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# Road freight transport and the environment in mountainous areas

## Case studies in the Alpine region and the Pyrenees

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# Summary


### Road freight transport and the environment in the EU

Freight transport has grown dramatically during the past two decades, both internally in the EU and for external trade. Changes in production and supply systems, increasing distances and low load factors have resulted in an increase of 55 % of freight-km between 1980 and 1998, with the largest annual growth in road transport (3.9 % on average) and short sea shipping (2.6 %). Freight transport is shifting increasingly towards road: trucking now accounts for 43 % of total freight transport (33 % in 1980), while rail transport is declining.

Even though fuel quality regulations (e.g. limits on sulphur content for diesel) and emission standards for heavy-duty vehicles (HDVs) have become more stringent (and will continue to be tightened), trucking is still the least eco-efficient mode of land transport, compared with rail and inland waterways. HDVs consume significantly more energy per tonne-km than rail or ship transport and have higher specific emissions of pollutants. Furthermore, transport growth has partly offset the benefits of cleaner technologies.

As a result, road freight transport exerts significant environmental pressures. In the EU in 1998, 25 % of carbon dioxide ($CO_2$) emissions, 39 % of acidifying emissions (nitrogen oxides, $NO_x$) and 52 % of particulate matter ($PM_{10}$) emissions from transport were generated by HDVs. The $PM_{10}$ emissions are currently a priority issue as they affect health.

If EU (and other international) measures, among others developed under the Auto-Oil Programme, are implemented, significant decreases in the emission of most pollutants are expected up to the year 2020. With the exception of $CO_2$, the contribution of HDVs to total transport emissions will be reduced by more than 50 %.

The outlook for $CO_2$ emissions from freight transport shows a worrying trend, however. These will continue to grow at a rate even faster than passenger transport emissions. This trend jeopardises the likelihood of the EU meeting its Kyoto Protocol targets of an 8 % reduction in greenhouse gas emissions from all sectors combined by 2008–12. It also emphasises the need for fuel-saving policies for freight transport.

***Case studies: Alpine region and Pyrenees***
Mountains act as natural barriers and force traffic flows on to a limited number of routes, mostly in narrow valleys, or along coasts, where population is the most dense. The large number of HDVs in the main corridors, and their emissions, have a large impact on human health and the ecosystem, especially in Austria, France, Italy and Switzerland.

Transit freight traffic is a particular problem in the Alpine region where a large proportion of international freight traffic passes through sensitive areas, and where transit transport has increased substantially during recent decades. In the Alpine region (from Mont Blanc/ Fréjus to Brenner) HDV tonne-km increased by 292 % between 1980 and 1998. While transit traffic from eastern European countries still forms a limited share of total freight traffic, the enlargement of the EU is expected to increase this proportion significantly.

Transport to and from the Iberian peninsula (Portugal, Spain) increased significantly after these states joined the EU. Between 1985 and 1995, traffic volume of lorries grew by 330 % in the Pyrenees.

The impact of emissions of pollutants and noise are increased in mountainous areas because of the specific morphological and meteorological conditions there. The amphitheatre shape of valleys and their narrowness means that emissions from combustion cannot escape and therefore the situation of ambient air pollution in these valleys is often as bad as in an urban area. Studies show that the same traffic load contributes to a three-times higher concentration of $NO_x$ in the ambient air in mountainous areas than in lowland areas.

Because of the specific meteorological conditions, $NO_x$ concentration is higher in winter than in summer, and higher at night than during the day — despite lower traffic volumes in both cases. Further inside the Alpine region, the effects differ considerably depending on the geographical situation (north rim, south rim) and the orientation of the mountains towards the main wind direction (capacity for air exchange in the particular valley).

In 1999 the average annual nitrogen oxide concentration (sum of NO and $NO_2$) exceeded the new EU air quality standards for the protection of vegetation of 0.030 milligrams per cubic metre (mg/m$^3$) on almost every measurement point in the Tyrol. EU air quality standards for $NO_x$ for the protection of human health (0.040 mg/m$^3$) were exceeded near the motorways (A13 Gärberbach, A12 Vomp) and in urban areas (Innsbruck). The $NO_2$ concentrations (daily mean values) measured in the valley of Biriatou (Pyrenees) and in the Maurienne valley (Alps) reached about 50 micrograms per cubic metre (µg/m$^3$), measured in France. The long-term ozone level for the protection of human health (0.10 mg/m$^3$ 8-hour mean value) and for the protection of vegetation (0.06 mg/m$^3$ 8-hour mean value) were exceeded in the Tyrol.

Critical loads are exceeded by annual nutrient depositions (nitrogen). In the Tyrol annual nutrient deposition reached values up to 30 kilograms per hectare per year (kg/ha/a) which is considered critical for conifers in the long term. The critical load is 10–12 kg/ha/a. In Biriatou annual nutrient depositions (nitrogen) reached values of more than 35 kg/ha/a. The consequence is a destabilisation of the ecosystem. Alpine ecosystems are particularly sensitive to air pollutants and pollutant deposition due to higher altitudes, lower soil qualities, restricted vegetation periods and other biotic and abiotic hazards. Another important element is the protective function of the forests covering the slopes of alpine valleys, i.e. protecting local settlements and home industry from avalanches, mud slides, and erosion. Any impairment of this function may have disastrous consequences.

Due to the amphitheatre effect of valleys in mountainous areas, noise levels reach values that can, according to World Health Organization guidelines, be annoying or even harmful to health.

***Main policy instruments at EU level***

Given the international dimension of the transport system in mountainous areas, measures can only be effective if international concerted strategies and actions are agreed.

The tightening of emission standards for vehicles and fuel quality regulations has resulted in a significant improvement in the environmental performance of road vehicles and will continue to do so. However, it is clear that technological measures alone are not sufficient to reduce the environmental impact of traffic below critical levels and critical loads in mountainous areas.

Additional packages of measures are needed, including transport demand management, improvement of logistics, infrastructure measures (optimal use of existing infrastructure, promotion of rail, inland waterways, short sea shipping and combined transport), road pricing, driver training and provision of information. Road pricing should be differentiated according to the vehicle's environmental characteristics (emissions of pollutants, noise emissions, etc.), distance driven and location. The European Commission intends to propose a framework directive in 2002 to establish the principles of infrastructure charging and a pricing structure for all modes of transport.

In addition, serious efforts to improve technology for road and rail vehicles and infrastructure are necessary to reduce the specific characteristics of noise spread in mountainous areas.

Investigations should be made how to differentiate pricing according to the degree of sensitivity of the region or certain transport routes. This would require the development of EU criteria for the identification of sensitive routes or areas.

An agreement on transport and environment objectives and targets is a prerequisite for steering transport strategies in mountainous areas in a sustainable direction. Such targets should be agreed internationally and should address both the freight transport system (e.g. targets for traffic growth management and for modal split) and its environmental impacts. As emphasised in the recently signed transport protocol of the Alpine Convention, progress towards such targets should be regularly monitored on the basis of a set of carefully selected indicators.

Finally, to get a more comprehensive picture of current and future transport and environment problems in mountainous areas in Europe, a more thorough ‘hotspot’ analysis is necessary. This should be based on a wider range of case studies than was possible in the current study. Such an assessment should also include an analysis of the various driving forces governing transport through mountainous areas and the effectiveness of policy responses.

# 1. Introduction

This report was developed to support a study on the effectiveness of the Austrian ecopoint system conducted by the Directorate-General of Energy and Transport (DG TREN) of the European Commission (see Box 1). The aim of this present report is to put the ecopoint system in a wider environmental and European perspective, i.e. to analyse the broader environmental impacts of road freight transport and to investigate the specific problems of traffic impacts in sensitive mountainous areas (such as the Alpine region).

The information in this report is drawn from the indicators developed under the Transport and Environment Reporting Mechanism (EEA, 2001b; Eurostat 2001) and other existing information collated from an international literature review.

The report gives:

- an overview of the main environmental problems created by road freight transport in the EU, how these are developing over time and how trucking compares with other modes of transport (Chapter 2);
- an analysis of the specific environmental problems related to freight transport through mountainous areas (Chapter 3): these are illustrated by the findings of a (limited) number of case studies in the Alpine region and in the Pyrenees — the latter are described in detail in Annex 1;
- a review of the main policy instruments being developed and implemented at EU level to alleviate these freight/environment problems (Chapter 4);
- conclusions and recommendations (Chapter 5).

**Box 1: Transit freight transport through Austria and the ecopoint system**

Transit freight is concentrated on relatively few routes, all of which have very high transport volumes. It is a particular problem in the Alpine region where a large proportion of international freight traffic passes through especially sensitive areas, and where transit transport has increased substantially during recent decades. Austria saw a 10-fold increase in transit freight transport across the Brenner Pass between 1960 and 1996. At the same time road/rail market shares were almost reversed: in 1960 rail's market share was 87 %, but by 1996 it was down to just 30 %. A shift of transit road freight to rail transport is therefore an essential cornerstone of Austrian environment and transport policy. To achieve such a shift requires measures at the transnational level.

One of the instruments Austria is using to abate $NO_x$ emissions from freight transport is the ecopoint system. The ecopoint system was adopted in 1992 and came into operation on 1 January 1993 (and was continued largely unchanged after Austria's EU accession in 1995). It seeks to reduce $NO_x$ emissions starting from the base year of 1991 by 60 % by the year 2003. A limited number of ecopoints are attributed annually to each country in the European Community. Each heavy goods vehicle (weighing more than 7.5 tonnes, and registered in the Community) has to pay a number of ecopoints for each transit trip through Austria. The number of ecopoints depends on the emission characteristics of the truck.

As a safeguard to ensure that technical progress in the development of cleaner engines did not make the ecopoint system ineffective, the agreement also laid down a quantitative limit of 108 % of the journeys made in 1991. If this limit was exceeded then the number of ecopoints made available the following year would be revised downward through a formula laid down in the agreement.

An evaluation of the ecopoint system was made by the European Commission in 2000. This showed that the ecopoint system had had a very positive effect on encouraging road hauliers with lorries registered in the EU to use environment-friendly lorries to transit Austria. The target of a 60 % reduction of $NO_x$ emissions had, however, not been achieved and there was no evidence to show that the level of total emissions from lorries transiting Austria would remain stable if the ecopoint system were abolished on 31 December 2000. The Commission therefore recommended that the ecopoint system continue in operation until 31 December 2003. It also recommended the system should be revised by removing the upper ceiling on trips per year (the '108 % clause') without prejudice to the primary goal of the ecopoint system, namely a 60 % reduction in emissions.

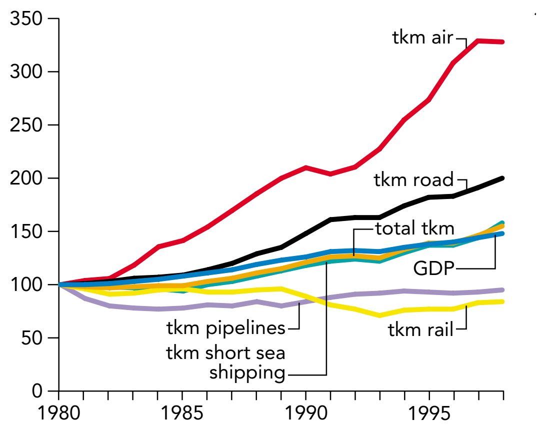
**Sources**: European Commission, 1998b; European Commission, 2000b.

# 2. Environmental effects of road freight transport

## 2.1. Road freight transport trends in the European Union

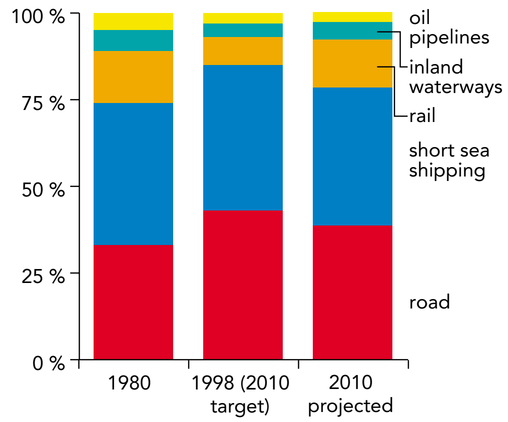
Freight transport has grown dramatically during the past two decades, both internally in the EU and for external trade. Changes in production and supply systems, increasing distances and low load factors (empty runs still account for around between 25 and 40 % of total vehicle-kilometres) have resulted in an increase of 55 % of freight-km between 1980 and 1998, with the largest annual growth in road transport (3.9 % on average) and short sea shipping (2.6 %).

**Freight transport trends — EU-15** Figure 1.




**Source**: Eurostat, 2001

**Modal shares in freight transport — EU-15** Figure 2.




**Source**: Eurostat, 2001

Freight transport is also shifting increasingly towards road: trucking now accounts for 43 % of total freight transport (33 % in 1980). While the European Community's freight transport action plans have resulted in better performance of short sea shipping, they have not yet reversed the declining shares of rail and inland waterways. A significant development has been 'just-in-time' deliveries: these require a flexibility and reliability that rail and water transport cannot offer, and they shift large stocks from warehouses to roads.

Traditional rail in the EU has been declining steadily. The recently published White Paper on the European Transport Policy (European Commission, 2001b) foresees an increase in total tonne-km between 1998 and 2010 of 38 % (for a projected increase in GDP of 43 %). The White Paper's proposed target of stabilisation of modal split at 1998 levels means that for e.g. rail a significant trend reversal is necessary: rail tonne-kilometres dropped by 10% in the 12 years before 1998, and should increase by 38 % in the 12 years between 1998 and 2010.

Austria and Sweden are the only Member States where a significant share (i.e. more than one third) of freight transport is carried by rail. Combined road/rail transport has, however, shown significant growth rates in recent years in the EU (7 % per year from 1985 to 1996). Already, according to DG TREN, about 50 billion tonne-km or 23 % of total tonne-km of EU rail freight is carried on combined road/rail services. Combined transport also represents a high share of rail freight in Italy (40 % of total tonne-km), Spain (34 %) and the Netherlands (30 %).

## 2.2 Emissions from road freight transport: past and future trends

Road freight transport puts significant pressure on the environment. In 1998, 25 % of transport carbon dioxide ($CO_2$) emissions and 39 % of acidifying emissions ($NO_x$) in the EU were generated by heavy-duty vehicles (HDVs). Of total transport emissions of particulate matter (PM10), which is currently a priority issue as it affects health, 52 % were generated by HDVs.

Community policies (see also Chapter 4) to curb air pollution from road traffic have been framed around the Auto-Oil Programme, with its follow-up programme Clean Air for Europe (CAFE). At the international level, various protocols under the Geneva Convention on Long-Range Transboundary Air Pollution (CLRTAP) set emission reduction targets for specific pollutants in the form of national emission ceilings based on a cost-effectiveness analysis. The European Commission has proposed slightly stricter national emission ceilings based on its acidification and ozone abatement strategy. The United Nations Framework Convention on Climate Change is also relevant since measures to reduce emissions of greenhouse gases from fuel consumption will at the same time reduce emissions of other compounds.

If such measures are well implemented, significant decreases in the emissions of most pollutants are expected until the year 2020 (see Figure 4). With the exception of $CO_2$, the contribution of HDVs to total transport emissions will be reduced by more than 50 %.

***$NO_x$***

According to Figure 3, total $NO_x$ emissions in the EU-15 countries show a decreasing trend from 1991 onwards, after a steady increase before that date (of the order of 20 % compared with 1980 levels). This progression was primarily caused by the introduction of three-way catalyst cars in the late 1980s and early 1990s in all EU countries. This was influenced by Directive 91/441/EEC — although many Member States had already encouraged the penetration of catalyst cars before 1990. The contribution of HDVs in $NO_x$ emissions amounted to 39 % in 1998. Emission standards for HDVs (Directive 91/542/EEC) also contributed — although to a smaller extent — to emission reductions in the period 1994-98.

***VOC emissions***

Volatile organic compound (VOC) emissions show a similar trend to that identified for $NO_x$. The contribution of HDVs is relatively small, as passenger cars are the main VOC emitters.

***CO emissions***

There was a steady decrease in carbon monoxide (CO) emissions during the whole of the period examined; the share of freight emissions in the total was — as expected — negligible.

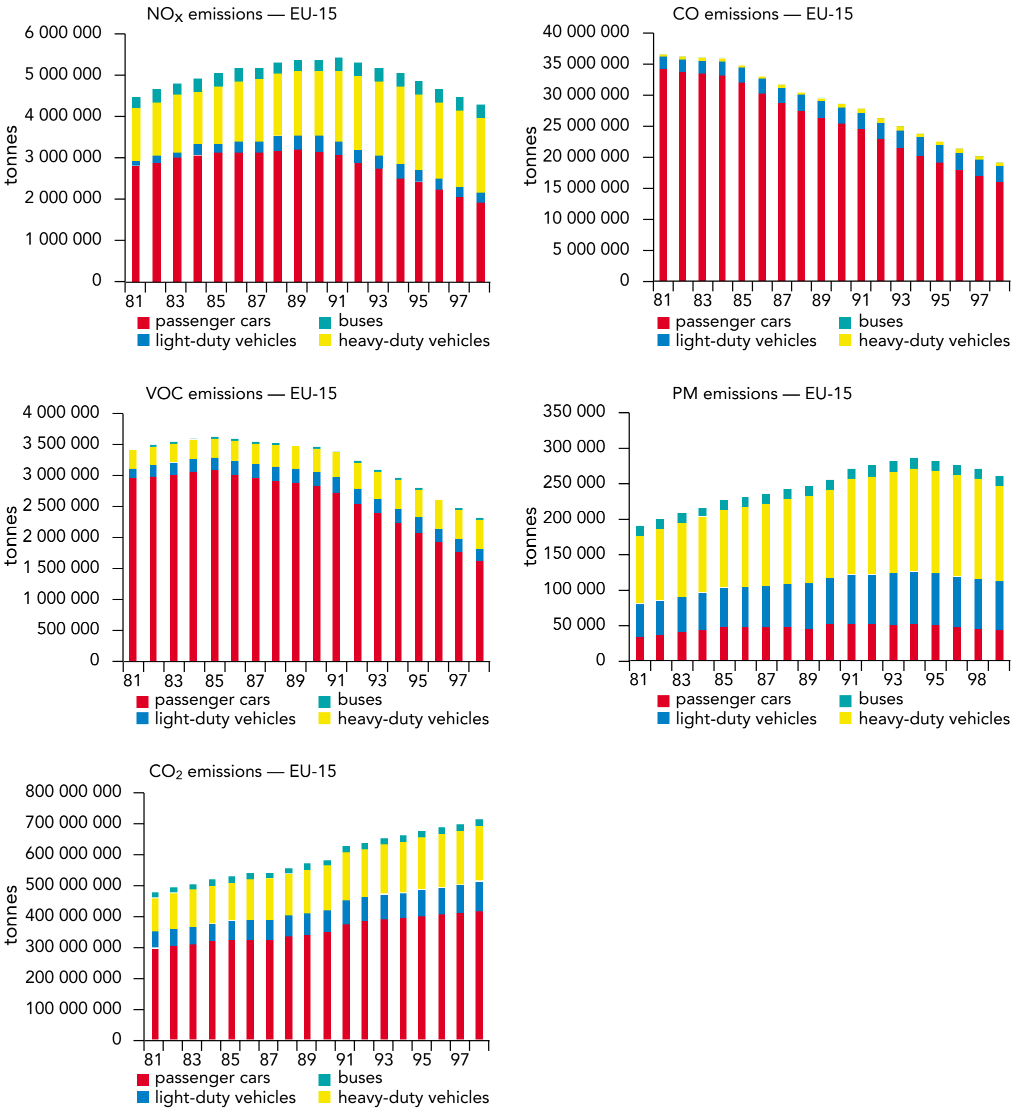
***PM emissions***

Road freight transport plays the most important role in particulate matter (PM) emissions: more than 50 % of total PM emissions are due to HDVs, a contribution which was slowly increasing from 1990 onwards.

In the case of PM emissions, the share of HDVs will remain relatively high until the year 2005. However, from the year 2010 and onwards, a significant decrease is predicted. This expected trends must be attributed to the introduction of more stringent emission standards for HDVs as quoted in Directive 1999/96/EC (see Chapter 4) in conjunction with the use of new, improved fuels (both gasoline and diesel) to be introduced in the market in two stages by the year 2005. It should be pointed out that diesel fuels will have a significantly lower sulphur content and also a decreased total aromatics content.

**Total $NO_x$, CO, exhaust VOC, PM and $CO_2$ central emission estimates and contribution of different vehicle categories for the period 1981–98** — Figure 3.

**Source**: EEA-ETC/AE, 2001



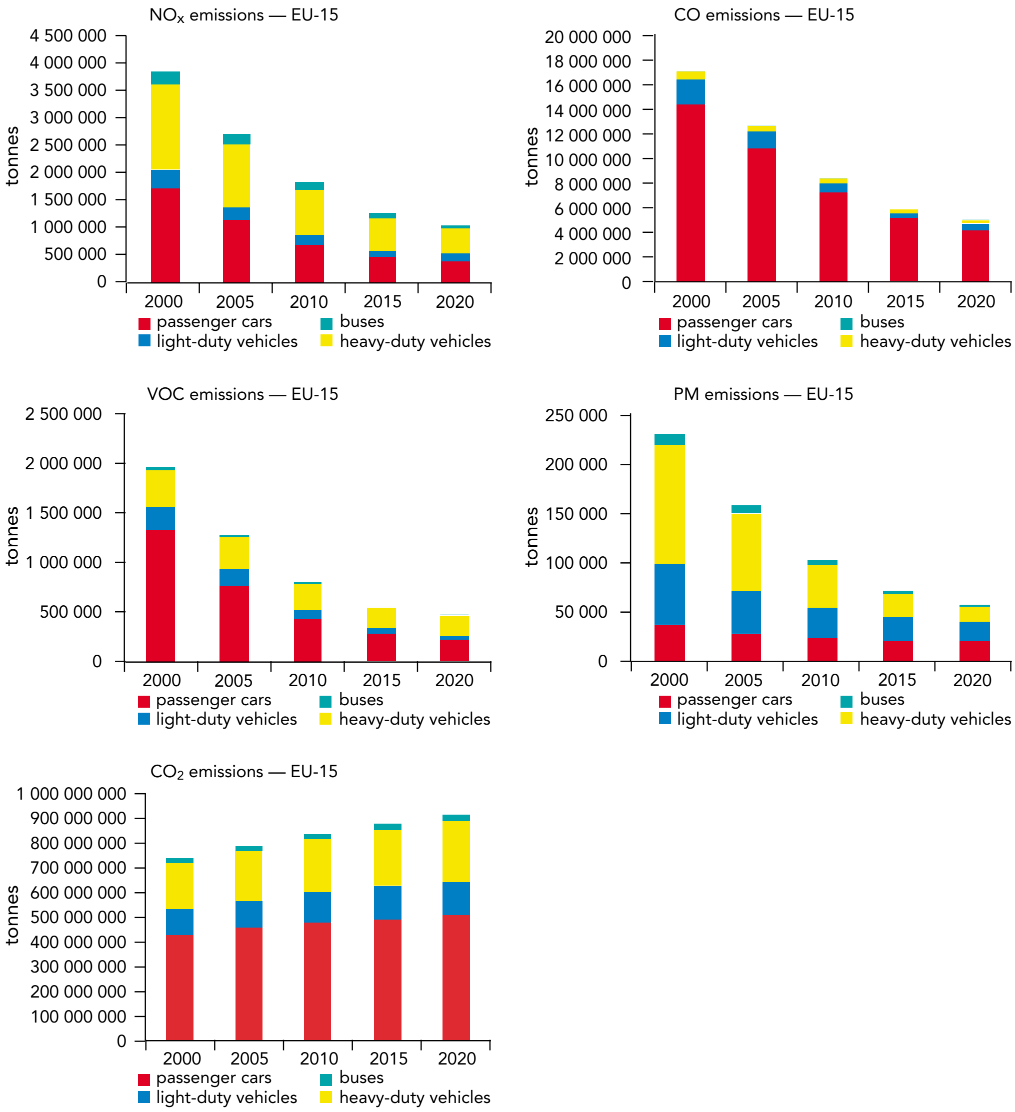
***$CO_2$ emissions***

In 1998, HDVs were responsible for 25 % of transport $CO_2$ emissions. There was a general increase over time in all vehicle categories (consistent with the increase in vehicle-km driven by each category). This trend jeopardises the possibility of the EU meeting its Kyoto Protocol targets of an 8 % reduction in greenhouse gas emissions by 2008–12. The $CO_2$ emission growth rates for freight transport are furthermore larger than for passenger transport.

