EU Transport GHG: Routes to 2050?

Infrastructure and spatial policy, speed and traffic management (Paper 8)

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Executive Summary

This paper is one of four policy papers drafted under the "EU Transport GHG: Routes to 2050?" Project. This paper focuses on GHG policy instruments related to transport infrastructure and spatial policy, and speed and traffic management. It aims to provide a high-level summary of the evidence based on existing studies.

The paper first provides general background information on infrastructure and spatial policy, speed and traffic management, in the context of greenhouse gas mitigation. It then discusses the following topics in more depth:

- The role of GHG emissions in environmental assessments and cost benefits analysis in infrastructure and spatial planning processes.
- The potential for GHG emission reduction in urban planning and development,
- Potential of GHG reduction in spatial and infrastructure development outside urban areas.
- Traffic management policies and speed limits.

Environmental assessments and cost benefit analyses

In infrastructure and special planning processes various instruments are used to assess the environmental implications of decisions: Environmental Impact Assessments (EIA), Cost Benefit Analyses (CBA) and Strategic Environmental Assessments (SEA). These instruments can help decision makers to make a choice that takes into account the environmental impacts of a project or a plan, e.g. for new transport infrastructure or spatial development.

It is concluded that further integration and improvement of GHG impacts in environmental assessments can have a significant impact on the GHG emissions of transport in the long term. The policies for doing this are:

- Ensure that all (very) long term impacts on GHG emissions are included in these assessments.
- Apply higher shadow prices for the long term emissions of CO_2 in CBAs, in order to better reflect the risks for possible long term dramatic climate changes.
- Introduce specific conditions or requirements to the overall impact on GHG emissions.

GHG emission reduction in urban planning and infrastructure development

A number of urban planning and infrastructure policies were identified that affect the GHG emissions of transport: urban planning, investments in public transport, cycling and walking infrastructure, parking policy and policies for advanced distribution concepts.

It is concluded that these policy instruments can help to reduce GHG emissions. However, they need to be combined with other measures such as pricing policies, otherwise the reduction is expected to be limited (or even negative). There is limited concrete, quantitative evidence on GHG reduction potential of these instruments, partly because of the complexity of effects induced by these policies, but also because of the lack of assessments: most of these instruments are not specifically applied with the goal to reduce GHG emissions.

These measures and policies can also have a positive impact on the liveability and accessibility of cities. Effects on GHG emission reductions are more limited and may even be negative in certain cases because of second order effects: some of these policies may also increase overall transport volume if no policies to prevent that are implemented.

GHG emission reduction in spatial and infrastructure development outside urban areas

Outside urban areas, most transport GHG emissions are from cars and trucks (for the shorter distances) and by airplanes and trucks (for the longer distances). To reduce GHG emissions from these trips, the main options are to prevent trips or to accomplish a shift from high-carbon kilometres towards lower-carbon kilometres for transport.

It is concluded that investments in the 'greener' modes can lead to better developed and more efficient transport networks. However, provision of new transport possibilities and/or infrastructure alone cannot be expected to lead to a GHG emission reduction but rather lead (in most cases) to more transport movements. Therefore, these investments should be part of a larger set of policy instruments like legislation regarding vehicle emissions or pricing policy.

Traffic management policy and speed limits

Traffic management policy can also be deployed to minimize fuel consumption and GHG emissions. Its main aims should then be to reduce the number of kilometres driven, to favour environmentally friendly transport modes and to enable vehicles to operate at favourable speeds and to keep a constant speed. Substantial reductions in GHG emissions can then be achieved. However, traffic management measures can also increase the capacity of roads and thus the attractiveness of (certain routes in) the transport network, which can result in extra kilometres driven and GHG emissions – unless this policy is part of a lager set of measures as described above. Lowering speed limits can be very effective in reducing GHG emissions, without generating this rebound effect of increasing transport volume.

Most important barriers to these policy instruments the economic consequences of longer travel times and user acceptance and compliance with speed limits. Costs of implementation are low to moderate. Most of the measures discussed have (significant) co benefits, for safety, air quality, noise and energy security.

In conclusion, there is a strong relationship between infrastructure, spatial planning and transport speed on the one hand, and transport demand and modal split on the other hand. Both inside and outside urban areas, GHG reduction can be attempted with spatial planning policies and investments in public transport, cycling and walking. Lower speed limits or traffic management may also be effective instruments to reduce GHG emissions of transport. In order to achieve GHG reduction, an important prerequisite is that the policies aim to reduce transport volume or to cause a shift towards 'greener' modes of transport. If successfully implemented, especially spatial policies will usually only be effective in the long run, since the impacts of urban planning take some time.

However, drivers for these policies are currently typically economical and social aims rather than environmental. Many of these policies may then lead to an increase in transport demand and thus GHG emissions if no other policies (such as pricing policies) are implemented to prevent this.

1 Introduction

1.1 Topic of this paper

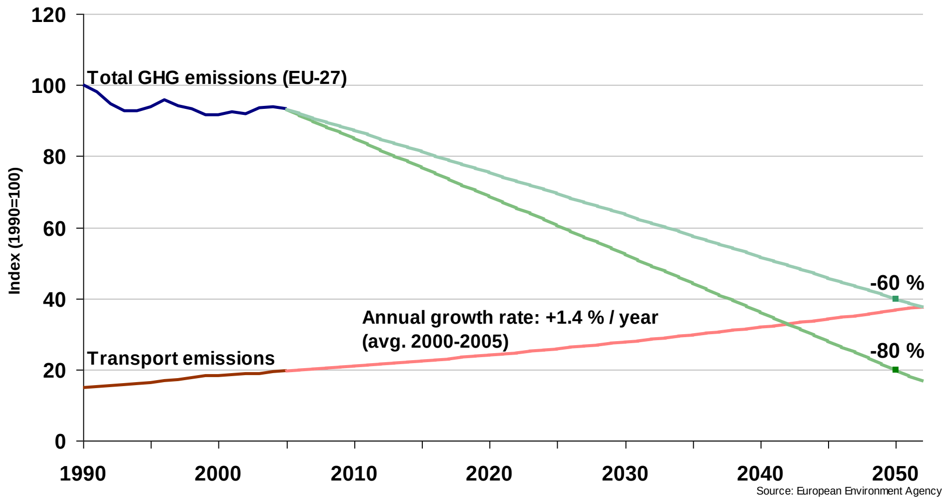
This paper is one of four policy papers drafted under the *EU Transport GHG: Routes to 2050?* Project. These papers review the policy instruments that could be used to stimulate the application and take up of the technical and non-technical options that could contribute to reducing transport's GHG emissions, both up to 2020 and in the period from 2020 to 2050. This paper focuses on GHG policy instruments related to transport infrastructure and spatial policy, and speed and traffic management. The papers aim to provide a high-level summary of the evidence based on existing studies.

This paper will be presented in draft form to a Technical Focus Group meeting (at which stakeholders will be present) to be held on 24 September 2009 after which it will be updated on the basis of any comments and further evidence received.

1.2 The contribution of transport to GHG emissions

The EU-27's greenhouse gas (GHG) emissions from transport have been increasing and are projected to continue to do so. The rate of growth of transport's GHG emissions has the potential to undermine the EU's efforts to meet potential, long-term GHG emission reduction targets if no action is taken to reduce these emissions. This is illustrated in Figure 1 (provided by the EEA), which shows the potential reductions that would be required by the EU if economy-wide emissions reductions targets for 2050 of either 60% or 80% (compared to 1990 levels) were agreed and if GHG emissions from transport continued to increase at their recent rate of growth. The figure is simplistic in that it assumes linear reductions and increases. However it shows that unless action is taken, by 2050 transport GHG emissions alone would exceed an 80% reduction target for all sectors or make up the vast majority of a 60% reduction target. This illustrates the scale of the challenge facing the transport sector given that it is unlikely that GHG emissions from other sectors will be eliminated entirely.

Figure 1: EU overall emissions trajectories against transport emissions (indexed)[1]

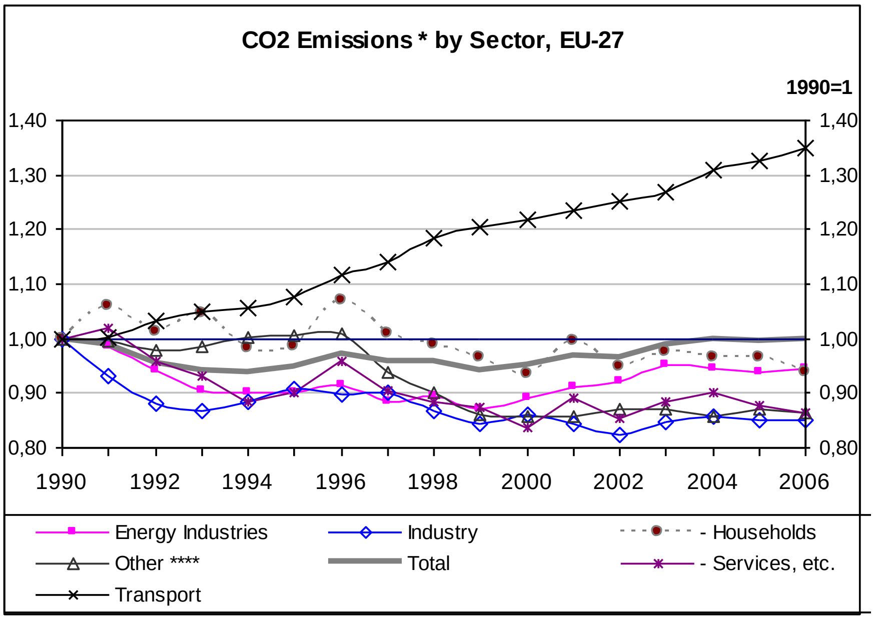


The extent of the recent growth in transport emissions is reinforced by Figure 2, which presents a sectoral split of trends in CO_2 emissions over recent years. Whilst the CO_2 emissions from other sectors have levelled out or have begun to decrease, transport's CO_2 emissions have risen

[1] Graph supplied by Peder Jensen, EEA

steadily since 1990. It should be noted that whilst Figure 2 is presented in terms of CO_2 emissions, very similar trends are evident for GHG emissions (in terms of CO_2 equivalent) since CO_2 emissions represent 98% of transport's GHG emissions.

Figure 2: Carbon dioxide emissions by sector EU-27 (indexed)[2]



Notes:

i) The figures include international bunker fuels (where relevant), but exclude land use, land use change and forestry

ii) The figures for transport include bunker fuels (international traffic departing from the EU), pipeline activities and ground activities in airports and ports

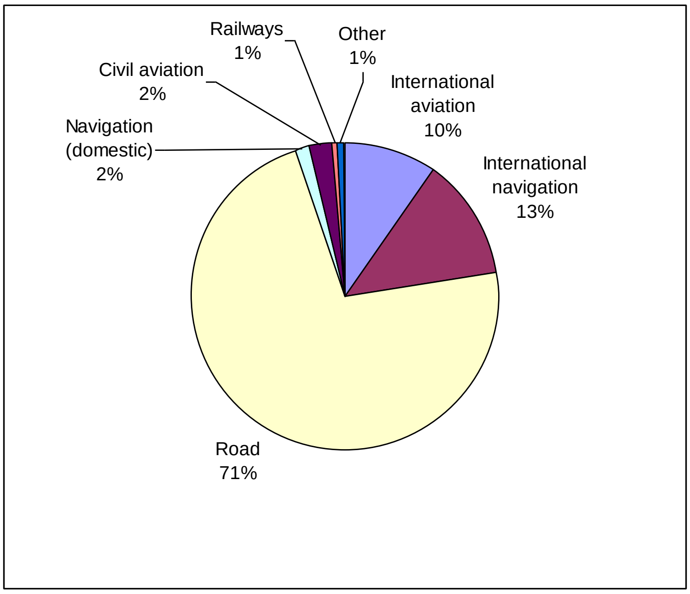
iii) "Other" emissions include solvent use, fugitive emissions, waste and agriculture

The vast majority of European transport's GHG emissions are produced by road transport, as illustrated in Figure 3, while international shipping and international aviation are other significant contributors.

