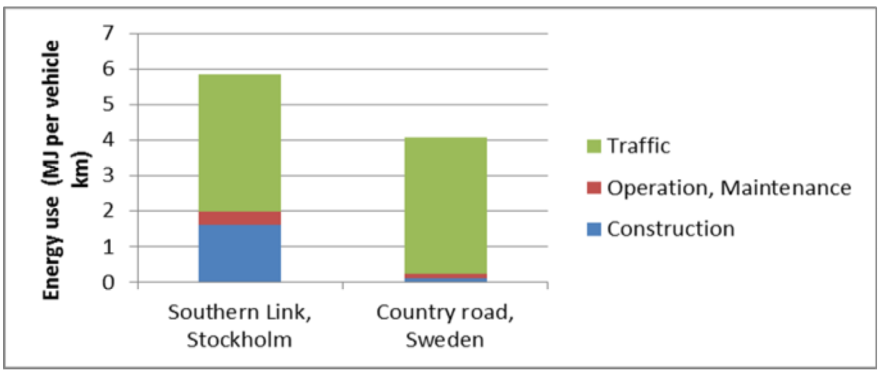

Figure 10.1: Difference in energy use for different types of roads

In France, the Grenelle law (which deals with environmental issues) requires that each transport mode discloses its carbon emissions. An energy and environment observatory for the transport sector was established in 2007.[48] Its objective is to define methods of assessing GHG emissions generated by the construction, operation, and maintenance of transport infrastructure. When planning a new infrastructure, the calculation of GHG emissions is mandatory.[49]

The Swedish Transport Administration is streamlining total energy use for the construction, operation, and maintenance of and the vehicles using an infrastructure. Another area of development is the design of and conditions for the use of dedicated infrastructure for specific tasks such as abnormal transports, energy-efficient, very long or heavy vehicles, or electrified corridors for goods vehicles.

Some general studies of road transport have been conducted in Sweden. Two specific infrastructure projects have also been calculated; the Botnia railway and the Stockholm road bypass. Even though performing calculations is not mandatory, there are more calculations on the way. The question of making this mandatory was addressed in a project carried out during 2011. To do calculations of GHG emissions generated by infrastructure using an Environmental Product Declaration, standardised product calculation rules (PCR) are needed. Such rules have been developed for railways within the Botnia project, but do not yet exist for road infrastructure.

In Hungary, some research has been done on emissions (see appendix on research), but general practice does not include calculations of GHG emissions generated by construction, maintenance, operation, and traffic. GHG calculation is not mandatory in either case. Companies may calculate GHG emissions and publish the results voluntarily. The NRA does not have a carbon calculation method.

10.2 Calculation methods

The methodology that was recently developed in Norway incorporates the impact of GHG emissions during the construction phase and from relevant maintenance work throughout the lifetime of the project. These indirect emissions, together with the direct emissions from traffic, are incorporated into the benefit-cost analysis (BCA) that is performed. The methodology has been operationalised and is integrated into the standard software package EFFEKT used for performing BCA.

This methodology, which is based on life cycle assessment (LCA), aggregates emissions from the extraction of raw materials, the processing of materials, construction, and usage. The underlying principle for calculation is that greenhouse gas emissions are equal to input factors multiplied by emission factors. Input factors may include concrete, steel, explosives, transport, etc. Emission factors are derived for all input factors from the environmental database ecoinvent and adapted to Norwegian conditions. The reason for the small number of input factors used (around 20) is that this analysis is carried out at an early planning stage when knowledge about the material used in construction is limited. For example, only one quality of steel is used; the same applies to concrete. The closer one gets to the start of construction work, the easier it should be to differentiate more and use more specified input factors.

[48] Observatoire énergie environnement transport: OEET
[49] Art.19 of the law relative to air and rational use of energy, Act n° 96-1236 of the 30 December 1996

The emissions—consisting of CO_2 (carbon dioxide), N_2O (nitrous oxide), and CH4 (methane)—are calculated in tonnes of CO_2-equivalents. To convert this volume into monetary terms for BCA applications, a unit value of NOK (Norwegian Kroner) per tonne is used.

This methodology is primarily designed for calculating GHG emissions from ordinary roads in open terrain, steel and concrete bridges, ferries and tunnels—all of which are elements that may be part of an ordinary transport project. The method is now used for most of the project candidates in the new National Transport Plan.

(photo: Colourbox.com)

ERA-NET ROAD-II has initiated a research programme called 'Energy – Sustainability and Energy Efficient Management of Roads'. One of the projects in this programme is LICCER – Life Cycle Considerations in EIA of Road Infrastructure. The project will develop an LCA model for calculating energy use and emissions that affect the climate. This model is primarily intended for use at the early stage of transport planning. The work on the model should be finalised during the course of 2013.

Calculations of GHG emissions and energy use during the life cycle will also be made for all projects included in the national transport plan in Sweden for the years 2014–2025. A methodology will be developed during 2012 and will be used to make calculations for the largest projects and a number of 'standard projects'. The total GHG emissions during the life cycle (including traffic) will be calculated for the largest projects, standard projects, and indicative parameters. The calculations will also function as a first estimation in the process of making the aggregate footprint of the projects as small as possible. The calculation for the individual projects will be improved for the process from planning to opening of the road (or rail line) and the maintenance and operational phase.

10.3 Energy efficiency of roadside equipment

Roadside equipment is a part of any modern road system and of motorway systems in particular. Most of this equipment needs electric power to function during the night or during the 24-hour period. This includes road lighting, illuminated signs, message signals, traffic signals, communication systems, cameras, emergency roadside telephones, and other devices such as weather stations. The amount of roadside equipment in use is increasing rapidly.

Road lighting accounts for most of the energy consumed by roadside equipment. In 2008/2009, 70% of the electricity used by the Highways Agency in the UK was for road lighting (Energy Strategy for Roadside Equipment, Department for Transport 2010). Road lighting is used for several reasons, one of them being traffic safety. Experience shows that there is a higher risk of being involved in an accident when travelling in the dark on an unlit road compared with a lit road. The accident risk is particularly high for pedestrians. However, drivers on a lit road seem to offset the lower risk to a certain extent by increasing their speed.

It is important to have a strategy for how to light the road network 'at the right place, at the right time, at the right level'. Member states have different practices when it comes to the times for lighting. Some countries keep the motorways lit all night when it is dark, while other countries turn off the lights on the motorways outside cities during the low traffic period (e.g. 1.00 a.m. to 5.00 a.m.) in order to save energy. Regardless of the times for lighting, reduced-energy lamps (for instance LED) should be considered for road lighting, traffic signals, and illuminated signs in order to reduce energy use and GHG emissions.