The outlook is that emission levels are expected to increase during the period 2000–20, primarily due to constantly increasing fuel/energy demand.

**Figure 4.** **$NO_x$, CO, exhaust VOC, PM and $CO_2$ emission trends and contribution of different vehicle categories for the period 2000–20**

**Source**: EEA-ETC/AE, 2001



### 2.3 Real emissions versus tested emissions

The need to estimate actual emissions from vehicles arises because actual vehicle use covers driving and ambient conditions, which deviate significantly from those set by the legislative emission tests. Emission factors therefore have to be developed on the basis of detailed measurements on individual in-use vehicles and under various test conditions. The emission factors are then combined with activity data to provide total emission estimates.

There are some general factors relating to uncertainties about the estimation of emissions. Some affect the quality and accuracy of emission estimates for standard (average speed) and instantaneous models, and others are important only in the second case. General factors include:

- the selection of a small vehicle sample to represent vehicle fleets comprising millions of vehicles;
- the definition of representative test driving cycles and influences from the test measurement conditions (i.e. a speed cycle cannot be followed precisely, while gear changes are never repeated in exactly the same way) — the application of legislative driving cycles ensures comparability of data from different origins but some test driving cycles have little to do with real driving on roads;
- the fact that a large number of measurements are performed under identical — unrealistic — conditions.

Apart from these sources of uncertainty, calculated emission levels are also strongly influenced by several other factors such as vehicle age (mileage), degradation of pollution control measures, use of improved fuels and — in the case of HDVs — road gradient and vehicle load.

As far as the impact of vehicle age on emission levels is concerned, emission degradation has only been thoroughly examined in the case of gasoline passenger cars and light-duty vehicles. An impact is expected because of:

- ageing of the catalyst and normal wear of the engine, build-up of deposits on the cylinder walls and head, etc., although regular maintenance can limit this degradation process;
- the increasing probability of malfunctioning or severely damaged engine parts, which lead to very high emissions, as vehicles get older, although implementation of inspection and maintenance schemes could reduce the environmental impact of such vehicles.

It should be pointed out that, for diesel passenger vehicles, CO, HC (hydrocarbon) and $NO_x$ emissions were always found to be well below the emission standards. This was verified by the findings of a recent inspection and maintenance (I&M) project (LAT/AUTh et al., 1998), according to which diesel passenger cars were found — as expected — to be high polluters only in the case of particulate emissions.

The absence or insufficiency of corresponding experimental data for HDVs restrains — at least for the present — the introduction of both a degradation scheme for PM emissions and an enhanced inspection and maintenance scheme. In conclusion, the emission calculations for HDVs are still very uncertain because the data available for the calculations are insufficient either in terms of engines and vehicles or in terms of driving cycles (see Sams and Tieber, 1997).

### 2.4 Comparison of freight modes

Even though fuel quality regulations (limits on sulphur content for diesel) and emission standards for trucks have become more stringent (and will continue to be strengthened), compared with other land-modes (rail, inland waterways) trucking is still the least energy efficient. Trucks consume significantly more energy per tonne-km than rail or ship transport (Figure 5).

**Figure 5.** **Energy use per tonne-km of road and rail freight transport — selected EU countries**

**Source**: Odyssee

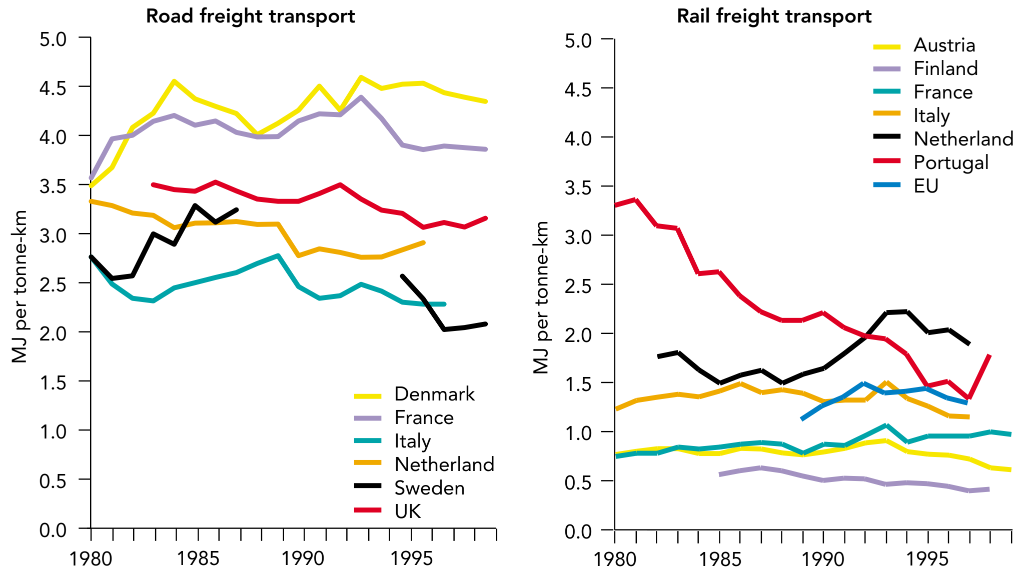



**Figure 6.** **Specific emissions of air pollutants and $CO_2$ from different transport modes of freight transport — Austria, 1995**

**Source**: Molitor et al., 1997

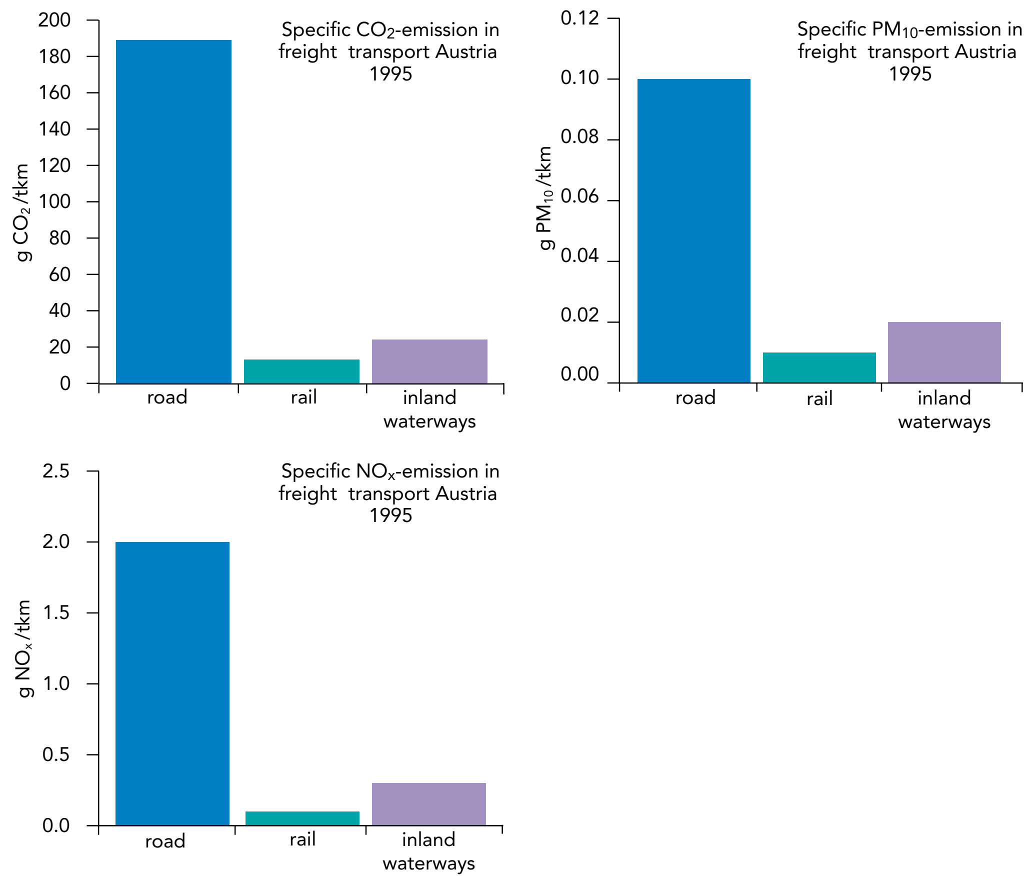


Figure 7 and Figure 8 compare the specific emission figures of different freight modes, based on the emission calculation methods adopted or developed in the TRENDS project.

- The emission levels from aviation (especially short haul) are significantly higher than those of other freight modes. Marine transport is by far the 'cleanest' mode.
- Trucking is much less eco-efficient than electric rail transport.
- A comparison of emissions from diesel trains and HDVs shows that the differences are quite small, indicating that neither mode is preferred in terms of emission levels.
- A closer look at $CO_2$ emissions shows, however, that HDVs' fuel demand is relatively higher than that of diesel freight trains, independent of load.
- As expected, partially loaded freight transport results in higher emission levels.

**$NO_x$ and CO emission estimates per freight tonne-km for different modes of freight transport** Figure 7.

**Source**: TRENDS, 2000

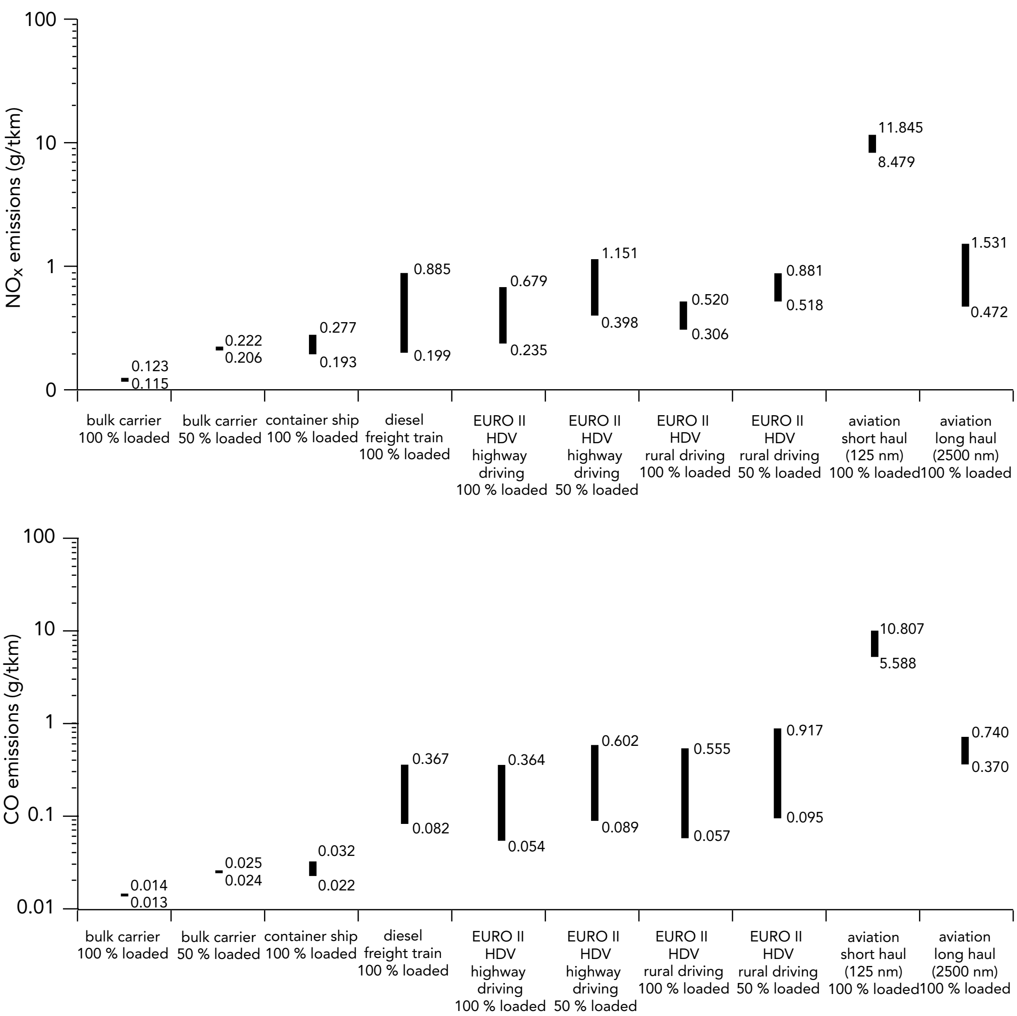
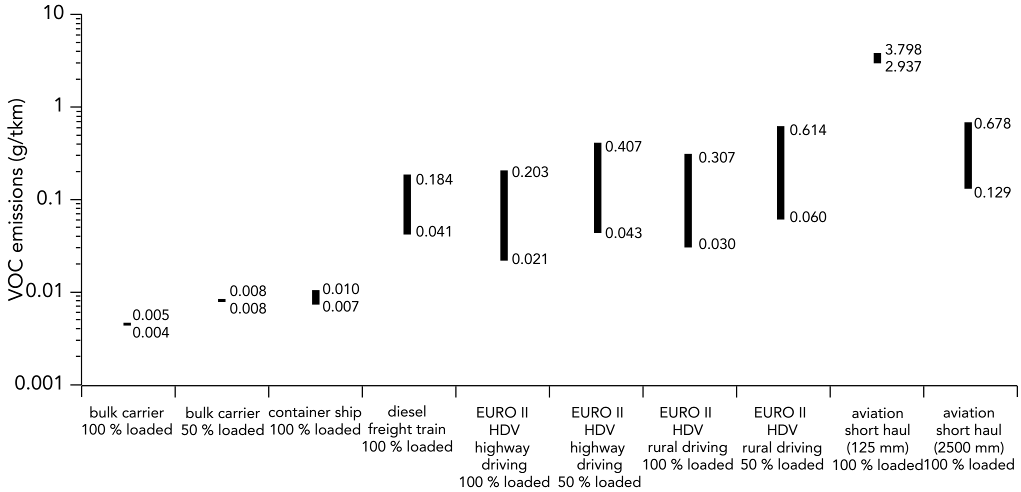
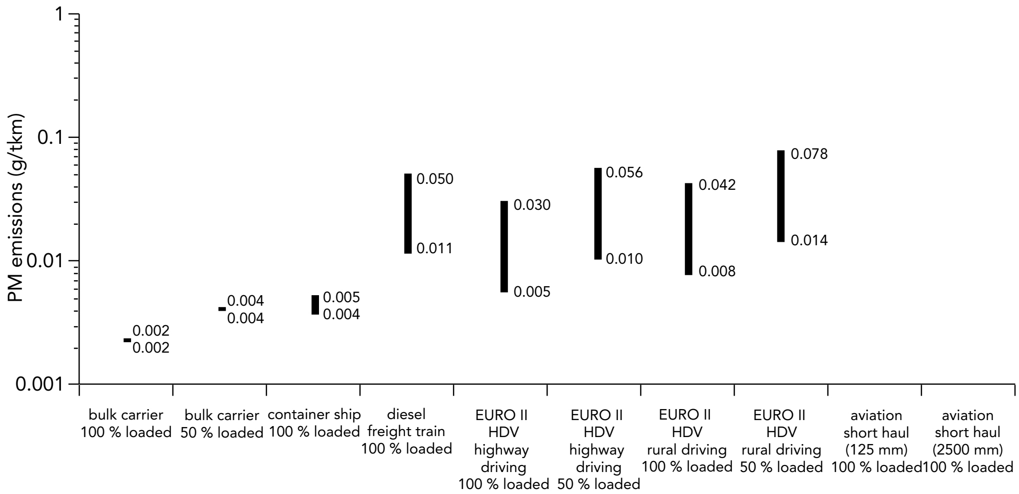
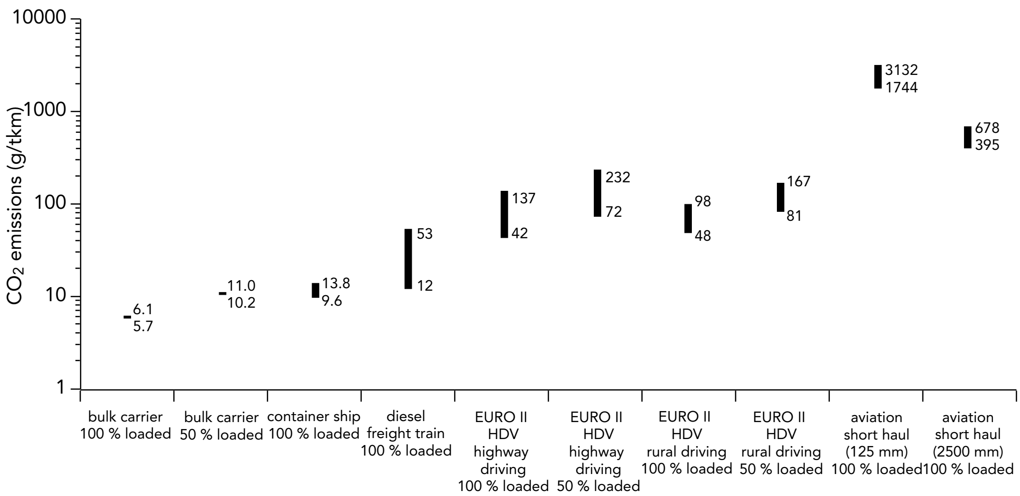


Figure 8. **VOC, PM and $CO_2$ emission estimates per freight tonne-km for different modes of freight transport**

**Source**: TRENDS, 2000



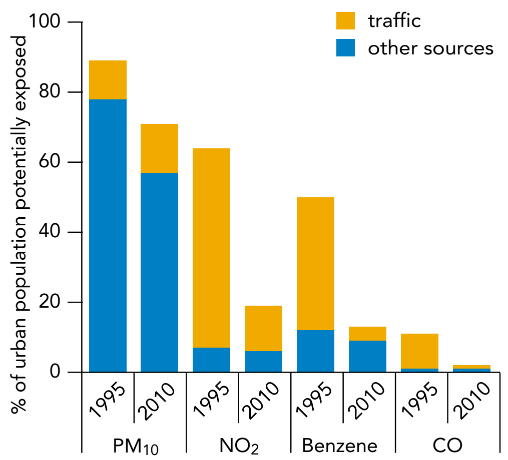



## 2.5. Impacts on air quality

Although air quality in Europe (and particularly in the large urban areas) has improved in recent decades, nearly all urban dwellers still experience levels of air pollution above EU limits. About 90 % of urban populations experience levels of particulate matter higher than both the 24-hour and annual average EU targets. Exposure to excesses of nitrogen dioxide ($NO_2$), benzene and ozone are also frequent (EEA, 2000a).

**Urban population potentially exposed to exceedances of EU air quality standards set for the protection of human health** Figure 9.




**Source**: EEA, ETC/AQ, 2001
**Note**: Figure indicates 'potential exposure' as estimates are based on the assumption of exposure for a person permanently in ambient air (i.e. not taking into account the indoor exposure)

Several air quality limits for ambient concentrations have been set to protect human health. Current EU legislation (the EC framework directive on ambient air quality and management and related daughter directives) is based on threshold values recommended by the World Health Organization (WHO).

Figure 9 shows the results of the EEA's generalised empirical approach, which is being developed and applied in the context of the Clean Air for Europe programme, and which provides a methodology for estimating the transport contribution to urban air pollution. Assuming zero pollution from road transport in a given city, the times when threshold values for typical transport-related pollutants like $NO_2$, CO and benzene were exceeded would fall dramatically, but there would be less impact on $PM_{10}$ levels, most of which result from particles transported over long distances. It should be noted that data on $PM_{10}$ emissions and concentrations are quite uncertain and measurement methods are being improved through the UN Economic Commission for Europe (UNECE), CLRTAP and the EU CAFE programme.

Ozone limit values set to protect vegetation are widely and largely exceeded in Europe (EEA, 2001c). Road transport contributed 43 % to 1998 ozone precursor emissions. Critical loads for acidification by deposition of sulphur and nitrogen compounds were exceeded in 1998 in about 10 % of the area of the 18 EEA countries (EEA, 2001c).

## 2.6. Traffic noise

Road, rail and aviation transport are major sources of noise annoyance. It is estimated that more than 30 % of Europeans are exposed to road noise levels, and around 10 % to rail noise levels, above 55 $L_{dn}$ dB(A)[1] (EEA, 2001b).

Permanently high noise levels can cause health problems (insomnia and poor concentration, stress, high blood pressure and ischaemic heart diseases). WHO therefore recommends strict limits to permanent noise levels: for example, for residential areas 55 dB(A) during the day and 45 dB(A) during the night.

[1] Ldn, day-night level, is a descriptor of noise level based on energy equivalent noise level (Leq) over the whole day with a penalty of 10 dB(A) for night-time noise (22.00-07.00 hrs).

An Austrian study on external costs of freight transport (Herry et al., 2000) shows that in 1998 total external noise costs were around ATS 6.2 billion. The majority, 84 % (ATS 5.2 billion), was caused by road transport and 16 % (ATS 960 million) by rail. Generally, noise costs constitute about 18 % of the total external costs (ATS 35.3 billion) of freight transport. In road freight traffic the share of noise costs is only 16 % of all external costs, whereas in rail traffic the share is 55 %.

### 2.7. Spatial and ecological impacts

Transport also has impacts on land use and biodiversity. The following conclusions are drawn from TERM 2000.

- Land is under continuous pressure for new transport infrastructure: during 1990–96, a total of some 25 000 hectares (ha), about 10 ha of land every day, were taken for motorway construction in the EU.
- Depending on its density, transport infrastructure can divide homogeneous areas into 'islands' and can isolate sensitive ecological areas (e.g. wetlands), thus restricting the functionality of the habitat and impeding the movement of the fauna within it.
- Road and rail infrastructure takes land mainly from agricultural use, but also from built-up areas, forests, semi-natural areas and wetlands.
- Linear infrastructure can constitute an important barrier, dividing communities. Transport infrastructure also imposes a significant threat to nature conservation by fragmenting and disturbing habitats and putting areas designated for nature protection under pressure. Already 65 % of special protected areas for birds and Ramsar areas (wetlands) are near major transport infrastructure.

It is difficult, however, to attribute a certain share of these effects specifically to freight transport.

# 3. Freight transport through mountainous areas

This chapter builds on the case studies that are reported in detail in Annex 1.