Recent trends in CO_2 emissions from transport are also expected to continue, as can be seen from Table 1 below. Between 2000 and 2050, the JRC (2008) estimates that GHG emissions from domestic transport in the EU-27 will increase by 24%, during which time emissions from road transport are projected to increase by 19% and those from domestic aviation by 45%. It is important to note that these projections do not include emissions from international aviation and maritime transport, which are also expected to increase due to the growth in world trade and tourism.

[2] Graph based on figures in DG TREN (2008) *EU energy and transport in figures 2007-2008: Statistical Pocketbook* Luxembourg, Office for Official Publications of the European Communities.

Figure 3: Greenhouse gases emissions by transport mode (EU-27; 2005)[3]



Note: The figures include international bunker fuels for aviation and navigation (domestic and international)

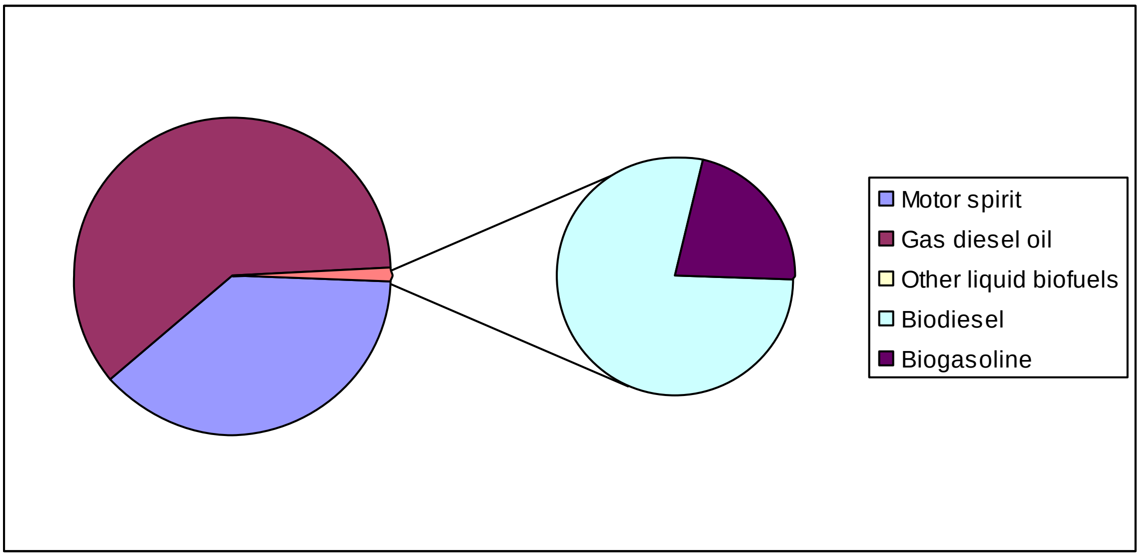
Table 1: CO_2 emissions projection for 2050 by end-users in the EU-27, in Millions tonnes of Carbon[4]

End user Category	1990	2000	2010	2020	2030	2050
Road transport	695	825	905	980	1002	1018
Rail	29	29	27	27	21	20
Domestic Aviation	86	134	179	206	237	244
Inland navigation	21	16	16	17	17	17
Total	**810**	**988**	**1110**	**1213**	**1260**	**1299**

Figures from the EEA (2008), illustrate the recent growth in GHG emissions from international aviation, as they estimate that these increased in the EU by 90% (60 Mt CO_2e) between 1990 and 2005; international aviation emissions will thus become an ever more significant contributor to transport's GHG emissions if current trends continue. Furthermore, the IPCC has estimated that the total impact of aviation on climate change is currently at least twice as high as that from CO_2 emissions alone, notably due to aircrafts' emissions of nitrogen oxides (NO_x) and water vapour in their condensation trails. However, it should be noted that there is significant scientific uncertainty with regard to these estimates, and research is ongoing in this area.

[3] Graph based on figures in EEA (2008) *Climate for a transport change – TERM 2007: Indicators tracking transport and environment in the European Union* EEA Report 1/2008, Luxembourg, Office for Official Publications of the European Communities.
[4] Taken from JRC (2008) *Backcasting approach for sustainable mobility* Luxembourg, EUR 23387/ISSN 1018-5593, Office for Official Publications of the European Communities.

Figure 4: Final transport energy consumption by liquid fuels in EU-27 (2005), ktoe[5]



The principal source of transport's GHG emissions is the combustion of fossil fuels. Currently, petrol (motor spirit), which is mainly used in road transport (e.g. in passenger cars and some light commercial vehicles in some countries), and diesel, which is used by other modes (e.g. heavy duty road vehicles, some railways, inland waterways and maritime vessels) in various forms, are the most common fuels in the transport sector (see Figure 4). Additionally, liquid petroleum gas (LPG) supplies around 2% of the fuels for the European passenger car fuel market (AEGPL, 2009[6]), while the main source of energy for railways in Europe is electricity, neither of which are included in Figure 4. While, alternative fuels are anticipated to play a larger role in providing the transport sector's energy in the future, currently they only contribute 1.1% of the sector's liquid fuel use.

1.3 Background to project and its objectives

The context of the *EU Transport GHG: Routes to 2050* is the Commission's long-term objective for tackling climate change, which entails limiting global warming to 2°C and includes the definition of a strategic target for 2050. The Commission's President Barosso recently underlined the importance of the transport sector in this respect be noting that the next Commission "needs to maintain the momentum towards a low carbon economy, and in particular towards decarbonising our electricity supply and the transport sector"[7]. There are various recent policy measures that are aimed at controlling emissions from the transport sector, but these measures are not part of a broad strategy or overarching goal. Hence, the key objective of this project is to provide guidance and evidence on the broader policy framework for controlling GHG emissions from the transport sector. Hence, the project's objectives are defined as to:

- Begin to consider the long-term transport policy framework in context of need to reduce greenhouse gas (GHG) emissions economy-wide.
- Deal with medium- to longer-term (post 2020; to 2050), i.e. moving beyond recent focus on short-term policy measures.
- Identify what we know about reducing transport's GHG emissions; and what we do not.
- Identify by when we need to take action and what this action should be.

[5] Graph based on figures in DG TREN (2008), page 206
[6] European LPG Association (2009) *Autogas in Europe, The Sustainable Alternative: An LPG Industry Roadmap,* AEGPL, Brussels. See http://www.aegpl.eu/content/default.asp?PageID=78&DocID=994
[7] http://ec.europa.eu/commission_barroso/president/pdf/press_20090903_EN.pdf

Given the timescales being considered, the project will take a qualitative and, where possible, a quantitative approach. The project has three Parts, as follows:

- Part I ('Review of the available information') has collated the relevant evidence for options to reduce transport's GHG emissions, which was presented in a series of Papers (1 to 5), and is in the process of developing four policy papers (Papers 6 to 9) that outline the evidence for these instruments to stimulate the application and up take of the options.
- Part II ('In depth assessment and creation of framework for policy making') involves bringing the work of Part I together to develop a long-term policy framework for reducing transport's GHG emissions.
- Part III ('Ongoing tasks') covers the stakeholder engagement and the development of additional papers on subjects not covered elsewhere in the project.

As noted under Part III, stakeholder engagement is an important element of the project. The following meetings were held:

  - A large stakeholder meeting was held in March 2009 at which the project was introduced to stakeholders.
  - A series of stakeholder meetings (or Technical Focus Groups) on the technical and non-technical options for reducing transport's GHG emissions. These were held in July 2009.
  - A series of Technical Focus Groups on the policy instruments that could be used to stimulate the application of the options for reducing transport's GHG emissions. These were held in September/October 2009.
  - Two additional large stakeholder meetings at which the findings of the project were discussed.

As part of the project a number of papers have been produced, all of which can be found on the project's website, as can all of the presentations from the project's meetings.

1.4 Background and purpose of the paper

This paper is one of four policy papers (Papers 6 to 9) being developed under the *EU Transport GHG: Routes to 2050* project. The aim of these papers is to review the policy instruments that could be used to stimulate the application and take up of the technical and non-technical options that could contribute to reducing transport's GHG emissions, both up to 2020 and in the period from 2020 to 2050. For the purpose of the project, we are using the following definitions:

- **Options** deliver GHG emissions reductions in transport – these can be technical, operational or modal shift.
- **Policy instruments** may be implemented to promote the application of these options.

The options were reviewed in a series of papers developed earlier in the project, i.e.:

1. Technical options for fossil fuel based road transport.
2. Alternative energy carriers and powertrains.
3. Technical options for non-road transport modes.
4. Operational options for all modes.
5. Modal split and decoupling.

These "options" papers are in the process of being revised to take into account comments received at an earlier set of stakeholder meetings (in early July 2009), as well as any additional evidence that has been supplied by stakeholders since those meetings. It is anticipated that revised versions of the options papers will be put on the project's website in early October.

This paper is the third of a series of “policy” papers that review the policy instruments for reducing CO_2 emissions from transport between 2010 and 2050. These papers cover:

6. Regulation of vehicles and energy carriers.
7. Economic instruments.
8. Infrastructure and spatial policy, speed and traffic management.
9. Information, R&D, pilots, voluntary agreements.

All of these papers use evidence from existing studies to assess each of these instruments against a number of key criteria. The paper has been presented in draft form to a Technical Focus Group meeting (at which stakeholders were present) on 24 September 2009. After this meeting, the paper has been the subject of consultation on the project’s website.

The final version of the paper will be uploaded on to the project’s website.

1.5 Structure of the paper

This paper is structured in the following way:

- Section 2 provides background information on infrastructure and spatial policy, speed and traffic management, in the context of greenhouse gas mitigation.
- Section 3 discusses the role of GHG emissions in environmental assessments and cost benefits analysis in infrastructure and spatial planning processes.
- Section 4 looks at the potential for GHG emission reduction in urban planning and development.
- Section 5 assesses the potential of GHG reduction in spatial and infrastructure development outside urban areas.
- Section 6 addresses traffic management policies and speed limits.
- The main conclusions are drawn in section 7.

2 Infrastructure and spatial policy, speed and traffic management in perspective

2.1 Introduction

The relationship between infrastructure and spatial policy on the one hand and transport on the other hand is a strong one, but is complex and often difficult to quantify. Transport infrastructure, i.e., roads, railways, airports, ports, inland waterways etc., are an enabler for transport, and building additional infrastructure is well known to create additional transport as it reduces travel cost and travel time for trips of people or goods. It affects rather fundamental choices of individuals and companies, such as location of houses and companies, or of production locations and logistics. It also affects the modal split, as, for example, additional railway infrastructure may result in a shift of transport from road, inland shipping or even aviation to rail.

