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Mobility in a flat world

Solving the sustainability equation for transport-related sectors

Pan European Equity
Europe

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Foreword

We are pleased to be able to present our study ‘Mobility in a flat world – Solving the sustainability equation for transport-related sectors’.

In the last 10 years or so we’ve entered a new stage in the globalisation process. The world has become ‘flat’ – predominantly driven by: (1) a leap in ICT and (2) the participation of China and Eastern Europe in world trade. Today almost any good can be manufactured almost anywhere in the world. The two major implications are: (1) the demand for transport of goods has been increasing dramatically and will continue to do so (2) due to the increasing individual wealth in emerging markets like China, the demand for individual mobility is rising sharply as well. This mega-trend certainly implies enormous economic opportunities for transport-related sectors like the auto industry, airlines, and container shipping. ‘Business as usual’ scenarios for the future, however, show that the looming age of ‘unlimited mobility’ can be expected to have unacceptable, unsustainable environmental and social side-effects. But what would a sustainable mobility future actually look like? In which directions do policy makers have to steer the regulatory environment in which transport-related sectors have to operate? And what should companies do to reduce the external costs of their products and activities?

This note has two parts. The first one describes current mobility trends, their causes, their linkages, their implications and possible future development paths. It looks at developed countries as well as at developing ones (focus on China). In the second part we take a closer look at specific issues related to the different transport modes. In doing this, we even go down to the individual company level in some areas (e.g. the cost implications of emission regulation changes for the car industry).

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10 hypotheses about sustainable mobility in a flat world

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- Mobility is not sustainable, either environmentally or socially, if current trends continue. All technological advances will be thwarted by rising transport volumes.
- Mobility can only be made more sustainable via a combination of technological innovation and the introduction of effective demand channelling measures. Free market solutions will not suffice.
- Fuel taxes and infrastructure charging seem to be the most effective ways of internalising the external costs of transport, thereby reducing its current over-consumption.
- Infrastructure measures should focus on improving inter-modality, rather than on enlarging transport capacities. Policy makers need to target the allocation of transport volumes across the different modes as well as the capping of overall transport growth.
- Linking measures to increase population densities with the deployment of intelligent public transport systems is the best policy option to confront transport-related mobility concerns in urban areas – particularly in developing countries.
- It is unlikely that current trends will persist. Exogenous shocks may, for example, lead to a world that is characterised by localisation rather than globalisation. The pressure to make mobility more sustainable will decrease under this alternative scenario.
- Road has the lion's share of overall external costs of transport. Infrastructure charging and emissions/fuel consumption regulation are the two major policy options in this area. The global regulatory environment in which European companies have to operate will become much stricter. Companies should start accepting the unavoidable and need to take a more pro-active approach in adapting to the new conditions. Adaptation costs will differ strongly across OEMs
- Rail is a very efficient mode of transport in terms of capacity, energy, space and time while being environmental friendly and able to support social equity. However, its lack of flexibility could be its downfall if it is not sufficiently supported by policy makers.
- Aviation: flying is the most climate-intensive mode of travel between two places. And although the companies do a lot to reduce the negative impact, those measures are overwhelmed by the rapid growth of the sector. Regulatory measures currently barely help to reduce the effects. Companies have to be prepared for the inclusion of aviation in the European emission trading scheme, although this does not appear to be the most effective means of reducing the climatic impact of the industry.
- Maritime shipping is one of the most efficient forms of transport – and has the potential to be one of the most environmentally friendly ones, too. But the lack of regulation leaves the door open to misconduct. It will be very difficult to achieve effective multilateral agreements in this area, so companies are likely to retain their mostly defensive approach for the time being.

Contents

The age of 'unlimited' mobility

In the last 10 years or so we've entered a new stage in the globalisation process. The world has become 'flat' – predominantly driven by: (1) a leap in ICT and (2) the participation of China and Eastern Europe in world trade. The two major implications are: (1) the demand for transport of goods has been increasing dramatically and will continue to do so (2) due to the increasing individual wealth in emerging markets like China, the demand for individual mobility is rising sharply as well. This mega-trend certainly implies enormous economic opportunities for transport-related sectors like the auto industry, airlines, and container shipping.

Mobility – some definitions

Mobility is more than just transport

What exactly is meant by 'mobility' and how is it measured? It indicates both the opportunity and the ability to transport goods and/or people from one location to another. This hardly sounds spectacular – but there is much more to it than that. Mobility has farther-reaching socioeconomic implications than almost any other capability. It is both a condition for and a consequence of economic growth, promoting jobs and wealth. It gives people access to goods and services. It unites people, even across great distances, and is a synonym for globalisation. However, this is just one side of the coin; there is also a darker side to mobility, which should not be overlooked. Some of the adverse effects of mobility include its contribution to global warming, local pollution in the new mega-cities of the emerging nations, noise pollution in inner cities and near airports, and social injustice related to access to mobility. For years, there has been a desire to promote more sustainable mobility. Many reports and studies have been published on this topic, often written from the point of view of special interest groups. There is therefore a baffling proliferation of information. In this study, we aim to shed some light into this confusing situation. But before we address these issues, we would like to define some standards that will help us measure and understand mobility.

Modes of transport

It is important to differentiate between mobility of people and of goods. Another key distinction within passenger mobility is between private and public transport options. The latter is very significant for big cities, although trends such as suburbanisation represent a real threat to public transport networks. It is important to remember when differentiating between traditional modes of transport that they need not be mutually exclusive: they can also coexist. For instance, there are numerous examples in developing countries of a rational switching between individual and public transport. Depending on the time of day, purpose and destination, many people in cities are used to combining travel in cars, trains and buses. This is known as intermodality and has become a buzzword for many politicians seeking solutions to problems of transport sustainability.

Evaluation criteria

So how can we ultimately evaluate the mobility of individuals or an entire society or economy? Key criteria would certainly include access, cost, time expended, reliability and safety.

Access to mobility

Availability and proximity

One very important factor is the 'penetration rate'. This measures, for example, how large a percentage of the population owns a car or other vehicle. This figure is often quoted when measuring how developed an economy is. Access to mobility, however, means more than just access to individual modes of transport. The availability and proximity of public transport is particularly important in developing and emerging nations. Most important, in terms of the mobility of goods, is the speed with which deliveries can be shipped and received, for instance the distance from the nearest post office.

(Private) costs of mobility

Transport costs as a percentage of consumer spending

Here we are referring only to the private costs of mobility, in other words, the costs incurred by an individual in using a transport service. This distinction is necessary, as much of the discussion surrounding sustainable mobility concerns the high external costs generated by passenger and freight transport; more of which later. In terms of private costs, the primary question is the affordability of transport services for individuals. The significance of these costs can be measured, for example, in terms of how much of a person's or family's budget is spent on transport. For goods mobility, we include all transport and logistics costs incurred per unit of weight and per unit of distance transported. The significance of transport costs can also be measured as a percentage of total manufacturing costs.

Time expended

Infrastructure overload is a growing problem

The cost dimension of mobility is closely tied to its time dimension. How long does it take to transport a person or a product from point A to point B? The speed of transport is just part of the answer. The advantages of high speed may be wiped out by long waiting periods. Other important factors are the reliability of the mode of transport and the degree to which it is overloaded. Infrastructure overload, e.g. as evidenced by the growing problem of road congestion, can prolong commuting times and so push up economic costs.

Reliability

Focus on unexpected delays

How certain can a traveller be that their preferred mode of transport will get them to their destination on time? In daily business life, reliability plays a key role in selecting a mode of transport. The critical issue here is unexpected delays that can arise with certain transport methods; this does not mean the traffic jam that builds up at the same place at the same time every morning, causing delays of roughly the same duration. Reliability is particularly important when connecting different modes of transport, which is the politically desirable and promoted goal of intermodality.

Security and safety

Risks of terrorist attacks, accidents and criminality

In matters of security, the issue is the probability with which passengers and goods can reach their destination unharmed? Security concerns the risk of accidents that can befall passengers and goods while in transit; how security can be jeopardised by external forces is another factor. A new challenge was introduced by the terrorist attacks of 11 September 2001. Less spectacular, but not to be overlooked, are the effects of ordinary criminal activity, such as robbery and theft.

Mobility in a ‘flat world’ – the background

Booming world trade

Global trade is booming like never before, and with it demand for transport services. The beneficiaries include providers of transport services, such as airlines, and the manufacturers of transport vehicles, from cars all the way to modern container ships. Other winners include infrastructure providers like ports and airports, as well as companies that construct or expand them and those that provide the necessary modern equipment (e.g. cranes for container ports). Naturally, packaging firms and logistics providers are also profiting from brisk global trade. Their businesses are further encouraged by special new technologies, such as the use of radio frequency identification (RFID) chips in packaging.

A new era of globalisation

The great relevance of the mobility issue in terms of individual companies and sectors is obvious. However, when evaluating the further risks and returns, it is necessary to understand the origins of the current boom in world trade.

We see two particular factors as responsible for moving world trade into a new globalised age:

- China and the former Eastern Bloc countries opening up their economies and participating in global trade
- Technological advances in IT and communication technologies.

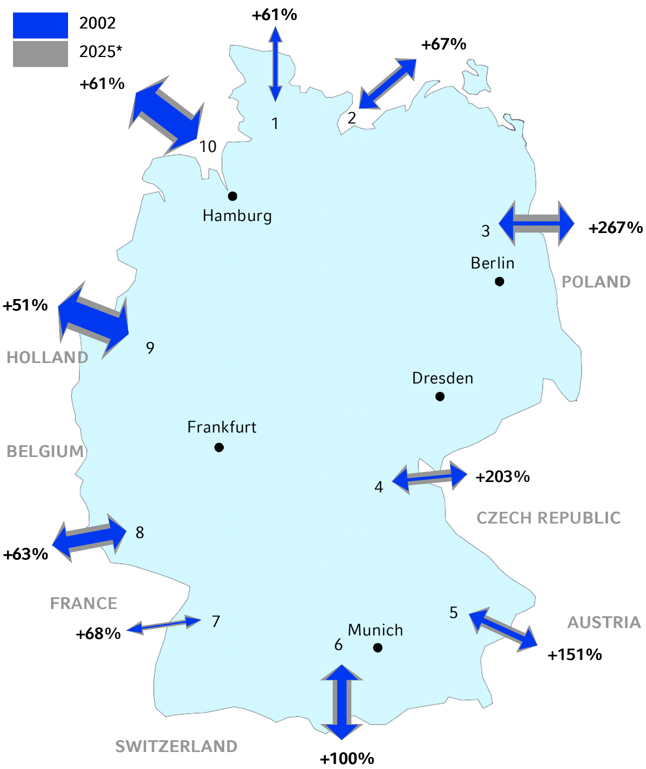
Fundamental change in corporate strategies

These two factors have resulted in a fundamental strategic reorientation for companies in developed countries. They now focus more closely tapping new markets and are more likely to make use of production offshoring and outsourcing. Access to cheap labour in China and the former Eastern Bloc is not the only factor. New IT and communication technologies have also given companies more opportunities to break up their value chains. The theory that a knowledge-based economy would have less need of transport services has been proved wrong, at least so far. The fact is, the construction of virtual networks and the increasing significance of non-material services has tended to dampen growth in the transport sector. However, this is clearly more than made up for by the transformation of vertically integrated companies in a large number of separate, specialised industries. This disintegration is taking place not only at national level, but all around the world – the world is becoming flat. As a result, there is more and not less need to transport goods and people.

The example of Germany

For countries, such as Germany, the consequences of the increasing international division of labour and the break up of companies’ value chains will be a further dramatic increase in cross-border freight transport volumes, as the following chart shows.

Expected increase in cross-border trade volumes for Germany



1	Northern corridor	25,656	41,353
2	Baltic canal ports	55,396	92,463
3	Oder corridor	31,244	114,630
4	Czech border crossings	26,902	81,569
5	Balkan crossings	42,774	107,335
6	Alps crossings	80,883	161,456
7	Belfort gap	24,859	41,833
8	Western corridor	99,851	162,998
9	Netherlands	205,567	310,065
10	North Sea ports	182,868	293,830

Source ifmo, 2005

Many companies are winners in a 'flat world'

Many companies are winners in a 'flat world'; we have listed several examples above. But it is not only the immediate beneficiaries that are affected. Companies everywhere seem to be benefiting from the new era ushered in by globalisation over the last few years. In developed countries around the world, we see that corporate profit margins have reached new highs despite supposedly tough competitive pressure, just as corporate gains are accounting for a greater share of national income. This can also be interpreted as a signal that workers in developed economies tend not to be among the winners of the new globalisation. As China and the former Eastern Bloc open up their economies, they are producing a terrific supply shock on the global labour market, which is exerting considerable downward pressure on wages in the established industrial nations. This is evident, for example, from the largely flat wage trends in these countries. What is good for companies is not necessarily good for the economy, as illustrated by Germany's sluggish growth, which many economists link to weak income growth and poor job security.