### 3.1. Mountains are sensitive areas

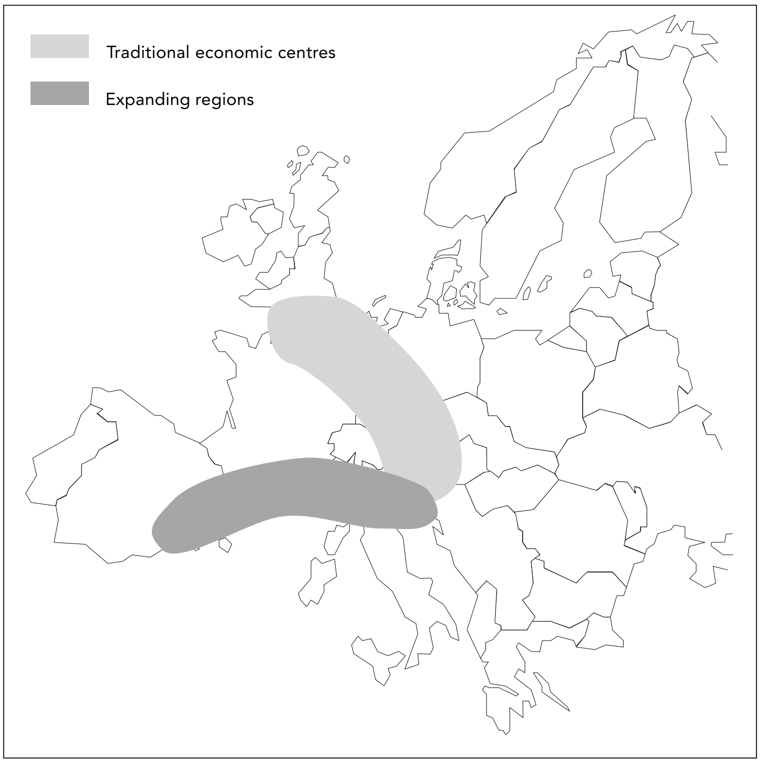
Mountainous areas provide aesthetic and recreational landscapes, high biodiversity of species and habitats embedded in sustainable land-use systems. Mountains extend through different altitudinal zones and have a wide variety of habitats. They include — in the remotest regions in Europe — the last retreat for animals with large habitats. The extreme physical conditions let mountains become a fragile environment, where natural phenomena, often increased by human land uses or misbehaviour, interfere with people's activities and then cause natural hazards.

The Alpine region, like the Pyrenees, has some characteristics that intensify the conflict between the needs of its inhabitants, the ecological balance and (transalpine) traffic. Mountainous areas act also as a natural barrier. Thus traffic flows are concentrated on a limited number of routes, mostly in narrow valleys. There is a heavy impact on human health and the ecosystem, especially in Austria, France, Italy and Switzerland, caused by the large number of HDVs on the main routes.

The morphological shape of the valleys (U- or V-shape) in mountainous areas and the narrowness of these valleys means that emissions from combustion cannot escape; ambient air pollution along these valleys is often as bad as in an urban area. The particular meteorological conditions, especially in the inner-alpine valleys (tendency towards inversion,

**Traditional economic centres and expanding economic regions in the EU** Figure 10.

**Source**: BAUM et al., 1994



little wind but local wind systems due to thermionics, higher amounts of precipitation along the northern side of the Alps and therefore higher deposition of pollutants), impede the rarefaction and the transportation of pollutants.

Studies show that the same traffic load contributes to a three-times higher concentration of nitrogen oxides in the ambient air in mountainous areas than in lowland areas due to the meteorological particularities. In mountainous areas during night-time in summer, the emissions of a road vehicle induce a six-times higher load on the ambient air quality than during daytime (Kocsis O., Ökoscience, 2000).

## 3.2. Traffic flows are governed by economic needs of regions outside the mountains

For the Alpine Region and the Pyrenees - two major mountainous areas in Europe — the specific traffic problems are closely linked to the fact that both areas are located between two centres of economic activity in the European Union (Figure 10). The high growth rates of freight transport in mountainous areas are a result of growing transport links between the traditional economic centres in the north and the growing economic regions in the south.

Over the next 20 years, long-distance freight traffic across the Alps is expected to double, and passenger transport to increase by 50 %. When much of the traffic is in transit, the mountain areas enjoy little benefit, but can suffer serious environmental and social impacts.

Furthermore, the impact of transport networks is concentrated in valleys where population density is often high. For instance, the northern section of the Brenner transit route (motorways A12 and A13 in Austria) is located in the lower Inn valley (the central region of the Austrian federal province Tyrol with a population density of almost 500 inhabitants per square kilometre ($km^2$)) and the Wipp valley. Thus in the Alpine region there is a severe impact from traffic noise and pollution, particularly from nitrogen oxides. Potential conflict between transport requirements and the protection of the mountain environment is shown by the experience of Austria, where reducing road infrastructure charges to comply with EU legislation was followed by an increase in freight traffic.

Due to increasing international traffic flows, and the development of the trans-European transport network (TEN-T, see section 4.5.1), more EU corridors certainly will cross mountains (e.g. the transalpine link Rome-Milan-Zurich/Munich; Madrid-Barcelona-Rhone valley; Milan-Venice-Vienna-Budapest-Kiev; Bologna-Milan-Lyon; Madrid-Bordeaux-Toulouse). While transport network density is higher in the Alps than in other European mountain ranges, rapid increases may be expected for accession countries' mountains (Carpathian, Rhodope and Balkan) with the extension of TEN-T to the east.

## 3.3. Environmental impacts from road freight transport in mountainous regions

### *3.3.1. Alpine region*

Emissions of pollutants from road freight traffic pose a major environmental problem especially on trunk roads through mountainous regions. The reasons for the increased environmental impact are the following.

- Road traffic is concentrated on only a few heavily frequented trunk routes, which results in high concentrations of pollutants in the ambient air in the valleys and areas concerned.

- In the mountainous regions, the permanent settlement area covers only a small part of the whole area and so the concentration of inhabitants, especially in some Alpine valleys, can reach urban levels. Transport infrastructure has a relatively high share of land use and is inevitably situated close to living and recreation areas.

- The specific topographic and meteorological conditions of Alpine valleys hamper the dispersion of air pollutants, thus increasing the harmful effects of pollutant emissions compared to extra-alpine lowlands. The direct effects on the concentration of pollutants in the ambient air per unit $NO_x$ emission is almost one order of magnitude higher than in lowland areas.

- Alpine ecosystems are particularly sensitive to air pollutants and pollutant deposition owing to higher altitudes, lower soil quality, restricted vegetation periods and other biotic and abiotic hazards.

- One important function of forests covering the slopes of Alpine valleys is to protect local settlements from avalanches, mud slides, and erosion. Any impairment of this function may have disastrous consequences.

According to current knowledge, the most relevant air pollutant is $NO_x$ and its reaction products like $NO_2$. High $NO_x$ emissions result in $NO_2$ concentrations exceeding both the EC limit threshold and air quality guidelines recommended by WHO in recent years. There may be effects on human health.

The specific meteorological and topographic conditions in Alpine valleys are the decisive key factors for high air pollution. The mountains alongside the valley hamper the dilution of locally emitted pollutants, and in addition the frequent occurrence of persistent inversions and low wind velocities compared with extra-alpine lowlands favour local pollutant accumulation. In winter and at night, air quality in the Alpine valleys is worsened by weather inversion. The cold air lies on the ground of the valleys and is divided from the sunshine on the mountains through a layer of fog. Therefore pollutants cannot escape either.

**Inversion in an Alpine valley** Figure 11.

**Source**: KOCSIS O., 2000 (Urner Reusstal: LUBETRAX I-Campaign 1997)

Further ambient air quality in the Alpine regions is also degraded by long-range air pollution: by plumes of ozone and nitrogen oxides from outside the Alpine area. The long-range air flows from the peri-alpine areas such as the Po plateau, the Danube corridor, the conurbation of Munich or the Rhône-Saône corridor are an additional source of air pollutants that have to be added to the already considerable concentration caused by local emissions (i.e. $NO_2$, ozone). Under high solar radiation Alpine valleys work as a pump, transferring air from ground level to altitudes of 2 000 to 4 000 metres (m) above sea level. Thus polluted air is transferred in the lower troposphere with considerable effects (higher ozone concentration) (Kocsis, 2000).

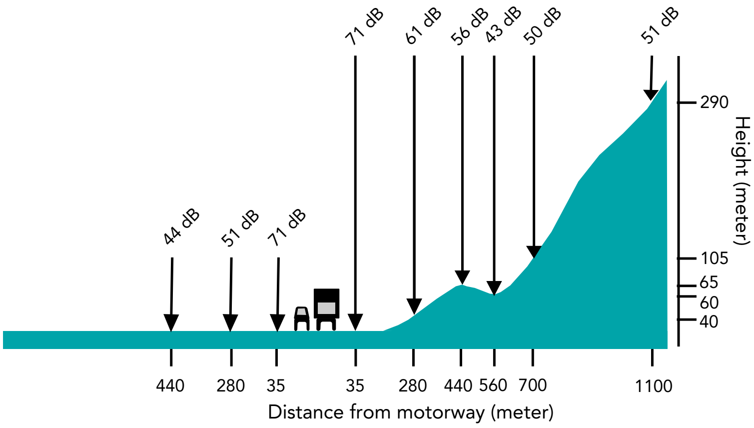
Noise also has a significant environmental impact in mountainous areas. The morphological shape of the Alpine valleys means that noise emissions are intensified (an effect comparable to an amphitheatre). In lowland areas noise is damped through soil and vegetation, which is not the case in mountainous areas where vegetation is sparse). Due to the narrowness of the valleys and to the reduced space available for settlement areas, it is impossible to evade.

***3.3.2. Pyrenees***

Only a limited number of high-capacity road and rail routes are available for the exchange of goods between the Iberian peninsula and northern Europe. As a consequence, freight

Figure 12. **Noise spread in mountainous areas compared with lowland areas**

**Source**: Gruber, 1994, cit. in BMVIT, 2000




traffic flows are concentrated on two main routes, i.e. Biriatou and Le Perthus at the east and west borders of the Pyrenees. Thus the altitude of both passes is much lower than those in the Alpine region (approximately 50 metres (m) compared with 300 m).

Exchanges between the Iberian peninsula (Portugal and Spain) have grown since these states became members of the European Union (EU). The growth in freight transport is similar to that already shown in the case of the Alpine region. From 1985 to 1995, the traffic of HDVs grew by 330 % in the Pyrenees and by 280 % on the French Alpine passes (Mont Blanc, Fréjus). Thus the environmental pressures (e.g. emission of pollutants) rose as well. The modal split is heavily weighted to road: only 8.6 % of freight transport in the Pyrenees is carried by rail. The share of transit traffic, at approximately 50 %, is high compared to the western Alpine region. Short sea shipping is already a major alternative to inland traffic through the Pyrenees (accounting for 43 % of total exchange of goods).

Ongoing research into the environmental effects of road freight transport in the Pyrenees allows only preliminary conclusions to be drawn, including some details on ambient air quality and deposition of pollutants. If noise is considered, the morphologic situation in the Pyrenees is similar to the Alpine region, so that the conclusions drawn in the Alpine case studies can also be applied to the Pyrenees. The $NO_2$ concentrations found at Biriatou are similar to the highest urban values found in France. Similar to the findings on the effects of $NO_2$ concentrations in the Alpine valleys, in the vallée d'Aspe the dispersion of pollutants is lower by a factor of three compared with the site of Biriatou.

# 4. What is being done?

The issue of transit traffic through mountainous areas obviously requires an international approach. Packages of measures are needed, including technology improvements, transport demand management, pricing, optimal use of existing infrastructure and promotion of rail and inland waterways.

## 4.1. Air quality policies

Community policies to curb air pollution from road traffic have been framed around the Auto-Oil I and II Programmes. Further development of policies is foreseen in the programme Clean Air for Europe. At the international level, various protocols under the Geneva Convention on Long-Range Transboundary Air Pollution (CLRTAP) set emission reduction targets for specific pollutants in the form of national emission ceilings based on a cost-effectiveness analysis. The Commission has proposed similar national emission ceilings based on its acidification and ozone abatement strategy. The United Nations Framework Convention on Climate Change is also relevant since measures to reduce emissions of greenhouse gases from fuel consumption will at the same time reduce emissions of other compounds.

Several air quality limit values for ambient concentrations have been set to protect human health and ecosystems (EEA, 2001a). Current EU legislation (the EC framework directive on ambient air quality and management (European Commission, 1996a) and related daughter directives) is based on WHO-recommended threshold values.

## 4.2. Technological and fuel standards

The tightening of emission standards for vehicles was the first instrument used to achieve a significant improvement in the environmental performance of road vehicles (see Box 2 on page 26). The improvement of fuel composition has been another important measure in reducing the emissions of certain air pollutants.

### *4.2.1. EU vehicle emission legislation for HDVs*

With the exception of an early directive restricting visible smoke (72/306/EEC), until 1989 HDV legislation followed the ECE R49 emission limits. In 1989, the EC Directive 88/77/EEC adopted type approval limits for gaseous vehicle emissions based on ECE Regulation 24.03. Two years later the clean lorry directive (Directive 91/542/EEC) was adopted, reducing in two phases the limit values of gaseous and particulate emissions by diesel engines and other heavy utility vehicles (see Table 1). The Council subsequently relaxed the particulate limit for vehicles with engines ( 0.7 cubic decimetre ($dm^3$) cylinder capacity to 0.25 grams per kilowatt hour (g/kWh) for the transitional period from 1 October 1995 to 30 September 1997, but allowed Member States to give tax incentives for small diesel engines meeting the 0.15 g/kWh limit before this date. In 1996 the EC submitted a proposal for the further regulation of vehicle emissions to take effect during the period 2000–10. These were based on the Auto-Oil I study and, among other measures, introduced a series of new limits for light- and heavy-duty commercial vehicles. In 1997 the Commission issued its proposals for the year 2000 limits (COM(97) 627 final), including:

- two new test cycles (ESC/ELR and ETC)
- limits for both diesel- and gas-fuelled heavy duty engines for the year 2000
- specifications for diesel and gaseous reference fuels
- the concept of enhanced environmental vehicles (EEVs).

Two additional vehicle classes have been introduced according to proposal COM(98) 776 (adopted by the Council on 20 December 1998, amending COM(97) 627), which aim at the introduction of even more stringent emission standards for gaseous and particulate pollutants. In order to comply with the above, Euro IV (valid from 2005 to 2008) and Euro V (starting in year 2008) classes have been introduced in COPERT III (EEA, 2000b) to cover those requirements.

Finally, Directive 1999/96/EC adopted by the Council of Environment Ministers on 13 December 1999 amends Directive 88/77/EEC and aims at the reduction of gaseous and particulate pollutants from diesel HDVs by 30 % starting in year 2000 up to 2005 (see also Table 2).

Table 1. **Past and current limits for HDVs of more than 3.5 tonnes gross vehicle weight**

| | Effective date | Type approval (g/kWh) | | | | Conformity of production (g/kWh) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CO | HC | $NO_x$ | PM | CO | HC | $NO_x$ | PM |
| **ECE R49** | | 14 | 3.5 | 18 | | | | | |
| **88/77/EEC** | 1.7.1988 (new models)<br>1.10.1990 (all production) | 11.2 | 2.4 | 14.4 | [3] | 13.2 | 2.64 | 15.8 | [3] |
| **91/542/EEC** | 1.07.1992 (new models)<br>1.10.1993 (all production) | 4.5 | 1.1 | 8.0 | 0.36[1] | 4.9 | 1.23 | 9.0 | 0.4[1] |
| | 1.10.1995 (new models)<br>1.10.1996 (all production) | 4.0 | 1.1 | 7.0 | 0.15[2] | 4.0 | 1.1 | 7.0 | 0.15[2] |

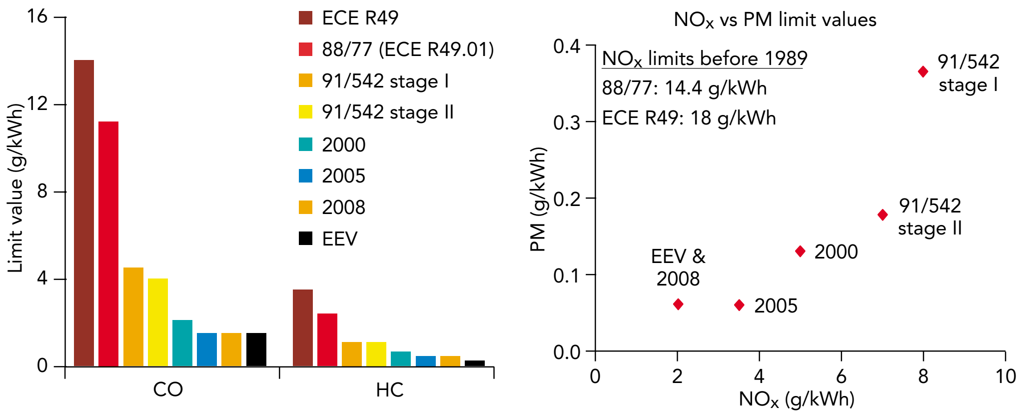
(1) For engines of 85 kW or less, the limit value for particulate emissions is increased by multiplying the quoted limit by a coefficient of 1.7.
(2) For engines with a cylinder swept volume of ( 0.7 $dm^3$ and a rated power speed > 3000 min -1 the limit was 0.25 g/kWh max. until 30.9.1997 for new models and 30.9.1998 for all production respectively.
(3) Smoke according to ECE Regulation 24.03, EU Directive 72/306/EEC.

Table 2. **Heavy-duty limit values for diesel engines over the ESC/ELR and ETC test cycles, as imposed by Directive 1999/96/EC (adopted on 13 December 1999)**

| Implementation date | ESC/ELR test cycles (g/kWh) | | | | ETC test cycle (g/kWh) | | | |
|---|---|---|---|---|---|---|---|---|
| | CO | HC | $NO_x$ | PM | CO | NMHC | $NO_x$ | PM |
| 1996[1] | 2.99 | 0.94 | 7.2 | 0.14 | 7.91 | 1.19 | 7.33 | 0.23 |
| Stage A - 1.10.2000 | 2.1 | 0.66 | 5.0 | 0.10[2] | 5.45 | 0.78 | 5.0 | 0.16[4] |
| Stage $B_1$ - 1.10.2005 | 1.5 | 0.46 | 3.5 | 0.02 | 4.0 | 0.55 | 3.5 | 0.03 |
| Stage $B_2$ - 1.10.2008 | 1.5 | 0.46 | 2.0 | 0.02 | 4.0 | 0.55 | 2.0 | 0.03 |
| EEV- 1.10.1999 | 1.5 | 0.25 | 2.0 | 0.02[3] | 3.0 | 0.40 | 2.0 | 0.02[5] |

(1) For comparative purposes, the 1996 emission standards (Directive 91/542/EEC, stage II) have been converted to the values that would have been obtained over the new test cycles.
(2) A derogation to 0.13 g/kWh applies for small engines having a swept volume of less than 0.75 $dm^3$ per cylinder and a rated speed > 3000 min-1.
(3) The Commission has proposed a reduction to 0.01 g/kWh, which could apply for fiscal incentives from 1.10.1999.
(4) A derogation to 0.21 g/kWh applies for small engines having a swept volume of less than 0.75 $dm^3$ per cylinder and a rated speed > 3000 min-1.
(5) The Commission has proposed a reduction to 0.015 g/kWh, which could apply for fiscal incentives from 1.10.1999.

Changes in emission limits for HDVs — Figure 13.




**Source**: EEA-ETC-AE, 2001; CONCAWE, 2001

Limit values from the year 2000 onwards are converted so as to comply with the ESC/ELR test cycle.

#### *4.2.2. Diesel fuel standards*

In 1987, the EU Council agreed to a directive reducing the maximum sulphur content of all gas oils (with the exception of those used by shipping or for further processing) to 0.3 % m/m (mass sulphur per mass fuel) and allowed Member States to set the limit of 0.2 % m/m in heavily polluted areas. Member States were required to implement Directive EEC/85/716 by 1 January1989.

In 1993, a single limit (of 0.2 % m/m to be applied to all gas oil, including diesel fuel) was set for the whole EU through Directive 93/12/EEC. The latter additionally required a maximum limit of 0.05 % for diesel fuel to be implemented until 1 October 1996.

Currently all the EU countries have adopted the CEN diesel fuel specifications (EN590:1998). Directive 98/70/EC set stringent specifications for automotive fuels to be introduced in 2000 and 2005. Thus, from the year 2000 diesel fuels must comply with a maximum limit of polycyclic aromatic hydrocarbons of 11 % m/m and a reduction in sulphur content to 350 milligrams per kilogram (mg/kg). In 2005 the sulphur content will be reduced to 50 mg/kg.

### 4.3. Noise policy and legislation

Community noise emission limits have been considerably tightened since 1972 and legislation now sets maximum sound levels for motor vehicles. However, methodological inconsistencies (non-harmonised indices and inadequate testing procedures for vehicles) have hampered progress on urban acoustic quality standards and severely limit the accuracy of noise assessments. The Green Paper on future noise policy (European Commission, 1996) was the first step in the development of a Community noise policy.

The proposed framework directive relating to the assessment and management of environmental noise seeks to monitor the environmental problems caused by noise, requires noise action plans to be produced, the public to be informed and consulted about noise pollution and the measures being taken to deal with it, and a long-term EU noise strategy to be developed with a view to reducing the number of people being affected.

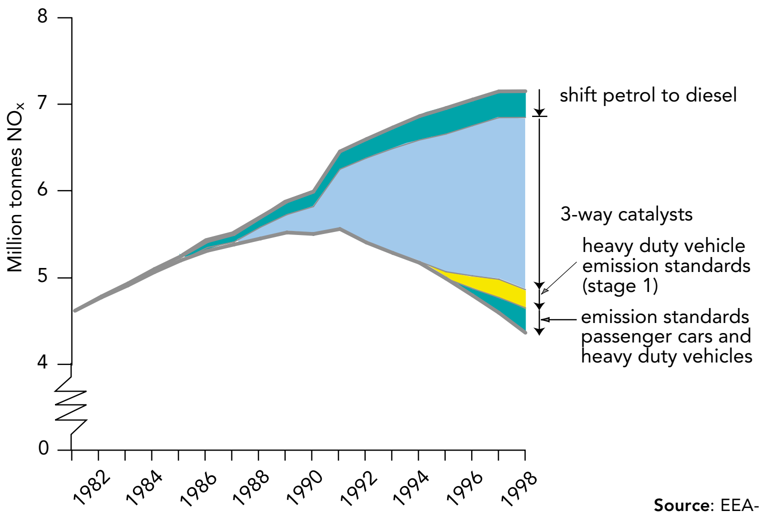
The directive sets the framework for a harmonised collection of data and indicator development to monitor noise nuisance and annoyance in the EU. It requires the production of noise maps of major agglomerations, roads, railways and around airports. Some Member States are already monitoring noise and setting limits to noise pollution in sensitive areas.

**Box 2: Effectiveness of measures to reduce $NO_x$ emissions**

Figure 14 presents $NO_x$ emission estimates for the EU-15 and gives an impresion of the effectiveness of various measures in reducing $NO_x$ emissions from road transport. For this assessment the central emission estimates (ForeMove results) for the period 1981 to 1998 were used.

As already noted, $NO_x$ emissions from road transport in the EU-15 increased by about 20 % from 1980 to 1990 and were then reduced, so that by 1998 they essentially returned to 1980 levels. This trend must be attributed to the introduction of three-way catalyst cars in the late 1980s and early 1990s in all EU countries. Directive 91/542/EEC (Stage I) for HDVs led to further emission reductions. Without these measures, emissions in the EU would have been up to 50 % higher in 1998. The introduction of stricter directives both for passenger cars (94/12/EC) and HDVs (91/542/EEC Stage II) resulted in further reduction of $NO_x$ emissions (of the order of 5–10 %) after 1995, which will become more apparent in the following years. Additional measures at national level, implemented in the late 1980s, such as the early introduction of oxidation catalysts for gasoline cars, did not have any significant effect, as the phase-in of three-way catalysts was a much more drastic measure. The gradual increase in sales of diesel passenger cars in some European countries contributed further to a reduction in $NO_x$ emissions, which was significant in Austria, Belgium, France, Germany and the Netherlands. EU-wide, dieselisation caused a drop in emissions of 2–4 % in the 1990s.