(photo: Knut Opeide, Norwegian Public Roads Administration)

In 2004, the Swedish Transport Administration (previously the Swedish Road Administration) developed a strategy for lighting. An important principle was good lighting for vulnerable road users and adequate lighting for car traffic. This means that the light levels on roads and streets were lowered in general, while environments with vulnerable road users were given a higher light level than before. The administration is currently conducting a project on 'smart lighting on roads' as a part of the European project ESOLI (Energy Saving Outdoor Lighting).[50] One challenging project has been to change the lighting system on the 6-km-long Öland bridge to LED with smart controls, which will save two-thirds of the energy used for lighting on the bridge.

10.4 Meeting and travel policy for NRA employees

Alternatives to business travel—such as video conferencing, audio conferencing, etc.—should always be considered before business travel takes place. If business travel is still necessary, it should be conducted in the safest, most cost-effective, and most environmentally friendly way possible.

It is the responsibility of the individual employee to ensure that environmentally friendly options are considered and that environmental and safety aspects are incorporated. Public transport should always be considered and should be used unless this means significant disadvantages for the traveller or the road administration. For shorter trips, use of a bicycle or electric bicycle should be considered.

People should coordinate their travel to achieve the most environmentally friendly and cost-effective transport. When the requirements for safety conflict with other objectives, safety requirements take precedence over environmental considerations and cost effectiveness.

When passenger cars are used for business travel, the road administration should have clearly defined safety and environmental performance requirements for the vehicles used. The environmental performance requirement may include standards for CO_2 emissions, noise levels, and Euro emission classification. Safety performance requirements based on Euro NCAP standards may also be included. Employees that drive frequently for work should also be obliged to complete a course in ecodriving. Examples of this meeting and travel policy—including the requirements mentioned above—can be found on the website of the Swedish Transport Administration.

[50] Energy-saving outdoor lightning, www.esoli.org

11 Cooperation with other partners

11.1 Introduction

Due to their generally complex nature, environmental issues can be addressed from several angles. In their efforts to mitigate climate change, the NRAs should seek partners and offer partnership in different sectors and fields. NRAs should be aware of and seek to collaborate with those initiatives that contribute to GHG reduction. Even though they may not have direct influence on certain processes, the NRAs can play an important catalysing role by seeking contacts with potential partners and encouraging and supporting these partners' own activities to reduce GHG emissions. In the field of cooperation, the exchange of information is essential.

The potential partners will vary depending on the different ways of dealing with GHG reduction. The following sections present some examples of GHG reduction alternatives and possible relevant partners

11.2 Reduction of GHG emissions generated by road construction and maintenance

As construction and maintenance have some common features from a technological perspective, they will be discussed together. GHG reduction can be achieved through the increasing use of technologies that:

- minimise energy use (e.g. by decreasing the mixing temperature of asphalt: cold mixing instead of hot mixing whenever possible)
- minimise the use of primary material (re-use of the material from old pavements and structures)
- use primary material with a low-carbon content (e.g. by replacing standard concrete with concrete or another material where less carbon has been emitted during production)
- minimise the transportation of building materials (e.g. re-use on site)
- minimise the energy used by trucks and machinery by promoting the acquisition and use of more energy-efficient equipment, and by introducing ecodriving requirements. Also demand follow-up of energy used.

These aspects should be kept in mind throughout the procurement of planning and implementation. It is also important to consider the life cycle of the infrastructure, including the energy consumed by the vehicles that utilise it. NRAs can promote the dissemination of information on such technologies. Potential partners include research institutions, construction companies, municipalities, and agencies for technical standards and guidelines.

11.3 Planning strategy: the four-step principle

The four-step principle is used by some NRAs to widen the planners' toolbox and to find the most cost-effective measures. This principle requires that four different kinds of measures are analysed, in the following order, when addressing transport problems:

1. measures that affect transport needs and choice of transport mode
2. measures that lead to more efficient utilisation of the existing road network
3. minor road improvements
4. major investments

This approach to planning is likely to yield a more cost-effective solution to a number of transport problems.

11.4 Reducing GHG emissions outside the NRAs' sphere of authority

In order to plan, construct, maintain, and operate the transport network, NRAs need to cooperate with other partners. In this cooperation, the NRA should bear in mind the possibilities for reducing GHG emissions. Listed below are some examples to consider:

- Reduction of the use of natural resources (energy and materials) by limiting the volume of production to a sustainable level, matching production and consumption, and avoiding unnecessary production
- Promotion of spatial planning that minimises transport demands and makes transport more efficient: compact cities with high densities near public transport hubs, and less parking space in the city centres
- Promotion of a change in priorities when planning streets and cities to give precedence to pedestrians, then cyclists, public transport, coordinated goods logistics and, last of all, passenger cars
- Development of a high-standard public transport system in cities
- Promotion of a modal shift from cars to public transport by encouraging the use of congestion charges and parking restrictions
- Promotion of taxation and other economic incentives that reduce vehicle use, such as a CO_2-based fuel tax, road tolls, congestion charges, market based parking fees and fewer parking spaces etc.
- Promotion of better use of vehicles, such as ecodriving
- Promotion of lower fuel consumption based on the taxation of cars and car use
- More efficient use of less-polluting energy
- Promotion of low-emission vehicles

Oslo Central Station, Norway (photo: Knut Opeide, Norwegian Public Roads Administration)

12 Conclusions

Task group 17 (Mitigating Climate Change) would like to highlight the following:

- There is scientific evidence that emissions of GHG resulting from human activities are causing an overall warming of the earth's atmosphere and that climate change is the most likely result.
- Almost all European countries are individually on track towards meetings their commitments under the Kyoto Protocol. The countries at the 2012 UN Climate Conference in Doha, Qatar, extended the Kyoto Protocol to the end of 2020.
- The 2011 EU White Paper on the Future of Transport outlines very ambitious long-term goals. A 2050 Transport Roadmap has been drawn up. This sets different goals for different types of journey: within cities, between cities, and long distance.
- Very few of the 12 CEDR member states that participated in the Project Group on Climate Change have a separate strategy for reducing energy use and GHG emissions in the road sector. Most countries incorporate the road sector into their overall strategy for the transport sector. However, all the countries that responded to the survey have a national policy for mitigating climate change.
- The transport sector's share of GHG emissions has increased from 14% in 1990 to 20% in 2010 in the EU-27. Road transport is the largest energy user within the transport sector, with a peak in GHG emissions for some member states in CEDR-12 in 2000 and 2005.
- Energy efficiency increased during the 1990s; accordingly, GHG emissions and total energy use per unit of gross domestic product decreased during the decade. However, final energy use per capita increased in most countries.
- Statistics for seven of the CEDR-12 show that the total level of emissions from freight transport on roads has been steadily increasing for all seven countries from 1990 to 2010. Moreover, freight transport accounts for an increasing share of the total emissions generated by the road sector.
- In 2010, an average 83% of passenger transport within the CEDR-12 was car transport. In the same year, 80% of inland freight was transported by road, which was the main mode of transport for all CEDR-12.
- In order to reach climate objectives, an 80% reduction in GHG emissions generated by road transport in the EU by 2030 on 2004 emission levels might be needed. Actions are needed in three different areas: increased use of energy-efficient vehicles, replacing fossil fuels with renewable fuels and electricity, and measures to decrease VKT (vehicle kilometres travelled).
- Transport system planning should be based on realistic traffic scenarios that also take into account climate objectives and other goals related to air quality, noise abatement, health, and social integration. These areas will all benefit from a society and a transport system with less car traffic.
- There is substantial potential for improved energy efficiency in passenger cars and light-duty trucks. The energy efficiency of heavy-duty vehicles can be improved through improved aerodynamics, lower rolling resistance and increased engine and transmission efficiency.
- An example from Sweden indicates that reductions of GHG in line with the 2 °C climate target are possible for the road transport sector. The crucial element is the production of biofuel. Sufficient production of second- and third-generation biofuels is required, and this production must be sustainable.