Spatial policy may have similar impacts on transport volume and modal choice. Urban sprawl typically creates extra road transport, whereas creating compact cities (high density) with mixed functions (houses, shops and businesses) may reduce transport. Traffic speed policy directly impacts on vehicle GHG emissions, traffic management policy can also affect kilometres driven i.e. transport demand.

All these issues therefore impact on the GHG emissions of transport, making them a potentially important part of future GHG policy. Currently, however, these policy areas are often driven by other objectives than GHG emissions, namely economic development, reducing congestion, improving the environmental quality of urban areas, safety, etc.

2.2 Existing EU infrastructure, spatial and speed/traffic management policy, in relation to GHG reduction

Current EU infrastructure policy is mainly part of European Transport Policy (ETP) and the Trans-European Transport Networks (TEN-T) policy, supplemented by European Regional Development (ERDF) and Cohesion Funds. The ETP of the past decade was basically set out in 2001, when the European Commission issued a White Paper (COM(2001) 370) that described the agenda for the ETP until 2010. It was then reviewed and updated in 2006 (COM(2006) 314 final). A new White Paper for transport is due to be published in 2010.

The main objectives of the ETP are to meet society’s economic, social and environmental needs, by helping providing Europeans with efficient effective transport systems (EC, 2006). Regarding EU infrastructure, the White Paper established a key strategic objective of eliminating bottlenecks on the European transport network. This was a priority area for EU-level action because many of the bottlenecks are at the crossings between Member States, reflecting the fact that the transport networks within Member States were generally designed on a national basis (SDG, 2009).

In 2009, the effects of the ETP policy was assessed against the policy objectives set in the mid-term review of the White Paper, and those set for transport by the Sustainable Development Strategy (SDS) of 2006. The review [EC, 2009] concluded that many of the objectives in the field of economic development, competitiveness, market opening and integration, safety, security, passenger rights and working conditions were largely achieved. However, the goals of the EU SDS were still far away, and the EU transport system was considered to be still not on a sustainable path on several aspects – including that of GHG emissions.

The TEN-T was found to have increased coordination in the planning of infrastructure projects between Member States, thus eliminating infrastructure bottlenecks etc. However, progress has been much slower than anticipated with only a few projects currently completed (e.g., the Oresund link and the Betuwe rail freight line) due to issues such as lack of financial resources and public and political opposition to projects (SDG, 2009). Various short sea shipping projects 'motorway of the sea' are planned or ongoing (supported by the TEN-T budget, ERDF and Cohesion Fund), as are inland shipping projects (to remove bottlenecks).

Related to this, the SDS II has focused on a number of key actions for transport, including to consider alternatives to road transport, including by developing the Trans-European Networks and intermodal links for freight logistics, to allow goods to shift easily between road, rail, and water transport.

In view of the subsidiarity principle, spatial planning and urban transport policies are largely considered to be Member State Policy areas, as are traffic speed and traffic management. However, the EU aims to support and facilitate sustainable developments in that area, through a number of papers and communications. In 2006, the European Commission published a Thematic Strategy on the Urban Environment (COM(2005)718 final). Transport plays quite a large role in this Strategy, as it contributes significantly to various environmental problems such as air quality, noise, congestion, safety issues and greenhouse gas emissions. The development of Sustainable Urban Transport Plans is one of the main parts of this Strategy, and the Commission strongly recommends local authorities to develop and implement these plans.

Aiming to play an active role in coordination and cooperation of urban transport efforts at European level, the EU has published a Green Paper on urban transport in 2006, 'Towards a new culture for urban mobility' (COM(2007) 551 final). This paper is also concerned with several issues of urban infrastructure and spatial planning. Concrete actions on infrastructure or spatial planning development are not (yet) proposed in this Green Paper.

Regarding speed limitation, the EU has implemented policy on speed limiters. This is discussed in more detail in paper 6.

An important conclusion that can be drawn from this is that in most cases, the main objective of the policies discussed in this paper is not GHG reduction, but rather economic development of an area or region, reducing congestion and improving accessibility, improving the environmental quality of urban areas, safety (speed policy), etc. However, their impact on GHG emissions can be very significant, either positive or negative. For example, extra infrastructure can be an enabler of demand growth of the mode concerned, which may induce a shift from other modes and lead to total transport demand growth. On the other hand, efficiency will increase if transport distances are shortened or traffic is brought to a higher level of efficiency from the perspective of fuel consumption. The net impact of an infrastructure project on GHG emissions will have to be determined for each project separately, as local and regional circumstances will be different for each project. In view of this strong linkage between these policy areas and GHG emissions of transport, they should be an integral part of GHG emission policy. The long term impact of infrastructure and spatial planning (infrastructure, buildings, housing, etc. are, of course, build to be used for many decades), further strengthens this conclusion. Decisions that are taken now may impact transport demand for many decades.

2.3 The role of infrastructure and spatial policy and demand management

Transport demand for a specific route is largely determined by cost, travel time and/or inconvenience of that route [CE, 2004]. These three terms are often taken together as the generalised cost for access. Choice of mode (e.g., airplane, car, bus, tram or bicycle) depends largely on availability of the mode on that route, and the associated cost and trip time of that mode, in comparison with the alternatives. These mechanisms result in a strong relationship between infrastructure and spatial policy and demand management. This is linked to the discussion in chapter 4 of paper 5, where the relation between travel speed, travel time and transport volume is further discussed.

Building extra infrastructure or improving current infrastructure, for example building a new road, railway or bicycle track, expanding an airport, a port or a lock on an inland shipping route, can all reduce travel time and cost over a certain route, or accessibility of a specific region or area with the mode concerned. People, shippers and hauliers will react to this, as the cost for access reduces.

In the short term, people might react by changing to other routes or to different modes for certain trips, e.g., from airplane to high-speed train, from train to car or from car to bicycle – depending on the infrastructure project concerned. They may also decide to make more trips (i.e., travel more) or change their destinations, for example go shopping in a city or shopping centre further away than usual, as travel times are reduced. Shippers and hauliers may be able to reduce travel time and transport costs of their product, perhaps increasing their market share in the longer run. Any of these changes will have both environmental and economical impact – positive or negative, depending on the specific infrastructure project and circumstances.

In the longer long term, the impact may even be more significant. People may choose to move houses further away from their work or family, for example to a more pleasant area, if the new infrastructure results in acceptable travel times from their new home. Alternatively, they may also accept jobs further away from their home. Companies may change their location, logistics or distribution patterns as the new infrastructure provides new opportunities for both commuters and goods transport. If these effects of new infrastructure are significant, they may thus impact spatial and urban planning.

Especially these long term effects can impact on spatial and urban planning, as infrastructure will facilitate new transport movements, and can thus affect peoples choices regarding where to live, work, shop, etc. New or improved infrastructure improves the accessibility to regions or locations, making them a more attractive location for both companies and housing, often resulting in increased economic development of that region or location. This is, of course, one of the drivers behind infrastructure policy, both at regional and Member States level, and at EU level (TEN-T projects). At all levels, new infrastructure will create extra economic and social activity which makes use of the new infrastructure. This will partly result in a shift of transport from a different location, e.g., people may go shopping at a different shopping centre if that is now more accessible than before. This will cause different mobility patterns but also further development of that shopping centre, at the expense of the one they used to go before (e.g., in their neighbourhood or city centre). It will, however, partly also result in new transport, e.g., people may visit their family more often than before as travel times have been reduced, or companies may relocate to the newly developed area, causing commuting distances of their staff to increase.

All these effects will impact on transport volume, and thus on GHG emissions of transport, both in the long and short term. Typically, the mechanisms described here result in an increase of transport, and a less dense type of spatial planning (i.e., with less housing, shops, work, etc. per km^2), causing GHG emissions of transport to increase.

Spatial planning itself can also have a significant impact on transport demand and thus on GHG emissions of the sector. In an urban environment with high population density and mixed functions, i.e., with schools, shops, medical facilities and employment within walking or cycling distance, or with high quality public transport, car ownership and use is typically significantly lower than in urban areas were these functions are further away [CE, 2004]. Despite the evidence for the influence of urban spatial patterns on transportation volumes, there is little consensus about the potential influence of policy (see e.g. Ruth, 2006 and Maat, 2009). This chapter provides the main viewpoints, without attempting to be exhaustive in this review, and provides conclusions as to the expected effectiveness of infrastructure and spatial policies to reduce GHG emissions.

2.4 Relation with reduction options

The policy instruments discussed here mainly impact on reduction options related to modal shift, demand reduction and car ownership reduction.

These policy instruments need to be seen in conjunction with other types of instruments, in particular economic instruments like appropriate pricing measures (see Paper 7). These may be used to reduce or even prevent the transport demand increase described above, whilst still improving accessibility and economic development of an area. Economic instruments such as infrastructure charging, CO_2 charges, fuel taxation and parking fees may thus reduce the potential increase of GHG emissions due to new infrastructure or spatial planning decisions. The potential impact of speed limitations is also related to other policies, namely regulation or CO_2 emissions of vehicles (speed limitations may have less effect on more efficient, future vehicles). It may also be related to economic instruments such as CO_2 charges, as these will also promote slower driving, at more fuel efficient speeds. This effect will be the most profound in modes were there is a strong relationship between speed and fuel use, such as in shipping.

An overview of the relationship between the instruments discussed here and the various reduction options is provided in the table below. The green colour indicates that this policy instrument could potentially lead to (minor or larger) GHG reduction in the long term by inducing this reduction option, the red colour indicates that a rebound effect is likely to be dominant: the policy instrument leads to GHG increase by negative impact on this reduction option. The table is an indication of the feasible set of policies, i.e. those policies that might deliver, if applied to the right trips and successfully implemented. We elaborate on these aspects of policy in sections 4-6 of this paper.

	Reduced car-ownership	More f fuel efficient vehicles	Shift to low-carbon energy carriers	Fuel efficient driving/sailing/flying	Reduced vehicle-kms due to higher vehicle utilisation	Modal shift to low-carbon modes	Limiting overall transport growth
Environmental assessments and cost benefits analysis							
Higher shadow price for CO_2 in CBAs							
Specific conditions to the overall impact on GHG in CBAs							
GHG reduction in urban planning							
Location of living and business areas							
Investments in public transport							
Investments in cycling and walking infrastructure							
Parking policy							
GHG reduction spatial planning and infrastructure development outside urban areas							
Investments in long distance and high speed rail infrastructure							
Investments in waterway infrastructure and ports							
Investments in intermodal connections for freight transport							
Traffic management policy and speed limits							
Optimization of traffic flows in cities							
Measures to reduce congestion on main roads							
Access restrictions for high emitting vehicles							
Dynamic speed limits							
Lower speed limits for road transport							
Traffic management for non-road transport modes							
Speed policy for non-road transport modes							

3 Environmental assessments and cost benefits analysis

3.1 Introduction

In infrastructure and spatial planning processes various instruments are used to assess the environmental implications of decisions. The most relevant instruments are:

- Environmental Impact Assessments (EIA) for assessing the environmental impacts of individual projects such as a transport infrastructure (e.g. railway, motorway, port, airport), factory or windmill park;
- Cost Benefit Analysis (CBA) for analysing the cost and benefits of the same types of individual projects and to see whether or not a project is expected to lead to a net increase in the overall welfare.
- Strategic Environmental Assessments (SEA) for assessing the environmental impacts of plans, programmes and policies.