Figure 14. **Effectiveness of measures to reduce $NO_x$ emissions from road transport in EU-15**




**Source**: EEA- ETC/AE, 2001

Noise can be reduced by technical measures at the source (e.g. vehicle and driving characteristics, reduction of traffic volume, speed limiting, route planning, anti-noise pavements), in its propogation (noise screens) and at reception (insulation of houses). All anti-noise measures require regular inspection and maintenance in order to continue to be effective, and monitoring facilities need to be in place to evaluate the performance of noise abatement measures.

### 4.4. Fair and efficient pricing

The European Commission is committed to developing a fair and efficient Community pricing system. The objectives are described in the Commission's Green Paper 'Towards fair and efficient pricing in transport' (European Commission, 1995) and in the White Paper 'Fair payment for infrastructure use' (European Commission, 1998a). It is argued that pricing instruments should be used to ensure that all external costs, such as air pollution, accidents, noise and congestion, are covered in the prices paid by the user.

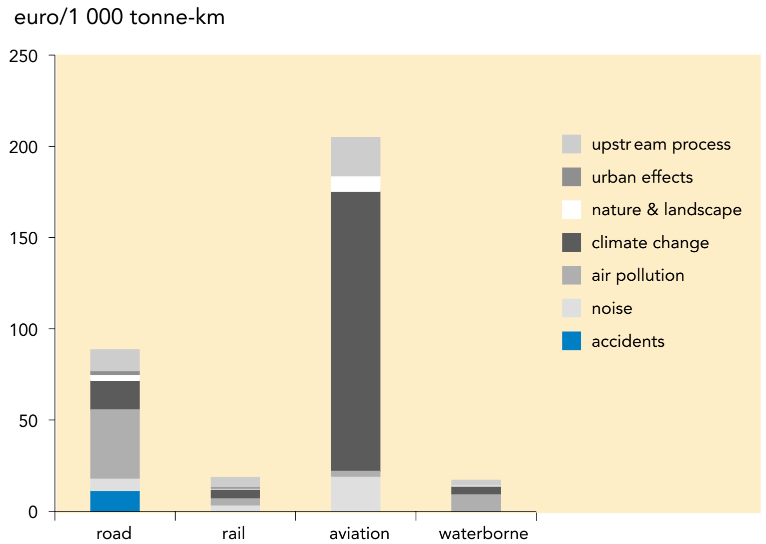
The fair and efficient pricing policy relies on taxes on road transport fuels and charges for road use. It also proposes that taxes and charges should be used to differentiate prices across 'time, space and modes'.

The external costs of transport in the EU are estimated to amount to around 8 % of gross domestic product. Motorised road transport — which takes the highest share in both freight and passenger trips — accounts for more than 90 % of these costs (INFRAS/IWW, 2000). Accidents, noise, air pollution and climate change are the most important external costs.

Freight transport is estimated to be responsible for 35 % of total external costs. For freight, water and rail transport have the lowest external costs per tonne-km, with air transport and trucking 10 and five times, respectively, more than rail.

**Average external costs of freight transport by transport mode and cost category (excluding congestion costs and uncovered parking costs) — EUR 17, 1995**

Figure 15.




**Source**: INFRAS/IWW, 2000

*4.4.1. Eurovignette*

Current European law does not allow Member States to levy road charges above the level of infrastructure costs. According to Directive 93/89/EWG on the application of taxes on certain vehicles and user charges for the use of certain infrastructures (the 'Eurovignette directive') the aim of the Eurovignette system is to internalise infrastructure costs into the calculation of road use charges. Because of the damages caused to road infrastructure heavy goods vehicles are charged annual fees. Charges are based on emissions (EURO standard) and the size of the vehicle (number of axles) and range from EUR 750 to EUR 1 550 per year. The system is restricted to seven EU Member States (Austria, Belgium, Denmark, Germany, Luxembourg, Netherlands and Sweden) which do not levy motorway tolls. Vehicles registered in Greece are allowed a 50 % reduction in rates because of the country's geopolitical position.

The Eurovignette represents a fixed cost which does not take into account the annual mileage per vehicle; it therefore fulfils only to a very small extent the 'user pays' principle and is not an adequate instrument for internalisation of external costs.

In Austria the application of the Eurovignette was introduced stepwise (see Figure 16). Between 1978 and 1994 the annual fee for HDVs (gross weight larger than 18 tonnes) amounted to approximately ATS 80 000 (EUR 5 800). This sum was reduced between 1995 and 1997, and after 1997 was equivalent to the EU-level of about ATS 16 700 (EUR 1 200), which represents a substantial reduction to nearly a fifth of the original level.

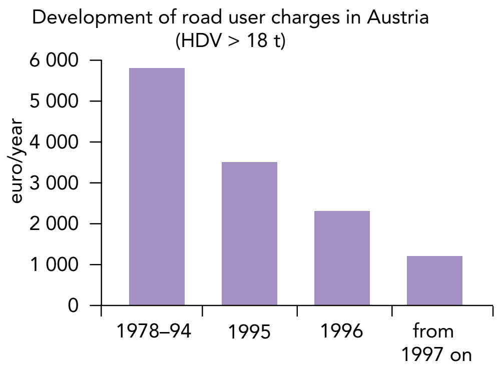
The reduction in road user charges was a price signal in the wrong direction, and has been a factor in the increase in road freight transport in Austria.

*4.4.2. Ecopoints system*

The Ecopoints system was introduced in Austria to control the growth of transit road traffic (see Box 1). As a consequence of Austria's geographical position the north-south route crossing the Alps is of special importance. The strategy is to charge heavy goods vehicles according to their emission levels ($NO_x$) each time the vehicle transits Austria. The lower the

Figure 16. **Road user charges — Austria**

**Source**: Trafico




$NO_x$ emissions, the less is paid. The total number of available ecopoints is limited. Until a certain target (60 % reduction by 2003 compared to 1991) is achieved, the total number will be reduced gradually year by year. In addition to the environmental $NO_x$ reduction target, the ecopoint system also foresees an upper ceiling of for the number of annual transit trips, i.e. these should not be more than 108 % of 1991 numbers.

Because the share of road freight transport (light-duty vehicles (LDVs) and HDVs) increased significantly in the past few decades, road traffic $NO_x$ emissions only decreased slightly in Austria. Whereas in 1980 HDVs were responsible for 33 % of the transport-related $NO_x$ emissions, in 1999 the share had increased to 51 %.

As a result of the ecopoint system introduced in 1991, $NO_x$ emissions per vehicle decreased on the Brenner route, but the achievements of the ecopoint system have been offset by the growth rate of road transport. Other emissions like those of $CO_2$ and noise have not so far been reduced. A detailed description of the effects on the Brenner route is given in Annex 1.

***4.4.3. Road kilometre charging***

The Commission is planning to revise the current road charging regime (including the Eurovignette system), to comply with the policy outlined in the White Paper (European Commission, 2001b) and to provide a charging regime which can keep the positive elements of the Austrian Ecopoints system. The White Paper develops the following guidelines:

- harmonisation of fuel taxation for commercial users, particularly in road transport;
- alignment of the principles for charging for infrastructure use; the integration of external costs must encourage the use of modes of lesser environmental impact and, using the revenue raised in the process, allow investment in new infrastructure.

The Commission plans to propose a framework directive in 2002 to establish the principles of infrastructure charging and a pricing structure for all modes of transport. This would include the option — in certain sensitive areas — to levy tolls or fees on the entire area in order to finance future infrastructure should there be insufficient surplus revenue where, for example, infrastructure has to be built across natural barriers.

A number of countries have already moved in the direction of road kilometre pricing. Switzerland has already introduced a distance-related fee for HDVs on all roads effective from January 2001. This measure is connected to a gradual increase in the total weight of lorries allowed on Swiss roads from 28 tonnes to 40 tonnes. According to the emission standards of the vehicle, EUR 0.009–0.013/tonne-km of the total admissible weight will be charged. For a 40-tonne lorry this equates to EUR 0.35–0.50/vehicle-km. Transit trips will be levied an additional charge, starting in 2008 at the latest. Apart from the distance travelled within Switzerland, Alps crossings are registered electronically.

Germany intends to replace the Eurovignette with a kilometre charge (for vehicles over 12 tonnes) from the beginning of 2003. The charge will be based on infrastructure costs and not external costs, and will vary with weight and vehicle emissions. Austria is also planning to introduce a kilometre charging scheme on motorways and principal roads in 2003. The Netherlands has announced plans to introduce kilometre road charging between 2004 and 2006.

#### *4.4.4. Night ban for 'noisy' lorries; higher toll levies during night hours*

In 1976 Austria introduced a weekend ban on lorries. At weekends, from 15.00 hrs on Saturday until 24.00 hrs on Sunday, the use of lorries with a maximum weight of more than 3.5 tonnes was prohibited (with exemptions for lorries carrying food and for maintenance vehicles). In 1989 (by 1 December 1989) a night ban on all lorries with a total weight of more than 7.5 tonnes, except low-noise lorries (lärmarme Lkws) was introduced on the Brenner route (Kufstein-Brenner). In addition in 1994 (by 1 January 1995) a night ban for all lorries with a total weight more than 7.5 tonnes, except low-noise lorries was extended to the whole of Austria.

In 1996, to give more incentives for the use of greener lorries and combined transport and to reduce the noise impact at night, toll levies during night hours (22.00 to 6.00 hrs) were doubled on the Brenner motorway. These measures on the one hand resulted in a decrease in road transport and on the other hand in an increase in transported lorries on the Rollende Landstrasse (see Annex 1).

In accordance with these regulations, combined transport services — and piggyback services — have been improved on several transit routes. In combined transport, lorries are allowed to use roads from or to a terminal if the stretch is no longer than 65 km.

### 4.5. Revitalisation of rail, inland waterways and short sea shipping

The European Community's freight strategy focuses mainly on the promotion of intermodal and combined transport, and the revitalisation of railways, inland waterways and short sea shipping. The trans-European transport network is a main element in this strategy.

#### *4.5.1. The trans-European transport network (TEN-T)*

In 1996 the European Parliament and the European Council adopted Decision 1692/96/EC on guidelines for the development of the TEN-T by 2010. This decision groups together, in a single reference framework, the priority projects initially adopted by the European Council and the outline plans for identifying other projects of common interest.

The main objective of the TEN-T is to develop a better integrated and multi-modal transport system in the EU, and hence to contribute to growth, competitiveness and employment in Europe. An additional aim is to improve economic and social cohesion by better linking of peripheral regions to EU networks.

The European Commission recently issued a proposal to amend the TEN-T Guidelines (European Commission, 2001a). The amendment aims at reversing the current trend towards a strong increase in road share and a decline in environment-friendly modes of transport. The strategy includes elements such as concentrating infrastructure financing on creating quality alternatives to roads. Priorities would be projects to eliminate bottlenecks such as cross-border interconnections, freight rail, rail connections to ports and airports, and high-speed lines.

The TEN-T network is, under current plans, made up of some 75 185 km of roads, 20 609 km of which are planned, 79 440 km of conventional and high-speed railway lines, 23 005 km of which are planned, 381 airports, 273 international seaports and 210 inland ports. In addition, the network includes traffic management, user information and navigation systems. The trans-European network accounts for almost half of total goods and passenger traffic in the EU.

The TEN-T investment plan (originally estimated to be in excess of EUR 400 billion up to 2010) was initially intended to have a 60 % rail, 30 % motorway and 10 % 'other' split, with rail investment mainly for the high-speed network. This targeted share has, however, to date been far from achieved, especially as the road network implementation is running ahead of other projects. It is expected that most of the road links planned will be completed by 2010, but the railway and inland waterway network components will probably not be fully completed. The indicative multiannual programme of the TEN-T budget adopted by the Commission on 19 September 2001 already provides for total aid of 822 million for the period 2001–06.

Two TEN-T projects which involve the construction of long Alpine tunnels are experiencing difficulties due to technical and financial uncertainty and the timetable. These two projects, the Lyon-Turin tunnel and the Brenner tunnel, are considered by the Commission to be essential for the development of intermodality in the Alps. A high-capacity rail link through the Pyrenees is one of the new proposed projects.

As part of the enlargement process, the Commission and several of the Member States are supporting the development of 10 pan-European transport corridors and four pan-European transport regions. The projects for these corridors are being supported financially by the Commission through the Instrument for Structural Policies for Pre-Accession and the Transport Infrastructure Needs Assessment process (TINA).

As requested by the 1996 decision on the guidelines, the Commission has developed methods for the strategic environmental assessment of the whole network and of its corridors. To date, however, no strategic assessment has been made of the network's potential environmental and socio-economic impacts.

#### *4.5.2. The 'Railway package'*

In 1998 the Commission tabled three proposals concerning railway infrastructure dubbed the 'infrastructure package'. The purpose of the first proposal for a directive is to make the various activities of the rail sector more transparent by ensuring separate accounting for infrastructure management and rail services. The second proposal aims to extend the provisions of Directive 95/18/EC on licensing to all the railway undertakings in the Community, irrespective of whether they offer the services referred to in Article 10 of Directive 91/440/EEC, in order to prevent licences becoming an obstacle to market entry. The third proposal envisages replacing Directive 95/19/EC by a new directive on the allocation of railway infrastructure capacity and charges for the use of railway infrastructure (to be calculated on the basis of marginal costs).

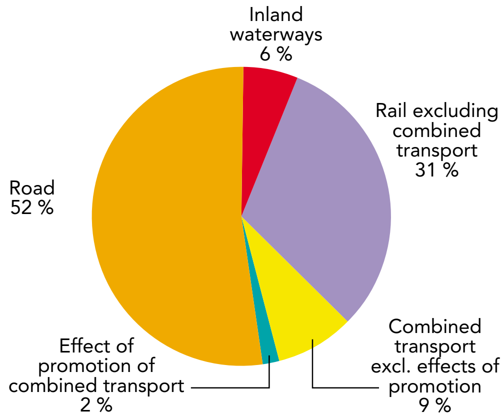
The creation of a European railway system will revitalise rail transport, which must once again become a competitive transport mode and offer a real alternative to road transport. The aim of the recently adopted 'railway package' (EP, 2000) is to create a legislative framework enabling the railway undertakings to provide better services to their customers. It proposes measures to enhance transparency in the rail sector: opening up of rail freight transport, separation of transport operations and essential functions relating to capacity allocation and infrastructure charging, improved safety, greater efficiency and increased harmonisation of the rules and procedures at European level.

#### *4.5.3. State aid for rail and combined transport*

In accordance with the EC Treaty (pursuant to Article 93(3)), there exist serveral programmes both at EU and at national level for giving subsidies to rail and combined transport in order to compensate for the negative external effects per goods tonne-km, which are far worse for transport by road than transport by rail.

At EU level, PACT — the pilot actions for combined transport programme — should encourage traffic to move from road to other modes of transport such as rail and ship. At a national level, Danish state aid — an environmental subsidy for the transport of goods by rail — tries to promote more rail transport. In Austria a programme for the promotion of combined freight transport by road, rail and ship ran from 1992 to 1996. Grants and aid for investment in combined transport at the interfaces between road, rail and ship modes have been offered to carriers, shipping companies and operators in combined transport, terminals, ports and transshipment facilities. An evaluation of the programme shows that the effects are quite positive. The programme led to a 2 % higher share in combined transport in Austria (see ?). It should be noted that combined transport has an 11 % share in long-distance freight transport in Austria, whereas the figure for the whole of Europe is rather low at 5 %.

**Share of modes in Austria's long-distance freight transport volume, 1997** | Figure 17.




**Source**: Käfer et al., 1999

Due to Austria's geographical situation, the positive effects of this programme can also be noticed to a great extent outside Austria. The success of the programme resulted in its extension to 2002.

### 4.6. The Alpine Convention and its transport protocol

Mountains are widely recognised as important and sensitive ecosystems, but little progress has been made in developing comprehensive policies, particularly at EU level, to build upon the good intentions set out in mountain charters.

Mountains are subject to various types of policy measure. Policy approaches may propose a general mountain policy, may target certain mountain ranges, may affect mountains directly without distinguishing between different mountain areas, or may have purely incidental effects on mountain areas.

Mountains have been directly addressed in few policy documents. On a global scale mountains have been recognised by Article 13 of Agenda 21 as highly sensitive ecosystems and an important source of natural resources. On the European scale the inter-governmental consultation on sustainable mountain development 1996 recommended the need to work towards an integrated policy framework for sustainable mountain development, environmentally sustainable mountain action plans and programmes as well as more sustainable sectoral policies and the assessment of impacts of existing national and European policies. All European mountains have been covered by the European charter on mountain areas (1994) to be elaborated into a European convention on mountain areas. The charter covers almost every political sector which affects mountains and requires a 'comprehensive spatial policy' for mountain areas.

For the Pyrenees, a special charter has been adopted, and efforts are beginning towards the development of charters in the Carpathians and Caucasus. Underlying the Charter for the Protection of the Pyrenees (CIAPP, 1995) are three key objectives: to protect the environment, to allow access for visitors and to support environmentally sustainable economic development.

Much more detailed is the framework of the Alpine Convention signed in 1991 by Austria, France, Germany, Italy, Lichtenstein, Monaco, Slovenia, Switzerland and the EU. Since 1990 several protocols which define the principles for different sectors have been drawn up, signed, or are under discussion.

The transport protocol was signed on 31 October 2000 by all states, except Slovenia, and the EU. It is the first internationally binding agreement on a common approach to transport policy in the Alpine region. The transport protocol is based on the common understanding that among other things the Alpine region is an ecologically sensitive area and that transport has negative environmental and health-related impacts.

The transport protocol has some strong clauses concerning transport and environment-related policy:

- not constructing new high-capacity roads for transalpine traffic (motorways, freeways);
- construction of new trunk roads for inner-alpine traffic only under strict conditions concerning the environment- and transport-related (e.g. potential modal shifts) impact;
- commitment to international consultation on measures with cross-border impact;
- commitment to improve public transport;
- improvement and modernisation of the rail infrastructure, especially measures for modal shift in long-distance freight transport and promotion of intermodality (rail, coastal ship, intermodal terminals);
- stepwise introduction of pricing systems in order to internalise social costs;
- creation of car-free tourist resorts and measures to improve car-free mobility for tourists in the Alpine region;
- agreement to set environmental quality standards and environmental goals and indicators based on the specific conditions of the Alpine region;
- consideration of the negative environmental impacts of air traffic.

# 5. Measures needed

Given the international dimension of the transport system in mountainous areas, measures can only be effective if international concerted strategies and action are agreed.

A further reduction of $NO_x$ emissions per vehicle under real driving conditions can be achieved through stricter emission standards and technology improvements. However, technological measures alone may not succeed in reducing the environmental impacts of traffic below the critical levels and critical loads in the mountainous areas.

Additional measures are needed to restrain transport growth, and in particular to limit the number of heavy-duty vehicles (HDVs) passing through sensitive areas. Measures could include the improvement of logistics, infrastructure measures, the promotion of rail, inland waterways and combined transport, the use of economic instruments (e.g. road pricing), driver training and provision of information.

Road pricing should be differentiated according to the vehicle's environmental characteristics (emissions of pollutants, noise emissions, etc.), distance driven and location. Investigations should be made as to whether pricing policies could be differentiated according to the degree of sensitivity of the region or certain transport routes. This would require the development of EU criteria for the identification of sensitive routes or areas.

Efforts to improve the technology for road (vehicles and pavement) and rail are necessary to reduce the specific characteristics of noise spread in mountainous areas. Speed limits should further help to decrease noise nuisance. In addition, traffic suspension for HDVs at night not only reduces noise nuisance, but would also lower $NO_x$ peak concentrations during unfavourable nocturnal dispersion conditions. Detailed examinations of measurements conducted have clearly shown the positive effects of a suspension of HDVs at night and weekends.

The recently adopted OECD guidelines for environmentally sustainable transport emphasise that the development of objectives and targets is a prerequisite for steering transport strategies in mountainous areas into a sustainable direction (Box 4). Such targets should be agreed internationally and should address both the freight transport system (e.g. targets for traffic growth management and for modal split) and its environmental impacts. As also emphasised in the recently signed transport protocol of the Alpine Convention, progress towards such targets should be regularly monitored on the basis of a set of carefully selected indicators.

**Box 4: OECD guidelines for environmentally sustainable transport (EST)**

Guideline 1. **Develop a long-term vision of a desirable transport future** that is sustainable for environment and health and provides the benefits of mobility and access.

Guideline 2. **Assess long-term transport trends**, considering all aspects of transport, their health and environmental impacts, and the economic and social implications of continuing with 'business as usual'.

Guideline 3. **Define health and environmental quality objectives** based on health and environmental criteria, standards and sustainability requirements.

Guideline 4. **Set quantified, sector-specific targets** derived from the environmental and health quality objectives, and set target dates and milestones.

Guideline 5. **Identify strategies to achieve EST** and combinations of measures to ensure technological improvements and changes in transport activity.

Guideline 6. **Assess the social and economic implications** of the vision, and ensure that they are consistent with social and economic sustainability.

Guideline 7. **Construct packages of measures and instruments** for reaching the milestones and targets of EST. Highlight 'win-win' strategies incorporating, in particular, technology policy, infrastructure investment, pricing, transport demand and traffic management, improvement of public transport, and encouragement of walking and cycling; capture synergies (e.g. those contributing to improved road safety) and avoid counteracting effects among instruments.

Guideline 8. **Develop an implementation plan** that involves the well-phased application of packages of instruments capable of achieving EST, taking into account local, regional and national circumstances. Set a clear timetable and assign responsibilities for implementation. Assess whether proposed policies, plans and programmes contribute to or counteract EST in transport and associated sectors using tools such as strategic environmental assessment (SEA).

Guideline 9. **Set provisions for monitoring implementation and for public reporting on the EST strategy**; use consistent, well-defined sustainable transport indicators to communicate the results; ensure follow-up action to adapt the strategy according to inputs received and new scientific evidence.

Guideline 10. **Build broad support and cooperation for implementing EST**; involve concerned parties, ensure their active support and commitment, and enable broad public participation; raise public awareness and provide education programmes. Ensure that all actions are consistent with global responsibility for sustainable development.