Traditional industrialised countries, by contrast, may be among the losers

For traditional industrialised countries, there can be no question of a win-win situation, which explains the political shift back towards protectionist measures. It is beyond the scope of this study to evaluate these developments, and this is therefore omitted. However, we can still comment on the emerging and developing countries, although space allows only for fairly superficial observations. The new globalised era represents a great opportunity to combat poverty in countries like China. Economic growth in these countries, spurred on by the boom in global trade, is also lifting per capita incomes, even though the new wealth is still unevenly distributed and in China, for example, is almost exclusively concentrated in the urban coastal regions. The enormous improvement in individual incomes and wealth in these regions has also triggered substantial growth in demand for individual mobility. This process has only just begun, but in the near future is likely to grow to levels of motorisation comparable to those in western industrialised countries. Some sustainable development goals, such as climate protection, will be fundamentally undermined by trends such as these. Before we address sustainable mobility in detail, we would like to take a glimpse at the world of tomorrow. We are not considering how the future could look if certain measures are taken to reverse the effects of non-sustainable growth; rather, we intend to show how the relevant indicators are likely to develop over the coming decades, assuming a continuation of the current trends in technology, attitudes, economic growth and politics. They can therefore be regarded as projections and not forecasts.

The 'BAU' scenario – the age of unlimited mobility

The elements of the 'business as usual' (BAU) scenario discussed below are based on estimates from various institutions and working groups. These include the European Environment Agency (EEA), the International Energy Agency (IEA) and the Sustainable Mobility Project (SMP) – an expert group commissioned by various companies in the car industry, which has published two highly regarded reports on the issue of sustainable mobility. The SMP employs a quantitative model of the transport sector developed by the IEA.

Selected projections drawn from the BAU scenario

Passenger and freight transport activities will increase sharply

The main reason for the surge in transport activity will be the forecast strong increase in real per capita incomes. The rise in transport activity will be driven in particular by growth in emerging nations, although the traditional industrialised countries will retain a sizeable lead in general mobility.

Individual mobility: strong growth in the emerging nations

Income growth is the main driver

Income growth in the emerging countries is the main driver for the projected sharp increase in the level of motorisation. It also explains the assumption of rising activity per member of the population as well as of a greater average distance travelled per trip. Higher incomes also mean that the time expended is worth more, which explains the assumption of an growing preference for faster forms of transport. Finally, the increase in per capita incomes and hence economic output in general implies expectations of increasing demand for freight transport. Overall, the BAU scenario assumes an average 1.6% p.a. rise in global transport volumes until 2030. Growth rates vary from one region and one form of transport to another. The highest projected growth in terms of individual mobility, for example, is for air travel, at a rate of 3.5% p.a.

Global increase in motor vehicle penetration rates

Projections under the BAU scenario sees that motor vehicle penetration rates increasing around the world. In some regions, growth rates are highest for automobiles and light duty vehicles (LDVs). In others, motorised two and three-wheeled vehicles head the list. If the current trends do indeed persist, then motorisation rates in the former Eastern Bloc countries will exceed the current rates in the OECD countries by 2050. In Latin America and China, on the other hand, motorisation rates should correspond with levels for European OECD countries today.

Great significance of urbanisation in emerging countries

The marked trend towards urbanisation and suburbanisation is a key driver for growth in individual motor vehicle transport in emerging countries. The latter indicates the decentralisation of large cities, i.e. the migration of important functions out of the inner city towards outer regions, enlarging the area of cities while simultaneously reducing population density per square kilometre. This notably heightens demand for private mobility and hampers public transport planning.

The growth of selected metropolitan areas, 1960–1990

Metropolitan Area	Data for 1990 Population (thousands)	Area (km^2)	Density (persons/km^2)	Annual Rate of Change, 1960–1990 Population	Area	Density
Tokyo	31,797	4,480	7,097	2.40%	3.10%	-0.60%
New York	16,044	7,690	2,086	0.40%	1.50%	-1.10%
Paris	10,662	2,311	4,614	0.80%	2.10%	-1.30%
London	6,680	1,578	4,232	-0.60%	0.90%	-1.40%
Detroit	3,697	2,900	1,275	0.00%	1.40%	-1.40%
San Francisco	3,630	2,265	1,602	1.30%	1.40%	-0.10%
Washington, DC	3,363	2,449	1,373	2.10%	3.50%	-1.30%
Melbourne	3,023	2,027	1,491	1.40%	2.50%	-1.00%
Hamburg	1,652	415	3,982	-0.30%	1.50%	-1.80%
Vienna	1,540	225	6,830	-0.20%	0.80%	-1.00%
Brisbane	1,334	1,363	978	2.60%	5.20%	-2.50%
Copenhagen	1,153	333	3,467	-0.50%	0.70%	-1.20%
Amsterdam	805	144	5,591	-0.30%	1.60%	-1.90%
Zurich	788	167	4,708	0.40%	1.20%	-0.80%
Frankfurt	634	136	4,661	-0.20%	1.90%	-2.10%

Source Demographia, 2001

Declining share for public transport

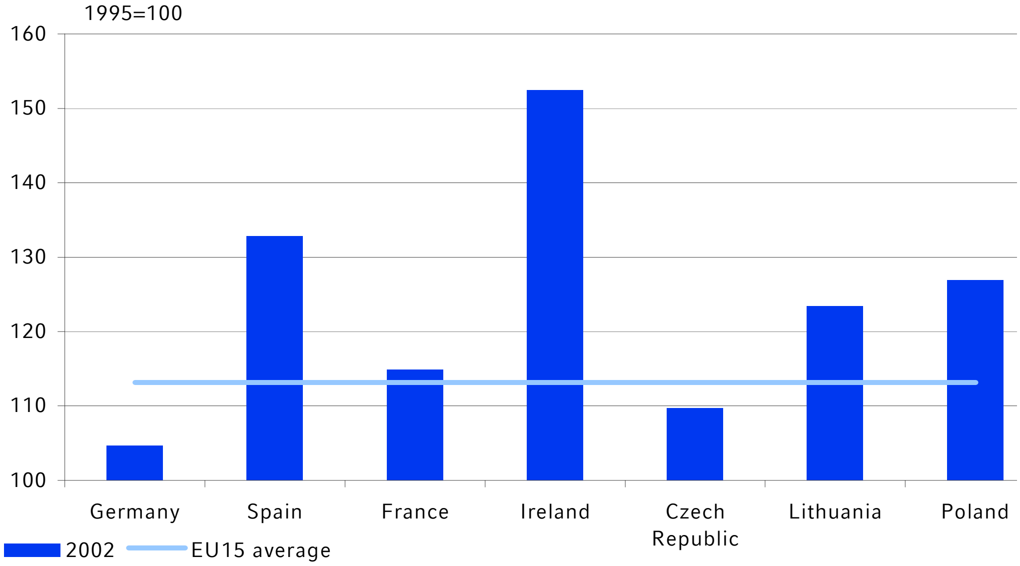
Today, public transport already makes up a declining proportion of total individual transport volumes in many urban areas, in industrialised countries and emerging nations alike. The lower population density mentioned above can certainly be blamed to some extent, but so can the growing desire for maximum individual flexibility.

Budget problems in many countries hamper adequate provision

The greatest challenge for local public transport will be to provide a sufficiently widespread service at an affordable price, without overstepping a subsidy level that society perceives as acceptable. Given the current budget problems in many countries, the latter consideration should not be underestimated. Finally, the debate surrounding public transport also has a sociopolitical dimension, since underprivileged social groups – the poor, the elderly, people with disabilities, etc. – are most dependent on public transport. Funding cutbacks are therefore equated with greater social exclusion for these groups. In the following chapter we will address the social factors more thoroughly.

The EEA also admits that the political goal of shifting demand from road to rail has yet to be achieved. In passenger transport, both forms are growing at about the same rate, while the significance of air travel is increasing at the expense of bus travel.

Country trends in passenger transport demand, 1995-2002



Source EEA, 2006

Share of air travel is up sharply

The share of cars (around 73%) and railways (around 6%) in passenger transport has changed little since the mid-1990s. In contrast, air travel's share has risen considerably and now stands at 12%. Bus travel (scheduled buses and holiday coaches) has declined by a quarter since 1990 to around 9%.

Flexibility has become more important

The EEA also concludes that more flexible and rapid means of transport have gained in relative importance. Besides cars and aeroplanes, this also includes high-speed trains such as Germany's ICE and France's TGV. The main reasons for this shift are rising incomes and the available infrastructure. The increased significance of the ICE and TGV can certainly be viewed as a success story for a supply-led transport policy and so is an encouragement that the desired 'modal shift' may be achievable in other areas.

Undesired side effects

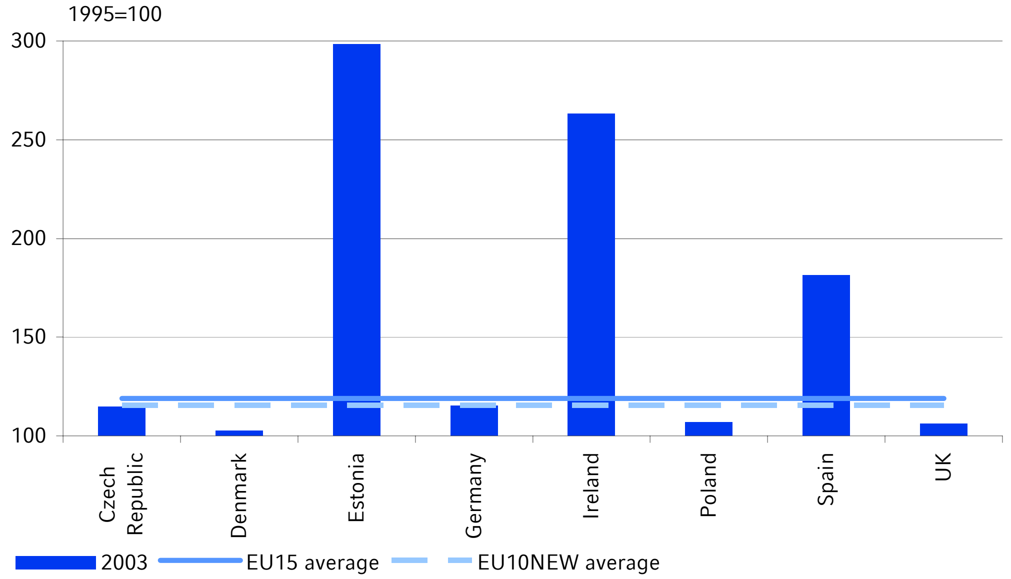
At the same time, there are also limits and undesired side effects. In the case of the desired shift from private cars to local public transport, it is obviously not enough to provide the necessary infrastructure. Experience teaches us that infrastructure measures in this segment often result in pedestrians and cyclists switching to public transport, but not drivers. Often, this simply means a rise in total transport volumes.

Goods mobility: Road freight continues to gain market share

Goal of moving traffic from road to rail recedes further

The EEA reports that the share of road transport in total domestic goods transport within the EU had risen to around 77% by 2003. This represents a 2.6 percentage point increase since 1998. The goal of shifting from road to rail is no nearer in goods transport either. An EU white paper on transport policy originally assumed that the share of road transport would stabilise at the 1998 level by 2010. This target threatens to recede ever further into the distance.

Country trends in freight transport demand, 1995-2003



Source EEA, 2006

Competitive advantages of road transport

The rising market share of road transport is explained by its obvious competitive advantages. Road transport is generally faster, cheaper, more reliable and more flexible than other modes of transport. In an era of just-in-time delivery, the need for flexibility in particular often favours lorry transport. For one thing, rising real estate prices, especially in urban regions, have boosted storage costs and so encouraged the preference for a greater number of smaller deliveries. Moreover, the big trading companies have altered their delivery strategies. They have moved away from the decentralised strategy of many smallish depots located close to major customers, and towards a centralised strategy of fewer large warehouses, which increases total transport volumes due to the greater distances involved. Another reason for the rising importance of road transport is the general increase in high-value end-products, which, in contrast to mass-produced goods, are typically conveyed by road. Another factor promoting road transport in Europe is the slow progress being made in harmonising rail technology.

Merely improving rail infrastructure is not a complete solution

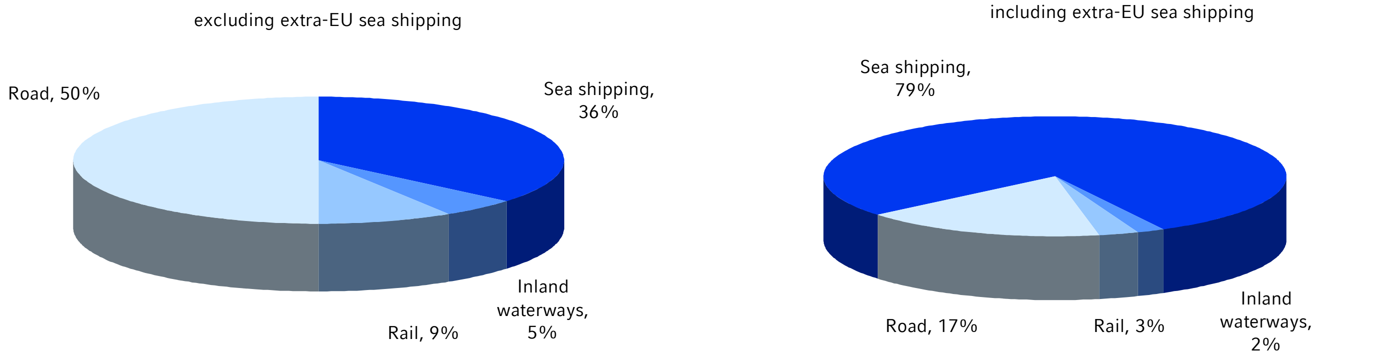
There are already many programmes in the EU to encourage goods transport off the roads and onto the railways. The European Commission's proposed Marco Polo II programme (EC, 2004) aims to shift at least the forecast 144 billion tonne-km increase in goods volumes between 2007 and 2013 onto the railways. The main argument for such a modal shift policy is the varying environmental impact of the different modes of transport – here, politicians definitely favour the railways over other forms of transport. The EEA notes, and we agree, that such sweeping judgments can also be problematic. For instance, improving the rail infrastructure can result in a total increase in transport volumes without reducing the volume of road transport. The consequence of such policies could therefore be to increase, not reduce, emissions. It therefore seems wise to carefully analyse the effects of all political promotional measure, including evaluating the likely behavioural changes of all concerned.