These type of assessments can help decision makers to make a choice that takes into account the environmental impacts of a project or a plan, e.g. for new transport infrastructure or spatial development.

Greenhouse gas emissions are just one of many environmental impacts that are included in environmental assessments. Other impacts that are assessed include impacts on water, soil and air quality, noise, ecosystems, nature and landscape and sometimes also social and social cultural impacts.

The nature of these various impacts is very different. Cost Benefit Analysis (CBA) is a way to express these impacts in one single unit (Euro) to be able to compare them with the investment costs.

In this chapter we give a brief overview of the current practice regarding environmental assessments and CBA of transport infrastructure and spatial plans. Next we discuss how these procedures could contribute to further GHG reductions in transport.

3.2 Existing framework and practice

3.2.1 EU Legislation

There exist two EU directives on environmental assessments (DG Environment, 2009):

- The Environmental Impact Assessment (EIA) Directive (85/337/EEC on the assessment of the effects of certain public and private projects on the environment, as amended by Directive 97/11/EC and Directive 2003/35/EC). The EIA procedure ensures that environmental consequences of projects are identified and assessed before authorisation is given. The public can give its opinion and all results are taken into account in the authorisation procedure of the project. The public is informed of the decision afterwards. The EIA Directive outlines which project categories shall be made subject to an EIA, which procedure shall be followed and the content of the assessment.
- The Strategic Environmental Assessment (SEA) Directive (2001/42/EC) on the assessment of the environmental consequences of certain plans and programmes. This Directive ensures that the impacts are identified and assessed during their preparation and before their adoption. The public and environmental authorities can give their opinion and all results are integrated and taken into account in the course of the planning procedure. After the adoption of the plan or programme the public is informed about the decision and the way in which it was made. In the case of likely transboundary significant

effects the affected Member State and its public are informed and have the possibility to make comments which are also integrated into the national decision making process.

Environmental assessments includes the following steps (DG Environment, 2009):

- an analysis of the likely effects on the environment;
- recording those effects in a report;
- undertaking a public consultation exercise on the report taking into account the comments
- the report when making the final decision and informing the public about that decision afterwards.

3.2.2 Climate impacts in EIA and SEA

In 2009, COWI published two studies, commissioned by DG Environment, evaluating the application and effectiveness of the EIA and SEA Directives. Regarding Climate impacts of transport, these studies conclude (COWI, 2009):

- In most Member States climate change issues are assessed within the framework of EIAs, usually by considering GHG emissions and sometimes energy efficiency.
- The cumulative effects on climate change of an additional project are not sufficiently considered with EIAs and particular attention should be given to this aspect at the scoping stage.
- Climate change issues in SEA are usually limited to plans and programmes which have an obvious impact on climate through increased greenhouse gas emissions.
- Impacts on climate change are rarely subject to specific requirements. One of the reasons could be the lack of proper tools and methodologies to carry out such assessments.
- There is a need for further guidance and/or assessment tools on the integration of climate change issues in EIAs and SEAs. Such guidance could focus on projects for which these issues are particularly relevant, including projects in the transport sector. The Commission should consider the development of EU level guidelines on this topic, including the definition of indicators and objectives, along with methodological guidance on impact prediction.

Also an independent NGO report produced by the European Environmental Bureau (EEB), concluded that much progress is still to be made to address climate change in SEAs. In the majority of countries climate change has not been included in SEAs, or information has not been easily available (EEB, 2005).

In cases where climate change impacts are included in EIAs or SEAs, they usually play no or just a minor role in the final assessment.

3.2.3 Carbon price in CBA

In a CBA all impacts are expressed in monetary terms by valuing the impacts. For this valuation estimates are used such as shadow prices per tonne of pollutant. For emissions, these prices can either be based on the cost related to the damage caused or the cost of reducing emissions to a certain level. Besides environmental impacts, CBAs usually also include other impacts in order to compare all cost and benefits form a project or plan.

The EU project HEATCO assessed the various approaches and values. HEATCO compared CBA-approaches in EU25 countries. Not all countries include global warming in their CBA methodology. Table 2 lists the monetization method and the CO_2 costs used in different countries. Analysis of these numbers reveals no correlation with e.g. GDP or other relevant indicators.

Table 2 Results taken from HEATCO, 2005

	Country	Monetisation Method	Road	Rail	General	Unit
North/West	Austria	Avoidance costs- based on literature	---	---	7.80	€/t
	Denmark	Official stated 'cut off' price	23.50	17.30	---	€/t
	Finland	Damage costs (all modes)	---	---	23.20	€/t
	France	Avoidance costs for reaching Kyoto targets in France	---	---	84.60	€/t
	Germany	Avoidance costs for reducing German CO_2 emissions in the year 2050 by 80% compared to 1987	---	---	194.80	€/t
	Netherlands	Avoidance costs for EU15 emission stabilisation at 1990 levels	---	---	46.30	€/t
	Sweden	Avoidance costs – transport sector specific reduction target	---	---	108.90	€/t
	Switzerland	Avoidance costs – Kyoto targets	---	---	54.20	€/t
South	Portugal	Value used in the Extension of the Lisbon Metro Assessment	---	---	35.70	€/t

Source: IMPACT(2008) , based on data from HEATCO, 2005.

HEATCO, 2005 suggests to use a range of CO_2 cost factors for the external costs assessment because of the uncertainties related to:

- The high level of uncertainty in estimating damage costs.
- The undecided debate on the appropriateness of using avoidance costs instead of damage costs.
- The variation of avoidance costs with the target set, and the uncertainty about the public acceptance of ambitious future targets.

HEATCO mentions that recent work (e.g. (Watkiss et al., 2005)) confirms the assumption that future emission years will have stronger total impacts than present emissions. Subsequently it is proposed to increase CO_2 cost factors as a function of time.

These estimates are well in line with the external cost estimates proposed by the IMPACT project (CE Delft, 2008; see also paper 7) and shown in the table below.

Table 3 Shadow prices from HEATCO, based on Watkiss et al. (2005), €2002 (factor prices) per tonne of CO2 equivalent emitted.

Year of emission	Central guidance	For sensitivity analysis	
		Lower central estimate	Upper central estimate
2000 – 2009	22	14	51
2010 – 2019	26	16	63
2020 – 2029	32	20	81

Year of emission	Central guidance	For sensitivity analysis	
		Lower central estimate	Upper central estimate
2030 – 2039	40	26	103
2040 – 2049	55	36	131
2050	83	51	166

Notes: Values are for year of emission and were derived combining damage cost and marginal abatement cost estimates. The damage cost estimates are based on declining discount rates and include equity weighting. Some major climatic system events as well as socially contingent effects are excluded. For details see Watkiss et al. (2005).

In a CBA for transport infrastructure , CO_2 emissions usually play a minor role. Infrastructure costs and the impacts on congestion, air quality and accidents are usually dominant because their cost and benefits weight much more than the climate impacts. Therefore with the existing practice, GHG reduction plays only a minor role in the assessment of projects and plans.

In the assessment of GHG impacts of transport infrastructure projects, GHG emissions over the whole lifetime should be considered, including those of extra traffic generated due to travel time savings. It appears that in many CBAs all these long term impacts on overall GHG emissions are not fully taken into account. Improving this could contribute to a higher weight of GHG emissions in CBA's and a more balanced overview of the long term cost that are associated with it.

3.3 The role of environmental assessment in further GHG reduction in transport

Environmental assessments are suitable instruments to assess the climate impacts of spatial and infrastructure projects. However, in practice climate impacts usually play no or just a very minor role in the final decision process.

In the long run, infrastructure and spatial decisions can play an important role in the trends in **transport volumes** and **modal split**. Therefore putting more weight to the impacts on GHG emissions when assessing spatial and infrastructure plans could be part of an overall GHG policy for transport.

There are various options to put more weight to GHG reduction in environmental assessments:
- Ensure that all long term impacts on GHG emissions are included in both EIAs, SEAs and CBAs.
- Apply higher shadow price for CO_2 in CBAs
- Introduce specific conditions or requirements to the overall impact on GHG emissions.

The first option was mentioned before and particularly requires clear guidelines and tools. The second and third options are discussed below.

The overall GHG reduction potential of these approaches can be quite substantial, but will only pay back at a long term. Therefore they are very relevant for a long-term GHG policy for transport. Quantification of the possible GHG reduction potential of these approaches is not possible.

3.3.1 Higher shadow price for CO_2 in CBAs

Higher shadow prices for CO_2 directly affect the way CO_2 emissions are weighted in CBAs. However, shadow prices should be based on sound economic analysis in order to reflect the true macro-economic costs and benefits of each impact. Therefore higher shadow prices for CO_2 emissions can only be justified by higher estimates for either the damage cost or the mitigation cost. There is a very high uncertainty in the potential damage cost of a ton of CO_2 and also in the mitigation cost. Many of the most extreme potential long term impacts of climate change as well as the economic cost to reach certain emission levels are very uncertain. This uncertainty is reflected in the bandwidths presented by HEATCO en IMPACT. As we saw in section 3.2.3, there is a wide range of uncertainty in CO_2 shadow prices and they also increase over time.

The precautionary principle might justify the use of the estimates at the higher end and for long term impacts long term shadow prices should be used. However, within the framework of CBA, shadow prices for CO_2 should be based on similar principles as the financial valuation of other impacts. Too high shadow prices for CO_2 carry the risk that other (environmental) impacts are undervalued compared to GHG emission reduction.

On the other hand, long term emissions should be valued against higher shadow prices. As mentioned before, in a proper assessment, all impacts on transport volumes and modal split, including those in a very long term, and the resulting future GHG should be included. When all long term emissions would be included and be valued against the higher long term shadow prices, the weight of GHG emissions will increase compared to an approach in which only short to medium impacts are included.

3.3.2 Specific conditions to the overall impact on GHG emissions

In environmental assessment additional requirements or conditions might be put on the impacts on GHG emissions. One option could be to require that an infrastructure or spatial plan should not lead to an overall increase in GHG emissions or even should contribute to a certain amount of GHG reduction. This would have a huge impact on spatial and infrastructure development and may even have the effect that most plans would be blocked.

A similar situation occurred in the Netherlands with the way the European air quality legislation was implemented at the national level. This was done in such a way that all infrastructure and spatial developments were only authorised when they did not lead to additional bottlenecks for meeting the European air quality standards. The result was that many infrastructural and spatial plans were blocked for several years.

More recently, the air quality legislation in the Netherlands was adapted in such a way that projects that are expected to result in additional emissions of pollutants around air quality bottlenecks can be authorised when, among others, the plan includes sufficient measures for reducing pollutant emissions elsewhere.

A similar approach might be considered for GHG emissions. This would mean that a constraint is put on the net impact of a project or set of projects on the overall GHG emissions with some options for compensating extra GHG emissions elsewhere. It would force policy makers to consider GHG reductions measures in every spatial or infrastructural plan.

Such a radical policy would require a very clear definition of the GHG emissions that should be included, how they should be calculated and what types of compensation measures can and can not be included.

3.4 Conclusions

Further integration and improvement of GHG impacts in Environmental assessments can have a significant impact on the GHG emissions of transport. However, these impacts will only be effective in the long term (and may last for various decades).