**Source**: OECD, 2000a.

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# Glossary

| | |
|---|---|
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| dB(A) | international sound pressure level unit meaning ‘decibel with an A frequency weighting’ which reflects the sensitivity of the human ear |
| $dm^3$ | cubic decimetre (= litre) |
| ESC | European stationary cycle |
| ELR | European load response cycle |
| ETC | European transient cycle |
| ETC-AE | European Topic Centre Air Emissions |
| Euro I | Vehicles that comply with the emission standards as defined in Directive 93/59/EEC |
| Euro II | Vehicles that comply with the emission standards as defined in Directive 94/12/EC |
| Eurostat | Statistical Office of the European Union |
| g/kWh | gram per kilowatt-hour |
| GVW | gross vehicle weight |
| ha | hectare |
| HC | hydrocarbon |
| HDV | heavy-duty vehicle (more than 18 tonnes) |
| km | kilometre |
| $km^2$ | square kilometre |
| $L_{Aeq}$ | energy equivalent sound pressure level in dB(A) |
| $L_{dn}$ | day-night level, is a descriptor of noise level based on energy equivalent noise level (Leq) over the whole day with a penalty of 10 dB(A) for night-time noise (22.00-07.00 hours). |
| $m^3$ | cubic metre |
| m/m | mass per mass |
| mg/kg | milligram per kilogram |
| MJ/tkm | mega-Joule per tonne-kilometre |
| NMVOC | non-methane volatile organic compound |
| $NO_x$ | nitrogen oxides |
| PM | particulate matter |
| $PM_{10}$ | respirable particulate matter with aerodynamic diameter between 2.5 and 10 µm |
| TRENDS | transport and environment database system |
| µg | microgram |
| UNECE | United Nations Economic Commission for Europe |
| VOC | volatile organic compound |
| t | tonne |

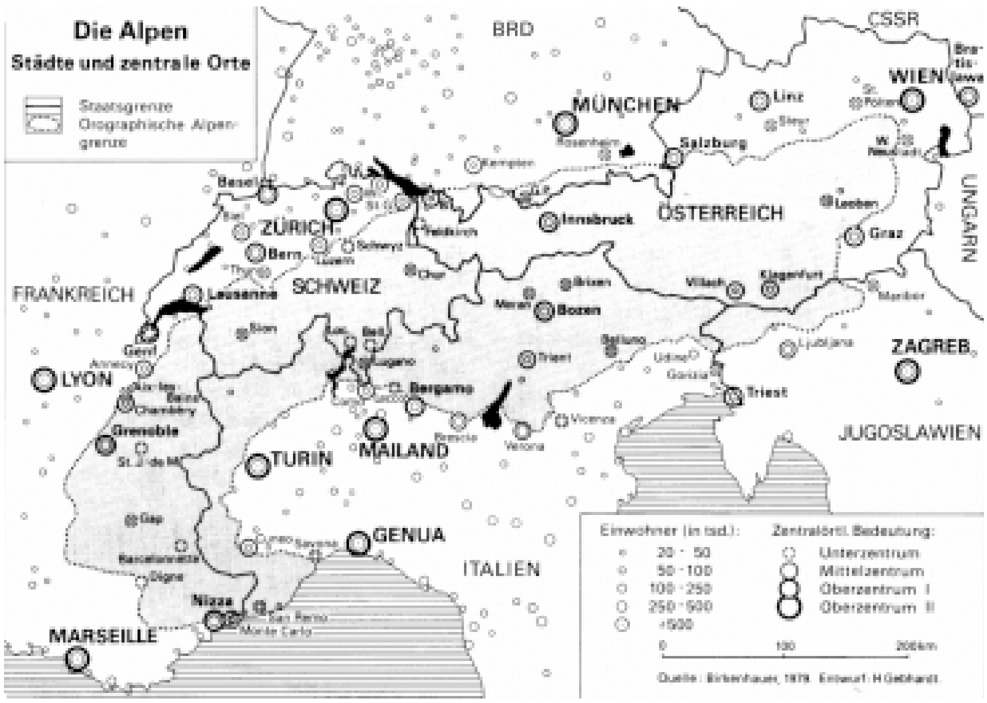
# Annex: Case studies

# Alpine region

***Definition of the Alpine region***
According to Bätzing (1991), who defines the Alpine region based on the orographic borderline of the Alps, the Alpine region stretches from Nice to the Viennese basin. In the Alpine Convention the area covered by the Alpine region is slightly, but very negligibly larger.

| **Alpine region** | Map A1. |
|---|---|

**Source**: Bätzing, W., 1991




For the exchange of goods between northern and southern Europe, only a limited amount of adequate high-capacity transport infrastructure is available. The consequence is that traffic is concentrated on these routes. For road freight transport the routes cross the following passes:

- Ventimiglia (motorway A8/A10), Fréjus tunnel (motorway A43/N506/N6), Mont Blanc tunnel (motorway A40/N205/A5 to Chamonix — closed to all traffic since 24 March 1999) for France;
- Gr. St Bernhard (federal road 21/27), Gotthard (motorway N2), San Bernardino (N13) for Switzerland;
- Reschen (federal road B315), Brenner (motorway A12/A13), Felbertauern (federal road B108), Tauern (motorway A10), Schoberpass (motorway A9/federal road B138), Semmering (motorway S31, federal road B306), Wechsel (motorway A2) for Austria.

For rail freight transport these passes are:

- Ventimiglia (two tracks electrified), Mont Cénis tunnel (two tracks electrified) for France;
- Simplon (two tracks electrified with single track sections), Gotthard (two tracks electrified) for Switzerland;

- Brenner (two tracks electrified), Tauern (two tracks electrified with single-track sections), Schoberpass (two tracks electrified with single-track sections), Semmering (two tracks electrified), Wechsel (single track, not electrified) for Austria.

Other existing passes and routes are of only local or regional importance.

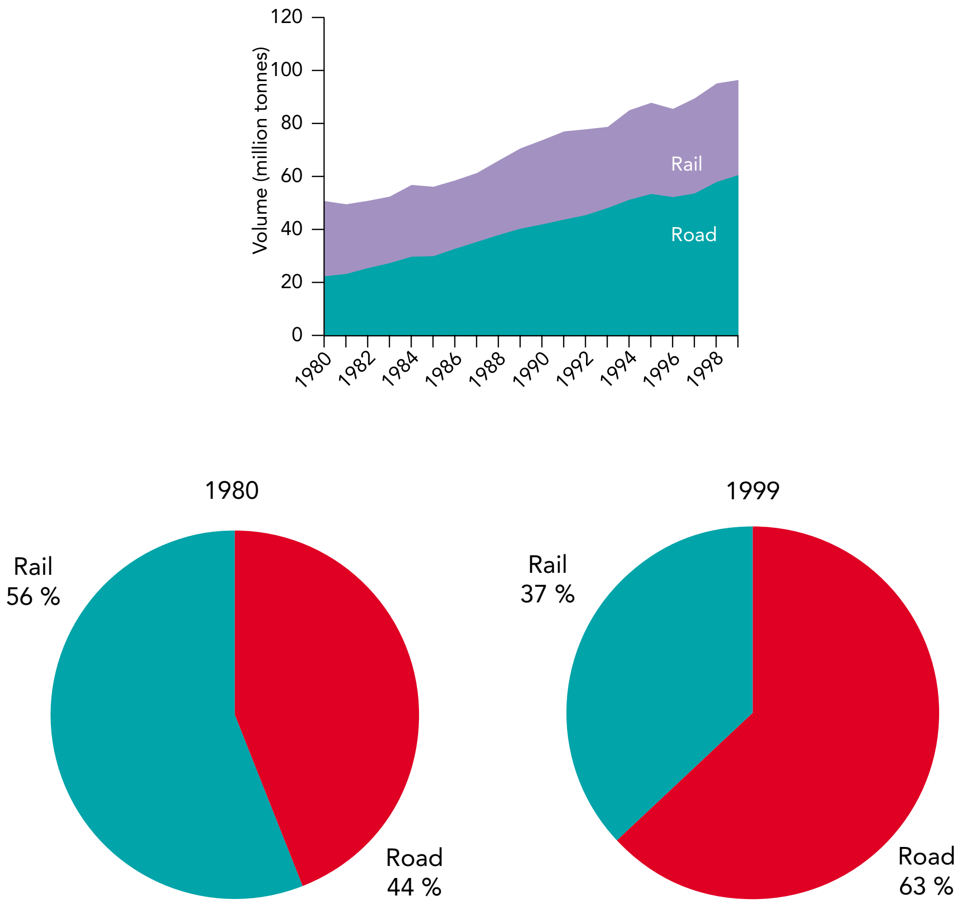
***Definition of transalpine freight transport***
Transalpine freight transport is defined as freight transport passing through the main Alps in a north-south direction or vice versa. Freight transport on the Arlberg route (east-west) is not included, unless it later uses another north-south route (e.g. the Brenner route).

***Growth of transalpine freight transport***
During the past few decades transalpine freight transport on the eight major routes in the central area of the Alpine arc from Mont Cénis to Brenner has experienced undiminished growth. In total, transalpine freight transport grew from 50.4 million tonnes in 1980 to 96.4 million tonnes in 1999 in this particular section of the Alpine arc: almost a doubling of transport volume. Rail freight transport grew by only 26 % from 1980 to 1999, whereas road freight transport nearly tripled from 1980 to 1999 (+171 %) (Figure A1).

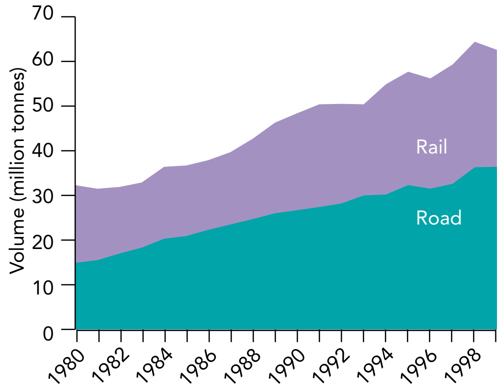
Transalpine transit freight traffic growth was slightly stronger than total transalpine freight transport. It went up from 32.3 million tonnes in 1980 to 62.6 million tonnes in 1999. The changes in modal split are similar to those for total transalpine freight transport (Figure A2).

Figure A1. **Development of transalpine freight transport (Mont Cénis-Brenner) 1980–99**

**Source**: UVEK/GVF, 2000



Development of transalpine transit freight transport (Mont Cénis-Brenner) 1980–99 | Figure A2.




**Sources**: UVEK/GVF, 2000; UVEK/GVF, 1999; UVEK/GVF, 1996

Among the 14 major transalpine routes, the Brenner has the highest volume of freight transport, totalling 33.5 million tonnes in 1999. The Mont Cénis/Fréjus (32 million tonnes in 1999) and the Gotthard (21.9 million tonnes in 1999) routes are also heavily used. In 1999 the situation changed dramatically as the lion's share of the transport volume of the Mont Blanc tunnel was diverted after March 1999 onto the Mont Cénis/Fréjus route. In 1998 the Mont Blanc tunnel showed a transport volume of 13.5 million tonnes (road only).

As far as shares of transit traffic are included, the Brenner route and the Gotthard route are again the most important routes for north-south freight transport. On the Gotthard route rail is the dominant means of transport, whereas on the Brenner route road is more important (Figure A3).

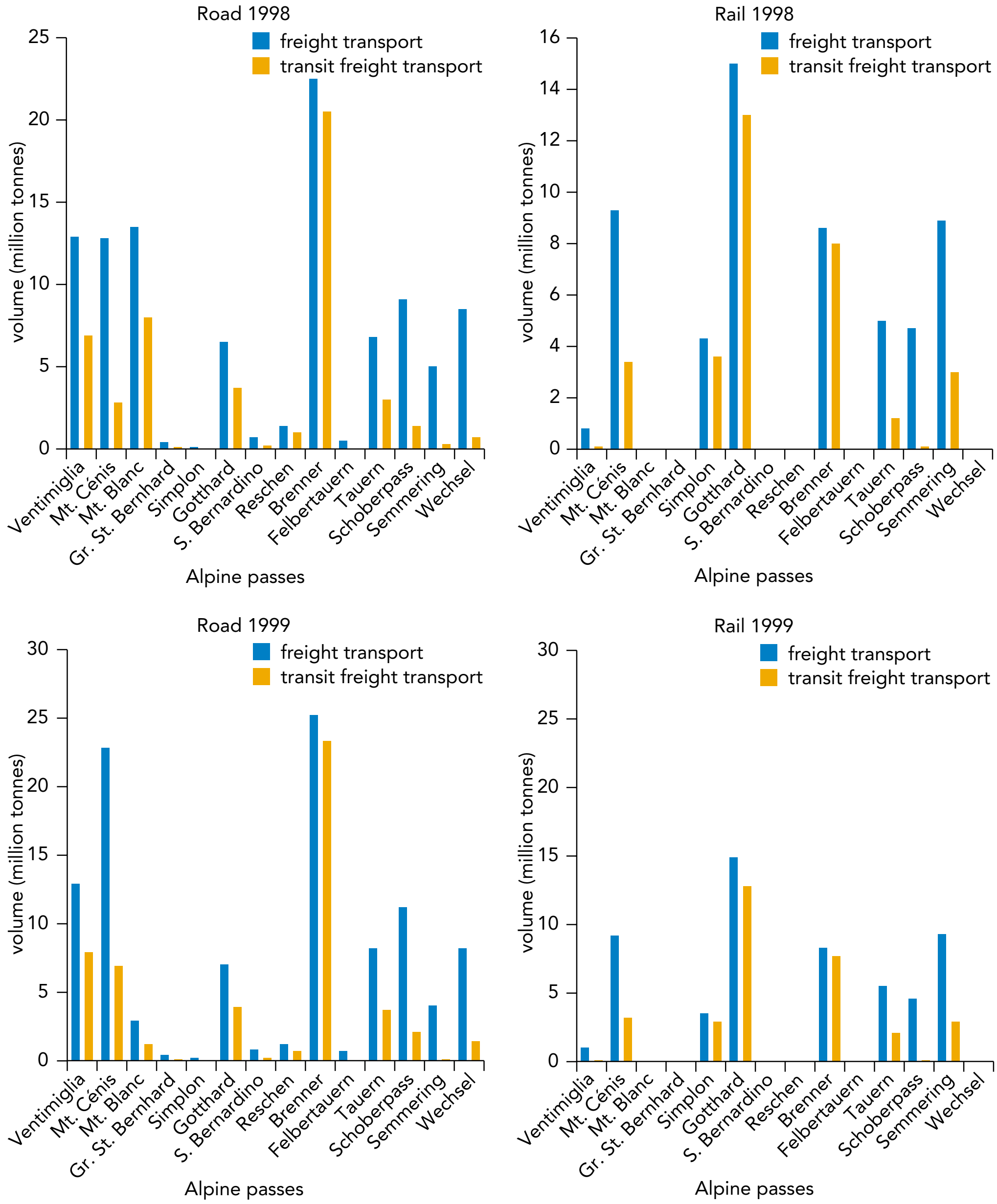
***Enlargement of the EU and effects on transalpine transport***
The share of transport flows of transalpine transit transport between the acceding countries and the EU is still low compared with intra-union transalpine transit transport flows. In order to assess the impact, changes in the volume of transalpine transit transport using Austrian Alpine passes to move between the acceding countries and the EU in 1994 and in 1999 have been analysed. In the western Austrian Alpine passes (Reschen and Brenner including the Rollende Landstrasse) the share of transalpine transit transport between the acceding countries and the EU grew from 3 % to 5 %; in the central Austrian Alpine passes (Tauern and Schoberpass including the Rollende Landstrasse) the share of transalpine transit transport between the acceding countries and the EU dropped from 63 % to 46 %; and in the eastern passes (Semmering and Wechsel) the share of transalpine transit transport between the acceding countries and the EU was unchanged at almost 100 %. In total the volume of transalpine transit transport through Austria between the acceding countries and the EU grew from 2.6 million tonnes in 1994 to 5.8 million tonnes in 1999 and the share of transalpine transit transport grew from 12 % to 17 %. Total transalpine transit transport through Austria grew from 20.9 million tonnes in 1994 to 34.3 million tonnes in 1999.

On the one hand, it is clear that the volumes and the share of transalpine transit transport between the acceding countries and the EU will grow substantially after enlargement of the EU. On the other hand, the main routes of these flows are the Alpine passes on the eastern part of the Austrian Alpine arc, which might be by-passed in future (routes via Hungary to Slovenia and Italy with no steep slopes). The share of transit transport using the by-pass routes via Hungary will also depend on future road infrastructure.

Currently heavy-duty vehicle (HDV) traffic with the acceding countries is controlled by bilateral and multilateral quotas. The multilateral quotas are agreed within the European Conference of Ministers of Transport (ECMT). The ECMT quota system is based on a number of conventional licences (usually 16 per country). According to the Euro classification, a country can switch to another class if the HDV fleet is upgraded technically.

Figure A3. **Distribution of transalpine freight transport on the different routes in 1998 and 1999**

**Sources**: UVEK/GVF, 2000; UVEK/GVF, 1999




In this way countries may join the 'green' HDV system or the 'greener and safe' HDV system. The number of licences in the basic quota is raised in a ratio of 1 : 2 by each following class (16 conventional : 32 green : 64 greener and safe licences). Although a number of technical improvements in vehicle technology are likely, emissions from HDVs, in particular emissions of nitrogen oxides ($NO_x$), will not be sufficiently reduced to compensate for the increased number of vehicles. Therefore the negative impacts on the environment continue to increase, although it was assumed that technical improvements would also bring environmental improvements.

It can be assumed that after the full accession process HDV traffic with the acceding countries will be opened up totally. Pressure on the environment will increase heavily. Furthermore the volume of traffic will rise on the east-west Danube axes.

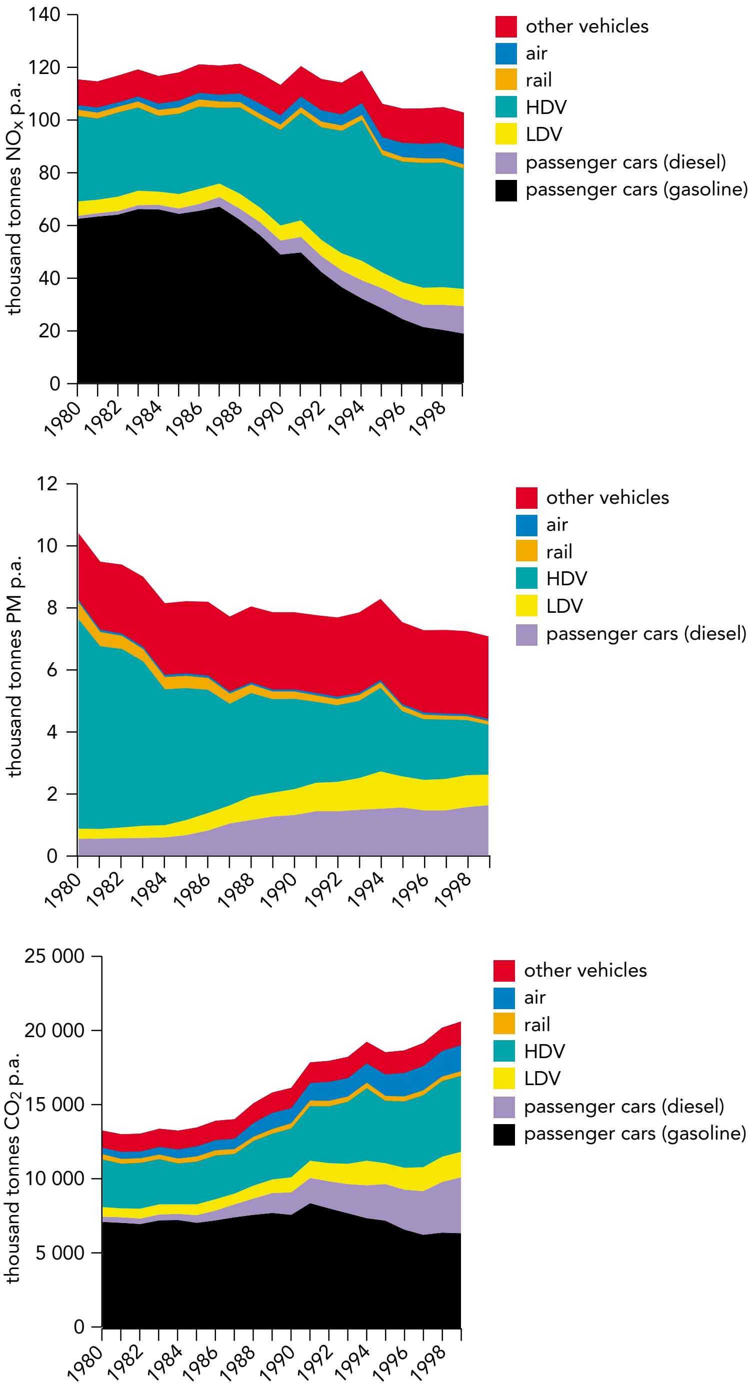
Detailed analyses are necessary in order to assess properly the future impact of the enlargement of the EU on transalpine transport. Nevertheless the share of transalpine transit transport between the acceding countries and the EU will grow and aggravate the environmental situation in the Alpine valleys.

***Development of emissions from motor vehicles in Austria***

An analysis has been made of the trends in emissions of selected pollutants $NO_x$, particulate matter (PM) and carbon dioxide ($CO_2$) over the past 20 years.

**Development of $NO_x$, PM and $CO_2$ emissions from transport in Austria 1980–99**

Figure A4.



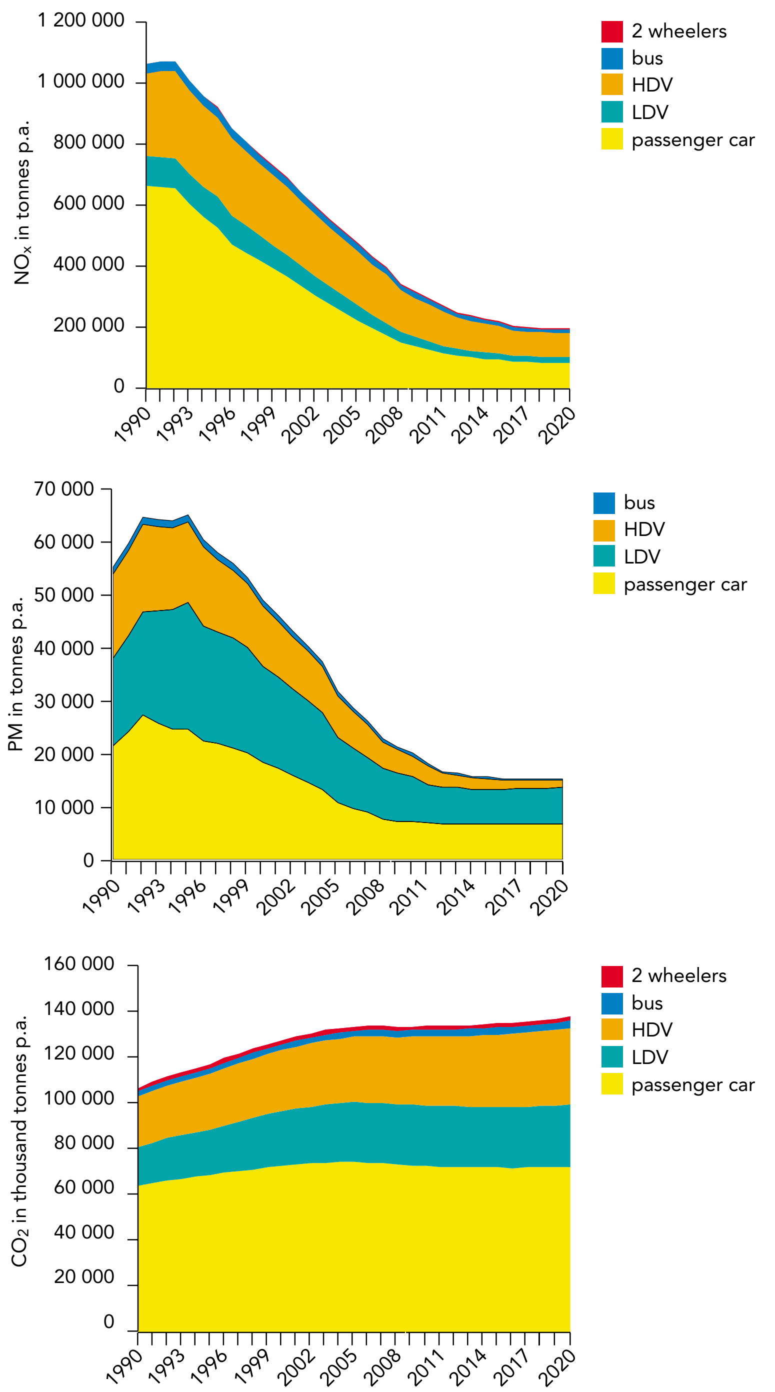

**Source**: Data from Umweltbundesamt, 2000

There has been a slight decrease in $NO_x$, a key pollutant of road traffic in the past 20 years in Austria, as the share of road freight transport (light-duty vehicles (LDVs) and HDVs) has increased significantly. In 1980 HDVs were responsible for 33 % of the transport-related $NO_x$ emissions whereas in 1999 their share had grown to 51 %.