Sea transport is often overlooked

The main problem with sea shipping is its international nature

Sea shipping accounts for a large proportion of total freight transport. Estimates for the EU-25 assume a sea shipping share that far exceeds the combined shares of road, rail and inland waterways. The big problem for sea shipping is its international nature and the related difficulties in terms of regulation, oversight and sanction of wrongdoing. For example, there is no way to allocate international freight volumes clearly and unambiguously to individual countries, so estimates are based on rough assumptions. The figures given here, for example, assume that half of the EU's international goods transport can be allocated to sea shipping.

Current shares of freight transport volume (tonne-km), by mode, EU25



Source EEA, 2006

(Private) costs of mobility

Mobility of goods

Logistics costs as percentage of GDP has nearly halved in the USA

The (private) costs of goods mobility are contained in the general prices for products and are not directly visible to consumers. It is a complex undertaking to estimate these costs. Explicit estimates of transport and warehousing costs in the USA are published yearly in the 'State of Logistics Report'. These statistics show that such costs as a percentage of GDP nearly halved between 1981 and 2002. Their share fell from 16.2% to 8.7%. The number of private households in the USA rose by around 30% over the same period, so the logistics costs for a typical American household fell by around 60%.

Pronounced drop in warehousing costs

Part of this decline can be blamed on the erosion of freight prices, which fall by an average of 3% each year in the USA. Their share of GDP shrank from 7.5% to 5.5% during the period we are studying. It is plain that a majority of the entire cost reduction stemmed from the decline in warehousing costs: their share of GDP sank from 8.3% in 1981 to 2.8% in 2002.

Unfortunately, the availability of such data for other countries is extremely limited. For example, there are no aggregated data for the EU. The figures for the Netherlands, however, indicate that the forces working in the USA to dramatically lower logistics costs are also factors in other countries. Freight costs in the Netherlands fell by 36% (road), 45% (rail) and 52% (inland waterways) between 1980 and 1999. Some observers are already speaking of the increasing irrelevance of transport costs.

Growing infrastructure overload should slow the decline in freight costs

One factor that could limit further reductions in the cost of goods mobility is the increasing overload of transport infrastructure. As mentioned earlier, overloading the road network, for example, can lengthen delivery times and increase fuel and wage costs. Costs also rise due to the greater unreliability of the overloaded transport system. In particular, this jeopardises just-in-time deliveries and the goal of keeping inventories as low as possible. Efficiency gains due to the application of new technologies (see page 72) can only go some way towards offsetting this effect.

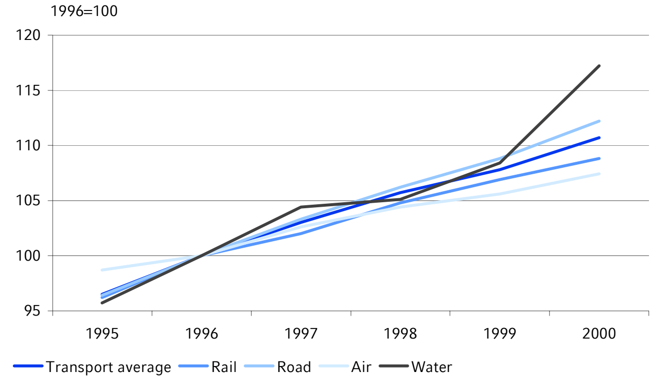
Mobility of people

Lowest price increase registered in air travel

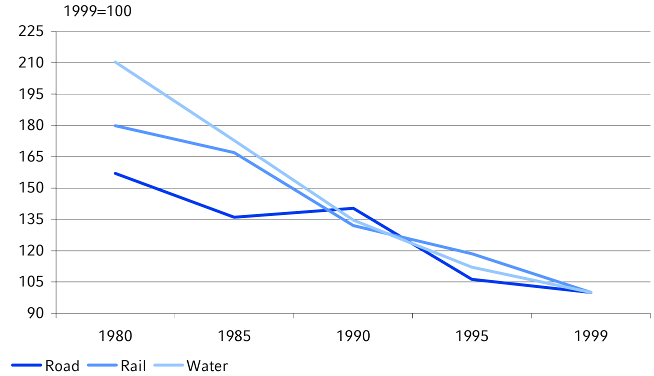
Unlike freight costs, passenger transport costs are tending to rise. The average cost of individual mobility in the EU has risen faster than consumer prices. The EEA arrives at this conclusion by looking at the rather brief period from 1995 to 2000. However, the opposite is true in Italy, Denmark and Luxembourg, where growth rates were lower than general price rises. A glance at the individual modes of transport indicates that air traffic experienced the lowest price increase during this period, due to some extent to the establishment of budget airlines like Ryanair.

Transport prices – divergent trends

Average EU 15 trend in transport prices (1996=100)



Price trend for international freight transport in the Netherlands (1999=100)



Source EEA, 2006

Composition of transport spending by private households

Main cost factor is owning and operating a motor vehicle

Although there are great differences in the composition of transport spending by private households, in general the largest single item is owning and operating a motor vehicle. This is just as true in industrialised as in emerging countries.

Income level is the most important determinant

The key determining factor in motor vehicle ownership is a household's real per capita income. Estimates indicate that 90% of national differences in motorisation levels can be explained by income. However, it is equally clear that there are countries with similar income levels that nonetheless display differences of up to 50% in vehicle penetration rates. When comparing urban areas, these variations can be explained by differences in population density, in the availability of public transport and in transport infrastructure overload.

Household transportation expenditure*

	United States	United Kingdom	Japan
Household Transportation Expenditures as a Share of Total Household Expenditures	**19.30%**	**16.70%**	**8.50%**
Composition of Household Transport and Travel Expenditures			
Public Transportation	**5.20%**	**13.50%**	**28.70%**
Rail	n.a.	3.10%	15.60%
Bus	n.a.	2.20%	3.00%
Taxi	n.a.	n.a.	2.90%
Air	n.a.	2.00%	2.70%
Highway	n.a.	n.a.	4.10%
Other	n.a.	6.00%	0.40%
Private Transportation	**94.7%**	**86.50%**	**71.30%**
Vehicle Purchase	46.90%	36.90%	22.70%
Automobile Purchase	46.30%	34.70%	21.20%
Two-Wheel/Other Purchase	0.6%	2.20%	1.50%
Vehicle Operation and Maintenance	47.90%	49.60%	48.60%
Gasoline/Motor Oil	16.80%	24.50%	16.60%
Maintenance/Repairs/Parts	8.70%	9.60%	8.30%
Parking	n.a.	n.a.	7.10%
Insurance	10.70%	12.70%	11.50%
Other	11.70%	2.80%	5.00%

* n.a. = data not provided by source; may be included in 'other'

Source Demographia, 2001

Solving the sustainability equation

'Business as usual' scenarios for the future, however, show that the looming age of 'unlimited mobility' can be expected to have unacceptable, unsustainable environmental and social side-effects. But what would a sustainable mobility future actually look like? In which directions do policy makers have to steer the regulatory environment in which transport-related sectors have to operate? And what should companies do to reduce the external costs of their products and activities?

The two faces of mobility

Mobility brings many economic and social benefits

It cannot be denied that mobility brings people great economic and social benefits. Mobility is both a condition of economic growth and rising living standards, and a consequence of it. Impressive figures testify to this: the number of jobs in the transport sector in the G7 countries ranges from 872,000 in the UK to 10.3m in the USA (US DOT, 1999). For the EU-15 the figure is around 7m (Panorama of Transport, 2002). In the USA, private spending on transport services reached nearly US$800bn in 2001, which corresponds to around 11% of total disposable income (US DOT, 2002). The picture is similar in the EU, where transport spending amounted to €700bn in 2000, or a good 14% of total consumer spending by private households.

Indirect positive effects are also immense

But even these impressive figures do not tell the whole story when it comes to the significance of the transport sector to the overall economy. The transport sector makes resources accessible, broadens opportunities to combine products and services, and increases the flexibility and mobility of labour. It expands occupational options and opens doors to career success. It can improve resource allocation and it allows comparative advantages to be exploited. Without mobility, there would be no international division of labour. It grants access to healthcare and education, and thus raises prosperity and quality of life. Its general ability to connect people and products is extremely useful. People who can rely on a functioning transport system are better able to plan and organise their private and professional lives. Mobility enlarges product offerings for consumers, and tends to stimulate competition and depress prices.

However, there is a growing belief that the transport sector cannot continue its growth trajectory

Despite all these positive attributes, there is a growing conviction that the current growth in transport volumes cannot be sustained in the long term because the 'price' to pay is just too high. This 'price', most of which is not yet reflected in the private cost of mobility, is to be paid in many ways, the first and most obvious being its effects on the environment and the health of the population. Local pollution and its associated health risks remain a worrying topic, particularly due to the trend towards urbanisation in emerging nations and despite the indisputable (partial) successes in combating pollution in OECD countries. According to the European Commission, the transport sector in general contributes more than 50% to local and regional air pollution. Increasing noise pollution as a result of expanding transport infrastructures in urban regions presents another global problem. UN projections estimate that the degree of urbanisation will rise to 81.7% by 2025. This is 8.2 percentage points more than in 1995.

Kyoto Protocol is becoming increasingly meaningless

On top of this, the sharp rise in the degree of motorisation in countries such as China raises doubts about the worth of the climate protection targets contained in the Kyoto Protocol, which excluded the entire transport sector from the beginning. Pressure on politicians to include air transport in the European emissions trading system is rising rapidly. The underlying question is: how much can our ecosystem take? Robust growth in demand for mobility has also raised concerns due to events in the international oil and gas markets. Resource depletion and supply security have become high-priority topics on the economic and political agenda.

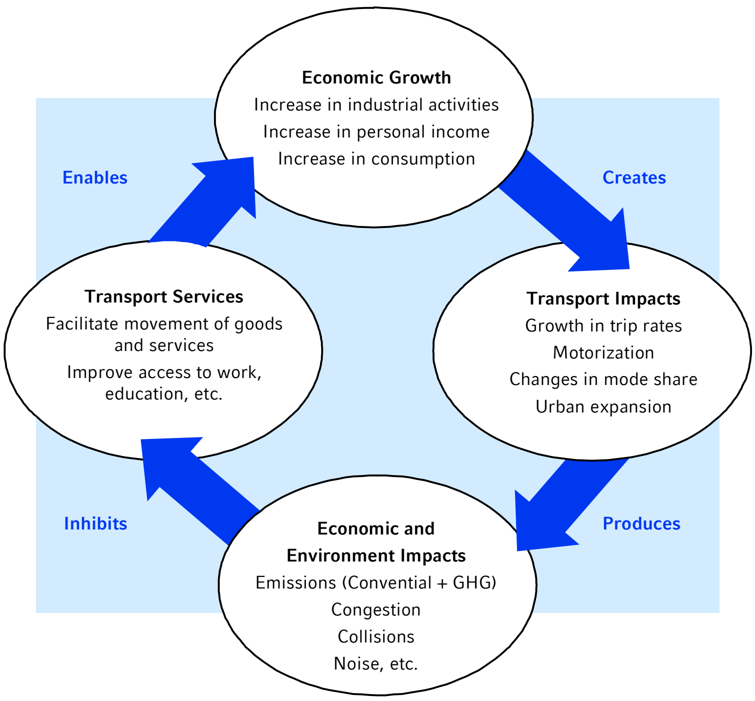
Many undesired side effects

Current trends in emerging nations raise questions of social justice in the distribution of the costs and benefits of a surge in mobility in these societies. In developed countries, on the other hand, concerns are being voiced over the decentralisation of urban regions and the subsequent fall in public transport services that is threatening to exacerbate the social exclusion of certain groups (the poor, the elderly and the disabled). Other undesired side effects of increasing mobility are the increased security risk of terrorist attacks and the growing risk of accidents in emerging countries. Europe too has room for improvement in terms of safety. According to the European Commission, some 40,000-50,000 people are killed in traffic accidents in the EU-15 every year. The direct costs of automobile accidents alone are estimated at €45bn. Including the indirect costs (for example, associated healthcare costs) would raise this figure to some €160bn. The adverse economic, ecological and social effects of increasing mobility could ultimately jeopardise the transport system's ability to fulfil its central socioeconomic role. The system could even be in danger of choking on its own expansion.

Signs of more sustainable development in the transport sector

This is only a brief outline of the trade-offs facing politicians, companies and private households. It is a highly complex mix comprising many reciprocal relationships and reverse interactions. The key question is how to meet the challenges presented by strong growth in demand for mobility in future: how to balance economic growth and a high material standard of living on the one hand against the environmental and social aspects of sustainable growth on the other. The chart below lists some ideas about how to better exploit the potential of mobility and how to reduce the cost of that potential.