- When the ambition is lower growth or zero growth in passenger car traffic, this should be the basis for planning rather than the prevailing trend, which is continuous growth. This is especially relevant in urban areas, where it is possible to provide other means of transport at a reasonable cost.
- As a basis for transport planning, the desirable future that meets political objectives must first be defined; then planners must work backwards to identify the tools and measures needed to connect the future to the present. The method is called 'back-casting'. It is often required when the objective (the desired future) is long term and deviates substantially from the current trend.
- Denser cities, with mixed use and proximity, efficient public transport, and good opportunities for walking and cycling would provide increased accessibility, and reduce the need for car use.
- In the countryside, cars will continue to be the main mode of transport. It is important to design measures and tools that do not compromise the viability of these areas.
- On a local city street, the speed that generates the lowest emissions is 30 km/h or lower. In addition to this direct effect related to the actual speed, there is also an indirect effect in the long term as a result of changed speed and hence changed travel time. Taking this into account, the total emission level would decrease when actual speed is lowered.
- When traffic flow is improved and travel time reduced, the volume of traffic usually increases. The induced traffic could slightly reduce the environmental benefits of the traffic flow improvement.
- One demand management method is congestion charging, also called congestion tax or congestion pricing. Large-scale congestion charging systems are in place in Singapore, London, Stockholm, and Milan. In London, traffic was reduced by 237 million vehicle km and GHG emissions by 120,000 tonnes. Energy use is not limited to the vehicles using the infrastructure. Construction, maintenance, and operation of the infrastructure also require energy. To minimise energy use, it is important to consider the life cycle of the infrastructure, including the energy consumed by the vehicles that utilise it.
- It is important for NRAs to cooperate with other partners in their efforts to mitigate climate change. NRAs can play an important catalysing role by seeking contact with potential partners and encouraging and supporting these partners' own activities to reduce GHG emissions.

13 Recommendations

This report takes account of the fact that the road sector is a major contributor to a nation's GHG emissions and that the growth in road transport will lead to a growing share of the total emissions in each country unless cleaner vehicles are developed.

This report has shown that while the EU and the participating CEDR countries have ambitious targets for reducing GHG emissions, the measures implemented in each country are not yet ambitious enough to reach these targets.

The measures implemented so far seem to focus mainly on technology, including taxation and the introduction of biofuel, and to a lesser extent aim to reduce traffic volumes.

Task group 17 recommends that further work in CEDR's Strategic Plan 3 (2013–2017) should have a special focus on how the NRAs can contribute to developing a carbon-neutral transport system society, and how reducing emissions from transport can also contribute to the reaching of other targets (road safety, reduced local emissions, etc.)

Consequently, task group 17 calls for an emphasis on the development of effective measures and their implementation.

The objectives of this work are described in SP3 as follows:

'The objective of the work shall be to keep CEDR's members informed about on-going activities and best practices in mitigating strategies and adaptive measures in the road sector in view of the global challenge climate change.'

APPENDIX

Task group 17 conducted a survey of policies and targets among the countries participating in the project group. A summary of the conclusions was included in chapter 5; the full report is available in this appendix. There follows a report on the responses to the survey: first on policies (section A) and then on targets (section B).

The survey also included questions about the research conducted in the participating countries. Two topics are highlighted:

- the impact of the construction, operation, and maintenance of the national road network on energy use and climate gas emissions;
- mitigation of energy use and GHG emissions generated by the transport sector in urban areas

This part of the survey was presented in Chapter 12, as a part of the discussion on possible ways forward. Section C (below) contains more details.

Survey responses were received from 10 of the 12 participating countries:

Austria
Denmark
Finland
France
Hungary
Ireland
Italy
Norway
Spain
Sweden

The first survey was conducted in between November 2009 and January 2010. The survey was updated in December 2010 for the second report, and then again in December 2011 for this report. The main purpose of the survey was to provide a rough overview of the field as a basis for further work by task group 17.

A POLICIES

A.1 Different roles for the national road administrations in different countries

All national road administrations (NRAs) plan, build, and maintain road infrastructure. Additional roles defined by the individual countries include:

Austria: No response to this question.

Denmark: Participant in spatial planning. Responsible for building and maintaining highways, infrastructure and the monitoring/controlling of traffic.

Finland: Participant in spatial planning. Consultative body for land use plans. Responsible for building and maintaining pedestrian footpaths and bicycle lanes, for infrastructure and traffic monitoring/controlling devices relating to public transportation. A multi-modal perspective is applied. A recent reorganisation of the transport administration in Finland provides better opportunities for coping with climate change mitigation.

At regional level, the organisation has a broader responsibility for bus traffic; environmental and business professionals are working together with regional transportation professionals. At national level, the new organisation has combined rail, maritime, and road transportation.

France: The French Directorate of Transport Infrastructure is part of the French Ministry of Ecology, Sustainable Development, Transport, and Housing. It defines the national multimodal transport policy and plans the main projects for the development of road, rail, inland navigation infrastructures, inland and sea harbours, and national airports. It is in charge of drafting the national transport infrastructure scheme (SNIT) (see below).

It establishes and implements national policy for traffic management and user information. It is also responsible for highway contracts and ensures that they are honoured.

Hungary: Coordination of technical regulation and research. Toll/road usage pricing strategy.

Ireland: Responsibility limited to the delivery and maintenance of the national road network. Partly responsible for ensuring that design standards for roads take climate change into account.

Italy: Implements laws and regulations governing state roads and highways as well as handling traffic and signage; conducts and participates in studies, research, and experiments in the fields of roadways and traffic, taking into account both sustainability and climate change.