The share of road freight transport grew slightly in transport-related $CO_2$ emissions in Austria. For PM emissions however, the trend is different. The growing share of diesel-powered passenger cars in Austria from the turn of the 1980s to the 1990s was responsible

**Figure A5.** **Development of $NO_x$, PM and $CO_2$ emissions from transport in France 1990–99 and projections to 2020**

**Source**: CEC, 1999



for the rise in particulates emitted by passenger cars. Other vehicles (mainly tractors, agriculture motor vehicles and construction machines) have very high PM emissions because of the age of the vehicle fleet and therefore the low penetration rate of recent environmental standards and low environmental standards in general.

To conclude, the figures for Austria show that HDVs are responsible for a significant share of emissions from road transport; increasing freight emissions from $NO_x$ and $CO_2$ are in particular offsetting emission reductions achieved by passenger transport (Figure A4).

***Development of emissions from motor vehicles in France***

The trend in emissions of selected pollutants $NO_x$, PM and $CO_2$ has been analysed over the past 10 years, and a projection made for the Auto Oil Programme II.

There was a reduction in $NO_x$, a key pollutant of road traffic, after 1993 with the introduction of catalytic converters for passenger cars (Euro I). For HDVs there has been less reduction in $NO_x$ emissions. Therefore the share of HDVs in $NO_x$ emissions from motor vehicles has been growing and the projection for 2020 shows that their share will continue to grow. In 1990 HDVs were responsible for 26 % of the motor vehicle-related $NO_x$ emissions whereas in 1999 the share had grown to 29 %. By 2020 HDVs will be responsible for about 40 % of the $NO_x$ emissions from motor vehicles.

A similar trend can be noticed in $CO_2$ emissions. However the contribution made by HDVs to $CO_2$ emissions has not grown as much as in the case of $NO_x$ emissions.

For PM the picture is quite different: the share of PM emissions caused by HDVs will be reduced significantly by 2020.

## 1.1. Brenner

### *1.1.1. Development of traffic*

*Transalpine freight transport*

The Brenner route connects the dynamic regions of southern Germany (Bavaria) and northern Italy (Venetia, Lombardia). It goes from Munich to Verona passing through Austria for 110 kilometres (km) (road and rail). The Brenner pass at the border between Austria and Italy is at an altitude of 1 374 metres (m) — which is the lowest natural crossing of the Alpine arc.

Within Austria, the Brenner transit route consists of the lower Inn valley motorway A12 (75 km) between Kufstein (German border) and Innsbruck (altitude 540 m, capital of the Tyrol), and the Brenner motorway A13 (35 km) in the Wipp valley between Innsbruck and the Brenner pass (Italian border). The lower Inn valley is quite flat and broad (2 km wide) and densely settled; the Wipp valley is comparatively steep and less densely inhabited.

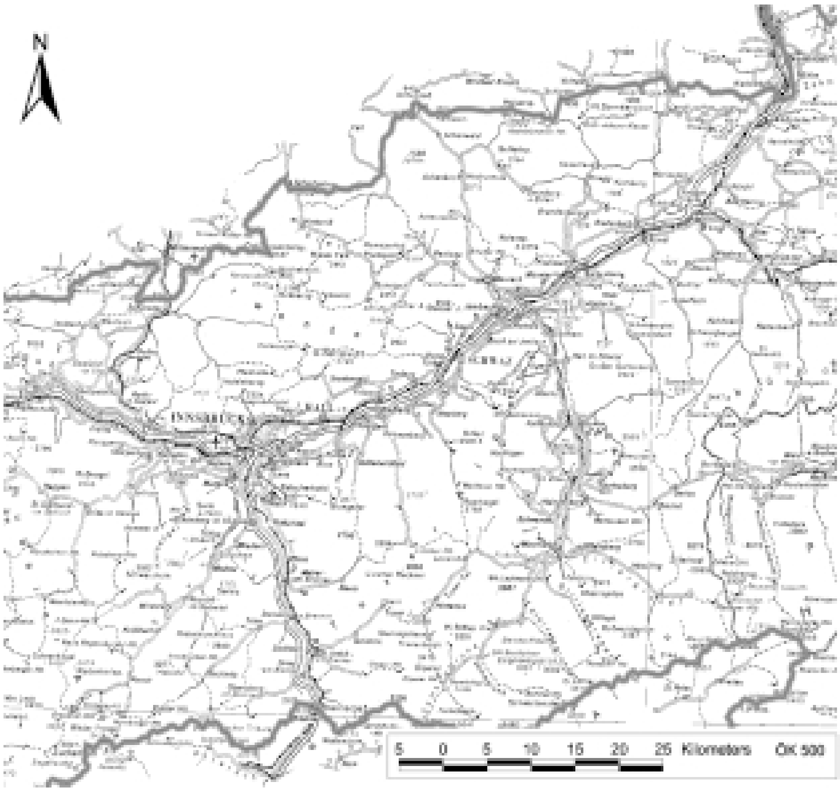
Substantial growth in road transit freight transport has taken place on the Brenner route in the past few decades. Road transport experienced the highest growth in 1976, 1992, 1995, 1998 and 1999. In 1995 new regulations, especially for transport within the EU Member States (lower road user charges, liberalisation of bilateral transport, raising of the maximum weight limits for HDVs and changes in border controls), changed the overall conditions of the transport market (Amt der Tiroler Landesregierung, 2000a).

In 1999 diverted traffic flows during the closure of the Tauern tunnel (and probably also the Mont Blanc tunnel) may have contributed to the high growth in transport volumes registered on the Brenner route (Figure A3).

The decline of road transport at the end of the 1980s and the beginning of the 1990s and in 1995/96 had a different explanation. At the end of the 1980s blockades of the motorway, the night ban for noisy HDVs and the introduction of the piggyback service led to a decline in road and a growth in rail transport. In 1990 the Inn Bridge near Kufstein collapsed, and the motorway was closed for a couple of months leading to a further decline (Figure A3)

Figure A6. **Central Tyrol with the Brenner route**

**Source**: Bundesamt für Eich - und Vermessungswesen, Österreichische Karte (ÖK), 1999




(UVEK/GVF, 1999). In 1996, however, the reduction in road transport was caused by a doubling of the toll levies during night hours (22.00 to 6.00 hrs) on the Brenner motorway.

Rail transport saw growth in the late 1980s and in the early 1990s with the introduction of combined transport. Unaccompanied combined transport was introduced at the beginning of the 1980s. By the end of 1989 a high-capacity service in accompanied combined transport was available, at the same time as the introduction of the night ban for noisy HDVs on the Brenner route.

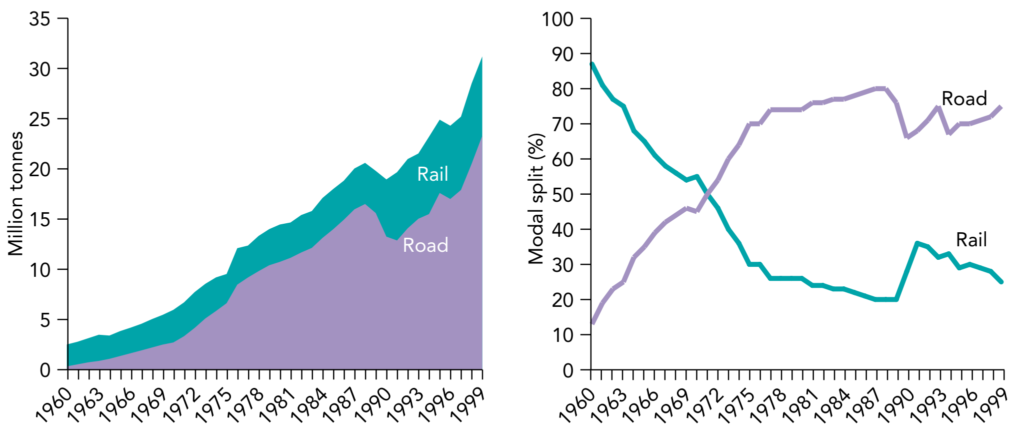
The following services of the piggyback Rollende Landstrasse were available on the Brenner route:

- Munich-Verona from 1982 to May 1992 (user restrictions concerning the size of HDVs due to small tunnel size between Brenner and Verona)
- Brenner-Munich from November 1993 to December 1995
- Brenner-Manching (Ingolstadt) from November 1989 on (gradual extension of capacity: in autumn 2000 15 train pairs were in operation)
- Wörgl-Trento, since early 2000.

In 1997 the services and productivity of the Rollende Landstrasse were improved. These measures brought growth of 9 % for the Rollende Landstrasse in total, and more than 31 % on the Brenner-route.

The volume of freight transport originating from and destined for the Tyrol via Brenner (road and rail) is low compared to the volume of transit freight transport. In 1999 total freight transport on the Brenner route reached a volume of 33.46 million tonnes, of which the volume of transit freight transport was 31.20 million tonnes (93 %). The modal split of origin and destination freight transport was 1.94 million tonnes by road (86 %) and 0.32 million tonnes by rail (14 %) (BMVIT, 2000).

Growth of transit freight transport on the Brenner route from 1960 to 1999 — Figure A7.




**Sources**: BMVIT, 2000; Molitor et al., 1997; UVEK/GVF, 1999

*Other vehicles*
Not only HDVs but also other vehicles such as passenger cars, LDVs or buses are responsible for environmental pressures. In order to evaluate the effects of transalpine freight traffic accurately, changes in the traffic of other vehicles on the Brenner route have to be taken into consideration.

Traffic volume on two cross-sections has been investigated in detail: Vomp on the A12 (lower Inn valley) and Plon on the A13 (Brenner, Wipp valley) (Table A1). In 1999 in Vomp the share of HDVs in overall traffic flow was 16 %, of which about 50 % can be allocated to transit traffic (equivalent to 8 % considering the traffic flow of all vehicles). In Plon the share of HDVs in overall traffic flow was 17.5 %, of which about 80 % can be allocated to transit traffic.

### *1.1.2. Environmental pressure and effects*
The environmental pressure and effects caused by traffic on the Brenner route are analysed below. The analysis is limited to effects on the ambient air quality, noise and the consequences of both on land use and nature.

*$NO_x$ emissions*[1]
Looking at the effects of traffic on the Brenner route on ambient air quality, $NO_x$ emissions — a key traffic-related pollutant — are the most important. On the Brenner route $NO_x$ are only directly emitted by motor vehicles, as the railway is electrified and the traction of the trains is totally electric. Rail $NO_x$ emissions come indirectly from thermal power plants.

A further factor is that for transit traffic through Austria the ecopoint system is in use, based on HDV $NO_x$ emissions.

Road traffic is responsible for about 66 % (8 300 tonnes) of the total $NO_x$ emissions (12 600 tonnes in 1996) in the Tyrol (Schneider, 1999). Of the 8 300 tonnes of $NO_x$ emissions caused by road traffic in the Tyrol, 2 800 tonnes can be attributed to the Brenner route (motorway A12 in the lower Inn valley, A13 in the Wipp valley), of which HDVs account for 1 850 tonnes and transit HDVs for 1 130 tonnes.

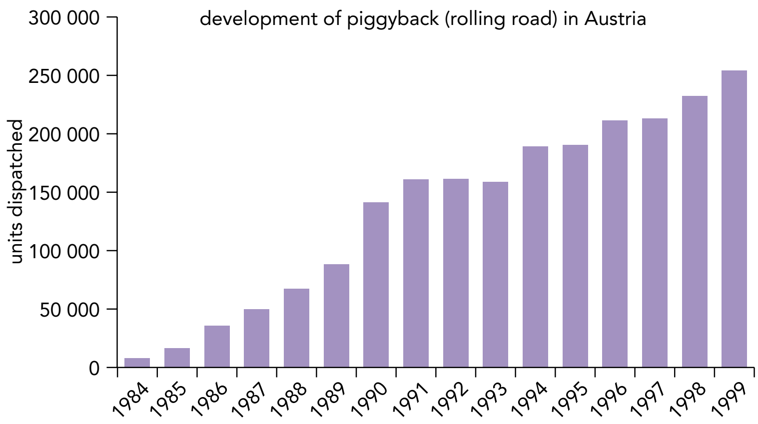
In the lower Inn valley which is the central settlement region in the Tyrol between Kufstein and Innsbruck, traffic emissions (3 700 tonnes) account for 61 % of total $NO_x$ emissions (6 100 tonnes), of which 59 % (2 200 tonnes) can be attributed to the motorway A12, which accounts for 36 % of total $NO_x$ emissions. HDVs contribute 22 % (1 320 tonnes) and transit HDVs 11 % (660 tonnes) to total $NO_x$ emissions in the lower Inn valley.

Figure A9 shows the relative amounts of $NO_x$ emissions from road traffic in the lower Inn valley in 1996. Sections 1 + 2 represent road freight transport (HDVs) on the motorway A12; sections 1 + 2 + 3 represent total $NO_x$ emissions on the motorway A12.

[1] It should be stressed that the following emissions data are estimates based on traffic census, emission parameters per vehicle, fuel consumption, etc., and are subject to large uncertainties, whereas air quality data are directly measured and validated values.

Figure A8. **Development of piggyback services (Rollende Landstrasse) in Austria**

**Source**: Käfer et al., 2000




More detailed calculations of motor vehicle-related $NO_x$ emissions have been made for two selected cross-sections of the Brenner route (Amt der Tiroler Landesregierung, 2000c) [(2)]:

- Vomp on the section Kufstein-Innsbruck located in the Inn valley (motorway A12)
- Plon on the section Innsbruck-Brenner located south of Innsbruck (motorway A13).

Table A2 gives, for the lower Inn valley (A12) and the Wipp valley (A13):

- total $NO_x$ emissions in tonnes per kilometre (t/km)
- $NO_x$ emissions from road freight transport (HDVs) in t/km
- $NO_x$ emissions from HDVs transiting Austria in t/km.

In the lower Inn valley (Vomp, A12) total $NO_x$ emissions per km from traffic slightly decreased from 44.7 t/km in 1980 to 40.1 t/km in 1999. Emissions from both road freight traffic and from transit road freight traffic increased steadily up to 1999. In the Wipp valley (Plon, A13), despite lower total transport volume, NOx emissions per km from HDVs are higher than in the Inn valley because of the road gradient (Figure A10).

Until the early 1990s estimates of $NO_x$ emissions of HDVs in Vomp (A12) and Plon (A13) paralleled road transport volumes. From about 1992 until 1999 $NO_x$ emissions from HDVs showed only slight growth, which did not correspond with the much higher growth of road freight transport. The effect of stricter emission standards for HDVs introduced in 1991 with Euro I and later Euro II clearly shows a decoupling of $NO_x$ emissions and transport volume. Nevertheless the gain through stricter standards was counteracted by the growth rate of road freight transport.

[(2)] The total NOx emissions for the Brenner route (Kufstein-Innsbruck-Brenner) calculated from Amt der Tiroler Landesregierung (2000c) and Wotawa et al. (2000) amount to 2 970 tonnes and are slightly higher than the emissions on the Brenner route of 2 800 tonnes calculated from Schneider (1999).

Table A1. **Development of traffic on the Brenner route**

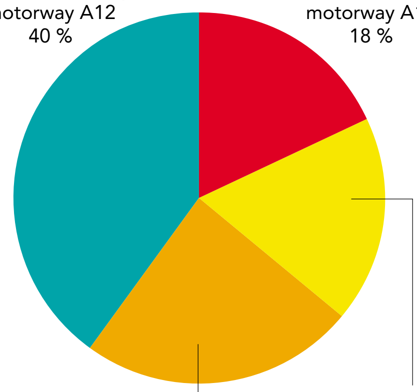
**Source**: Amt der Tiroler Landesregierung, 2000c

| | **Vomp (A12)** | | **Plon (A13)** | |
|---|---|---|---|---|
| | **Other vehicles (passenger cars, LDVs, buses) [veh/24h]** | **HDVs (> 7.5 t) [veh/24h]** | **Other vehicles (passenger cars, LDVs, buses) [veh/24h]** | **HDVs (> 7.5 t) [veh/24h]** |
| 1980 | 23 485 | 3 494 | 13 055 | 2 115 |
| 1990 | 30 118 | 4 651 | 14 686 | 2 374 |
| 1999 | 40 907 | 7 528 | 21 898 | 4 637 |

ADT : average daily traffic

Relative contributions to $NO_x$ emissions from road traffic in the lower Inn valley in 1996

Figure A9.




**Source**: Data from Amt der Tiroler Landesregierung, 2000c

Forecast emissions for the next 10 years show a decline in total traffic emissions in the lower Inn valley (A12) from 40.1 t/km in 1999 to 35.2 t/km in 2005 and 26.1 t/km in 2010. The contribution from transit freight transport will increase from 33.8 % (1999) to 39.1 % by 2005 and 41.9 % by 2010 (Amt der Tiroler Landesregierung, 2000c).

On the A13 a reduction of traffic emissions from 36.9 t/km in 1999 to 36.6 t/km in 2005 and 29.1 t/km in 2010 is expected; the share from transit freight traffic will increase from 65.4 % in 1999 to 67.1 % by 2005 and 67.0 % by 2010.

A similar picture is forecast for south Tyrol (Brenner route from Brenner to Bolzano/Bozen and Verona). Road traffic was responsible for 80 % of $NO_x$ emissions in south Tyrol in 1997. Of the total estimated $NO_x$ emissions caused by transport in 1997 (8 515 tonnes), 56 % (4 507 tonnes) are attributed to the Brenner motorway on the section Brenner to Salurn (116 km) (Landesagentur für Umweltschutz, 2000, pp. 6–7).

***Local air quality problems***

*Exceedance of EC threshold values and WHO guideline values for nitrogen dioxide ($NO_2$) and $NO_x$*

High $NO_x$ emissions pose the major air quality problem in the Inn valley and the Wipp valley. Other pollutants such as carbon monoxide (CO), lead and total suspended particles (TSP) are of minor interest and have not caused exceedances of threshold values during the last few years. So far insufficient data are available for an assessment of $PM_{10}$ (respirable particulate matter with aerodynamic diameter between 2.5 and 10 micrometres (µm)) pollution.

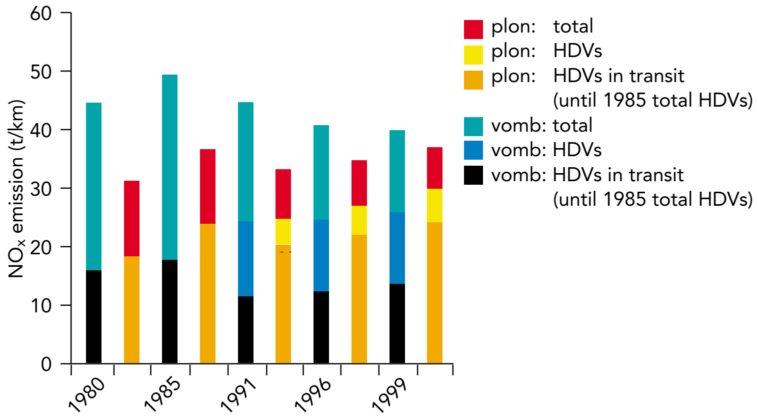
Emissions from road traffic on the Brenner route

Table A2.

| | A12 lower Inn valley (t/km) | | | A13 Wipp valley (t/km) | | |
|---|---|---|---|---|---|---|
| | total | HDVs | transit HDVs | total | HDVs | transit HDVs |
| 1980 | 44.7 | 15.9 | n.a. | 31.3 | 18.3 | n.a. |
| 1991 | 44.8 | 24.3 | 11.4 | 33.3 | 24.8 | 20.3 |
| 1995 | 42.6 | 25.2 | 13.4 | 37.4 | 29.3 | 24.0 |
| 1999 | 40.1 | 25.9 | 13.6 | 36.9 | 29.9 | 24.2 |

**Figure A10.** **Estimated $NO_x$ emissions on two selected sections (A12 Vomp and A13 Plon) of the route Kufstein-Brenner**

**Source**: Data from Amt der Tiroler Landesregierung, 2000c



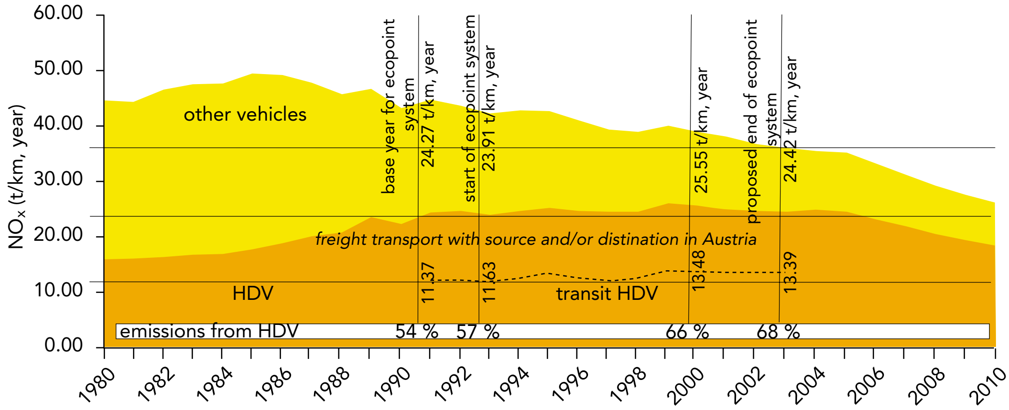

To assess the impact of road traffic emissions on local air quality, data from the following monitoring sites have been used:

- Gärberbach: in the immediate vicinity of the A13 (10 m away) south of Innsbruck;
- Vomp: next to the A12 (5 m from the roadside) between Hall in Tyrol and Schwaz;
- Hall in Tyrol: approximately 200 m from the A12 on the outskirts of Hall, separated from the motorway by the Inn river;
- Innsbruck centre, Fallmerayerstrasse, which is affected mainly by local urban emissions.

These monitoring sites show a decline in annual mean $NO_2$ and $NO_x$ values from 1989 to 1996, followed by a slight increase (Figure 12).

Table A3 gives the annual mean values for $NO_2$ at these four monitoring sites for the years 1993 to 1999 in micrograms per cubic metre (µg/m³). Exceedances of the threshold value set in Directive 1999/30/EC — 40 µg/m³ as annual mean value — are shaded in grey.

**Figure A11.** **Changes in $NO_x$-emissions (in t/km) on a selected section of the Brenner route (lower Inn valley, A12) at Vomp, 1980–2010**




**Source**: Amt der Tiroler Landesregierung, 2000c, modified by Umweltbundesamt Vienna

As shown in the table, the threshold value for $NO_2$ for the protection of human health of Directive 1999/30/EC — identical to the WHO guideline value for the protection of human health — was exceeded at Gärberbach in 1999, at Hall in Tyrol in 1993 and 1999, at Innsbruck centre in 1997 and 1999, and at Vomp in 1998 and 1999. At Vomp the sum of threshold value and margin of tolerance was exceeded in 1999.

The WHO guideline value for the protection of vegetation of 30 µg/m³ as an annual mean — identical to the EC threshold value for the protection of vegetation — was exceeded at all monitoring sites in the Inn valley and the Wipp valley during this period. Directive 1999/30/EC requires $NO_x$ monitoring only at a distance of 5 km or more from motorways. Nevertheless, the severe forest damage observed in the Tyrol may be at least partially attributed to high $NO_x$ levels.