The challenge is to put more weight to GHG reduction in environmental assessments. The policies for doing this are:

- Ensure that all (very) long term impacts on GHG emissions are included in both EIAs, SEAs and CBAs.
- Apply higher shadow price for the long term emissions CO_2 in CBA's, in order to better reflect the risks for possible long term dramatic changes.
- Introduce specific conditions or requirements to the overall impact on GHG emissions.

4 GHG emission reduction in urban planning and infrastructure development

4.1 Introduction

In this chapter the different policy-oriented options relating to urban planning and infrastructure development are discussed. There is a strong connection between these options in the process of policy making. All options together can result in a reduction of the GHG impact, which is necessary to reach a sustainable city in 2050. This chapter will discuss policy instruments in the following fields:

- urban planning;
- investments in public transport;
- investments in cycling and walking infrastructure;
- parking policy;
- policy for advanced distribution concepts.

4.2 Urban Planning

In the previous century the improvement of the transport system made it possible to travel larger distances in the same amount of time. People wanting to live in larger houses moved away from the city centres. This can be seen especially in the United States, but also in Europe. In cities like London and New York, the construction of the subway gave people the opportunity to live in suburbs and travel to work in 'The City' or Manhattan. Some decades later the, the higher ownership and use of the passenger car and the construction of highways increased the commuting distance, leading to the strong urban sprawl currently seen in American cities. In Europe, the more historical structure of cities led to less sprawl, but here the commuting distances have continuously increased over the last decades as well.

In the context of the aim to reduce GHG emissions from transport, it would thus seem to be desirable to counter sprawl, introduce other measures to reduce the distances travelled in cities and/or influence the mode choice towards more environmentally friendly modes. Within cities, a certain amount of traffic is always needed to let the city function, since people and goods need to travel to functions and activities. But urban planning can contribute to decreasing the distance between the functions, with the aim to reduce the number of kilometers driven within the urban area. A planning concept, developed for this purpose, is the compact city: an intensive use of the available space within the city. The city has a high density of residential areas and new houses and offices are preferably built inside the city (on redeveloped land) and not as extensions to the city (causing urban sprawl). Some experts expect that a reduction in GHG emissions of approximately 5% can be achieved by making cities more compact. However, we found no (written) evidence to corroborate this. It seems clear that spatial characteristics influence the amount of CO2 emitted by residents. Goudappel (2009) shows that in The Netherlands urbanised regions have lower CO2 emissions per resident than rural areas, and that there are substantial differences between similar sized cities (in terms of number of inhabitants), which can be explained by the structure of the city and the facilities and functions it offers.

More sources report the expectation that creating more compact cities can reduce GHG emissions. Bart (2009) shows that sprawl occurs in the EU in close relation with a strong increase of transport-related CO2 emissions. Sprawl (an increase of the area covered by buildings and roads) is a stronger cause of increased transport emissions than other possible causes.
Several other sources indicate that substantial differences in GHG emissions exist between cities with low and high levels of density (see, e.g. [Grazi, 2008]). Given these differences, looking forward to 2050, it seems attractive to stimulate compact cities. However, the city of 2050 already exists for a large part - already constructed areas remain for long periods the same [PBL, 2007] - which limits the effects of high density building. Ruth and Rong (2006, pp 29) point out that the

fact that urban forms explain part of the variations in transport intensity of cities, does not mean that policies can be devised that create positive effects at a system level, due to distribution and rebound effects. As also supported by Maat (2009), cause-effect relationships appear to be difficult to establish because of (unobserved and unmodelled) correlations between segmentation and behavioural variables.

Therefore, the big question, whether spatial planning can really be expected to make cities more compact or reduce the number of kilometres driven, remains difficult to answer. Dutch spatial planning is often seen as a successful example of restrictive planning. For instance, in the Netherlands building activities were to be concentrated in and near central cities – the so-called VINEX locations [VROM, 1990].This policy was followed in the development of new housing estates, as well as in the planning of building activities for businesses – the ABC policy (see box). The goal of this policy instrument was to reduce the car use. This policy instrument was popular in the 1990s, but since then there has been a change towards more pro-active planning – instead of dictating what is not allowed, it is now stimulated what is desirable. In other parts of Europe, cities developed similar policies; a project like TRANSPLUS gives some interesting good practice examples [see www.transplus.net].

The ABC policy [Eijkelenbergh & Martens, 2003]
The core element of the ABC location policy for companies is the classification of types of locations and types of companies. Companies are graded according to access needs and modal shift potential (mobility profile) while locations are graded according to their accessibility by public and private transport (accessibility profile). The accessibility profiles are graded A, B or C. A-locations are highly accessible by Public Transport. Examples of A-locations are major Public Transport nodes such as central stations in the larger urban areas. B-locations are reasonably accessible both by Public Transport and by car while C-locations are defined as typical car-oriented locations. Examples can be found near motorway exits in fringe areas having poor Public Transport access. R(est)-locations have bad access to both the road system and the public transport system.

Both the ABC and the VINEX policies were unsuccessful in reducing average commuting distances or car use (Dieleman & Musterd, 1999). The basic reason for this was that travelling by car continued to get cheaper and faster (because of improvements in the road network). People chose to maintain their spatial footprints to a large extent, optimizing their economic opportunities and spending the same amount of time on average daily travel as before. Therefore, despite targeted urban densification policies, average trip distances in The Netherlands have maintained their rate of growth, and public transport shares both within as well as to and from urban areas have not improved substantially. Perhaps larger improvements can be expected in urban areas with lower densities such as in the US (see Maat, 2009).

If it is assumed that spatial planning can have an impact, it is expected that urban planning policy instruments will show the largest effect in countries where strict planning regulations do not yet exist. National authorities or the EU should take the initiative to introduce this kind of regulation in their legislation. Land value taxation is a measure that might ensure higher densities while letting the market decide without regulation.

There are links with other policy areas. Changing functions of areas in cities offers possibilities for building high density urban areas. Policy makers can regulate building densities and can stimulate multi-level buildings for offices and commercial areas. There is a link with public transport and cycling and walking policies, in that compact cities are attractive places to invest in high quality public transport and walking and cycling facilities. Also, in compact cities road capacity is generally limited which means that car transport is slow. Parking spaces are also limited in compact cities due to a lack of space. This creates possibilities for car sharing initiatives.

The price of real estate can be a barrier, in two ways. Developing high density urban areas can be very expensive. Also, many people in large cities live far away from the city centre because the prices of real estate in the centre are too high for them.

All the above policies are supply oriented, i.e. focusing on facilities, as opposed to demand oriented, i.e. focusing on human behaviour and household decision making. The impact of changes in housing supply, parking charges, public transport networks and infrastructure all depend on the degree to which the consumers respond to this and actually change their behaviour. As long as this behavioural change is not stimulated in more direct ways (e.g. pricing or speed moderation), spatial planning policy seems to fall in the category "modest impact, low feasibility".

4.3 Investments in public transport

Public Transport in urban areas is generally more environmentally friendly (depending on the occupancy rate) than car use because the GHG emissions per travelled kilometre per passenger are lower. Electric transport, like trains, light-rail or trolley buses, has no local GHG emissions, but the electricity generation may cause GHG emissions elsewhere. Busses can use alternative fuels to reduce the GHG emissions. For the further future, personal rapid transport can be an option.

Public transport will reduce the GHG emissions only if people shift from their car towards public transport and when no new car users will use the road space that has become available. This is a serious barrier; in practice it proves very hard to reduce the number of car movements just by improving public transport. People will use public transport when it is a good option compared to other modes of transport. In most urban areas, the speed of public transport is low compared with that of cars. Congestion in the road network may increase the competitiveness of public transport. Other ways to make public transport more competitive are:

- increasing the frequency of the services to reduce the waiting time;
- reducing travel times by the construction of dedicated infrastructure.

These investments have the most effect when they are made in combination with measures that reduce the attractiveness of cars like urban charging systems. Otherwise the induced transport effect is often large. In congested city centres, public transport can compete with cars. In general, however, the car is the preferred mode of transport for many people (not just for reasons of travel time). Public transport is therefore not expected to lead to a reduction of car movements in city centres if it is not combined with other policy instruments like a pricing policy for car transport, congestion charging or paid parking. Solitary investments in new infrastructure for public transport will mainly lead to an improvement of the accessibility of a city (which can be an objective in its own right). To illustrate this, consider that metro systems all over the world are heavily used, but the cities that have them still have large numbers of cars on the road.
Dedicated infrastructure for public transport is needed to ensure an acceptable speed of the trams or buses. The limited space in city centres can be a problem for providing this dedicated infrastructure. Therefore road lanes need to be transformed in bus lanes or trams ways.

Examples of cities that invested in (improved) public transport can be found all over Europe. Some well known recent examples can be found in France, where a number of light-rail projects in large and medium sized cities were carried out.
It generally takes a number of years to from the first ideas of investments in public transport to realizing the project. A barrier can be shortage of resources.
Also, public transport currently has low shares in the total number of trips and kilometres travelled. Expanding public transport to an extent that a significant reduction in the number of car kilometres can be seen requires enormous investments. The introduction of the VAL metro system and other public transport improvements in Toulouse show that it is possible to reduce car kilometres by investing in public transport, but the investments were very high (see e.g. [Ramella, 2001] and [Boufa, 2007]).

The above mentioned compact cities are the best environment for public transport systems to run break-even. Cities with high building densities have many potential customers within the catchment areas of public transport stops. This can make public transport more profitable.
When it is possible to reduce the number of cars, co–benefits are an improvement of the air quality and noise pollution as well as energy consumption will be reached.

The construction of new public transport can be stimulated or funded by Europe or national governments. However, it has to be considered that in order to reduce car use significantly, public transport patronage has to increase substantially (as it has a small share in the number of trips and kilometres travelled compare to the car) and road space becoming available as a result may induce traffic.

4.4 Investments in cycling and walking infrastructure

Cycling and walking are the two modes of transport with the lowest GHG emissions (although this depends on the GHG intensity of the food consumed). Supporting these modes seems to be a good option for reducing GHG emissions.

There are several conditions that have to be fulfilled (at least to some extent) to make cycling (and walking) a popular mode of transport. Facilities have to be good (separate bicycle lanes, attractive walking routes, bicycle parking facilities, showers at offices, etc.). Cyclists and pedestrians do not cover very large distances because they are relatively slow, so compact cities help make these modes attractive. For cycling, the terrain should not be too hilly and unfavourable weather conditions may prevent people from cycling.

With investments, a more attractive infrastructure for walking and cycling can be created. Pavements and cycling lanes will make walking and cycling trips safer and direct routes can make travels very competitive when compared to car travel times. Sustainable spatial and transport planning processes need to take the provision and improvement of these infrastructures into account, for new developments as well as for existing urban areas. Where there is little space for new or improved cycling and walking infrastructure, the closure of a lane for motorised traffic can be considered.
It is also possible to give priority to cycling and walking instead of motorised modes of traffic when these different modes cross each other. The English city of York made a policy decision to give pedestrians priority in the city.