Norway: Responsible for environmentally friendly and transport-effective spatial planning, promotion of changes in the modal split (for passenger and freight transport), promotion of low-emission vehicles, environmental standards within construction, issuance of driver's licences, and quality and content of driver training. Responsible for accessibility for all road users along national roads (pedestrians, cyclists, the disabled, public transport users, freight and motorised passenger transport).

Spain: Responsible for the development, supervision, and control of planning in general, sectoral plans, and planning studies in its field of competence. Change of modal split: promotes other sectors' efforts to achieve a more sustainable modal split.

Sweden: Defined roles in spatial planning, change of modal split (passenger and freight transport), promotion of low-emission vehicles, promotion of better use of vehicles (such as ecodriving and compliance with speed limits), and responsibility for energy-efficient road maintenance/road construction.

Conclusions*:*
Most, but not all, NRAs have a wider role in addition to their core mission of building and maintaining the national road network. Both emissions of GHG generated by road building and maintenance, and cooperation with other authorities on subjects concerning climate change seem to be interesting issues for further investigation.

A.2 The overall policy/strategy for national mitigation of climate change

Is there an overall policy/strategy adopted by the national assembly?

Austria: Austria's 'Climate Strategy 2010' was adopted by the federal government and the council of provincial governors in 2002. The effects of the Climate Strategy have been evaluated by independent consultants, and additional measures were implemented in March 2007. Most federal states (e.g. Vienna, Upper Austria, Lower Austria, Salzburg) have formulated their own regional climate change programmes, taking into account specific regional circumstances, needs, and areas of jurisdiction. These programmes ideally supplement the national programme, which can only describe general conditions and guidelines for provincial action at an abstract level.

Denmark: The Danish government published a climate (adaptation) strategy in March 2008: www.kemin.dk/Documents/Climate_adaptation_strategy.pdf.
The Ministry of Transport published a climate (adaptation) strategy in June 2010: http://www.trm.dk/DA/Publikationer/2010/Klimatilpasningstrategi (in Danish). Both strategies address the issue of the mitigation of climate change. The government's focus in relation to the mitigation of climate change is to reduce the use of fossil fuels in the energy sector.

Finland: The Finnish government introduced a long-term climate and energy strategy on 6 November 2008. It was adopted by the Finnish parliament in June 2009. The Ministry of Transportation and Communication adopted a climate policy programme on 17 March 2009. A national climate strategy was adopted in 2005 by the Ministry of Commerce and Industry.

France: Regarding the mitigation of climate change, France has several international and European commitments (Kyoto protocol, European Commission's communication of the 2007/01/10).

An act providing the framework for French energy policy supported the objective to halve global emissions of GHG by 2050 and called for a 75–80% reduction in developed countries. French commitments in terms of climate change mitigation were then confirmed and specified in the Grenelle laws (Grenelle 1 in 2009 (Law No. 2009-967 of 3 August 2009), and Grenelle 2 in 2010 (Law No. 2010-788 of 12 July 2010)). Grenelle 2 entails stricter climate policies at local level. Local authorities with more than 50,000 residents are required to assess their GHG balance and to draw up planning documents, taking into account climate and energy issues. Moreover, a strategy for climate, air, and energy issues must be defined at regional level.

Hungary: Parliamentary Decree No. 29/2008 (III. 20) on the National Climate Change Strategy was adopted in 2008. The National Climate Change Strategy applies to the period 2008–2025 and contains three main goals (reduction of GHG emissions, adaptation to the inevitable consequences of climate change, enhancement of public awareness of climate change in order to change human motivation).

Parliamentary Decree No. 96/2009 (XII. 9) on the National Environmental Programme for the period 2009–2014, was adopted in 2009. The National Environmental Programme includes an action plan on climate change. The main goals of the action plan are as follows: the reduction of GHG emissions; the improvement of energy savings and energy efficiency; increased binding of GHG by increasing and improving vegetation cover; mitigation of adverse ecological and social effects by enhancing adaptation capacity and preventing damage; protection of the stratospheric ozone layer; and enhanced awareness of climatic issues.

Ireland: The National Climate Change Strategy, which was published in 2007, covers the period 2007 to 2012.

Italy: The Italian government introduced a law on 1 June 2002: 'Ratification and implementation of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, signed in Kyoto on December 11, 1997'. This law established that Italy must reduce its GHG emissions by 6.5% by 2012 compared with 1990 levels, and that policies and measures to reduce emissions must be designed to improve the energy efficiency of the national economic system, promote alternative sources of energy and energy security, increase the amount of renewables in the total energy supply, promote technological innovation in transport and energy, promote sustainable agriculture and forestry and their 'sinks' for carbon, increase and improve international technology cooperation to support the participation of Italian companies in the 'Clean Development Mechanism' and 'Joint Implementation'.

Norway: Parliamentary Bill 34 (2006–2007) Norwegian Climate Policies was adopted by the Norwegian Parliament in March 2008. Parliamentary Bill 16 (2008–2009) National transport plan 2010–19 was adopted by the Parliament in June 2009. These bills outline the responsibility of the transport sector to contribute to a 2.5–4 million tonne reduction in CO_2 emissions compared with the current trend scenario.

Spain: 2007–2012–2020 Spanish Strategy on Climate Change and Clean Energy was approved by the Ministry of the Environment and Rural and Marine Affairs of Spain. It was also approved by the Ministry Council on 2 November 2007. This strategy provides stability and coherence for climate change policies in Spain and defines the basic guidelines for a medium-/long-term approach (2007–2012–2020), including a range of measures that entail a direct or indirect reduction of GHG and adjustment to their effects.

Sweden: The Energy and Climate Policy, adopted in summer 2009.

Conclusions:
All countries that responded to the survey have a national policy for mitigating climate change. Several of the respondents commented that such a national, cross-sectoral policy must be expressed in general terms.

Are there any sector-specific policies/strategies for the reduction of GHG emissions and energy use?

Austria: Sector-specific policies/strategies for the following sectors: energy, transport, industry, agriculture and forestry, and waste management.

Denmark: Sector-specific policies/strategies primarily for the following sectors: energy and industry

Finland: The Ministry of Transportation and Communication adopted a climate policy programme in March 2009. A national climate strategy was adopted in 2005 by the Ministry of Commerce and Industry.

France: Yes. Sector-specific policies have been established for the reduction of GHG emissions and energy use. The Grenelle laws have three main targets: construction, transport, and energy.

Hungary: Government Decree No. 2019/2008 (II. 23) on the National Energy Efficiency Action Plan was adopted in 2008. The National Energy Efficiency Action Plan applies to the period 2008–2016 and covers the following sectors: households, governments (local, state), industry, agriculture, and transport.

Ireland: A Sustainable Transport Future policy, which was published in 2009, covers the period 2009–2020.