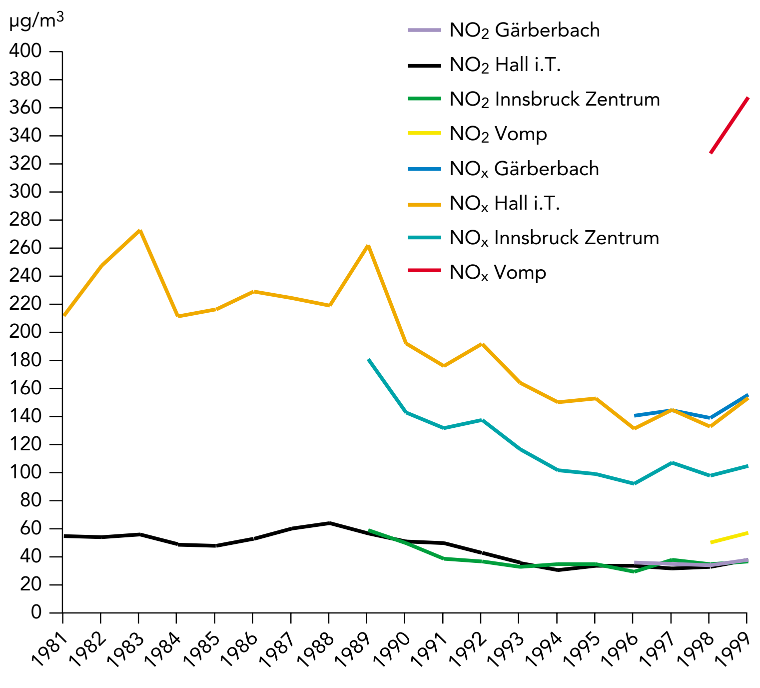
The EC threshold value set for the one-hour mean (200 µg/m³, 18 exceedances allowed per year) has not been violated at the Tyrolean monitoring sites. The Vomp monitoring station exceeds the upper assessment limit, defined as the sum over the last five years, with only two years' $NO_2$ data.

Exceedances of threshold values set in Directive 1999/30/EC require, according to the Air Quality Framework Directive 96/62/EC Art. 8, measures to be taken in order to improve air quality in the lower Inn valley.

*Exceedances of national legal threshold values*
The Austrian Air Quality Protection Law (BGBl. I 115/97) sets a threshold value for $NO_2$ of 200 µg/m³ as the half-hour mean. In the period 1994–99, this limit value was exceeded in 1999 in Hall in Tyrol four times and in Vomp twice (29 November and 1 December 1999).

*According to the Austrian Air Quality Protection Law the lower Inn valley will be an air quality management area, and measures have to be taken in order to improve air quality.*

**$NO_2$ and $NO_x$ (calculated as $NO_2$) concentrations (annual mean values) at the monitoring sites Innsbruck centre, Hall in Tyrol, Gärberbach and Vomp, 1982–99** Figure A12.




**Sources**: Data: Amt der Tiroler Landesregierung, 2000b; figure: Umweltbundesamt

Table A3. **Annual mean values of $NO_2$ at monitoring sites in Tyrolean valleys (µg/m³)**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|
| Gärberbach | | | | 40 | 39 | 38 | 42 |
| Hall in Tyrol | 41 | 36 | 39 | 39 | 37 | 38 | 43 |
| Innsbruck centre | 38 | 40 | 40 | 35 | 43 | 40 | 42 |
| Vomp | | | | | | 54 | 61 |

***Key parameters that influence local pollution levels***[(3)]

Nitrogen oxides ($NO_x$) are emitted mainly as NO (> 90 %) and then converted to $NO_2$ by oxidation. The NO concentration (daily mean values) at Vomp and Gärberbach corresponds closely to the daily number of HDVs. The influence of the other vehicles is comparatively small. The lowest daily mean values of NO are observed on Saturdays and Sundays, when a weekend ban on HDVs is in force (from 14.00 hours Saturday to 22.00 hours Sunday). In summer the average NO concentration is lower than in winter (Figure A13).

Nitrogen dioxide, which is formed from NO by oxidation with some time delay (depending mainly on ozone concentrations), shows a less pronounced correlation with local $NO_x$ emissions. Meteorological parameters which trigger the dilution of $NO_x$ are of major importance. However, the most pronounced influence arises from the concentration during the last 24 hours of. This is obviously due to the strongly depressed exchange rate of air masses in the Inn valley, especially during winter and at night.

Furthermore, the following are key parameters for pollutant dispersion and actual concentration level within these particular Alpine regions:

- the temperature lapse rate (i.e. vertical temperature gradient)
- the frequency as well as the extension of temperature inversions
- the wind speed.

All these factors result in higher concentrations of air pollutants at night, in the winter and during periods with low wind speed.

Further, the topographic situation in Alpine valleys is of major importance for the dispersion of pollutants. Compared with extra-alpine areas, horizontal dilution is hampered by the surrounding mountains. The occurrence of a valley wind circulation system with upward wind during the day and downward wind at night might favour local pollutant accumulation. The conditions in the Inn valley are exacerbated because it lies in an east-west direction, i.e. parallel to the Alpine ridges, and therefore large-scale air exchange with the extra-alpine lowlands from south to north and vice versa is inhibited. These factors are responsible for comparatively high pollutant levels in the Inn valley in relation to local emissions.

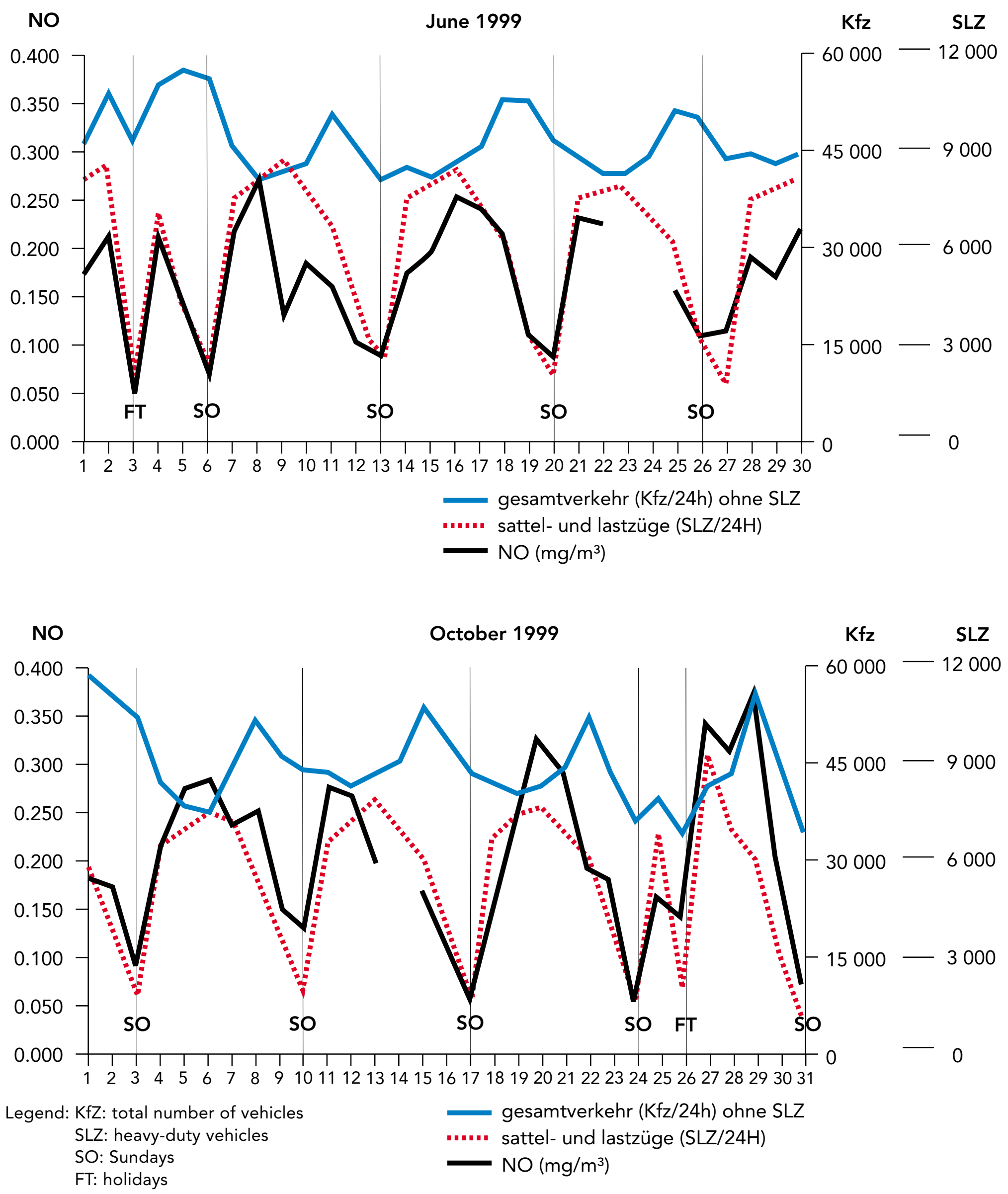
Scientific studies have been undertaken in order to estimate the influence of topographic and specific meteorological conditions in the Alpine valleys compared with extra-alpine flatlands (Wotawa, 2000). It is estimated that for per unit $NO_x$ emissions, the maximum (morning) $NO_x$ concentrations are roughly nine times higher in the Inn valley than in the Vienna basin (urban area).

On the other hand, the Wipp valley in the Austrian federal province of Tyrol and the Eisack/Isarco and Etsch/Adige valleys in southern Tyrol (Italy) are orientated north-south — i.e. at right angles to the Alpine ridges — which enables a better large-scale air exchange with extra-alpine regions, especially during föhn episodes (a hot southerly wind on the northern slopes of the Alps). Therefore the Wipp, Eisack and Etsch valleys suffer from lower pollutant levels in relation to the same amount of emissions on the Brenner route. Bad air quality is observed in the basins of Bozen/Bolzano and Sterzing/Vipiteno which are affected by frequent inversions.

(3) Amt der Tiroler Landesregierung, 2000a; Wotawa, 2000; Kocsis, 2000, p. 8.

**Time series of NO concentration at Vomp (A12 motorway) in June and October 1999 correlated with the traffic volumes (total vehicles and HDVs)** | Figure A13.

**Source**: Amt der Tiroler Landesregierung, 2000a, Annex 29




Great differences were also detected between congested valleys and those with low traffic levels. The Eisack valley, through which most transalpine traffic flows, shows on average $NO_x$ concentrations three times higher than the adjacent Sarn valley which has much less traffic.

*The MEMOSA project also demonstrated that during the closure of the Inn Bridge at Kufstein in 1990, $NO_x$ levels were a quarter the level that they were once it reopened.*

***Ozone***

Ozone levels are quite high in Alpine regions and exceed both the critical levels set by the United Nations Economic Commission for Europe (UNECE) and, by far, the threshold values of Directive 92/72/EEC.

The high ozone pollution in Alpine regions is primarily caused by a high background concentration as a result of ozone formation on a large scale over (at least) the central European region.. Therefore the high ozone levels in the Tyrol can be attributed to local traffic emissions only to a minor extent; the main reasons are high $NO_x$ and volatile organic compound (VOC) emissions in densely populated regions adjacent to the Alps. In some cases short-term peak values of ozone can be attributed to local emissions of ozone precursors (VOC and $NO_x$) (Graf and Schlager, 1990/91).

Table A4 gives for 1999 the number of the exceedances of:

- the threshold value for the protection of vegetation (Directive 92/72/EEC): 65 µg/m$^3$ as daily mean value;
- the threshold value for the protection of human health (Directive 92/72/EEC): 110 µg/m$^3$ as a mean value over four eight-hour periods per day;
- the critical level for forests (UNECE): 10 000 ppb*h;
- the critical level for crops (UNECE): 3 000 ppb*h, for the monitoring stations Innsbruck Sadrach (670 m) at the outskirts of Innsbruck, Innsbruck Nordkette (1 910 m) in high Alpine terrain and Kramsach (600 m), a rural site in the lower Inn valley.

It can be seen that for any parameter the pollution level rises with altitude. This is mainly due to the characteristics of the diurnal and annual variation of ozone concentrations, with rather constant high concentration at high altitudes and strong ozone depletion at night in the valleys (mainly due to dry deposition near the ground and lack of vertical air exchange). Also during the winter ozone levels are much higher at elevated sites than in the valleys.

Pollution levels vary considerable from year to year, especially short-term peak values. The long-term concentration shows a slight increase over the last four years.

The information threshold value in Directive 92/72/EEC — 180 µg/m$^3$ as the one-hour mean — was exceeded in the Tyrol for a small number of days over the last few years, varying between none and a maximum of four days in 1998. Therefore long-term high levels of tropospheric ozone concentrations pose a major problem for the Tyrol.

*So far no studies are available to assess the amount of local ozone formation in the Tyrol region due to local precursor emissions. The routine ground-based monitoring network, as well as special measurement campaigns (VOTALP-Project; MAP-Project, 2000; Graf and Schlager, 1990/91), including aircraft measurements, reveal long-term high ozone levels over the Alps as part of a large-scale phenomenon, caused by precursor emissions central Europe or an even larger area. Short-term high concentrations are attributed primarily to the transport of highly polluted air masses from extra-alpine regions — the Po valley and the pre-alpine lowlands in Germany — into the Alps. This transport may affect both high Alpine sites (e.g. the exceedances of the information threshold value in 1998 were caused by strong ozone formation in the northern pre-alpine lowlands in southern Germany and northern Austria), as well as more local ozone transport into the Inn valley and other northern Alpine valleys from southern Bavaria.*

Table A4. **Exceedances of threshold values for tropospheric ozone (1999)**

| | Innsbruck Sadrach | Innsbruck Nordkette | Kramsach |
|---|---|---|---|
| Above the threshold value for the protection of the vegetation (days) | 88 | 336 | 44 |
| Above the threshold value for the protection of human health (days) | 36 | 116 | 18 |
| Above the critical level for forests, pasture and natural vegetation (ppb*h) | 700 | 21 200 | 0 |
| Above the critical level for crops (ppb*h) | 3 300 | 14 900 | 1 100 |

***Deposition of pollutants***

Deposition of sulphur and nitrogen compounds may pose a serious problem to ecosystems with respect to acidification and eutrophication (nutrient nitrogen). The UNECE has developed the concept of critical loads in order to assess the maximum tolerable sulphur and nitrogen deposition.

In the Tyrol the total nitrogen deposition reaches values up to 30 kilograms per hectare per year (kg/ha/a) which is considered harmful for conifers and for high Alpine ecosystems in the long term. The critical load for eutrophication is 10 to 12 kg/ha/a. The consequences are a destabilisation of the ecosystem by malnutrition and a shift in species composition. As a result, a growing share of timber land and protective forest is damaged (Amt der Tiroler Landesregierung, 2000a, p. 39).

***Forest damage***

In the last two decades forest damage (Amt der Tiroler Landesregierung, 2000b, p. 21), both in timber areas ('Wirtschaftswald') and in protective forest ('Schutzwald') increased slightly (Figure 14). The state of the protective forest (essential to avert avalanche and soil erosion) has given particular reason for concern over the last few years. The proportion of damaged trees rose from about 40 % to 60 % between 1995 and 1999. Tree damage can be attributed to a combination of locally high $NO_x$ concentrations, high ozone levels, acid sulphur and nitrogen deposition and high eutrophying nitrogen deposition.

Furthermore, forests at the slopes of the Inn valley are crucial for protection against avalanches and erosion, and so represent an essential condition for human habitation of these areas.

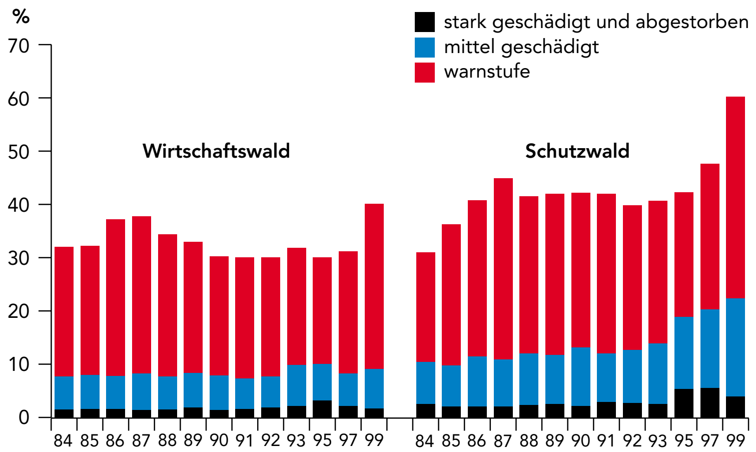
***Noise levels***

Noise affects people physiologically and psychologically: at noise levels above 50 dB $L_{Aeq}$ [4] most people are moderately annoyed; noise above 65 dB $L_{Aeq}$ is detrimental to health (TERM).

Due to the 'amphitheatre effect' of Alpine valleys, the noise levels on the Brenner route reach values far above set environmental quality standards. In order to illustrate the situation a section of the Brenner route at Matrei has been analysed in depth. At night a large area of the human settlement is in the isophone > 50 dB(A) [5] because of either road or rail traffic. It is obvious that road traffic is responsible for a higher share of the noise levels (Figure A15).

[4] LAeq is energy equivalent sound pressure level in dB(A).
[5] dB(A) is an international sound pressure level unit meaning 'decibel with an A frequency weighting' which reflects the sensitivity of the human ear.

**Development of forest damage in the Tyrol from 1981 to 1999** — Figure A14.




**Source:** Amt der Tiroler Landesregierung, 2000b, p. 21

Legend: Wirtschaftswald: Timber areas(managed forest)
Schutzwald: Protective forest
'stark geschädigt und abgestorben': severely damaged or dead
'mittel geschädigt:' moderately damaged
'Warnstufe': alert level

#### *1.1.3. Land use and habitations*

As the permanent settlement area covers only a small part of the whole area in the Alpine region, the concentration of inhabitants in some Alpine valleys is extremely high, even reaching urban values. In 1990 240 inhabitants were counted per square-kilometre settlement area in the Alpine region. Only densely populated countries like the Netherlands or Belgium show higher concentrations. In the Tyrol, where only 12.4 % of the whole area is settled, 397 inhabitants were counted per square kilometre in 1991 (Amt der Tiroler Landesregierung, 1996).

The rare usable space has to be split up among different kinds of land use. Transport infrastructure needs a relatively high share of land and is situated close to living and recreation areas. In the Tyrol 7.5 % of the total settlement area is dedicated to infrastructural needs, a peak value in Austria. Local as well as international transalpine traffic flows concentrate on a few routes.

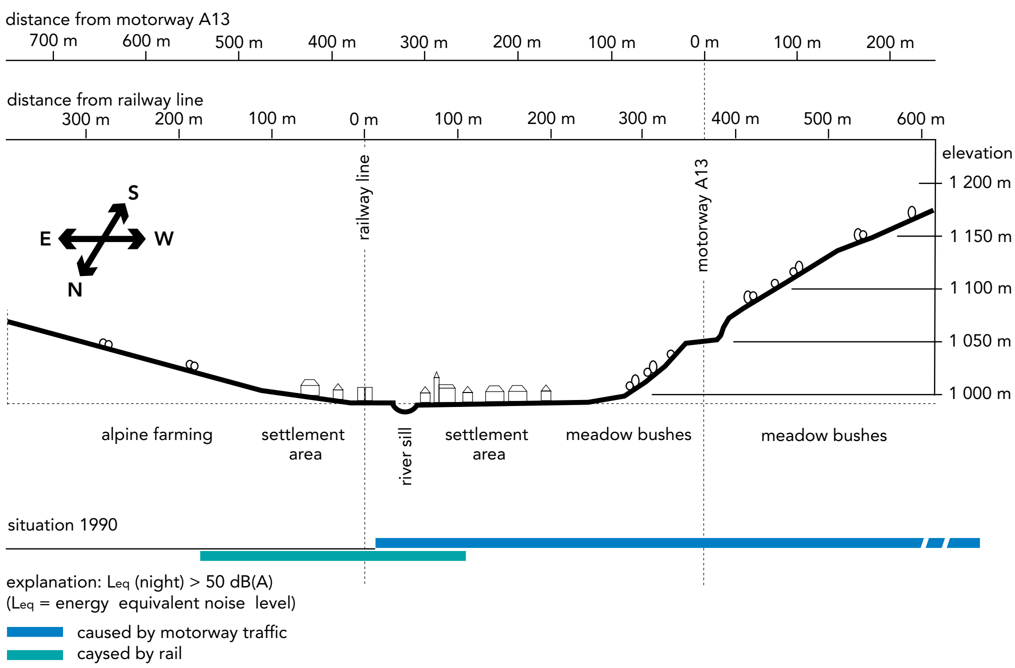
When considering the environmental effects of traffic on Alpine road transit routes, especially near the Brenner route, it should be taken into account that the lower Inn valley is only about 2 km wide and is the central region of the Tyrol with the highest population density (487 inhabitants/km$^2$ (over 603 km$^2$)). Innsbruck is the largest Alpine city (120 000 inhabitants), followed by Bozen/Bolzano and Trento, both located near the Brenner pass.

### 1.2. Mont Cénis / Fréjus

The route analysed in detail is the section of the transalpine route Lyon-Chambéry-Torino between Aiguebelle and Modane (vallée de la Maurienne) in Haute Savoie. The Maurienne valley is a side valley of the Isère valley with an altitude range from 300 m to 1 100 m, and a length of 65 km. In1999 a total of 42 000 inhabitants lived in the valley.

Figure A15. **Matrei am Brenner, area affected by noise levels greater than 50 dB(A)**

**Source**: Modelling by Trafico based on Österreichische Bundesbahnen (ÖBB), 1993-1994. Schienenverkehrslärm, Isophonenplan, Innsbruck



***1.2.1. Development of traffic***

The transport infrastructure of the transalpine route through the Maurienne valley is composed of a double -track electrified railway line and a motorway under construction (A 43). The motorway is open for traffic as far as Saint-Michel-de-Maurienne. On the remaining section from Saint-Michel-de-Maurienne to Modane (approximately 20 km), traffic uses the national road (N 506).

Transalpine freight transport on the French Alpine passes has grown at a slightly slower rate than on the Brenner route. The split between origin and destination/internal freight transport and transit, however, is very different. The share of transit traffic is substantially lower than on the Brenner. However, the categorisation of what is transit traffic and what is origin and destination traffic also differs between the Brenner and the French Alpine passes. Transit traffic is defined as traffic that crosses the border of the state under consideration twice.

On the Brenner a large part of the transit traffic either originates from or is bound for Bavaria or northern Italy, both economically dynamic regions with a regional gross domestic product (GDP) surpassing the average GDP of the EU. Just 110 km of Austria is crossed. On the French Alpine passes, the corresponding traffic flow between France and northern Italy is allocated to origin and destination traffic. But the environmental impacts will still be there, regardless of which category an HDV is assigned to.

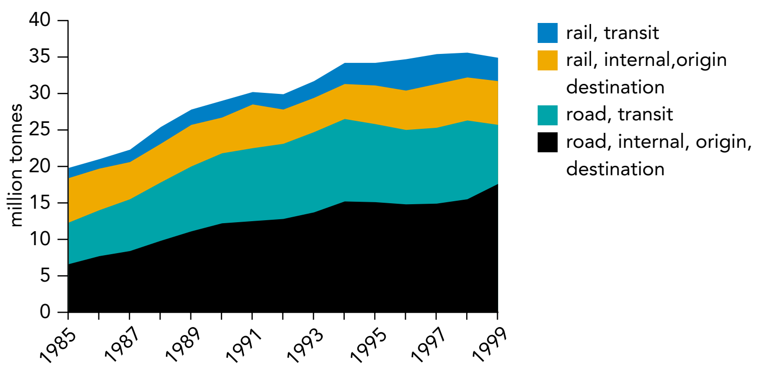
Transalpine freight transport on the Maurienne route through the Mont Cénis (rail) and Fréjus (road) passes shows a similar growth rate to the Brenner over the last few years. The modal split, however, is more in favour of rail, which was higher than 40 % in 1998 on the Maurienne route compared with under 30 % in 1998 on the Brenner route (Figure 17).