The challenges of making mobility sustainable



Source SMP, 2004

Separation of mobility and growth is a pipedream

Efficiency gains play a central role

When considering transport systems, the primary question is usually how to make an existing system more efficient. For some time, people have pursued a vision of decoupling the issue of mobility from that of economic growth. The new information and communication technologies, and the concept of dematerialising and 'virtualising' the economy, have played a major role in this vision. Now, however, many have come to the sobering conclusion that true separation cannot be achieved. What remains is the fundamental goal that underpins the decoupling thesis: to promote greater efficiency in passenger and freight transport. The required volume of additional transport per unit of growth in economic output must be reduced in order to lower both the private and the external costs of transport.

There is no way around active channelling of demand

Efficiency gains can be produced with new technologies as well as with a more intelligent organisation of transport responsibilities. Further, new technologies can help to lower external costs of mobility by reducing transport-related emissions. Another gateway can be found in the channelling of demand, which relates to influencing demand for certain modes of transport by creating economic incentives such as taxes and duties, or by trading emission rights.

Overview of definitions of sustainable mobility

- **WBCSD/SMP:** Sustainable mobility is *'the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values today or in the future'*.

- **OECD:** Environmentally sustainable transport (EST) is *'transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes'*.

- **European Federation For Transport & Environment:** *'A sustainable transport system minimises consumption of non-renewable resources, emissions, land take, impacts on ecosystems and human health, and limits waste, emissions and renewable resources within the absorption capacity of the planet. This system is socially inclusive, by providing access for all citizens to the most essential goods and services, offering choice of transport mode, and protecting vulnerable user and other groups from safety and health risks and nuisances caused by transport. In a sustainable transport system, users instead of taxpayers pay for their infrastructure use and environmental, health, safety and congestion costs so that they get incentives for smarter travel choices and do not leave an unpaid bill to society.'*

The (external) costs of mobility

Resource requirements: ecological 'footprint' of the transport sector will continue to expand

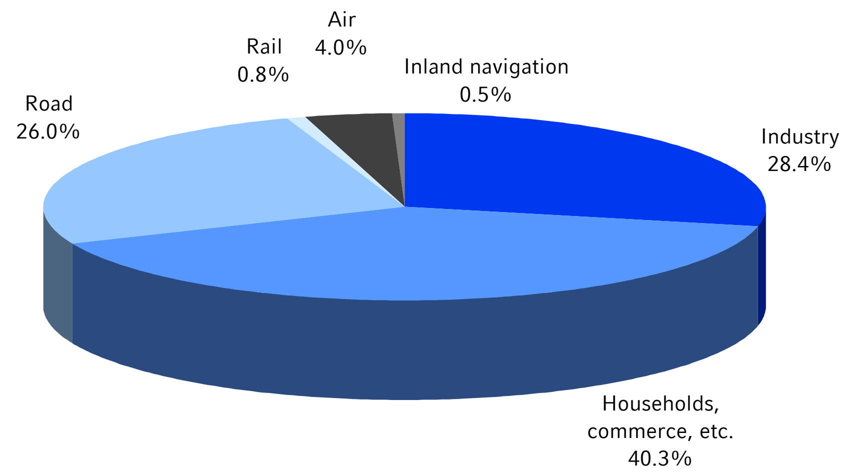
Energy consumption, land take and consumption of materials

The transport sector is one of the largest consumers of natural resources. There are three different categories of consumption: (1) the transport-related energy requirement, with its heavy dependence on fossil fuels; (2) transport-related land take, especially for building and expanding the necessary transport infrastructure; and (3) the consumption of materials in vehicle manufacture (the growing need to recycle) and in building and maintaining of transport infrastructure.

Energy requirement

Nearly one-third of total energy consumption in Europe is attributable to the transport sector. This percentage is likely to grow.

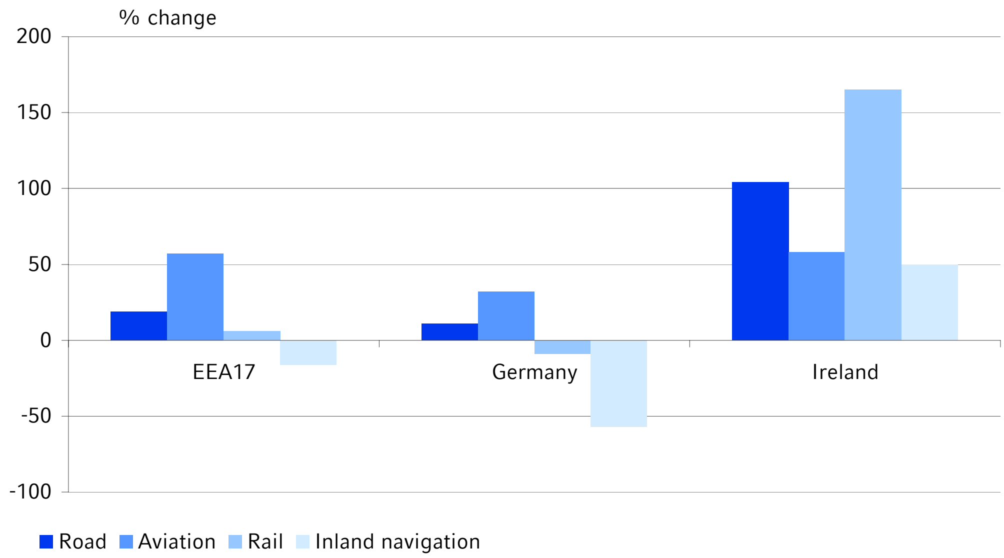
Shares of total EU energy consumption by sector, 2002 (m tons oil equivalent)



Source EEA, 2003

Efficiency gains due to the use of new technologies have been more than offset by increasing transport volumes. For example, energy consumption in the EEA-17 zone (EU-15 plus Iceland and Norway) rose by 22% from 1990 to 2000. Air transport shows the strongest growth in energy consumption, but road traffic makes by far the largest contribution in the transport sector.

Changes in energy consumption for the main modes between 1990 and 2000 in the EEA-17*



* EEA-17: EU-15 plus Iceland and Norway

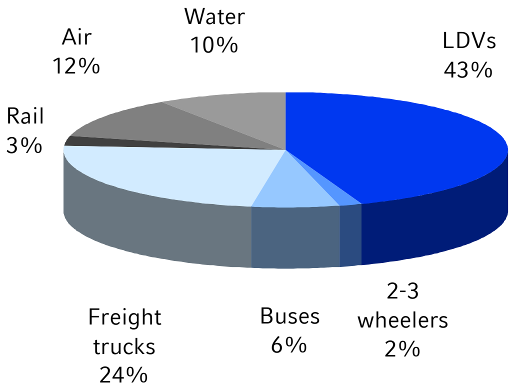
Source IEA, 2003

According to SMP estimates, even in 2050 most fuels will still be based on oil. By that time, the energy requirement of the transport sector will probably have almost doubled from its present level. However, there will be substantial regional shifts in energy consumption between now and then.

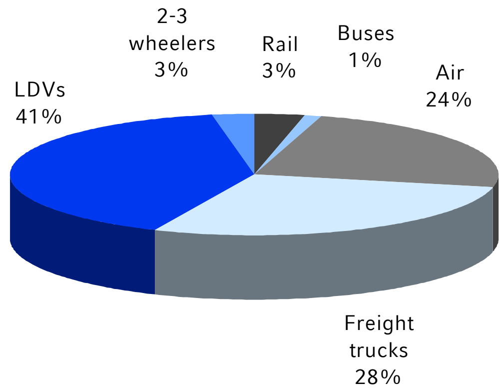
OECD countries will see massive loss of market share

OECD countries accounted for around 65% of the energy required for transport activities in 2000, but will steadily lose in significance until their share is around 40% in 2050. The emerging countries of South and East Asia, in contrast, will post the greatest growth: their share of the energy required for transport worldwide will climb from 11% to nearly 30%. China alone will answer for more than 12%. Note that these are simply projections based on the assumption that the current trends will persist into the coming decades. The following charts illustrate how the rising energy requirement of the transport sector could be allocated to the individual modes of transport.

Shares of world energy use for transport by mode, 2000 – all fuels



Shares of increase in fuel use by transport mode, 2000-2050E



Source SMP, 2004

Growing concern about possible shortages

The rising energy requirement in the transport sector must also be seen against the backdrop of generally rising demand for oil and growing concerns about potential fuel shortages. These fears are fuelled by the high level of geopolitical uncertainty. One current example is the issue of Iran's nuclear capability, and Tehran's undisguised threat to use fuel supplies to the West as a political card.

Oil production is nearing a peak

According to the IEA, energy consumption in the transport sector is 98% petroleum-based and is thus extremely vulnerable to a shrinking oil supply. The timing of the expected peak in oil production remains a hotly debated topic among experts. Still, there is a general consensus that it will be reached sometime in the next 25 years. From today's vantage point, alternative fuels, more efficient propulsion technologies and adjustments in demand volumes seem to be the main available options in response to this scenario. None of them, however, represent an automatic solution to the problem of greenhouse gas emissions. Their life cycle is considerably longer than that of the remaining oil reserves.

Land take

Evaluation differs completely in the industrialised and emerging countries

The pattern of land take for building transport infrastructure could not be more disparate. Whereas in emerging countries such land use is mainly considered a sign of economic development and increasing affluence, and is thus welcomed, the emphasis in developed countries is on the adverse effects of land take on the environment and quality of life. This is particularly true in Western Europe, with its high population density. Here, land use for the transport sector is generally viewed from the point of view of generating external costs and moving away from the goal of sustainable mobility. Adverse effects include the uncontrolled spread of urbanisation and the paving over of ground, and the consequences of this such as the increased risk of flooding and the destruction of natural habitats of plants and animals.

Direct and indirect land take by transport in the EU (1996)

Infrastructure Type		Direct [1] Land Take (ha/km)	Direct [1] + Indirect [2] Land Take (ha/km)
Road	Motorway	2.5	7.5
	State Road	2	6
	Provincial Road	1.5	4.5
	Municipal Road	0.7	2
Rail	Conventional and High Speed	1	3
Water	Canal	5	10
Air		none (runways not considered)	airports

(1) Direct land take refers to area covered by transport infrastructure.
(2) Indirect land take refers to associated land taken for security areas, junctions and service areas, stations, parking, etc.

Source EEA, 2001

A great deal of urban space is covered by transport infrastructure

Transport infrastructure covers large portions of urban land area in most countries in the developed world; this includes roads, parking spaces, railways and railway stations, airports, and harbours. In 1996, transport infrastructure covered around 1.2% of the entire ground surface of the EU, around 93% of this being roads (EEA, 2001). In future, further significant space could be required for producing alternative bio-fuels.

As a rule, transport infrastructure is taking an increasing share of space as economic output increases. The EEA estimates that from 1990 to 1998 a total of around 30,000 hectares (around 10 hectares each day) were 'lost' to building motorways alone.

Measures of transportation infrastructure per head (km/million inhabitants)

	Intercity Rail	Urban Rail	Roads	Motorways
EU 15	415	18	9,330	125
Central and Eastern European countries	635	50+	7,880	24
United States	140*/890	7	23,900	325
Japan	210	6	9,200	51
World	**210**	**4**	**4,750**	**35**

* Only 38,000 km in passenger service

Source EC, 2001

Congestion

Costs of infrastructure overload

Closely linked to the issue of land use is the detriment which can result from the overload of transport infrastructure. As has been pointed out above, the overload on transport nodal points, airports and road networks can have significant economic costs, while also having a severe effect on the quality of life of those affected. Thus, whilst the need for an expansion in infrastructure measures is rejected within the framework of land use and the resulting air pollution and noise, equally there is a call for such expansion under the banner of more sustainable mobility with a view to reducing the adverse effects of the current overload on the infrastructure.

It is hardly surprising that in the 'business as usual' projections produced by the SMP it is assumed that the problems arising from overload on transport infrastructure will continue to worsen. This assumption rests on the observation that transport volumes are currently growing substantially more quickly than infrastructure capacity.

Non-linearity and evasive action to be taken into account

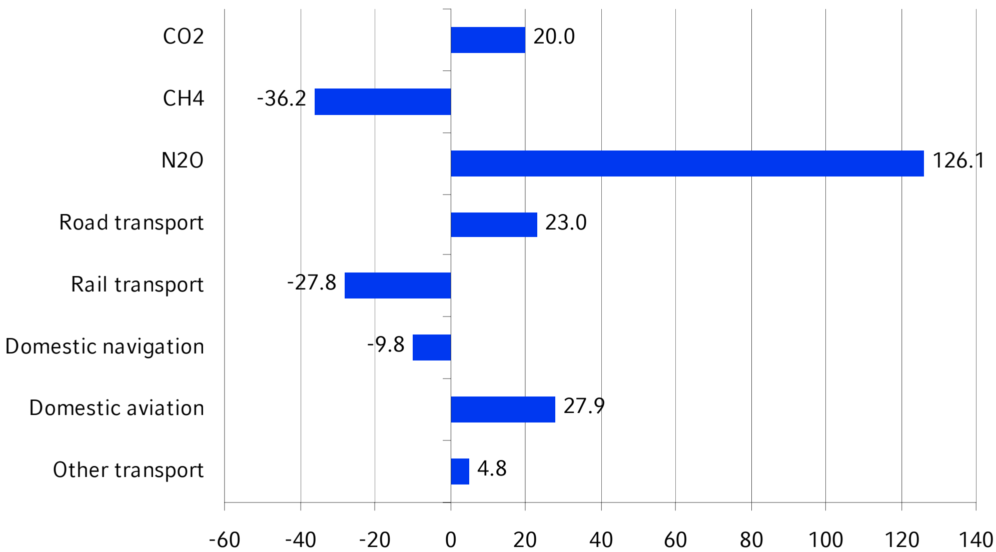
The planning of transport infrastructure measures to relieve the pressure is anything but trivial. It begins with non-linearity in the formation of jams and ends with the issue of having to factor in the adjustments made by users of the infrastructure. Thus at first sight it would seem logical to concentrate expansion measures on traffic bottlenecks. However, experience shows that expansion at these points can mean that, as a result of the increased attractiveness of a previously overburdened route, the number of people opting for this route also increases. After a relatively short space of time, the overload is the same as it was before the expansion. Nothing has been gained. Often, infrastructure measures also result merely in local shifts in the overload on transport routes and thus a shift in the way traffic is distributed. People who have accepted high private costs in order to avoid overburdened infrastructures (e.g. living in a more expensive location) can very quickly become the losers as a result of new infrastructure measures.