Italy: CIPE[51] approved by resolution No. 123/2002: 'National Action Plan (PAN) to reduce emissions of GHG and increase their absorption'. This plan identifies three different groups of measures: measures included in the reference state, aimed at promoting economic development of Italy, which have a side effect of reducing emissions; measures to be

[51] Interministerial Committee for Economical Planning

implemented in agriculture and forestry in order to increase the capacity of carbon absorption; additional mitigation measures to be implemented both at national level and through international cooperation mechanisms to bridge any gap with the target set.

The Ministry of Economic Development, collaborating with the Ministry of the Environment, Land and Sea and the Ministry of Agriculture, Food, and Forestry, developed the 'National Action Plan for renewable energy'. This plan contains a set of economic and non-economic measures and international cooperation measures, namely those aimed at the removal or reduction of problems relating to the reaching of objectives, such as authorisation procedures, the development of transmission and distribution of intelligent use of renewable energy potential, the technical specifications of equipment and facilities, and the certification of installers.

Norway: Parliamentary Bill 34 (2006–2007) Norwegian Climate Policies contains sectoral descriptions of strategies and policies for reducing GHG emissions (with transport as one of the sectors). There are no goals for reduction of energy use.

Spain: 2008–2012 Saving and Energy Efficiency Strategy in Spain Action Plan (E4+),

approved by the Council of Ministers in July 2007.

Spanish Sustainable Development Strategy, approved by the Council of Ministers in November 2007.

Spanish Strategy for Sustainable Mobility, approved by Council of Ministers in April 2009.

II National Programme for Emission Reduction, Ministry of the Environment and Rural and Marine Affairs of Spain, approved by the Council of Ministers in December 2007.

2005–2010 Renewable Energy Plan, approved by the Government in August 2005.

Plan of Urgent Measures for the Spanish Climate Change and Clean Energy Strategy (EECCEL-2007).

The 2005–2020 Strategic Infrastructures and Transport Plan (PEIT), Ministry of Public Works and Transport of Spain, approved by the Council of Ministers in July 2005.

Sweden: The transport sector shall contribute to the national environmental objectives (where climate is one of 16 environmental objectives) and by 2030, the vehicle fleet should not be dependent on fossil fuels. Adopted along with the energy and climate policy mentioned earlier.

Conclusions*: Sector-specific strategies appear to be in place in many of the countries that responded to this question in the survey. How specific these strategies are seems to vary. In subsequent work, it may be of interest to elaborate how specifically the countries have managed to make such strategies, paying special attention to the transport sector.*

A.3 Has a specific strategy been defined for the road sector?

Austria: Yes

Denmark: No, not yet, but it is a part of the transport sector.

Finland: No, part of a general strategy for the transport sector.

France: A pilot study of the national transport infrastructure scheme (SNIT) was published in 2010 and submitted for consultation. The final drafts will be presented to the French Parliament during the summer of 2011. This scheme resulted from the Grenelle 1 law. It is a planning document that i) lists the investments in new operations that seek to improve complementarities between transport modes, ii) sets the trend in terms of the maintenance, exploitation, and modernisation of the existing networks and in terms of reduction of their environmental impacts. The implementation of SNIT must lead to a reduction in GHG emissions of between 2 and 3 million tonnes CO_2-equivalents/year by 2020.

Alternative transport modes to road and air will be favoured in an integrated and multimodal framework; however, all modes have a role to play. An efficient transport system that will help France to honour its international, European, and national commitments in terms of the environment, economic development, and social progress will be built.

SNIT lists 60 actions that will direct policies of infrastructure managers in terms of maintenance, exploitation, and modernisation. Finally, SNIT introduces a selection of development projects based on a multi-criteria analysis (in collaboration with the Grenelle actors and in cohesion with the selection criteria introduced by the article 17 of the law of 3 August 2009).

Hungary: No, but the National Energy Efficiency Action Plan includes some actions for the road sector.

Ireland: No, but the issue is being included in appraisal guidelines.

Italy: No, but the 'National Action Plan (PAN) to reduce emissions of GHG and increase their absorption' includes some actions for the road sector.

Norway: No, part of a general strategy for the transport sector

Spain: No, part of the general strategy on Climate Change and Clean Energy, which includes a chapter on the transport sector.

Sweden: Yes, multi-modal decision-making for climate mitigation in planning was adopted in autumn 2010 by the Swedish Transport Administration.

Conclusions*:*
Very few of the participating countries have a separate strategy for reducing energy use and GHG emissions in the road sector. However, most countries treat the road sector as a part of an overall strategy for the transport sector. An interesting subject for further investigation will be how this approach affects concrete action in the road sector.

A.4 What measures are being taken in the road sector?

As seen above, many of the countries have a strategy for the transport sector. It is somewhat unclear whether the countries also have a specific strategy for the road sector. But measures implemented to reduce energy use and GHG emissions in the sector are reported.

Austria: CO_2 labelling and other measures to reduce emissions from passenger cars. Fuel consumption-based taxation. Support for shared transport. Promotion of public transport systems. Model projects and programmes for environmentally sound mobility. Public awareness-raising measures such as Ecodriving Austria. Promotion of energy-efficient and alternative engine concepts. A fuel consumption-based passenger car registration levy. A mileage-based highway toll for lorries and trucks. A mandatory target for transport fuels of a 5.75% share of biofuels.

Denmark: Fuel consumption-based taxation. Promotion of energy-efficient and alternative engine concepts. A mandatory target for transport fuels of a 5.75% share of biofuels. Car taxes are levied to reduce the average emissions on new cars sold to 120 g/km CO_2 by 2012.

Finland: The annual car tax will be based on emissions. Research and development on transportation pricing. Support for public transportation. A new gasoline standard is introduced which includes more biofuel. NRA started a strategic research and development (R&D) project dealing with climate change including both mitigation and adaptation, in cooperation with Motiva. It includes transport system management tool development, pedestrian and bicycle traffic research, and several studies on railways.

France: As previously mentioned, the French transport strategy is multimodal, thus a long-term strategy for changing the modal split is implemented. To that end, investments are allocated for the modernisation of rail and river infrastructure, or the development of public transport. For instance, a national commitment to rail freight transport (September 2009) and calls for proposals for public transport in cities were introduced. Some fiscal incentives have been implemented since 2008.

A combination of scrap incentives and a bonus scheme have been implemented in order to stimulate the production and purchase of private cars that consume less energy. These schemes have contributed to the reduction of GHG emissions from new vehicles: from 9.2 g CO_2/km between 2007 and 2008 to 6.3 g CO_2/km between 2008 and 2009.

A heavy goods vehicle eco-tax was introduced in a fiscal law in 2009 to be implemented on the non-contracted national road network and on the secondary roads that may be affected by traffic increase due to the taxation. Its implementation is planned for 2013.