Investments in cycling infrastructure is seen as a policy instrument that can be deployed widely and can lead to a reduction of short car trips. Planning and construction of new or improved infrastructure can cost several years. The highest benefits can be expected when a network of bicycle lanes is constructed. The construction of bicycle lanes is a task of local governments but it can be stimulated and/or funded by Europe or national governments. Also, campaigns to raise the awareness of the benefits to society and to individual citizens of walking and cycling can be organised.
A potential barrier is that the space needed for walking and cycling infrastructure is limited – or perceived to be limited; many bicycles and pedestrians fit in the space used by one car. Another possible barrier is the car drivers lobby.

The investment costs can be relatively low (for instance, if only repainting of the road surface is needed). In general, however, adding bicycle lanes and pavements for pedestrians is cheaper than building new roads for motorized traffic.

An extra positive aspect of this measure is that travelling by car becomes less attractive due to the smaller amount of car infrastructure available.
Health benefits due to the physical activity of cycling and walking are important benefits. The health benefits can be further improved when it is possible to reduce the number of cars. An improvement of the air quality and noise pollution as well as energy consumption can then be reached. Also, an improvement of the liveability of the city can be expected when investing in cycle and walking infrastructure.
Another co-benefit is that when having more people on the street will lead to social benefits as greater social interaction between people [ref john Adams].

An option to make cycling attractive for longer distances, in hilly terrain or for elderly and frail people, is the introduction of electric bicycles. There are bikes that assist the cyclist, who still has to pedal, and there are bicycles that completely take over from the cyclists during part of the trip. Dutch research showed that E-bikes allow commuters to use a bike for commuting over a larger distance (one and a half times more) than traditional bikes [TNO, 2008].
This can be a convenient opportunity for car drivers who do not want to use a conventional bike. The higher costs of electric bikes is at the moment the main barrier for a large-scale use but the purchase price will decrease, and sales of electric bikes are soaring in e.g. The Netherlands and Belgium.

4.5 Parking policy

The attractiveness of using a car depends on the travel time and the costs involved. Both these aspects can be influenced by parking policy. In most large cities you now need to pay for parking. When the price of parking facilities is high, people will consider alternative modes of transport for going to the city centre (or a different destination). Drivers will search for the cheapest parking location, so prices in an area should be kept the same, and boundaries of areas with different parking tariffs should be carefully chosen. Parking fees are further discussed in paper 7.

Another option to influence the mode choice of people in cities is to reduce the number of parking spaces in city centres. This will encourage people to not use cars for trips with this destination. However, alternatives to the car should be offered to ensure that visitors will not stay away, e.g. public transport or cycling facilities. A shortage of parking licenses (for residents) in the city centre can help to tempt residents to get rid of their car or to share one. All parking measures should be accompanied with (strict) enforcement. In addition, rules for the number of parking spaces in or near office buildings can help to discourage driving to these buildings.
A risk is that because a lack of parking spaces, people or companies might move out the city. This can result in more GHG emission because of the larger travelling distances.

The city of Amsterdam is an example of a town with an ambitious pricing policy for parking. The whole area inside the A10 motorway ring around the city (and a few areas outside the ring road) has paid parking and the closer you get to the city centre, the higher the parking tariff is (up to 5 euros per hour, see http://www.stadstoezicht.amsterdam.nl/parkeren/betaald_parkeren_in).

Another aspect of the parking policy can be the construction of park and ride facilities at the border of the cities. Visitors of the city can transfer here to public transport to avoid parking problems in the city centre. This measure can be implemented at the same time as the measures described above.

Looking to the future, parking policies can be further refined and intensified, and the paid parking area can be enlarged. The height of the tariffs can also be based on the emission level of the vehicle. Some cities have already implemented this (e.g. the city of Graz, see http://www.trendsetter-europe.org/index.php?ID=2551) (for a further discussion, see paper 7).

Low user acceptance of high parking fees and the reduction of the amount of parking place can be a barrier for introduction of paid parking or the increase of fees.
This policy instrument should be used by local authorities. It can be introduced at any time and results can be expected soon after introduction. Parking guidance systems (see paper 5) can enhance the effects.

4.6 Policy for advanced distribution concepts

Freight transport in cities is problematic in several ways (e.g. liveability, safety). The current way the logistical chain is organized generally results in a high number of trips to cities for delivering to stores. Transport costs are a minor category of costs and therefore transport firms are not inclined to reduce the number of trips or bundle goods into fewer trips. The popular just-in-time principle also results in extra trips.

Current legislation for the distribution of goods, for example time windows and vehicle restrictions, can lead to more GHG emissions because more trips are needed. There are several advanced distribution concepts that can help reduce GHG emissions. A number of them have been described in the EU project BESTUFS (bestufs.net). An example is urban consolidation centres, which are located at the border of the city and where goods are collected to bundle the transport into the city, are in theory a good solution to reduce the negative impacts of urban distribution. The extra costs for of the transhipment for the carriers at this urban consolidation centre, however, reduced the popularity of the centres. The use of an urban consolidation centre gives the possibility to use electric because in most cases only small distances need to be travelled. At the moment cities might be at a tipping point (congestion, delivery windows) making consolidation centres more feasible and effective.

In the Netherlands a new concept of an urban consolidation centre started recently, called Binnenstadservice ('Inner-city service'). Its mission is to reduce the negative environmental impacts of city logistics. It differs from initiatives in the past, as it focuses on receivers rather than carriers. The receivers, the stores in the city centre, change their address to the address of the urban consolidation centre. The transport savings are shared between the stores and the consolidation centre. The transport to the city centre by Binnenstadservice is done by low emission vehicles, e.g. using CNG or electric trucks and freight bicycles. After one year a 5% decrease in the number truck-kilometres and the truck-travel time in the Nijmegen city centre was reached (van Rooijen & Quak, 2009). New elements can be added to this concept in the near future, like revenue management principles to include dynamic price setting for the delivery of goods. Also, the pricing of entering the city for trucks and introduction of physical barriers for large trucks can strengthen the position of the consolidation centre. The concept is especially attractive for cities with a historic city centre far away from highways.

The case of this new distribution concept is an example of a wider trend which might hold a promise for the longer term at a wider scale as well: collaborative logistics planning. As companies are increasingly searching for economies of scale in transportation, they will be inclined more and more to co-operate by joining shipments. This will create new collective infrastructures increasing the degree of loading of vehicles (Tavasszy et al, 2003). Small initiatives have the possibility to grow once a certain mass is gained, transaction costs become acceptable and benefits can be shared (see Groothedde, 2006). Pricing of empty trips can stimulate this evolution.

4.7 Conclusions

The policy instruments described in this chapter can help to reduce GHG emissions. But these instruments need to be combined with other measures, like pricing policies, otherwise the reduction is expected to be limited. Exact numbers on GHG reduction potential are hard to give because most of these instruments were not specifically applied with the goal to reduce GHG emissions. Therefore the reduction potential has not been widely investigated.

We expect that due to the measures and policies described in this chapter the liveability of cities will improve. Investments in transport infrastructure improve accessibility. Effects on reductions of GHG emissions are more limited (and sometimes negative when complementary measures are not deployed) because of second order effects due to latent traffic demand – more or longer trips are made in total because people use the free road space that has been created by the modal shift from other car users to public transport, cycling or walking, if no policies to prevent that are implemented.

5 GHG emission reduction in spatial and infrastructure development outside urban areas

5.1 Introduction

Outside the urban areas most transport GHG emissions are from cars and trucks (for the shorter distances) and by airplanes and trucks (for the longer distances). The main options for a reduction of GHG emissions are to prevent trips or to accomplish a shift from high-carbon kilometres towards lower-carbon kilometers for transport.
In this chapter we discuss several investments in modes with lower GHG emissions, to promote a mode shift.
The main shifts regarded in this chapter are:

- Short haul air to rail;
- Long distance road transport to waterways;
- Long distance road transport to rail and waterways.

It has to be noted that in paper 5 of this paper series, "*EU Transport GHG: Routes to 2050*?" the authors stated that there are no reliable estimates available for the overall reduction potential of modal shift. Preliminary indicative estimates for the potential of modal shift for passenger transport range from 2 to 14%. For freight transport the estimates range from 4% to 23%, with most of the estimates being at the lower end. Any potential of modal shift can only be achieved with a very strong modal shift policy. The GHG emission reduction effects of the policies discussed in this chapter therefore seem to be limited. Also, there is a risk that by investing in new, additional infrastructure people will make extra trips or that they will make longer trips and that in the end emissions increase. Also, the construction of new infrastructure leads to GHG emissions.
The provision of new transport possibilities and/or infrastructure alone cannot be expected to lead to a GHG reduction. This should be part of a larger set of policy instruments like emission legislation of vehicles, pricing policy (based on emitted externalities) or speed policy.

5.2 Investments in long distance and high speed rail infrastructure

Rail infrastructure is a relatively clean mode of transport, in urban areas but also on inter-urban links, especially if renewable energy sources are used to power the trains. To increase the attractiveness of long-distance rail transport, high-speed sections across Europe have been realized and also rail sections for mainly freight transport have been improved in the last decades.

It was hoped that high speed train travel will be an alternative to short-haul flights (300-600km). High speed train travel emits less than air travel (though much more than conventional, slower, trains), so this could help reduce emissions. A shift from aviation to high speed rail was visible, for instance, when the first high speed rail section was opened between Paris and Lyon. High speed trains are, however, not only used to replace air travel. If people use high speed trains because this allows them to travel a longer distance in the same travel time or that they travel more often on a certain section due to the shorter travel time, this could have a negative effect on GHG emissions.

Improvement of the rail sector can be done in several ways. To reduce the transport emissions, investments in rail electrification should be made in order to increase the share of rail transport powered by electricity. Even if electricity is produced from fossil fuels, this reduces GHG emissions compared with diesel haulage.

At the moment many high speed rail connections are constructed in Europe. The construction of rail infrastructure can take many years (depending on policy process and legislation of the country or countries involved). To have a complete network of (high speed) railways throughout Europe in 2050, the planning process for missing links should start far in advance of 2050. For environmental reasons, it would be best to focus on connections between densely populated areas that are not too far apart, but not close enough to each other (to encourage commuting by high speed train, for instance), and to consider possible secondary effects like induced traffic.
A maximum amount of money reimbursed by companies for commuting costs per person can be an option to reduce long distance commuting.

A significant barrier is the high cost of the construction of (high speed) railways. Also, protest from environmental organizations and concerned citizens (because of noise annoyance) can be a barrier for realization of the infrastructure.

5.3 Investments in waterway infrastructure and ports

Waterway transport is a transport mode mainly used for freight transport on the longer distances. It is a slow but relatively reliable mode. It is particularly attractive when transporting large volumes. An example of current investments in waterways to create a mode shift from road to waterways is the new canal that will be constructed in the north of France to connect Paris with the ports of Antwerp and Rotterdam.

A small niche in waterway transport is the transport of passengers in urban areas, to reduce congestion on the roads.

The construction of waterway infrastructure (including locks and port facilities) can take many years (depending on the country). To have a complete network of canals throughout Europe in 2050, the planning process for missing links should start far in advance of 2050. A barrier is the high cost of the construction of waterway infrastructure and ports. Also opposition from environmental organisations concerned about other environmental impacts of the project can be a barrier for realisation of new infrastructure.