Greenhouse gas (GHG) emissions

Sharp increase in GHG emissions resulting from transport

In the fifteen EU member states, GHG emissions resulting from transport rose 21% between 1990 and 2001. CO_2 contributed the lion's share of these emissions at 97%, which were mainly caused by road transport (92% in 2001). Road transport's share of the overall increase during this period was 23 percentage points, only just lower than that attributable to domestic air transport (+27.9 percentage points). The reductions brought about in the case of rail transport and domestic navigation were not nearly enough to compensate for the overall increase.

Contribution to change in total EU15 GHG transport emissions by mode and pollutant, 1990-2001



Source EEA, 2003

Climate protection targets jeopardised by growth in mobility

A glance at the individual GHG components reveals a conspicuous increase in N_2O emissions. However, overall the transport sector contributes very little to total N_2O emissions, and so there is no significant effect here on general trends in GHG emissions. All in all, the transport sector accounted for around 21% of total GHG emissions in the EU in 2001 (not including international aviation and sea transport). The sharp increase in emissions created by the transport sector largely offset the successes achieved in other sectors in reducing emissions, and thus from today's perspective it would appear increasingly difficult to meet the climate protection targets formulated in the Kyoto Protocol. If the targets are to be achieved, the use of additional instruments, such as including air transport in emissions trading, can hardly be avoided.

Volume effects greater than efficiency gains

The total volume of GHG emissions caused by transport reflects the combined influence of four individual factors:

- Transport volumes, i.e. the number of passenger and tonne kilometres travelled,
- The modal mix in transport activity (i.e. the distribution over different modes of transport),
- The GHG characteristics of the fuels used by the different modes of transport, and
- The energy efficiency of the different modes of transport, i.e. the amount of fuel needed per passenger or tonne kilometre travelled. There are two dimensions to this: the utilisation of available capacity (e.g. the 'load factor' in air transport) and the fuel efficiency of new technologies.

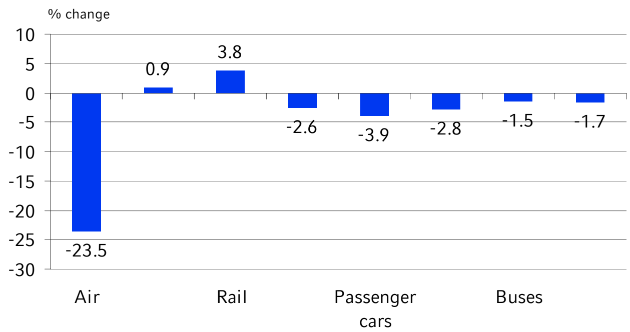
Transport volumes outstripping increased energy efficiency

The basic problem in the transport sector with regard to GHG emissions is that transport volumes are increasing more quickly than the energy efficiency of the individual modes of transport. Let us take cars as an example: on average in Europe, the energy efficiency of cars increases year on year. As a result, the EEA anticipates, for instance, a fall in CO_2 emissions per passenger kilometre in the EU 15 of just under 4% by 2010.

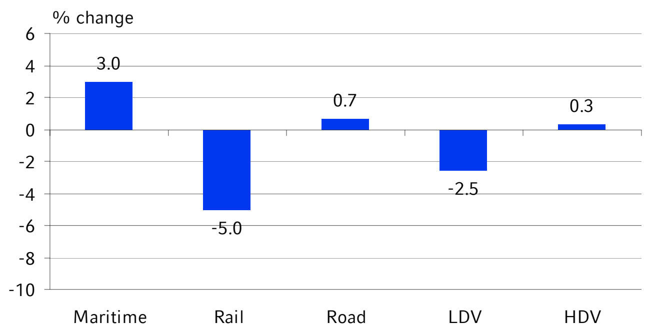
However, this pleasing improvement, brought about by the use of new technology and alternative fuels, will be counteracted by the sharp growth in car transport volumes expected (+16.4% from 2005 to 2015). There is a similar scenario in air transport, where the EEA anticipates the best improvements in CO_2 efficiency.

Estimated reductions in CO_2 emissions (grams) per passenger/tonne kilometre in EU15 (1990 – 2010)

Passenger transport



Freight transport



Source EEA, 2003

GHG emissions – the global long-term scenario

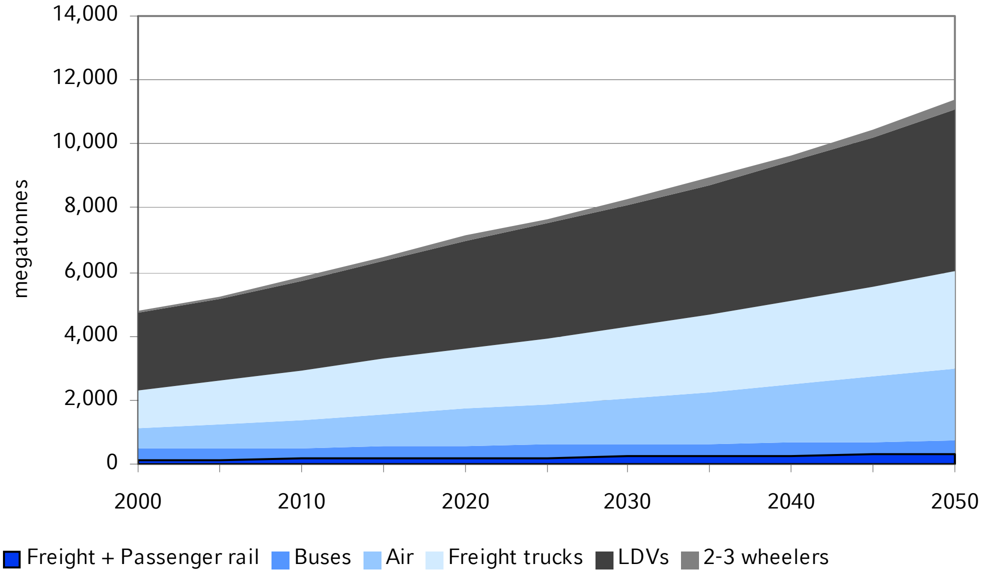
No dramatic changes to be expected in the modal mix

The SMP's 'business as usual' scenario also anticipates a sharp increase in transport volumes by 2050. A further projection sees no dramatic changes in the modal mix, – the distribution across different modes of transport. The same also applies to the fuels used. Thus, in this view, conventional, oil-based fuels will still clearly dominate the market in 2050.

Offsetting the increasing transport volumes scarcely seems possible

In its reference scenario, the SMP also expects a significant improvement in energy efficiency for those modes of transport for which the sharpest increase in volumes is expected. Thus, energy consumption per passenger and tonne kilometre for cars including light duty vehicles should fall by 18% by 2050, and by some 29% for heavy duty vehicles and aeroplanes. But even in the long term it will not be possible to offset the increased energy use resulting from growing transport volumes. Thus, in its reference scenario, the SMP anticipates growth rates in transport volumes of 123% (cars), 241% (trucks) and 400% (air transport) over the same period. As a consequence, GHG emissions resulting from transport will increase significantly.

Transportation Vehicle CO_2 Emissions by Mode

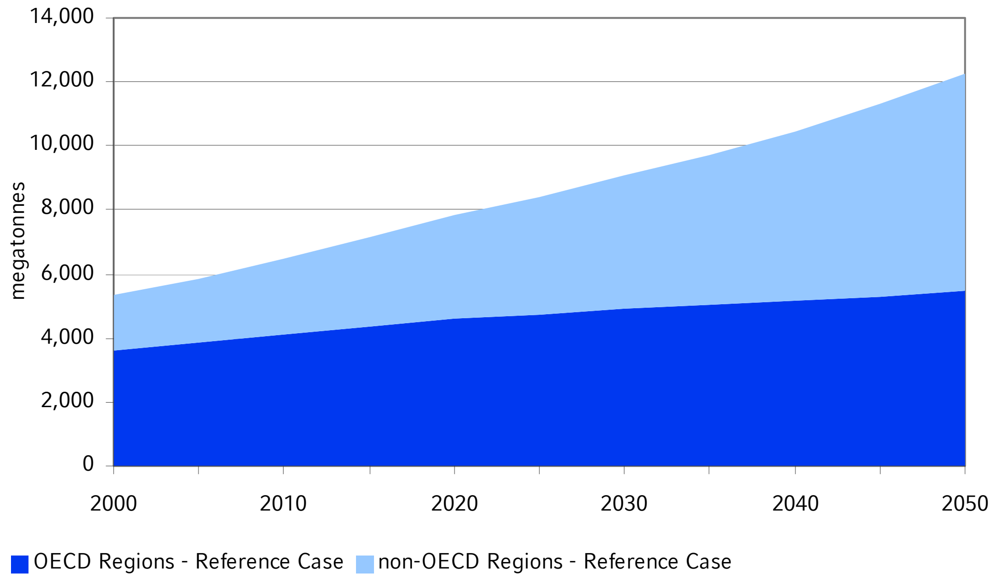


Source SMP, 2004

Large regional differences

A further feature of the projection is that extremely large regional differences are expected. Thus, a very sharp increase is anticipated in developing and newly industrialised countries, while growth in developed countries will be comparatively flat. This projection is based, firstly, on the assumption that transport volumes in newly industrialised countries such as China, for example, will increase much more sharply than in the United States or western Europe. The second assumption is that there will be some considerable delays in installing new technologies to improve energy efficiency in developing and newly industrialised countries.

Transportation Vehicle CO_2 Emissions by Region



Source SMP, 2004

‘Conventional’ emissions

Emissions will decline sharply across the developed world

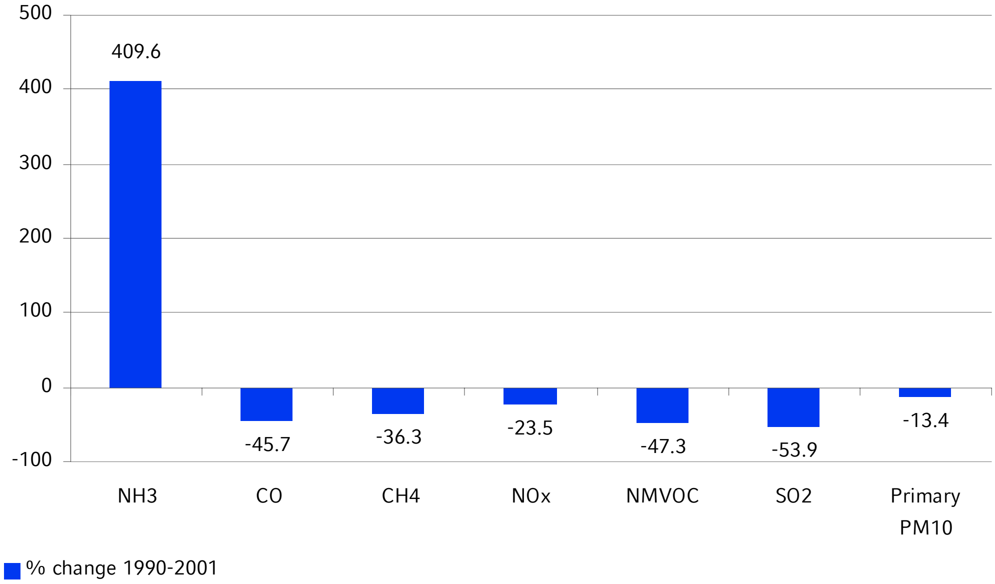
Local causes, local effects

Whilst, with GHG emissions, the damage to the environment is not subject to a local cause-and-effect relationship, there is just such a relationship with ‘conventional’ forms of pollution. These include lead, carbon, particulate matter (PM), nitrogen oxide (NOx) and ‘volatile organic compounds’ (VOCs). The last two are pollutants emitted by motor-driven vehicles and which, under the influence of the sun’s rays, are responsible for the formation of surface ozone. Other significant environmental effects result from ‘acidification’ and ‘eutrophication’, caused by the depositing of sulphur/nitrogen compounds.

Biggest success so far lies in introduction of unleaded petrol

The developed world has been trying for decades to reduce the conventional pollutants emitted by transport. The biggest success so far has without doubt been the extensive introduction of unleaded petrol. Thus, the lead content of exhaust gases from transport in the traditional industrialised countries is hardly an issue any more. The progress achieved with other conventional emissions is also significant, if not nearly as spectacular. For the 31 EEA countries (EU 25 plus other countries in eastern Europe), reductions in the key pollutants have been well into the double-digit zone, coming in between -13.4% (PM10) and -53.9% (SO_2) from 1990 to 2001.