The NRA promotes ecodriving (écoconduite) through training programmes. Moreover, the NRA has encouraged professionals to implement voluntary involvement conventions. Enterprises implement actions for sustainable development that are taken into account by the Ministry.

A few examples of signed conventions:

- regarding freight transport: carriers have committed themselves to reducing their GHG emissions (the convention is called 'Objectif CO_2 – les transporteurs s'engagent').
- regarding infrastructure design, construction, and maintenance: major players (the National Federation of Public Works (FNTP), Excavation Companies Union (SPTF), Unions of French Road Industry Syndicates (USIRF), Syntec Engineering Federation),

have become involved in and have signed a convention to implement the conclusions of the Grenelle laws. Reducing GHG emissions is one of the objectives (the targets are: GHG emissions reduction of 10% and 6% respectively for road construction and excavation firms by 2012, and 33% by 2020).

- regarding passenger transport: the National Federation of Passenger Transportation (FNTV) has become involved in promoting sustainable development.

Hungary: Road toll system, construction of bypass roads (to prevent congestion), traffic management, intelligent transport systems.

Ireland: No measures directly by the NRA, but the government has changed the vehicle registration tax and motor tax in favour of vehicles with lower emissions. The Department of Finance recently issued guidelines on the inclusion of CO_2 emissions in transport project appraisals, and the NRA is currently assessing these guidelines. The Climate Change Strategy document has a chapter on transport and includes policies on modal shift, fuel efficiency, vehicle registration tax and motor tax, biofuels, commuting patterns, and road freight. The Sustainable Transport Future document addresses the promotion of co-modality, managing congestion, road safety, transport research, strategic and land use planning, facilitating non-motorised transport, alternative fuels, and biofuels.

Italy: Buses and private vehicles with lower carbon density fuels (GPL, methane); optimisation systems and collectivisation of private transport; remodelling of the taxation of mineral oils; activation of computerised information systems; development of national infrastructure, and promotion of combined transport and cabotage.

Norway: New car sales taxes are levied to reduce the average emissions on new cars sold to the strategic target of 120 g/km CO_2 by 2012. Introduction of electric vehicles is encouraged by a broad package of fiscal incentives, development of a basic public charging infrastructure and various user incentives. In 2009, a mandatory requirement for the sale of biofuels in the road sector was introduced. In 2009, the target was 2.5% of road fuel sales. This target was increased to 3.5% in 2010 and to 5% for 2011.

A website is being developed to guide buyers who want to compare the emissions of new cars. Environmentally friendly urban mobility is promoted through financial incentives to the 13 most densely populated areas to encourage greater use of public transport and less use of private cars. Strategies and investments have been developed to promote more cycling and walking. More conscious land use planning and congestion charging in cities are being promoted by the NRA.

A legal framework for congestion charging is being drawn up. The government is demanding a comprehensive package of measures for new urban toll ring packages in cities. This includes requirements for strategies to increase the amount of cycling, walking, and public transport as well as the introduction of restrictions on car use such as congestion charges and parking restrictions/fees. Many large cities now have toll rings. Requirements for more energy-efficient street lamps based on CEN standards are implemented in the new Road Design Manual (2008).

Spain: Measures for modal change. Urban mobility plans (regulations, support of public transport, support for urban mobility plans), transport plans in businesses and activity centres, more public transport (information technology). Measures for more efficient use of means of transport: transport infrastructure management, road transport fleet management, efficient driving. Measures for improvement of energy efficiency of vehicles: renewal of the road transport fleet (regulations which favour more energy-efficient vehicles), renewal of private cars (modification of the tax system and development of regulatory tools).

Sweden: The energy and climate policy contains measures that have now been implemented. These include changes in vehicle tax (increased CO_2 factor), changes in the definition of the eco-car, eco-car subsidy replaced by exemption from vehicle tax for 5 years, increased energy tax on diesel, lower vehicle tax on diesel cars. A change in the definition of eco-car was also announced but there is still no proposal. There is, however, a proposal for an SEK40,000 (approx. € 4,675) super-eco car subsidy for vehicles that not only emit less than 50 g/km CO_2, but also meet stringent requirements for traffic safety, energy efficiency, and noise levels.

The work of the national transport administration to mitigate GHG emissions includes: collaboration with trade and industry and public organisations to encourage them to reduce their emissions, lowering of speed limits, more ecodriving, energy-efficient road maintenance (mainly more efficient street lamps), increased speed compliance (more speed cameras), a reduction in the use of studded tyres (mainly through information), and more efficient ferries (cable ferries and ecodriving). Through these measures, CO_2 emissions in 2009 and 2010 were reduced by 220,000 tonnes (nearly 1% of the sector's CO_2 emissions).

Conclusions*:*
The general impression is that measures involving taxation, technology, and fuels are being implemented, while measures to reduce traffic have not yet been contemplated to the same extent. An important question deserving further investigation is whether the targets adopted (including deadlines) can be reached by means of technology alone. Another interesting issue is how roads can be built and maintained with less energy use and lower emissions.

B Targets

B.1 What energy use/energy efficiency targets have been adopted?

Table B.1: Targets adopted for energy use

Energy use	For all sectors	For the transport sector	For the road sector
Austria	No response	No response	No response
Denmark	50% of animal manure to be used in biogas production by 2020 30% of electricity to be generated from renewable sources by 2020	5.75% biofuel in 2012	Not set
Finland	- 10% (EU target)	- 20% from basic estimate 2020 10% biofuels in 2020	Not set
France	20% increase in energy efficiency by 2020 23% of renewables in final energy use by 2020	7% of biofuels in 2010 and 10% in 2020	Not set
Hungary	- 15,960 GWh/year (= - 57.4 PJ/year) from 2008 until 2016 Targets for increasing renewable energy use through biofuels, electric energy production, and heat energy production.	- 900–1,500 GWh/year (= - 3.24–5.4 PJ/year) from 2008 until 2016	- 875–1,250 GWh/year (= - 3.15–4.5 PJ/year) from 2008 until 2016
Ireland	15% of electricity to be generated from renewable sources by 2010 and 30% by 2020. Biomass to contribute up to 30% of energy input at peat stations by 2015	Not set	Not set
Italy	Not set	Not set	Not set
Norway	Not set	Not set	Not set

Energy use	For all sectors	For the transport sector	For the road sector
Spain	Reduce primary energy use by at least 2% annually compared with the trend scenario, with special emphasis on the transport, industry, and construction sectors.	No target, just an estimate (33,472 ktep in 2012)	Not set
Sweden	20% more efficient energy use	Not set	The Transport Administration has an internal target to reduce energy use by 400 GWh in 2011

***Conclusions**:*
The targets for energy use are mostly formulated as a total for all sectors. Targets specified for the transport sector involve the introduction of biofuel. Only one country (Hungary) has specified a target for the road sector. One country (Norway) has no targets for energy efficiency.