5.4 Investments in intermodal connections for freight transport

Improvements of the intermodal connections can help to reduce the GHG emissions of transport, enabling low emissions modes to be used for part of a trip, for example waterways or rail transport. Other parts of the trip are usually done by trucks, as many destination cannot be reached by ship or train. Locations for the transhipment of the goods are needed to change modality. Container transport is especially suited to intermodal transport. A disadvantage of intermodal transport is the costs for the transhipment (in money and time).
There are a number of examples in Europe of intermodal transport. On some transalpine routes, transport has to use the train when they cross the Alps. The trucks are loaded onto the train and brought to the other side of the Alps.
Also, in The Netherlands, containers that arrive in the port of Rotterdam are brought by train to terminals in the hinterland and finally loaded onto trucks to reach their final destination.
Intermodal infrastructure can be realized throughout the whole of Europe. A barrier can be the lack of use of it because of the extra costs of transhipments, although this plays no role if no alternative is available or the alternative is costly as well (e.g. when crossing the Alps).

5.5 Conclusions

Investments in the 'greener' modes as discussed in this chapter can lead to better developed and more efficient transport networks. As said in the introduction of this chapter, provision of new transport possibilities and/or infrastructure alone cannot be expected to lead to a GHG emission reduction. They will lead to a better accessibility of the facilities and improve the reliability of the network, leading in many cases to more transport movements. Therefore, these investments should be part of a larger set of policy instruments like legislation regarding vehicle emissions or pricing policy (based on emitted externalities).

6 Traffic management policy and speed limits

6.1 Introduction

Traffic management policy can be deployed to minimize fuel consumption and GHG emissions. Its main aims should then be to reduce the number of kilometres driven (e.g. through better route planning and reduction of congestion on fuel-efficient routes), to favour environmentally friendly transport modes and to enable vehicles to operate at favourable speeds and to keep a constant speed.

Deploying traffic management measures to minimize fuel consumption and GHG emissions is a recent field of research. See also Paper 5 (Intelligent Transport Systems) for a discussion on developments in this area.

It should be noted that successful traffic management measures can increase the capacity of roads and thus the attractiveness of (certain routes in) the transport network, which can result in extra kilometres driven. This kind of side-effects is an uncertainty that should always be considered when developing traffic management measures.

6.2 Policy for advanced traffic management for road transport, prioritizing low-carbon means of transport

The majority of road authorities managing busy urban and/or interurban road networks have traffic management plans in place, and environmental objectives are often already part of these plans. The reduction potential of the measures is usually not quantified and most estimates of effects on GHG emissions available are for specific situations or are very rough. However, it is expected that in the coming years more research into the emission effects will be carried out, including empirical results from measures being implemented now. Future traffic management plans can therefore be based on more solid effect estimates.

As discussed in Paper 5 (chapter on Intelligent Transport Systems), traffic management will move from isolated measures to coordinated deployment of measures in a network (and finally will be made cooperative, i.e. including vehicle-vehicle and vehicle-infrastructure communication). The aim will be to be able to manage traffic under all possible circumstances (i.e. also during events, accidents, calamities, extreme weather conditions etc.). If the sense of urgency is high enough, GHG reduction targets could help shape future traffic management, for instance by regulating and restricting traffic more than is currently done. A balance between environmental goals and economic and safety objectives needs to be established.

There is a clear link with infrastructure planning, as the available infrastructure dictates how much can be achieved by traffic management measures. Robust road networks are therefore needed [Snelder, 2009] which prevent incidents from restricting network performance. Note that the expectation is that these investments in robustness do not lead to induced traffic in the same way as will the extension of infrastructure for everyday circumstances -- people will not form their habits on small probability, higher impact incidents. As these network level measures typically go beyond administrative boundaries, road authorities and other stakeholders (e.g. police) from different jurisdictions need to work together. Organisational as well as financial issues can be a barrier to implementation. Also, there is a need to develop management and control strategies that explicitly include environmental objectives.

Traffic management measures that are currently commonly considered for reduction of emissions are:

- Optimisation of traffic flows in cities (route choice and traffic control optimization, ramp metering)
- Measures to reduce congestion on main roads (e.g. travel time information, route advice, incident management)
- (Dynamic) access restrictions for high emitting vehicles, e.g. environmental or green zones
- Speed management by deploying dynamic speed limits (see par. 6.3 for a discussion of lower speed limits at all times)

Measures to reduce congestion have very little effect on overall GHG emission levels (because the share of kilometres driven under congested conditions is, although rising, still low; see e.g. [Wilmink, 2001]) and often result in more traffic. Such measures should therefore not be taken for environmental reasons only, unless the measure affects overall demand (e.g. through a congestion charge or kilometre dependent charges) so that congestion is reduced without an increase in the number of kilometres travelled.

The measures mentioned above could be taken in parallel to the regulation of GHG emission of public transport, or of urban areas. These type of policies are described in paper 6.

In order to reduce GHG emissions, traffic management measures can be designed to favour low-emission modes. For instance, traffic control systems (e.g. traffic lights at intersections) can give priority to public transport or slow traffic (walking, cycling). Low emission vehicles can be made exempt from charges or restrictions. In other cases, traffic management measures can be made more environmentally friendly by rethinking other objectives such as minimization of travel times.

Technically, much is possible, but the effects in terms of travel times and accessibility can be substantial, affecting people and businesses. Low acceptance of such measures is therefore a barrier. Other barriers are the lack of expertise on emission effects of traffic management measures and suitable models to analyse different options and explore the trade-off between environmental and other objectives (economic, safety). Costs can be a barrier, as expensive equipment may be needed (traffic lights, variable message signs, gantries over the road, etc.) and software costs (for programming the control strategies) can be substantial. Compared to building new infrastructure, however, traffic management is often considered to be a cheap option (to alleviate bottlenecks).

Traffic management measures are generally taken at the regional or local level. As many regions face the same problems, EU-funded research and development could help to make transparent the potential of traffic management to reduce GHG emissions (rather than improve throughput), and the impacts this would have on the transport system (mainly in terms of accessibility; traffic safety would most likely benefit from traffic management measures aimed at reducing emissions).

6.3 Lower speed limits for road transport

Speed limits have been introduced for various reasons, fuel consumption and emissions being one of them, although traffic safety is usually the main driver. However, several studies have been carried out to estimate the effect of a speed limit reduction on GHG emissions. These studies (e.g., [Vanhove, 2009][Ministère de l'écologie et du développement, 2004][Gohlisch, 1999][Wilmink, 2002]) mainly look at motorway passenger car traffic, where effects of reducing the speed limit to 100 km/h are reported in the order of 7-15% for motorway traffic, depending on the initial speed limit (120, 130 or no speed limit). Taking into account the share of motorway traffic in the kilometres driven (which can vary substantially from country to country; motorway shares are rising), the effects are less pronounced on the national level, resulting in reductions of 2-3% at most. Speed changes might become less important when technology develops.

Speed limits for heavy goods vehicles should be analysed separately. [Vlieger, 2005] reports substantial reductions in CO_2 emissions if truck speed limits are lowered to 80 km/h (based on tests with a small number of trucks).

For other road types than motorways, it is more difficult to assess the effect of lower speed limits. Vehicles are at the moment the most fuel efficient at speeds of around 80 km/h but this may change in future. So lowering a speed limit from 80 to 60 km/h or 50 to 30 km/h could potentially increase emissions, unless traffic flows are smoothed, i.e. vehicles drive at more constant speeds, or with fewer stops. In The Netherlands, the effects on CO2 emission of the “Drive slow go fast” concept, which involves (re)designing roads and their environment in such a way that cars cannot overtake anymore and forces cars to drive at a lower but more even speed, were calculated to be up to 26% [Beek, 2007].

Lowering the speed limit has important co-benefits in terms of traffic safety, if indeed the speed of traffic is reduced (see e.g. [Vanhove, 2009]). Other co-benefits include local air quality improvements and reduced noise annoyance. On several motorways in Europe, speed limits have been reduced (to 100, 90 or 80 km/h) for environmental reasons (e.g. around several cities in The Netherlands, Germany, Austria, Spain).

On the other hand, in several places there are discussions about (locally) increasing the speed limit. In Austria there were discussions about a speed limit of 160 on some stretches (but also reduced speed limits when air quality reaches critical levels); in The Netherlands there are trials with dynamic speed limits that include a test with a raised speed limit (during periods with low traffic volumes) and tests with reduced speed limits (of which one for air quality reasons) [Stoelhorst & Schreuder, 2009].

These plans to raise the speed limit stem from the innate desire to travel as far as possible within a certain time budget (more destinations can be reached if higher travel speeds are possible). On the other hand, lowering the speed limit leads to travel time increases that have effects for individual travellers and businesses (which contradicts many current economic/accessibility objectives). This explains why lowering the speed limit encounters resistance. Technically speaking, lowering the speed limit is a simple and not very expensive measure, but it needs to be accompanied by other measures (extensive enforcement, for instance) to achieve the full benefit possible. Also, if travel times are increased due to lower speed limits, the measure may result in a negative benefit-cost ratio.

Speed limits that have no obvious reason to drivers are often exceeded. Enforcement is one important instrument (it is expensive, but can be paid out of the revenues) and there are in-car systems such as speed limiters or SpeedAlert/ISA systems. Speed limit enforcement has been shown to be effective [Ministère de l’écologie et du développement, 2004]; however, requires substantial efforts if the aim is to have an effect everywhere and at any time. Speed limiter systems will only be implemented if there is legislation forcing vehicle owners to install and use them. SpeedAlert/ISA systems can have substantial effects, but this depends strongly on the type of system installed. Several sources expect a (small) reduction of CO2 emissions for mandatory systems (i.e. the prevailing speed limit cannot be exceeded). For instance, [Carsten, 2008] gives a reduction of CO2 emissions of 5.8% on 70 MPH roads, with small, variable changes on other road types. [CERTU, 2008] reports moderate effects on GHG emissions of a speed limiter.

If the ISA system is advisory, the effects are much smaller because drivers do not always follow the advice. In either case, the effect also depends on the number of drivers choosing to install and use the system. An estimate of the fleet penetration rate of SpeedAlert systems in 2020 as given by the eIMPACT project [Wilmink, 2004] is 25-39% for passenger cars, and 31-46% for goods vehicles. Still, user acceptance is a very important barrier in this respect; it is not expected that the more effective mandatory systems will reach substantial penetration rates without (EU) regulation. Also, it requires that it is organised that many or all vehicles are equipped with the system. Technically, there are few barriers, the main one that digital maps with speed limits need to be available. Some national governments encourage this. It requires substantial efforts to update the database whenever limits change. Speed limit information would also be part of eco-driving assistance systems (see paper 5).

If speed limits were to be lowered, or at least capped, throughout Europe, there are several added benefits:

- if travel speeds decrease, and time budget theory holds true, people would travel less kilometers;
- the design of vehicle engines could also be adapted (leading to reduced GHG emissions), because the power output of cars can be reduced as there are would be no roads on which high speeds are allowed.

Overall we can conclude that lower speed limits could contribute to a significant reduction of GHG emissions (with added benefits regarding air quality, noise and energy security), but generally face public resistance.

6.4 Traffic management and speed policy for non-road transport modes

Air traffic
Air traffic management (ATM) systems can be improved to reduce fuel consumption and emissions. Modernization of the air traffic management system could lead to the use of more direct tracks, allowing substantial savings in fuel. Improvement of ATM also has the potential to relieve congestion in high density traffic areas. Several sources show that for current (i.e., 1998-99), worldwide aircraft fleet operations, improvements to the ATM system alone could reduce fuel burn per trip by 6-12% [Penner et al., 2000]. If relieving congestion does not lead to more flights, there is a positive effect on GHG emissions.