Growth of 'conventional' transport emissions (EEA-31)



Source EEA, 2003

Introduction of strict emissions standards

These successes are mainly due to developments in road transport. Thus, emissions standards for motor vehicles have been tightened considerably in some cases, and the technical conditions have been created to meet these standards (e.g. the fitting of catalytic converters). The more stringent requirements thereby placed on vehicle fuels have meant that they have been produced in large volumes and made widely available. Another factor which reduced emissions was the renewal of vehicle fleets in eastern Europe in the second half of the 1990s. Despite the successes which have been achieved, further efforts will no doubt be required in the field of conventional emissions. One of the key challenges is clearly the reduction of particulate matter emissions in urban areas – a problem which has been exacerbated by increasing diesel penetration rates in the European car market.

Emissions will increase in many countries of the developing world

Sharper growth in transport and delays in emission-reducing factors

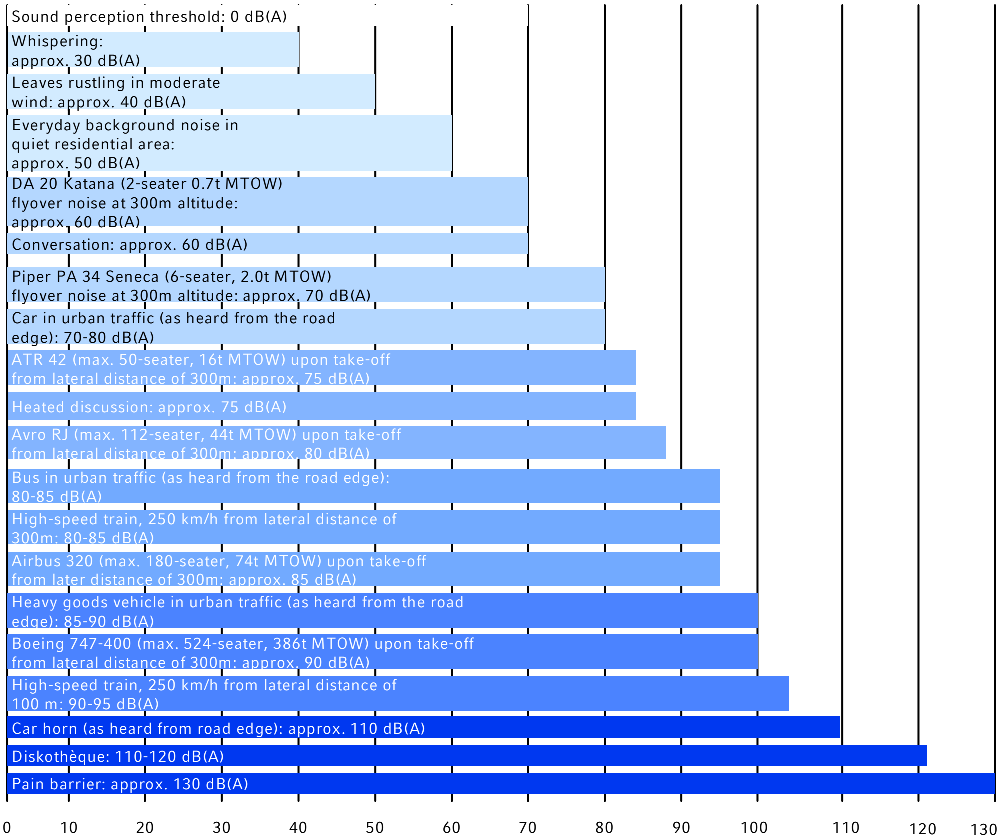
The same applies here as with GHG emissions: the significant difference in the developing and newly industrialised countries is that transport volumes are growing much more sharply than in the developed world, while factors which reduce emissions (more stringent regulation and new technologies such as higher-quality fuels) are taking longer, for instance in comparison with the countries in the European Union. In its reference scenario, the SMP expects a time lag of 10 years, including adaptation and effective implementation. Monitoring of adherence to newly introduced emissions standards is likely to prove particularly difficult in the newly industrialised and developing countries. It is therefore to be assumed that conventional emissions too will continue to rise for decades in these regions before they finally fall.

Noise

Physical and psychological components

Noise by definition is any kind of sound which is found to be disturbing, irksome or even painful. Noise pollution is a physical thing but also has a psychological dimension. Transport activity (road, rail and air traffic) is one of the main causes of noise in urban areas. The overall picture is made up of a highly complex interaction of emissions profiles, frequency of use and user behaviour.

Sounds and their specific noise levels



* MTOW: Maximum Take-Off-Weight

Source ADV, 2003

Differing perceptions of noise pollution

Noise caused by transport activity is also classed here as a conventional form of emission. The reason for this is that transport noise only has a local impact on health and general quality of life. However, in a similar way to land use issues, perceptions of noise pollution differ widely. Traffic noise is sometimes regarded as the most serious adverse side-effect of mobility, for example in many countries of densely populated Europe.

New transport infrastructure measures, such as the expansion of airports, are mainly judged by the population in terms of the additional noise they will create. Despite all the technical advances, for example in modern aircraft turbine engineering, experts assume that noise pollution created by transport activity will increase further in the coming decades.

Social equity concerns

Mobility as a catalyst for a better quality of life

Mobility is deemed to be a first-class means of opening up economic and social opportunities. In the developed world, both passenger and freight mobility have reached an unprecedented level for a large part of the population. Nonetheless, there remain large differences in levels of mobility, including in EU countries for example, depending on age, income and location. In contrast to this is the continuing situation in the developing and newly industrialised countries, where the vast majority of the population have very poor access to modern modes of transport, and such access is distributed in an increasingly inequitable way.

Social exclusion

Impaired quality of day-to-day life as a result of lack of access to transport

The issue of social exclusion is a top-priority social problem in developed countries. Modern industrial and knowledge-based societies are driven by the ability of individuals to travel over increasingly large distances in ever shorter intervals of time. Where people are deprived of this ability through lack of access to private or public transport, this considerably impairs their day-to-day quality of life. Thus, access to essential and non-essential goods, services (in particular educational and health facilities) and job opportunities is restricted. There are no extensive empirical studies on this subject. However, the results of investigations in individual regions give solid support to the argument presented here.

Social inequity as a consequence of a lack of personal mobility access

Indicator	Ratio
Girls Net Primary School Enrolment Rate	0.66
Boys Net Primary School Enrolment Rate	0.87
Females Literacy Rate (10 years and above)	0.57
Males Literacy Rate (10 years and above)	0.83
Immunization Coverage(1)	0.85
Contraception (2)	0.63
Pre-natal consultation	0.50
Births assisted by skilled attendant	0.67
Births at home	1.07
Post-natal consultation	0.71

* Ratios of social indicators in rural Pakistan's villages without all-weather motor accessible roads relative to those with (1) Fully immunized 12-23 months based on recall and record; (2) Percentage of married women of age 15-49 who ever used contraception.

Source World Bank, 2006

The poor, the old and the disabled are sections of the population disadvantaged by current mobility trends

The two contrasting trends which emerge when looking at access to mobility – the rise in the level of access to private motorised transport, coupled with the diminishing presence and competitiveness of public transport systems – will have significantly different effects in different regions. In developed countries, in which access to private motorised transport is already very high, the reduced emphasis placed on public transport will primarily affect those sections of the population which are disproportionately dependent on these modes of transport. These include the elderly, the poor and disabled people. Naturally, this also applies in general to developing and newly industrialised countries. But in these countries, a much larger section of the population than in developed countries is dependent on public transport as their primary means of transport.

Problems which are equally relevant in both sets of countries are urbanisation and suburbanisation. Social disparities arise here, for instance in terms of access to goods, in that the disappearance of small shops and the concomitant increase in large-scale shops contributes to the decentralisation of urban zones, because the large-scale shops tend to be located on the edges of the city (on the greenbelt) and can therefore often only be reached by car. In the developing and newly industrialised countries in particular, an additional problem is that the sprawl and decentralisation of cities will lead to a marginalisation of traditional and still much-used non-motorised modes of transport (cycling and walking).

Demographic developments exacerbate social justice problems

In general, the social issues resulting from the two contrasting mobility trends will worsen in the coming decades because of ageing populations. This will not just affect the traditional industrialised countries of western Europe and North America. Some of the newly industrialised countries too, such as China, will suffer similar demographic problems.

Inequality in exposure to transport-related safety risks

A subject for country comparisons

The issue of transport safety and risk of accidents also has a social dimension. However, this mainly emerges when comparing different countries. The gulf here between rich and poor countries is widening and this is expected to continue for the foreseeable future in the absence of effective countermeasures to overcome this gulf. Projections from the World Bank assume that between 2000 and 2020 the number of deaths from road traffic accidents in countries with low and medium income levels will rise by more than 80%, while for countries with a high level of income a 30% reduction is predicted over the same period.

Regional Disparities in Road Safety

	Change in Number of Deaths	Fatality Rate (Deaths/100,000 Persons)	
World Bank Regions	2000-2020	2000	2020
South Asia	144%	10.9	16.8
East Asia & Pacific	80%	19	21.2
Sub-Saharan Africa	80%	26.1	31
Middle East & North Africa	68%	19.2	22.3
Latin America & Caribbean	48%	10.2	18.9
Europe & Central Asia	18%	12.3	14.9
Sub-total	83%	13.3	19
High-income countries	-28%	11.8	7.8
Global total	66%	13	17.4

Source World Bank, 2006

Inequality in exposure to transport-related pollutants and noise

Inequality in the exposure to air pollution and noise

Another issue of social justice arises in the increasing disparity in the impairment of quality of life as a result of air pollution and noise. Thus, it is increasingly the case that many poor families in urban areas can only afford to live in districts which are disproportionately affected by air and noise pollution – for instance, accommodation in close proximity to airports, railway lines and main roads. The reduction in conventional emissions discussed above will obviously only partially cushion this disadvantage.

Mobility – where next?

Significant intervention will be necessary if currently unsustainable mobility trends are to be broken

To summarise what we have said at this point, mobility at present is not sustainable and will not be sustainable in the future if current trends continue. That means that intervention will be necessary to break these trends. This applies above all to developing and newly industrialised countries. It is obvious that we cannot rely simply on new technology to solve the problems, but also need to think about stemming and redirecting the overflowing demand for mobility. It is clear that this conclusion will not be all that welcome to those companies which seek to profit from the boom in mobility. Furthermore, the politicians will no doubt have difficulty warding off the concentrated power of the lobbyists. But there is no alternative.

Measuring the external costs of mobility

Defining external costs

Internal vs external costs

The total cost of mobility is the sum of its internal and external costs. The internal, or private, costs of mobility are those that must be paid directly by the individual user of a mode of transport. In the case of an automobile this would include the purchase price of the vehicle, routine maintenance and repair costs, tax and insurance premiums. The external costs of mobility, on the other hand, are borne not by individual users but by society as a whole. Thus the overriding goal of making mobility more sustainable is often equated with the goal of internalising its costs.

Fixed vs variable external costs

External costs can be either fixed or variable. Variable external costs are linked directly to transport volumes (tonne or passenger kilometre). Fixed external costs, on the other hand, are unrelated to the distance travelled. These are costs that are incurred over the entire mobility life cycle (upstream and downstream processes). They include environmental costs relating to producing fuel or building infrastructure, and the cost of disposing of obsolete vehicles.

Large differences in cost estimates

No standard method to estimate external costs

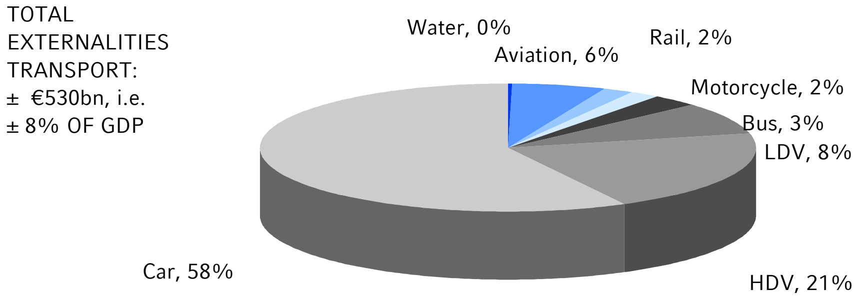
Estimating external costs is a difficult undertaking. There is no standard, generally accepted approach. In the past, many organisations and research institutions have attempted to draw up an explicit definition of external mobility costs, often expending a great deal of time and effort in the process. Studies differ in several ways, from the mode of transport under review to the range and specification of the influencing factors involved. Thus it is not surprising that empirical results too display significant differences. Despite the variations in approach and in numerical results, there are some general, qualitative conclusions to be drawn from such studies:

- The external costs of mobility are highly significant in both absolute and relative terms.
- Air pollution, global warming and the consequences of accidents make up most of the total external costs of mobility. Overloading of infrastructure (congestion) is much less significant overall, but is the greatest cost generator in urban regions.
- Road transport (of both passengers and freight) is by far the largest generator of external costs.

External costs make up 4-8% of GDP

Among the most important studies are those by Infras and the IWW in 2000, and by the European Conference of Ministers of Transport (ECMT) in 1998. Their estimates of the total external costs of mobility differ widely for the above-mentioned reasons. The ECMT study puts external transport costs at 4% of GDP, while Infras/IWW arrives at a considerably higher figure of 8%.