B.2 What targets for reduction of GHG emissions have been adopted?

Table B.2: Targets adopted for GHG emissions (changes)

GHG emissions	For all sectors	For the transport sector	For the road sector
Austria	No response	No response	No response
Denmark	-20% by 2020 (or even -30% if required by the EU). -80–95% by 2050	10% renewable energy by 2020	Not set
Finland	No response	- 2 million tonnes CO_2 compared with current emissions	Not set
France	- 20% by 2020 (ref 2050) - 75% by 2050	- 20% by 2020, to reach the 1990 level	Not set
Hungary	- 6% (on the basis of 1985–87) by 2012	Not set	Not set
Ireland	- 17.2 million tonnes CO_2 in the period 2008–2012	- 2.3 million tonnes CO_2 in the period 2008–2012	- 0.51 million tonnes CO_2 through modal shifts
Italy	-13% emissions by 2020 (EU) +17% renewable energy by 2020 (EU)	Not set	Not set
Norway	- 30% compared with 1990 by 2020	2.5–4 million tonnes compared with basic estimates in 2020. Targets for the use of biofuels	Not set
Spain	Limiting the growth of GHG net emissions to 15% in the horizon of 2012 compared with 1990 levels	Estimate: - 107 million tonnes CO_2 2008–2012	Not set
Sweden	40% reduction by 2020, zero net emissions by 2050	The vehicle fleet should not be dependent on fossil fuels by 2030	The Transport Administration has an internal target to reduce emissions by 130,000 tonnes in 2011

***Conclusions**:*
Most countries have targets for total emissions (all sectors), and for the transport sector as well. Two countries have adopted targets for the road sector. Some countries have formulated targets relative to a projected future (mostly 2020).

B.3 What targets for the implementation of measures have been adopted for the road sector?

The following responses to this question were received:

Austria: No targets for the implementation of measures reported.

Denmark: Use of 5.75% biofuels in 2012 (transport sector). No further target for the road sector.

Finland: Targets reported for the introduction of biofuels. No separate target for the road sector.

France: Alternatives to road transport must increase to 25% by 2022 instead of 14%. Moreover, the proportion of biofuels must reach at least 10% by 2020 (transposition of the directive 2009/28/CE).

Hungary: No targets for the implementation of measures are reported.

Ireland: No targets for the implementation of measures are reported.

Italy: No targets for the implementation of measures are reported.

Norway: No targets for the implementation of measures are reported.

Spain: The measures to be implemented are formulated, but not their scope (i.e. 'no targets for implementation').

Sweden: No targets for the implementation of measures in the road sector are reported.

Conclusions:
The most common targets for the road sector are targets for the introduction of biofuels. This target is generally not for the road sector alone, but for the transport sector as a whole. Most countries list measures without being specific as to the scope of the measures and when they are to be implemented. In subsequent work, it would be interesting to see how measures relating to infrastructure (building and maintenance) and traffic are used in different countries.

C Research

C.1 Research into the mitigation of climate change in the participating countries

The survey included some questions concerning on-going research. We chose to focus on two main issues:

- the impact of the construction, operation, and maintenance of road infrastructure on GHG emissions
- the reduction of energy use and GHG emissions in urban areas

Task group 17 suggests that further work should focus on on-going research and the exchange of new knowledge between participating countries.

A brief summary of on-going research (main research programmes identified in the survey responses) is presented below.

C.2 Research into the impact of the construction, operation, and maintenance of the national road network on energy use and climate gas emissions

Austria: No response to this question.

Denmark: Research on rolling resistance and the energy-saving road: energy savings in road transport as a function of the functional and structural properties of roads (A technical report: http://www.ncc.dk/The_energy-saving_road.pdf)

Finland: Strengthening the role of climate change policy in road maintenance (November 2009)

France: Ademe[52] supports research operations that seek to develop more efficient vehicles (for more information see the website: http://www.ademe.fr). Funding allocated for research in the transport sector was significantly increased within the PREDIT programme (2008–2012) in order to encourage energy and environmental efficiency. Research on clean vehicles as part of a clean vehicle development plan. Electric vehicles: €57 million in 2008 for 11 projects, €50 million in 2009; batteries: €75 million in 2008 for the National Institute of Solar Energy.

Demonstration of projects on plug infrastructure: €70 million in 2010; Clean mobility solution fund: €25 million in 2010, French road map for low-carbon vehicles. Biofuels: road map for second generation biofuels. National Research Agency programmes: National Action Plan on Hydrogen and Fuel Cells, Programme for Land Transport Vehicles (also deals with other transport issues).

Hungary: Basic principles for a comprehensive strategic environmental evaluation of transport systems. Encouraging the use of biofuels in transport. The effects of the Operational Programme for Transport (KözOP) on GHG emissions in Hungary. Assessment of the emissions of air pollutants from the bus fleet of Budapest Transport Ltd. The possibility of utilising buses with a purely electric drive system in Budapest. Comparison of railway passenger transport vs. public road transport from an environmental perspective: presentation of the Drégelypalánk–Ipolytarnóc side line. RKF Technology Data Base for environmentally friendly vehicle operation. Determination of emission records for domestic road, rail, air, and water transport at national,

[52] A French agency for Environment and Energy Management

regional, and local levels for the year 2005. QUANTIFY project (Quantifying the Climate Impact of Global and European Transport System).

European Database of Vehicle Fleet for the Calculation and Forecast of Pollutant and GHG Emissions with TREMOVE and COPERT. Assessment of goals for the road transport subsector that can be achieved by 2020 relating to energy efficiency, use of renewable energy sources and reduction of GHG emissions with a focus on public transport. Assessment of the possibility of introducing the ULEV- or ZEV-type buses to the Budapest transport system. Assessment of the effects of climate change on motorised transport. Action plan for adapting inland transport to climate change. Climate friendly cities: handbook on the responsibilities and opportunities ahead for European cities regarding climate change.

Ireland: ECRPD Project: Energy Conservation in Road Pavement Design, Maintenance and Utilisation (published in January 2010 and available at www.ecrpd.eu).

Italy: No response to this question.

Norway: Method for calculating energy use and CO_2 emissions from both road traffic and road construction projects, including maintenance and operation.

Spain: The Strategic Action Plan for Energy and Climate Change, within the National R&D and Innovation Plan of the Ministry of Science and Innovation, has a number of research programmes relating to energy efficiency, renewable energy, and technologies for clean coal combustion; R&D and innovation projects for sustainable mobility and global change; non-energy mitigation of climate change; climate observation and adaptation to climate change. Projects worth mentioning:

FENIX: about road paving, divided into 12 original research topics, such as nanomaterial to reduce pollution from vehicles and new production technologies to develop new bituminous mixtures (i.e. reusing tyres as a raw material). The research project 'Emission reduction from the road transport sector by efficient design and operation' helps to compare road project alternatives.