In Europe, the SESAR programme (the European Air Traffic Management (EATM) modernisation programme) combines technological, economic and regulatory aspects and will use the Single European Sky (SES) legislation to synchronise the plans and actions of the different stakeholders and bring together resources for the development and implementation of the required improvements throughout Europe, in both airborne and ground systems. The SESAR Definition Phase (2006-2008) produced the initial version of the European ATM Master Plan, which was endorsed by the EU Transport Council on 30 March 2009 [The European Air Traffic Management Master Plan Portal]. One of the targets of the programme is to minimise the impact aviation has on the environment [SESAR, 2006].

In addition to the use of shorter routes, optimizing the aircraft cruise speed is another way to minimize emissions. The optimum speeds varies between different types of aircraft. Airlines already routinely optimise cruise speed and it is expected that further reduction of fuel use by further speed optimization will be small.

Establishing a speed limit for aircraft may have impact on the longer term, as aircraft will then be designed for these lower speeds, and fuel consumption will be reduced. However, the existing fleet has been designed to achieve optimal fuel efficiency at certain cruising speed. Reducing the speed of these aircraft would not lead to improved fuel efficiency. Speed limits may then lead to impacts on the competitive position of airlines with old and newer aircraft. However, as speed limits in aviation have not been assessed yet in any detail, it might be an option for further study.

Other ways to optimize aircraft performance are to increase the load factor of aircraft, and to reduce the weight of aircraft, e.g. by reducing the number of occasions that extra fuel is carried (‘tankering’). More efficient airport capacity management could contribute to that [Penner et al., 2000].

Ships
As for air traffic, optimization of routes, better fleet planning and optimization of speed may help reduce emissions. Substantial reductions ([Marintek, 2005], e.g., reports reductions of up to 40%) can be achieved if such measures can be implemented.
River Information Systems have been implemented to manage traffic on waterways, its main aims being to enhance safety, reliability and efficiency (see, e.g. the EU directive on River Information

systems [Directive 2005/44/EC of the European Parliament, 2005]). It seems that it is not yet common to include environmental objectives.

Speed limits for shipping may have a strong impact on GHG emissions, as fuel consumption increases with (almost) the third power of the vessel's speed. Reducing the speed by 10% may then reduce fuel consumption by 27%. However, the economical impact of reduced speed is quite significant in this sector, so that the potential benefits should be weighed against the potential cost. Lower speeds may mean more ships are needed. In the current situation, the optimal speed is determined by an economical assessment, where the oil price play quite a significant role, indicating that the market functions properly. Increasing the fuel cost, for example by internalizing the cost of the CO_2 emissions, may then be a preferable option, compared to speed limits.

(High Speed) Trains
If high speed trains would travel at lower speeds (making the system less attractive to travellers), GHG emissions might be reduced. No sources were found to confirm this. If electricity generation is decarbonised, there would be no direct need to reduce train speeds from a GHG perspective – unless the additional electricity could better be used elsewhere.

The European Rail Traffic Management System (ERTMS) is designed to increase capacity but, by reducing the need to decelerate and accelerate trains, it also reduces CO2 emissions.

6.5 Conclusions

Substantial reductions in GHG emissions can be achieved by traffic management and speed management (by lowering speed limits or otherwise). The technology is available but there are significant barriers, most importantly the economic consequences of longer travel times and the user acceptance and compliance with speed limits. Costs of implementation are low to moderate. Most of the measures discussed have (significant) safety benefits as well as air quality, safety and energy security benefits, and reduced noise, which should make the cost-benefit ratio for many measures positive.

As user acceptance is such an important issue, (EU) regulation may be needed or at least sufficient and transparent communication with the people affected by these policies. Without regulation, increasing the use of speed limiters or ISA systems, enforcement on a large scale would be needed. High fuel prices or higher shadow costs for GHG emissions (likely in view of the longer term damage cost risk) may provide a strong incentive to increase the willingness for these type of measures.

7 Conclusion

There is clearly a strong relationship between infrastructure, spatial planning and transport speed on the one hand, and transport demand and modal split on the other hand. However, drivers for these policies are typically economical and social aims, rather than environmental: improving accessibility of regions and areas can have a significant economical impact on these regions. As improving accessibility means reducing travel times to and from the area, this automatically leads to an increase in transport demand. Depending on the exact impact, and on the mode for which accessibility is improved, this will affect GHG emissions of transport.

Typically, policies that aim to improve infrastructure will cause an increase in GHG emissions, as transport demand increases. In the longer term, these improvements may result in changes to spatial planning that rely on the increased accessibility, resulting in further transport demand increases: people will accept longer commuting distances (as travel times are reduced), they may choose to go shopping at a shopping centres further away, causing shops in their neighbourhood to close down, etc.

In infrastructure and spatial planning processes, various instruments are used to assess the environmental implications of decisions, namely Environmental Impact Assessments (EIA) and Strategic Environmental Assessments (SEA). However, it is concluded that further integration and improvement of GHG impacts in these environmental assessments is needed, and can have a significant impact on the GHG emissions of transport. These improvements may not have a short term impact, but they can be effective in the long term, lasting several decades.

Improvements should aim to put more weight to GHG reduction in environmental assessments. The following potential policy instruments for doing this were identified:

- Ensure that all (very) long term impacts on GHG emissions are included in both EIAs, SEAs and CBAs.
- Apply higher shadow price for the long term emissions CO_2 in CBA's, in order to better reflect the risks for possible long term dramatic changes.
- Introduce specific conditions or requirements to the overall impact on GHG emissions.

Both inside and outside urban areas, GHG reduction can be attempted with spatial planning policies that aim to reduce transport volume, or to cause a shift towards 'greener' modes of transport. Depending on the type of energy which is consumed by transport modes, a shift in modes in an urban region, which can be more public transport intensive for commuting trips, could contribute to reduction of GHG. There is no consensus however on the effectiveness of spatial policies to stimulate such a shift.

More specifically, it can be said that the impacts of spatial organization and physical (urban) planning on urban transport and associated GHG emissions may involve a number of routes and trajectories. Urban form and density of settlements affect transport distances and number of trips within a city, between neighborhood, home and work, and home and services like city centres and shopping areas. To increase the residential density, the reallocation of dwellings and business activities, changing location of existing buildings, etc, represent examples of spatial policies affecting commuting distances for passenger trips, and at the same time influencing location choices by firms and households. Spatial policies aiming at getting people, organizations and activities in close proximity increase the number of possible destinations that can be reached within the same range of distance. At urban level, this in turn promotes a shift in travel mode choice from automobile to other means, discouraged by the increased congestion in high-density centres.

Physical planning can try to change density of land use through a number of instruments, notably zoning of business areas, regulating density (and thus height) of buildings, and investment in infrastructure. In addition, changes in modal split, notably a shift from car use to energy-efficient transport modes like walking, biking and public transport, will positively affect the reduction of transport-related GHGemissions. Physical planning can try to stimulate such a shift, for example, by creating fast lanes for buses or separate and thus safe lanes for bicyclists.

Summing up,various policies can be used to reduce GHG emissions of transport in urban and interurban areas: urban planning, investments in public transport, investments in cycling and walking infrastructure, parking policy and promotion of advanced distribution concepts at urban level, relocation of buildings and business activities at interurban level, etc .

If successfully implemented, these spatial policies will usually only be effective in the long run, since the impacts of urban planning take some time, notably when involving relocation of activities, new buildings and new infrastructure (interurban level). Some policies may be beneficial in the short term (with the proper financial or coercive behavioural stimuli), but may drop back in the long term if these behavioural stimuli are not sustained.

The GHG reduction potential of these policies is difficult to quantify because most of these instruments were not specifically applied with the goal to reduce GHG emissions, and the reduction potential has not been widely investigated. In general, these instruments always will need to be combined with direct economic instruments such as pricing policies, otherwise the reduction is expected to be limited. The effectiveness of spatial planning measures on the reduction of trip-kilometres so far has been very limited, as the complexity of the transport-land use decision making process and the intractability of the impact of planning decisions make it difficult to apply in a focused way without unwanted side effects (Maat, 2009).

The largest benefit of spatial planning policies seem to lie in the liveability of local areas and, in case of investments in transport infrastructure, in local accessibility. Effects on reductions of GHG emissions may be limited, and may even be negative if they lead to traffic volume increases.

Outside urban areas, the main potential policies are those that shift transport to ‘greener’ modes: short haul air to rail, long distance road transport to waterways and long distance road transport to rail and waterways. However, modal shift potential is difficult to harvest with infrastructure or spatial planning policy, as any additional infrastructure will attract more transport – unless this policy is part of a larger set of policy instruments such as pricing policies or emission legislation.

The last set of policy instruments discussed in this paper is traffic management policy and speed limits. Traffic management policy can be deployed to minimize fuel consumption and GHG emissions, if its main aim is to reduce the number of kilometres driven (e.g. through better route planning and reduction of congestion on fuel-efficient routes), to favour environmentally friendly transport modes and to enable vehicles to operate at favourable speeds and to keep a constant speed. However, in practice, successful traffic management measures often increase the capacity of roads and thus the attractiveness of (certain routes in) the transport network, which can result in extra kilometres driven.

Lower speed limits have significant potential for GHG reduction, in almost every transport mode (with the possible exception of aviation) – with added benefits regarding air quality, noise and energy security, and, in case of road transport, safety. The main barrier for this type of policy seems to be user acceptance, and, especially in maritime transport, the potential negative economical impact. However, higher shadow costs for GHG emissions, a likely development in view of the long term damage cost risks, will increase the attractiveness of many of these types of measures.

The following table summarises the conclusions on the impacts of policy instruments on GHG reduction. The green colour indicates that this policy instrument leads to GHG reduction at the long term by inducing this reduction option, the red colour indicates that a rebound effect is likely: the policy instrument leads to GHG increase by negative impact on this reduction option.

	Reduced car-ownership	More f fuel efficient vehicles	Shift to low-carbon energy carriers	Fuel efficient driving/sailing/flying	Reduced vehicle-kms due to higher vehicle utilisation	Modal shift to low-carbon modes	Limiting overall transport growth
Environmental assessments and cost benefits analysis							
Higher shadow price for CO_2 in CBAs	green					green	green
Specific conditions to the overall impact on GHG in CBAs	green					green	green
GHG reduction in urban planning							
Urban Planning	green					green	green
Investments in public transport							
Investments in cycling and walking infrastructure	green					green	green
Parking policy	green					green	green
GHG reduction in spatial inter-urban planning							
Relocation of dwellings and buildings	green		green			green	green
Residential density	green		green			green	green
Changing function of existinmg buildings			green			green	
GHG reduction in infrastructure development outside urban areas							
Investments in long distance and high speed rail infrastructure	green		green			green	red
Investments in waterway infrastructure and ports						green	red
Investments in intermodal connections for freight transport						green	red
Traffic management policy and speed limits							
Optimization of traffic flows in cities	red			green		red	red
Measures to reduce congestion on main roads		green		green		red	red
Access restrictions for high emitting vehicles	green	green	green			green	green
Dynamic speed limits		green		green		red	green
Lower speed limits for road transport		green		green		green	green
Traffic management for non-road transport modes				green		green	red
Speed policy for non-road transport modes		green		green	green	red	green

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