Composition of external costs of transport in EU-15 plus Norway and Switzerland, by transport mode



Source Infras/IWW, 2000

Total external costs of mobility amount to more than €500bn p.a.

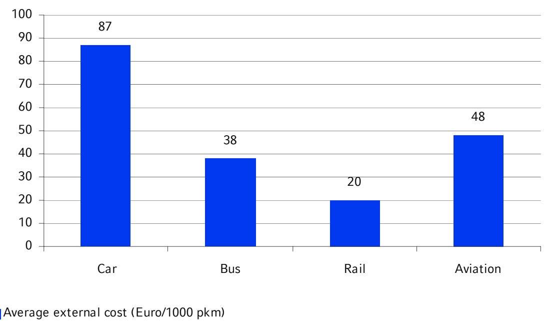
The chart above shows that more than half of the total external costs of over €500bn each year can be attributed to automobiles. According to these estimates, road transport as a whole – i.e. passenger and freight transport on roads – accounts for around 92% of the total external costs of transport. The shares for rail transport and inland waterways, on the other hand, are negligible.

Road transport's high share of external costs

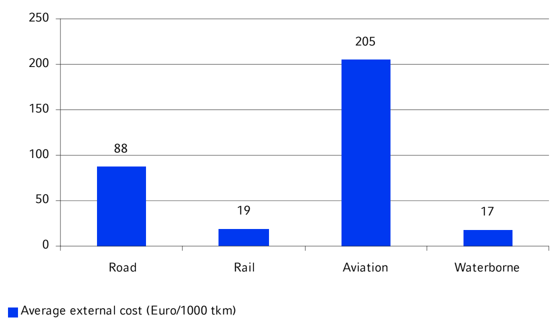
Road transport makes a poor showing even in terms of average unit costs. For example, Infras/IWW finds that the external cost of an automobile is €87 per 1,000 passenger kilometres (ECMT: €45), well above that of every other mode of transport reviewed. The tighter emission standards (up to the current Euro IV norm) implemented since this study was published should have improved the relative standing of automobiles somewhat since then. In the freight business, the average external cost of road transport is exceeded only by that of aviation – and substantially, as the following chart reveals.

Average external cost (EU-17)* by transport mode and type (excluding congestion costs), 1995

Passenger transport



Freight transport



* EU15 + Switzerland and Norway

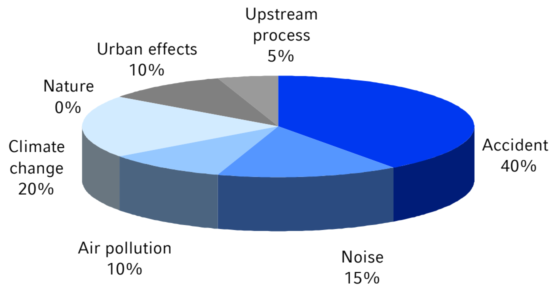
Source INFRAS/IWW, 2000

Marginal external costs

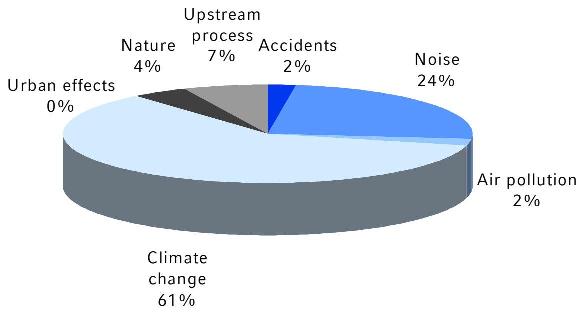
The last type of cost that we examine in this context is marginal external cost, i.e. the cost incurred per additional passenger or tonne kilometre. For these costs, much depends on where and when the final additional kilometres are travelled. Distances in urban regions, for example, cause much higher marginal external costs than they do in rural regions. This is mainly to do with higher population densities in cities, as a result of which a greater number of people are exposed to the adverse side effects of transport activities (such as health problems from air pollution). One example of the dependence of marginal external costs on the timing of transport activity relates to the cost of infrastructure overload. It makes a great deal of difference whether a traveller uses a traffic corridor during the rush hour rather than at night-time or at the weekend.

Marginal external cost of passenger transport – share by cost category

Car (max case with total marginal cost of €1.9/1,000 km)



Aviation (max case with total marginal cost of €4.5/1,000 km)



Source INFRAS/IWW, 2000

Great differences in the context of marginal external costs

If we compare the structure of marginal costs across various modes of transport we can observe significant differences. While automobiles, for example, have the greatest share of costs resulting from accidents (40%), aviation accounts for most of the external costs relating to greenhouse gas emissions. An analysis of marginal costs can indicate the areas in which progress can be made towards more sustainable mobility, provided measures are implemented that aim to reduce demand volume for certain modes of transport.

Internalisation of external costs is a policy goal

One of the main communicated goals of environmental and transport policy in the EU is the internalisation of external costs. However, progress to date has been very modest. One success has been the gradual tightening of emissions standards for automobiles. Positive examples of charges to travellers for using infrastructure are the London congestion charge, introduced in 2003, and the truck toll on German motorways, which was introduced in 2005 after several delays. Across the EU, the best and most differentiated measures to internalise external costs have been introduced in Germany, the UK and Sweden. Ireland, Greece, Luxembourg and Italy, on the other hand, still have great room for improvement. To date, very few efforts have been made to internalise the external costs of transport-related greenhouse gas emissions, or of infrastructure overload. The same is true of road- and rail-related noise.

The debate on internalising external costs raises the general question of what options and opportunities are available when attempting to make mobility more sustainable than it is at present.

Options and opportunities to make mobility more sustainable

Responding to the challenge of mobility

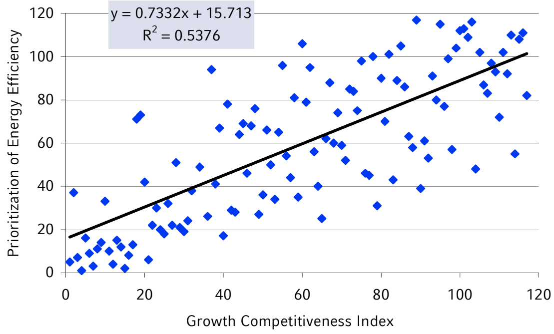
The challenge of making mobility more sustainable can basically be answered in two different ways: (1) intrinsically motivated reactions and (2) extrinsic, institutionally required or incentivised reactions.

Intrinsic vs extrinsic reactions

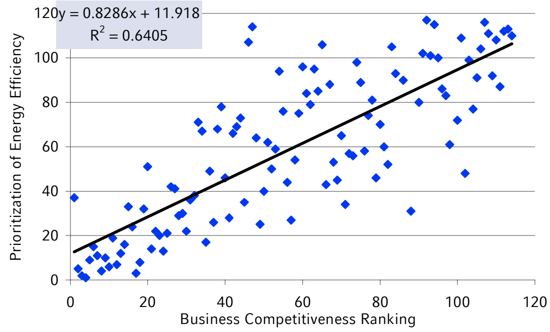
Intrinsically motivated reactions can be quickly explained. From an economic point of view, companies and consumers are intrinsically motivated when they identify a private, economic advantage to be gained from a change in their behaviour. It is therefore virtually a tautology to assert that it is in the interest of both groups to raise the energy efficiency of transport activities, and thus to automatically lower the external costs of mobility. In this case, both internal and external costs display significant positive correlation. This argument can also be made in relative terms: new technologies that raise energy efficiency can give companies a competitive advantage that translates into higher margins, and thus higher earnings. One current example is Toyota's launch of hybrid technology in the automobile market. The following charts show that the 'green' aims of a policy that encourages an economy's energy efficiency and the transition to renewable energies need not be at odds with economic competitiveness.

Correlation between competitiveness and focus on energy efficiency*

Growth Competitiveness Index by country



Business Competitiveness Index by country



* Prioritisation of energy efficiency: energy efficiency and transition to new and renewable sources of energy are of low/high priority

Source WestLB Research, WEF

The graphs show that countries that have a good score on the competitiveness index are generally more energy efficient than countries with a lower competitiveness score. In fact, energy efficiency is a corollary of transport efficiency: competitive countries are generally transport efficient.

Problems of economic incentives with new technologies

By reverse analogy this means that, in the absence of intrinsic economic incentives, measures to make mobility more sustainable will not be taken. One example of this is the widespread introduction of vehicles with fuel cells. Private purchase and operating costs, i.e. the costs an individual must pay out of his own pocket to buy and run such a vehicle, are prohibitively high at the current stage of development. On the other hand, the benefits of such an automobile, particularly the significantly lower cost of climate protection, would not benefit the user himself, but society as a whole. Under these conditions the motivation to purchase such an automobile is extremely low.

Demand channelling

Additional monetary incentives are often necessary to launch and implement new technologies. This is the duty of government institutions, which can use taxes, subsidies and other fiscal measures to influence the economic trade-offs for companies and households in such a way that the desired change in demand ultimately takes place. This process is called demand channelling.

The dream is over: decoupling remains highly improbable in the future

Greater sustainability without sacrificing growth

It has long been a political dream to promote new technologies that can decouple transport volumes from economic growth – a bit like wanting to have one's cake and eat it too. A fundamental 'yes' to greater sustainability in the transport sector would combine with a 'no' to diminished economic growth. Despite many plausible arguments, such as those in the first chapter concerning the transition to a 'virtual economy' or greater energy efficiency thanks to new technologies, experience shows that the decoupling hypothesis is not compatible with empirical reality.

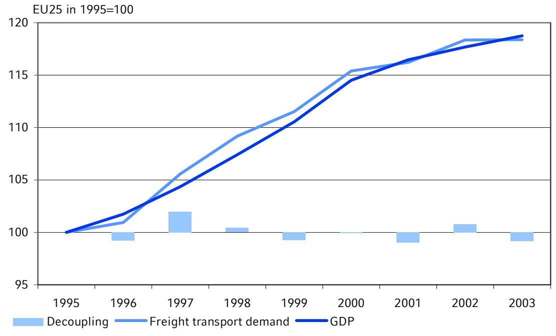
It is true that some efforts to enhance energy efficiency have been successful, resulting in a few cases in a relative decoupling of emissions and economic growth (Germany is one example). However, this success has been offset by a failure to contain the strong growth in transport volumes.

Not only has the number of globally transported goods and passengers increased, but so too has the average distance that they are transported. The vertical corporate value chain is increasingly being broken up, and products and product components can be manufactured and delivered anywhere in the world.

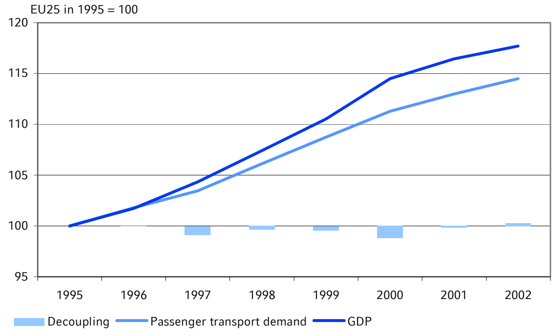
The world is flat after all: a new era of globalisation

This trend, far from being slowed by new information and communication technologies, has actually been accelerated. The second key factor to usher in a new era of globalisation has been the entry into global markets of China and the former Eastern bloc countries. The recent boom in global trade can be traced to the fact that the difference between the production costs in developed countries and those in emerging nations is much greater than the additional transport costs caused by long delivery chains. According to wealth theory, optimal transport volume is reached when the marginal cost of transport (including marginal external costs) correspond to the marginal income from transport. The very fact that transport costs, as mentioned above, come nowhere near to reflecting their external cost has triggered overuse of transport services.

Trend in freight transport demand and GDP growth, 1995-2003*



Trend in passenger transport demand and GDP growth, 1995-2003*



* decoupling columns represent annual decoupling; positive values indicate decoupling (percentage decline in transport intensity vs the previous year)

Source EEA, 2006

The time and cost budget for transport activities is fixed

The fact that no decoupling has occurred in passenger transport can be explained by the Brever law, which states that, on average, people tend to reserve a fixed amount of their time and income for transport. If faster and cheaper transport options are made available, people use additional transport services. A fixed time budget implies, for example, that additional infrastructure results in an expansion of transport activity only when the travelling time can be decreased. A fixed time budget also means that people are prepared to travel greater distances only when the speed of the mode of transport increases. A fixed budget also means that people tend to switch to more expensive modes of transport (e.g. from bicycle to automobile) only when their incomes rise. Since such a switch often involves a time advantage, a rise in income tends to be accompanied by an increase in the distance travelled.

Overconsumption of transport services is achievable only by full internalisation of external costs

In conclusion, overconsumption of transport services can be effectively countered only by full consideration of external costs. It is not enough to wait until technological progress in terms of pure energy efficiency can be made attractive at the level of private costs. Government intervention will be necessary in order to reach the goal of more sustainable mobility. Ideally, this intervention would be coordinated and harmonised across national borders. However, experience of the Kyoto Protocol illustrates how difficult it is to implement a multilateral approach.