Sweden: A number of research projects are on-going within the area supported by National Transport Administration.

C.3 Research into the mitigation of energy use and GHG from the transport sector in urban areas

Austria: No response to this question.

Denmark: No response to this question.

Finland: Congestion fee study for the Helsinki area.

France: No response to this question.

Hungary: Basic principles for a comprehensive strategic environmental evaluation of transport systems. Encouraging the use of biofuels in transport. The effects of the Operational Programme for Transport (KözOP) on the emission of GHG in Hungary (Institute for Transport Sciences). Assessment of the emission of air pollutants from the bus fleet of Budapest Transport Ltd. The possibility of utilising buses with a purely electric drive system in Budapest. Comparison of railway passenger transport vs. public road transport from an environmental perspective: presentation of the Drégelypalánk–Ipolytarnóc side line. RKF Technology Data Base for environmentally friendly vehicle operation.

Determination of emission records for domestic road, rail, air, and water transport at national, regional, and local levels for the year 2005. QUANTIFY project (Quantifying the Climate Impact of the Global and European Transport System). European Database of Vehicle Fleet for the Calculation and Forecast of Pollutant and GHG Emissions with TREMOVE and COPERT. Assessment of goals for the road transport subsector that can be achieved by 2020 relating to energy efficiency, use of renewable energy sources, and reduction of GHG emissions with a focus on public transport. Assessment of the possibility of introducing the ULEV- or ZEV-type buses to the Budapest transport system.

Ireland: Reported research projects mainly relating to drainage.

Italy: No response to this problem.

Norway: Research and trial projects for more environmentally friendly transport are promoted through financial incentives (Transnova) funded by the Ministry of Transport. Climate Cure – a recent report on possible measures for reducing national GHG emissions to achieve national goals (see http://www.klif.no/no/Publikasjoner/Publikasjoner/2010/Juli/Climate-Cure-2020-Measures-and-instruments-for-achieving-Norwegian-climate-coals-by-2020-Summary/).
TEMPO research programme: approx. €4 million in 2010–2013 to find environmentally friendly transport solutions in cooperation with users. Environmentally friendly transport in cities: research programme conducted by the NPRA 2006–2010 (see http://www.transportmiljo.no/forsiden/).

Spain: Within the National R&D and Innovation Plan, one of the lines of the Strategic Action for Energy and Climate Change deals with the transport sector in urban areas and sustainable mobility. Also, one of the objectives of the 2005–2020 Strategic Infrastructures and Transport Plan (PEIT) is promoting R&D+ Innovation programmes. Projects worth mentioning: built environment variables influencing pedestrian trips. Guidelines for the design of pedestrian-oriented urban development. Towards a walkable city.

INTERBUS: improving the service provided by bus networks and encouraging intermodality.

Plan for the improvement and spread of car sharing in the Bages region and promotion of rational use of private transport.

REACTIVA: reinforcement of positive attitudes in users of public transport.
Attitudes toward public and private transport systems: psychosocial and structural factors.

Sweden: LETS, Low-Carbon Energy and Transport (2009–2012). Swedish networks of excellence. http://www.lth.se/lets2050/english/
Mistra Urban Futures: centre for sustainable urban development: http://www.mistraurbanfutures.se/english/startpage.4.15c2317a1266994794c8000596.html.

C.4 Other on-going research programmes on the mitigation of climate change from the road sector

Austria: No response to this question.

Denmark: No response to this question.

Finland: An Ecologically Efficient and Safe Transport System R&D programme includes the projects 'Unit emissions of transportation' and 'Climate change and goods transportation' (expected to be published in March 2010). Other on-going projects: Management of road transportation demand guidelines, nationwide strategy and implementation plan for 2010–2015 of intelligent traffic systems and study of alternative transportation taxes and road user fees based on distance in kilometres.

France: Research into clean vehicles as part of a clean vehicle development plan. Electric vehicles: €57 million in 2008 for 11 projects, €50 million in 2009; batteries: €75 million in 2008 for the National Institute of Solar Energy.

Demonstration of projects on plug infrastructure: €70 million in 2010; clean mobility solution fund: €25 million in 2010, French road map for low-carbon vehicles. Biofuels: road map for second generation biofuels. National Research Agency programmes: National Action Plan on Hydrogen and Fuel Cells, Programme for Land Transport Vehicles (also deals with other transport issues).

Hungary: Assessment of goals for the road transport subsector that can be achieved by 2020 by means of energy efficiency, use of renewable energy sources and reduction of GHG emissions – with a focus on public transport.

Ireland: None.

Italy: No response to this question.

Norway: RENERGI by the Norwegian Research Council. The objective is to develop knowledge and solutions as a basis for ensuring environmentally friendly, economically efficient, and effective management of the country's energy resources, a highly reliable energy supply, and internationally competitive industrial development.

Spain: Within the National R&D and Innovation Plan there is a research focus on non-energy mitigation of climate change, climate observation, and adaptation to climate change where specific but not yet available projects are currently being developed.

Sweden: A number of research programmes, in addition to LETS (mentioned above). New is 'Energy efficient road vehicles' (2011–2014). On fuels: programmes on ethanol and gasification of black liquor were both ended in 2010. There are also programmes on vehicles with joint financing from the vehicle industry. http://www.energimyndigheten.se/en/Research/Transport/ and http://www.vinnova.se/en/Activities/Transportation/

Conclusions:
The survey shows that in the CEDR-12, considerable research is being conducted into various fields such as vehicle technology, fuels, multimodal transport systems, and methods for planning infrastructure construction, maintenance, construction and operation.
'Energy – Sustainability and Energy Efficient Management of Roads' is a cross-border funded, trans-national joint research programme that was initiated by ERA-NET ROAD II (ENR2). The overall aim of this joint research programme is to boost the common understanding and performance of sustainable development among the road authorities, by developing whole life consideration of sustainability and energy efficiency; developing decision-making tools with practical applications for all stages of road planning, design, construction, and maintenance; and addressing the need to assess the effects of operation, safety, and durability, which will deliver improvements in the energy efficiency performance of the road sector.

Four projects were selected with 19 partners from 10 different countries. These projects are:

- SUNRA: Sustainability - National Road Administrations
- CEREAL: CO_2 Emission REduction in roAd Lifecycles
- LICCER: Life Cycle Considerations in EIA of Road Infrastructure
- MIRAVEC: Modelling Infrastructure influence on RoAd Vehicle Energy Consumption

More information can be found at www.eranetroad.org.

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