The relative high share of rail on the French Alpine routes might also be a consequence of the missing links in the motorway network (e.g. Saint-Michel-de-Maurienne to Modane was still a missing link in 2000).

After the catastrophic accident in the Mont Blanc tunnel in March 1999, the tunnel was closed, and it was not reopened to traffic until mid 2001. The traffic flow was diverted mainly to Fréjus; the number of HDVs passing through the Fréjus tunnel grew by 75 % after the closure of the Mont Blanc tunnel. On average the number of HDVs going through the Fréjus tunnel rose from approximately 2 100 HDVs a day in 1998 to more than 4 000 HDVs a day in 1999. (Figure A18). Thus the share of HDVs in the total number of vehicles per 24 hours (average daily traffic (ADT)) rose to 42 % on the section Saint-Michel-de-Maurienne to Modane (measured at Orelle).

**Development of transalpine freight transport on the French Alpine passes (Mont Cénis/Fréjus and Mont Blanc) from 1984 to 1999**

Figure A16.




**Sources**: UVEK/GVF, 1999; UVEK/GVF 2000

### *1.2.2. Environmental effects (ambient air quality)*

*Emission of pollutants*
Traffic was the main cause of emissions of pollutants in the Maurienne valley in 1997. Traffic was responsible for:

- 10.2 % of sulphur dioxide ($SO_2$) emissions
- 80.2 % of emissions of nitrogen oxides ($NO_x$)
- 60.2 % of non-methane volatile organic compound (NMVOC) emissions
- 56.9 % of carbon monoxide (CO) emissions.

*$NO_x$ concentrations*
In the Maurienne valley a series of measurements was carried out during the winters of 1997/98 (November 1997 to April 1998) and 1999/2000 (November 1999 to April 2000). Measurement points were situated along the whole valley from Aiguebelle to Modane, the average distance to the road (A 43 and N 506) being between 2 and 400 m. The following pollutants were measured: $SO_2$; nitrogen oxide (NO); nitrogen dioxide ($NO_2$); respirable particulate matter with aerodynamic diameter between 2.5 and 10 µm ($PM_{10}$).

Figure A17. **Development of transalpine freight transport Mont Cénis/Fréjus from 1984 to 1999**

**Source**: UVEK/GVF, 2000

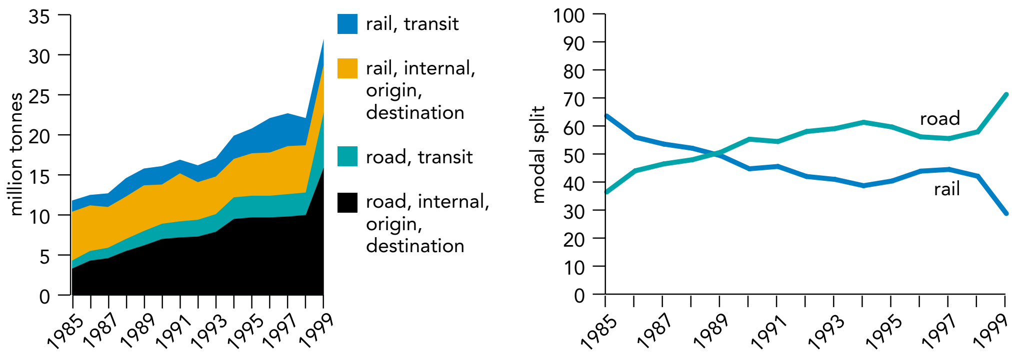
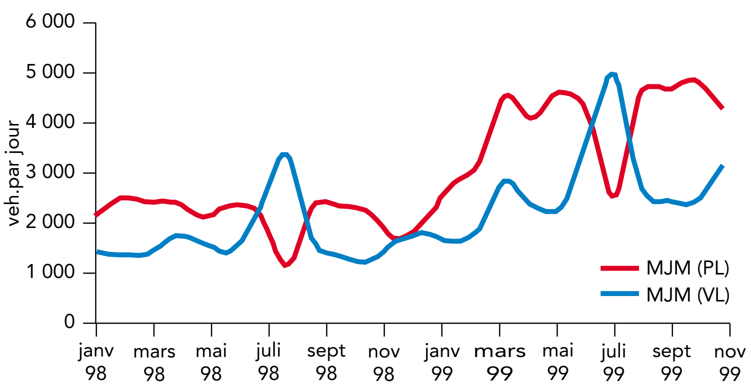



Figure A18. **Development of traffic through the Fréjus tunnel from 1998 to 1999**

**Source**: Observatoire Régional des Transports, 2000. Bilan d'activité 99, Lyon



As transport is responsible for a large share of the emissions of $NO_x$ and $PM_{10}$, the comparison of the ambient air quality between 1997/98 and 1999/2000 is limited to these pollutants. Between the two periods there was:

- an increase in NO concentration
- a slight increase in $NO_2$ concentration
- a decrease in $PM_{10}$ concentration.

The permanent measuring point at Saint-Jean-de-Maurienne reached a mean concentration of 35 (μ/m³ during the measuring period November 1999 to April 2000. It is likely that the annual mean threshold value of 40 (μ/m³ was exceeded in the Maurienne valley.

The $NO_2$ and $PM_{10}$ concentrations are strongly influenced by meteorological conditions. The influence of temperature and precipitation is high. At some measurement points precipitation in the period 1999/2000 was significantly higher than in the period 1997/98 with the result that concentrations of $NO_2$ and $PM_{10}$ were reduced. $PM_{10}$ concentration is also influenced by fuel quality (lower sulphur content).

The increase in NO concentrations is a consequence of traffic growth, especially of HDVs. Concentration levels of $NO_2$ have shown similar rises at those measuring points which experienced similar meteorological conditions during both measuring periods. The weather in the second period (1999/2000) helped to reduce $NO_2$ concentration. During typical mountainous meteorological situations (cold and dry weather), the cumulative effects of pollutant concentration through inversion could also be observed, as the daily mean value of 50 (μ/m³ was surpassed in January 2000 on 19 days out of 31 (ATMO, 2000a).

Concentrations of $NO_2$ in the ambient air can reach urban values in an area with low population density and absence of large-scale industry.

**Comparison of the concentration of NO, $NO_2$ and $PM_{10}$ between winter 1997/98 and winter 1999/2000 at 13 measurement points in the Maurienne valley** Table A5.

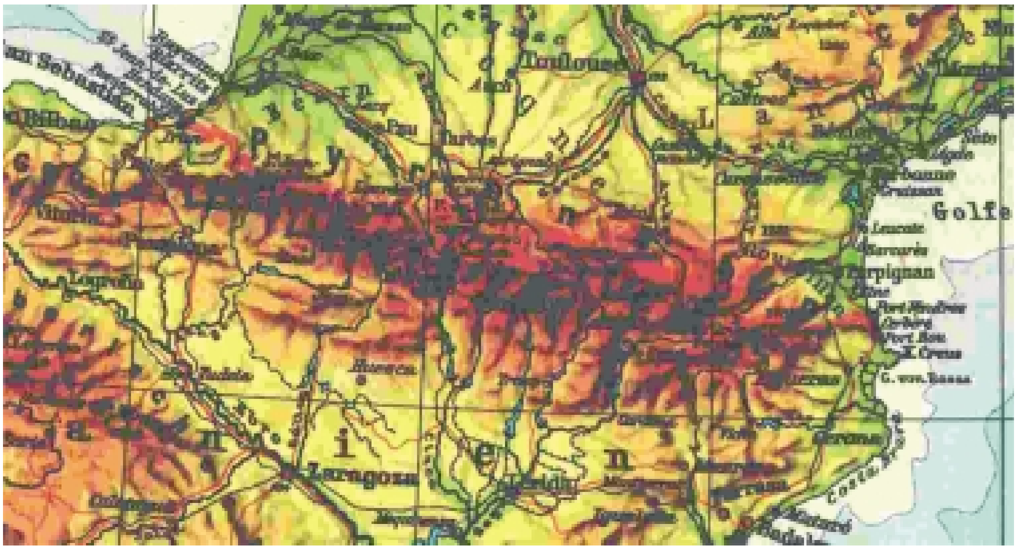
| Daily mean value [$NO_2$ (μ/m³] | Range in winter 1997/98 | Range in winter 1999/2000 |
|---|---|---|
| NO concentration | 8-148 | 23.9-163.8 |
| $NO_2$ concentration | 20.8-62.1 | 35-66.8 |
| $PM_{10}$ concentration | 23.1-61.6 | 18.2-59.5 |

**Source**: ATMO, 2000a

# Pyrenees

### 3. Definition of the Pyrenees

The Pyrenees stretch from the Atlantic Ocean to the Mediterranean Sea in the southwest of France and the northeast of the Iberian peninsula.




Only a limited number of high-capacity road and rail routes are available for the exchange of goods between the Iberian peninsula and northern Europe. As a consequence traffic flows are concentrated on the routes through the Pyrenees. For road freight transport the passes are:

- Biriatou (motorway A63)
- Somport (national road, two-three lanes, tunnel under construction)
- St Béat (national road, two lanes)
- Puymorens (national road, two lanes, tunnel)
- Le Perthus (motorway A9).

For rail freight transport the passes are:

- Biriatou (two tracks, electrified). The transhipment of the wagons (because of the different gauges in France, Portugal and Spain) takes place in Hendaye; the transhipment of the freight between wagons takes place in Hendaye and Irun; and transhipment between road and rail is organised in Biarritz and Irun.
- Le Perthus (two tracks, electrified). The transhipment of the wagons takes place in Cerbère; the transhipment of the freight between wagons in Portbou; and the transhipment between road and rail in Le Boulou, Perpignan and Rivesaltes.

As well as land transport, coastal and short sea shipping play an important role in freight transport between northern Europe and the Iberian peninsula. The harbours along the coast of the Iberian peninsula, such as — to cite the largest — Algeciras, Barcelona, Bilbao and Tarragona, allow the exchange of a substantial volume of goods to and from northern Europe.

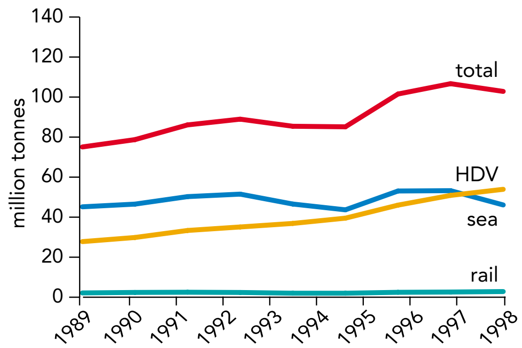
## 2. Growth of traffic

Exchanges between the Iberian peninsula and Europe grew substantially in the past decade (from 1989 to 1998 by 52 %). Freight transport by heavy-duty vehicles (HDVs) doubled in this period whereas freight transport by rail and short sea shipping grew by only 26 % (rail) and 18 % (sea).

Accordingly modal split changed. Despite the growing proportion of road freight transport, short sea shipping still has a high share.

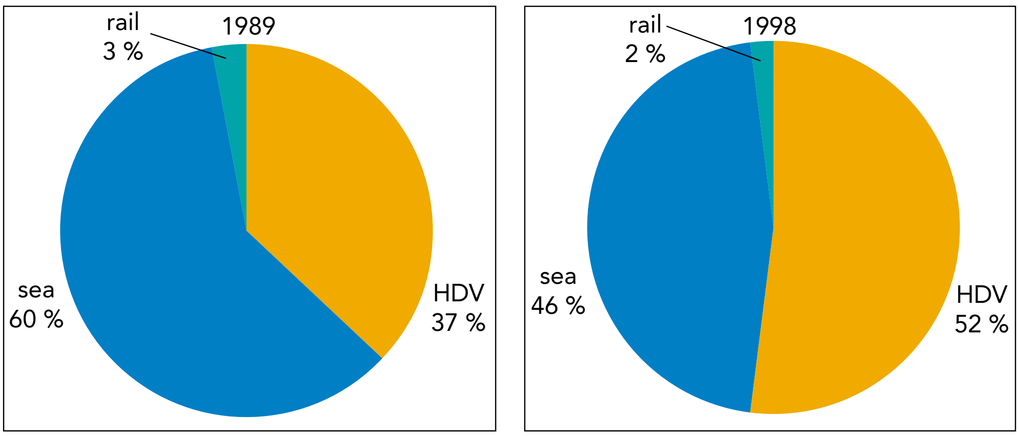
Looking more closely at land freight transport (road and rail), traffic flows across the Pyrenees, separating the Iberian peninsula from France, are concentrated on two major routes (Biriatou: Hendaye-Irun and Le Perthus: Cerbère-Port Bou). Three further routes are of local or regional importance (Somport, St Béat, Puymorens). By the end of 2001 or early 2002, the road tunnel of Somport (some 8 kilometres (km) in length) will be opened to traffic. The tunnel is designed to receive more than 1 million HDVs in transit every year, and more than 1 million passenger cars in transit, but the access roads are not yet ready to receive these traffic flows (Etchelecou and Deletraz, 2000). Thus the Somport tunnel might in future take over the function of the Biriatou route as a by-pass for transport flows between Bordeaux and the Zaragoza region, especially in the case of growing congestion on the Biriatou route (A8-A63). The different function of the routes passing the Pyrenees is mirrored in the traffic load (HDVs per 24 hours (hrs), see Figure A21).

**Development of freight transport between the Iberian peninsula and Europe** Figure A19.




**Source**: Ministère de l'Equipement, des Transports et du Logement, Ministerio de Fomento, 2000

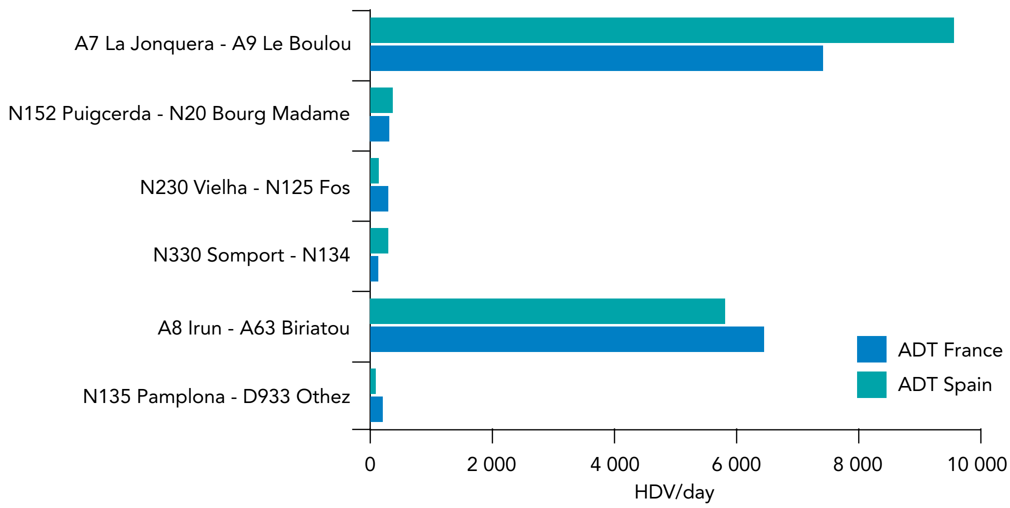
**Modal split of freight transport between the Iberian peninsula and Europe, 1989 and 1998** Figure A20.




**Source**: Ministère de l'Equipement, des Transports et du Logement, Ministerio de Fomento, 2000

Figure A21. **Number of HDVs per day on the Pyrénées routes in 1998**

**Source**: Ministère de l'Equipement, des Transports et du Logement, Ministerio de Fomento, 2000



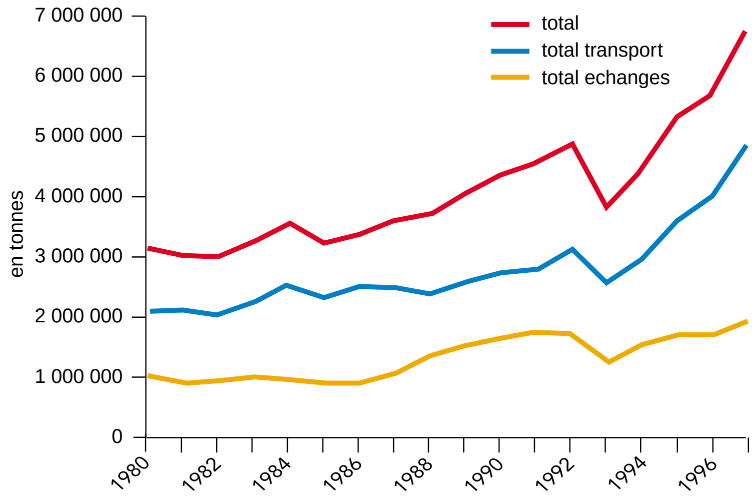

The two major routes for freight transport (Biriatou and Le Perthus) are at the east and west borders of the Pyrenees. Thus the altitude of both passes is much lower than those in the Alpine region (approximately 50 metres (m) compared with 300 m).

Exchanges between the Iberian peninsula (Portugal and Spain) have grown since these states became members of the European Union (EU). The growth in freight transport is similar to that already shown in the case of the Alpine region. From 1985 to 1995, the traffic of HDVs grew by 330 % in the Pyrenees and by 280 % on the French Alpine passes (Mont Blanc, Fréjus) (Figure A22 and Figure A23). Thus the environmental pressures (e.g. emission of pollutants) rose as well.

In 1995 the total volume of freight transport in the Pyrenees reached 63.6 million tonnes. The modal split is heavily weighted to road: only 8.6 % of freight transport in the Pyrenees is carried by rail. The share of transit traffic, at approximately 50 %, is high compared to the western Alpine region (Table A6).

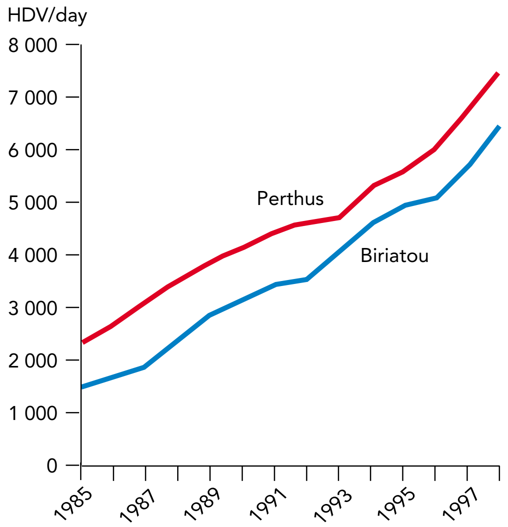
Figure A22. **Development of rail freight transport in the Pyrenees**

**Source**: DRE, 1999



Development of heavy-duty vehicle traffic on Biriatou (A8–A63) and Le Perthus (A7–A9)

Figure A23.




**Note**: Figure includes buses (based on toll statistics, which do not distinguish between heavy-duty vehicles and buses).
**Sources**: DRE, 1999; Minstère de l'Equipement, des Transports et du Logement, Ministerio de Fomento, 2000

Freight transport passing through the Pyrénées in 1995

Table A6

| | Freight transport France-Iberian peninsula | | Transit freight transport | | Total | |
|---|---|---|---|---|---|---|
| | Million tonnes | % | Million tonnes | % | Million tonnes | % |
| Road | 27.3 | 88.6 | 30.8 | 97.5 | 58.1 | 91.4 |
| Rail | 4.9 | 11.4 | 0.6 | 2.5 | 5.5 | 8.6 |
| **Total** | **32.2** | **100** | **31.4** | **100** | **63.6** | **100** |

**Source**: Etchélécou A., 1998, p. 32ff

Compared with road freight transport, rail transport passing through the Pyrenees faces a technical barrier in the different gauge of rail (France: 1 435 millimetres (mm), Spain: 1 676 mm). Thus at both sites (Biriatou and Le Perthus), the axles of freight wagons have to be exchanged and freight is passed from rail to rail, and from rail to road and vice versa.

## 3. Environmental effects

Ongoing research into the environmental effects of road freight transport in the Pyrenees allows only preliminary conclusions to be drawn, including some details on ambient air quality and deposition of pollutants. If noise is considered, the morphologic situation in the Pyrenees is similar to the Alpine region, so that the conclusions drawn in the Alpine case studies can also be applied to the Pyrenees.

### *3. 1. Ambient air quality*

*Concentrations of acidifying emissions/nitrogen oxides*
Recent research work undertaken in selected valleys with high and low traffic volumes gives some idea of the environmental effects of HDVs on ambient air quality. Measurements of nitrogen dioxide ($NO_2$) concentrations at road level were carried out during the summers of 1998 and 1999 at two sites — Biriatou and vallée d'Aspe (Somport).

At Biriatou, with a heavy traffic load (ADT: 7 054 HDVs/24 hrs and 18 832 passenger cars/ 24 hrs during the period May to September 1998), $NO_2$ reached a daily mean concentration of 49.4 micrograms per cubic metre ((g/m$^3$) in St-Jean-de-Luz and 52.2 (g/m$^3$ in Biriatou.

In the valley of d'Aspe (with the tunnel of Somport due to be opened in 2001/2002), which still has low traffic volumes (ADT: 224 HDVs/24 hrs and 2 974 passenger cars/24 hrs in Sarrance and 123 HDVs/24 hrs and 1 246 passenger cars/24 hrs in Urdos during the period April to August 1999), $NO_2$ reached a daily mean concentration of 9.4 (g/m$^3$ in Sarrance and 8.7 (g/m$^3$ in Urdos (Etchelecou and Deletraz, 2000).

The $NO_2$ concentrations found at Biriatou are similar to the highest urban values found in France. The annual mean concentration of $NO_2$ in 1999 covered a range of 18 (g/m$^3$ (Rennes) to 47 (g/m$^3$ (Paris) and 49 (g/m$^3$ (Cannes) (Ministère de l'Environnement, 2000). As the measurements at the two sites of Biriatou and d'Aspe were carried out only during a part of the year, the values are not directly comparable, but nevertheless they allow the ambient air quality values along the routes in the Pyrenees with high traffic loads to be set in context.

Similar to the findings on the effects of $NO_2$ concentrations in the Alpine valleys, in the vallée d'Aspe the dispersion of pollutants is lower by a factor of three compared with the site of Biriatou (Deletraz, 2000).

Similar $NO_2$ concentrations have been measured in Irun (daily mean concentration of $NO_2$ in1999: 60.5 (g/m$^3$), where the motorway is located close to the urban area (two-way influence of urban and motorway-related environmental pressures).

*Deposition of pollutants*
Nutrient deposition (nitrogen) in Biriatou reaches values of more than 35 kilograms per hectare per year (kg/ha/a) which is considered critical for conifers in the long term. In the vallée d'Aspe annual nutrient deposition (nitrogen) has a range between 4 and 13 kg/ha/a (Etchelecou and Deletraz, 2000).

The critical load ranges from 5 to 40 kg/ha/a depending of the type of ecosystem. The maximum critical load preserving the ecosystem from serious damage is recommended to be under 35 kg/ha/a; from 5 kg/ha/a on, effects can already be noticed on the more sensitive ecosystems.