Reducing the overconsumption of transport via improvements in transport pricing

Introduction of a fair and efficient price system

The above discussion shows that the prime political goal must be a comprehensive internalisation of external transport costs. A fair and efficient price system, such as that championed by the European Commission, means that each mode of transport must bear the external cost that it or its users generate. Efficient pricing also means that transport volumes will be reduced in areas that are currently underpriced. Moreover, there would be shifts in the respective shares of individual modes of transport, since not all are underpriced to the same extent. The full internalisation of external costs would mean that the transport system was making its maximum contribution to the wellbeing of society. Market efficiency would rise and there would be effective economic incentives to reduce the adverse effects of transport services on the environment.

A key characteristic is the completeness of the system

An important characteristic is the comprehensiveness of such a price system. All external costs of all modes of transport would have to be identified and evaluated. In addition to the price system itself, its effective implementation would be of decisive significance. The traditional instruments of such policy include taxes, duties, rebates and emission licences that can be traded on an exchange. In the next section we examine the instrument of taxation. This does not mean that other instruments will be ignored; they will be considered in depth in the second part of this report, comprising separate analyses of the individual modes of transport.

Taxation

Fiscal measures are traditional demand-channelling instruments

Fiscal measures (taxation) are a traditional instrument of price fixing and thus demand channelling. The focus is undoubtedly on road transportation. To include external costs in the taxation of road transportation two options are generally available: vehicle and fuel taxation. One example showing that tax measures can have considerable channelling effects is the favourable treatment of diesel-engine vehicles in Europe. This largely involves lower taxation of diesel fuel compared to petrol. Despite the considerably higher acquisition costs, the market share of diesel vehicles in new registrations in Europe has risen from less than 15% in 1990 to just under 50% at present – not least as a result of these measures.

Channelling effects of fuel taxes

This example shows that fuel taxes can be an extremely effective tool for steering demand towards more energy-efficient technologies. The advantage of fuel taxes is that they have a variable component – which means their level depends on the number of person or tonne kilometres driven – and also a differentiating component. Even a flat tax rate favours vehicles that are more energy-efficient. In addition, tax rates can be differentiated according to different types of fuel. For example, alternative fuels such as biodiesel can be promoted in this way. In vehicle taxation, distinctions can be made between energy efficiency and emission classes in order to achieve the desired effects. The classification of vehicles according to euro norms is an example.

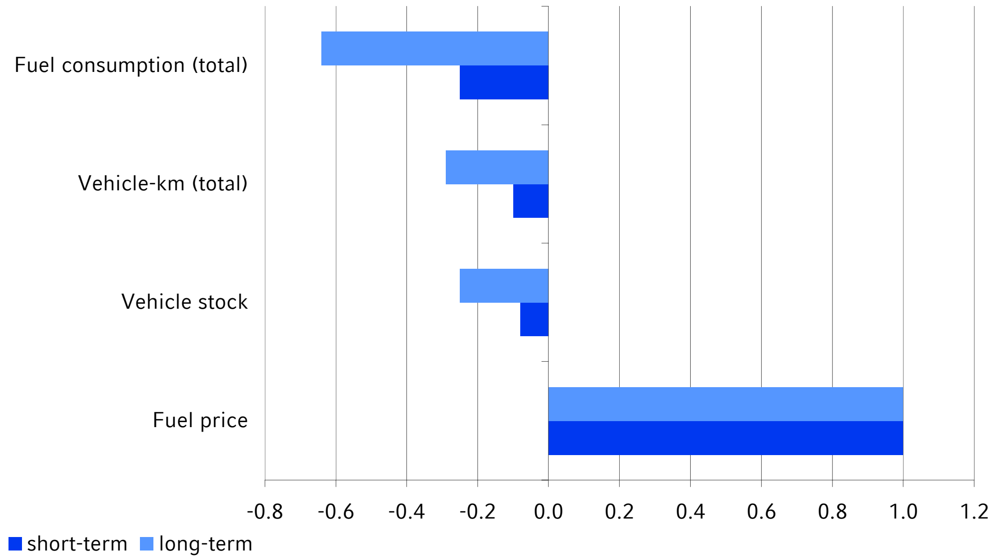
Differentiation between short- and long-term effects

One argument put forward by critics is that transport volumes have continued to grow unabated in Europe despite significant fuel taxation. This viewpoint is common among lobbyists and naturally goes down well with consumers as the taxation of fuel is subjectively considered much too high anyway. However, from a scientific standpoint such a line of reasoning has no basis at all. The results of numerous studies show that the level of fuel prices, which is largely determined by the level of their taxation, has a significant impact on long-term consumer behaviour and the long-term level of demand for fuel.

Long-term price elasticity 6.4%

However, it is important to emphasise the long-term nature of the quantity effect. The short-term reactions to an increase in fuel prices are fairly limited. In the short term, consumers have relatively few opportunities to adjust their behaviour. Empirically, this is reflected in hugely disparate estimates of price elasticities. For example, a highly regarded study (Goodwin et al., 2004) concludes that a 10% rise in the fuel price within one year leads to a decline of 'just' 2.5% in the quantity of fuel consumed. By contrast, long-term price elasticity (five years) is more than twice as high (6.4%), as those who are affected have more opportunities to adapt their behaviour to the change in the relative prices. This includes, for example, choosing place of residence and job.

Elasticity of transport demand with respect to fuel price



Source Goodwin, 2004

Higher fuel prices offer incentives for higher energy efficiency

There are also empirical indications that higher fuel prices create incentives to improve the energy efficiency of new vehicles. For example, the average energy efficiency of newly registered cars in the Netherlands increased in the period from 1980 to 1986 – in other words during the second oil crisis and the accompanying relatively high fuel prices – by 11% (petrol) and 14% (diesel). By contrast, during the period from 1986 to 1997 – when real fuel prices were markedly lower – efficiency actually declined by several percentage points. A comparison of EU countries also indicates that fuel prices and fuel consumption are closely correlated.

Problem of using global common goods

Regulatory gaps and heightened incentive problems

A major problem facing fiscal instruments is that they lose their effectiveness once national borders are passed. For example, international airspace and the high seas are so-called global common goods which are characterised by the fact that (1) the laws are inadequately defined and (2) the international community as a whole is responsible for their maintenance. This exacerbates the incentive problem and caused enormous regulatory gaps. For example, the CO_2 emissions caused by international air and sea transport are not recorded in national emission balance sheets and are therefore not covered by the quantitative commitments under the Kyoto Protocol. To solve the problem, scientific reports propose, for example, the introduction of so-called usage fees (see WBGU, 2002), which we consider in more detail in the following chapters. In addition to the ecological channelling effects of such usage fees based on the external costs of the various means of transportation, the revenues collected could be applied specifically to finance global sustainability policy. Taking climate policy as an example, this means that the revenues should be used to finance measures aimed at maintaining and restoring the quality of the public good 'climate' and those aimed at adapting to climate damage.

This ends our discussion for the time being on transport pricing. We will of course consider it in detail in the chapters devoted to the individual means of transport. We feel it important to note here that, while setting transport prices with regard to external costs is, in our view, the most important policy instrument for making mobility more sustainable in the future than it currently is, it is by no means the only one. Policy-makers have further opportunities at their disposal and we briefly consider some of these below.

Rethinking speed

Reducing mobility demand and improving energy efficiency

Speed is one of the key variables of transport policy

The speed with which persons and goods are transported is undoubtedly one of the key variables in transport policy. Speed is a driver for many important mobility indicators such as fuel consumption, GHG (greenhouse gas) emissions, conventional air pollution, noise, traffic safety, the danger of congestion and generally the transport volume demanded (see Brever law). A study conducted by the Environmental Agency (UBA) in 2003 concludes for example that a reduction in speed levels on German motorways from 120 to 100 km/h would lower car energy consumption by 10% to 20%.

The thesis that transport volumes overall would decline is based on the observation that consumers have reserved a time budget for transport activities that is fixed over a long period. The reduction in speed thus leads to lower demand for transport through the expected lengthening of travel times.

Influencing demand for powerful engines

A further effect is that imposing greater speed restrictions on motorways should tend to lower demand for powerful engines. Studies show that the average engine size of newly registered cars is currently rising 2% a year. This trend could possibly be stopped with extremely positive effects on energy efficiency. The UBA study cited above shows that a 30% reduction in engine size would lead to fuel savings of 13% to 19% in the case of petrol-fuelled cars and 5% to 15% in the case of diesel cars. This means in turn that if the current annual increase were stopped it would take some 17 years until (relative) savings in this range were achieved.

Effects on safety, air quality, congestion

Limiting speed to increase safety

It is largely undisputed that safety on roads in general and on motorways in particular can be improved if speed restrictions are tightened. For example, the 100 km/speed restriction introduced in Hesse during the second oil crisis in the 1980s resulted in a reduction of traffic fatalities of 25% to 50%. The European Commission also reports that stronger monitoring of compliance with speed restrictions in France by itself resulted in a 21% cut in traffic accident deaths.

Lowering speeds leads to lower nitrogen emissions

Imposing stricter speed limits could also have very beneficial results in terms of improving air quality in urban regions. For example, vehicle nitrogen emissions fall disproportionately relative to fuel consumption if speeds are reduced. The reason is simple: higher revolutions result in higher engine temperatures, which in turn lead to increased NOx emissions. Scientists also say that lower speeds have a positive impact on hydrogen and PM (particulate matter) emissions.

Optimising urban motorway utilisation

A positive example is provided by the experience gained in Rotterdam. There, lowering permitted maximum speeds on urban motorways from 100 to 80 km/h led to a 25% fall in nitrogen emissions and thus to a considerable improvement in air quality in the affected city areas. In addition, the reduction in permitted speeds lowered the tendency to congestion and overall resulted in an improved, more even utilisation. For example, the daily congestion period fell by some 30 minutes and the average length of tail-backs was cut by 2 kilometres, even though overall traffic volumes increased by 3%. These observations also confirm the results of numerous studies showing that maximum utilisation of highly frequented motorways in urban areas is reached at a speed of some 80 km/h.

Speed is also important for aircraft and ships

Technological progress focused on increasing speed of transport

Speed is an issue that is relevant not only in road transportation. For example, a recent study of the Dutch National Aerospace Laboratory (NLR) – which we will discuss in more detail in the chapter on sustainability in air transportation – shows that the energy efficiency of modern jet aircraft is no better than that of propeller planes of the late 1950s. Of course, this in no way means that technology has not progressed since then. However, the undoubted huge advances have focused entirely on increasing speed rather than raising the energy efficiency of aircraft as a means of transport. In modern shipping, this focus on speed is even more of a threat, as nearly every advance in shipbuilding is aimed at raising the speed of ships. Little attention is paid to energy efficiency. A 10% increase in the speed of a ship for example results on average in a 20% rise in energy consumption.

Urban development and infrastructure measures

Intermodality

A lack of intermodal infrastructure

One of the main reasons for the uneven growth in freight transport, which has tended to favour road travel, is the lack of intermodal infrastructure. Even in the developed countries of Western Europe it is not possible to transfer goods rapidly and efficiently from one mode of transport to another. While in harbours, at least, there are facilities to move goods between ships and trucks, such intermodal facilities are rare beyond portside. For example, there is no dense network of urban freight railway stations, without which there is no economical way to transfer goods from road to rail and, possibly for the final delivery, back onto the road.

This also explains the focus on road transport – a trend that has become increasingly pronounced over the last 10 to 15 years. The trend has been fostered by the growing importance of just-in-time and supply-on-demand deliveries. In today's environment, it is much faster and, above all, more flexible to move goods by truck from door to door. Politicians in the EU criticise this situation as non-sustainable. However, there is a dearth of large-scale efforts that would be required to develop the necessary infrastructure, in particular a broad range of intermodal transfer points and harmonisation of regulations and standards (e.g. for freight containers) in individual member states.

Lack of intermodality affects not only freight transport

The lack of intermodality is a problem that goes beyond freight transport. There are also considerable shortcomings in this respect in passenger transport. While there are some good examples, such as better links between major airports and high-speed train networks in Germany and France, in general there are too few integrated transport networks of this type. As a result, most passengers flying from regional airports must still use private cars to get to the airport.

Urban development and transport systems

Maintenance and optimisation of public transport is probably the best policy option

In urban regions, the maintenance and optimisation of public transport is probably the key policy option with a view to making mobility more sustainable in the future. The large cities of the developed world, such as London, Paris and Tokyo, could not function without their public transport systems. The existence and smooth function of public transport is even more vital for the growing mega-cities of the developing nations. At the same time, however, its ability to fulfil its key role is being steadily undermined by the decentralisation of large urban regions (suburbanisation). As a result of declining population densities in the inner cities, public transport costs must rise if the system is to continue to meet user needs. One solution to this problem could be to use urban planning and development to create greater incentives to raise population densities. If the suburbanisation trend could be reversed, the technological, financial and operational challenges confronting public transport systems in urban regions could be much more easily overcome.

Intermeshing of urban planning and transport system development

Such efforts might also include attempts to improve the cooperation and coordination between urban planning and the development of transport systems. A study by the University of Tokyo conducted for the Initiative Alliance for Global Sustainability (AGS), for example, concludes that strategies to centralise or decentralise the location of jobs in Tokyo and Bangkok can reduce dependence on private automobiles, thus also reducing the associated environmental damage (especially air pollution). Commuting distances with private automobiles can also be reduced markedly by optimising regional planning using the suggested measures.

Introducing innovative intelligent transport systems

Alternatives to public mass transport

New technologies open up new possibilities in public transport, such as cybernetic transport systems (CTS). This represents an urban transport system based on a large fleet of smaller, driver-less, automated vehicles to move passengers and freight. The advantage of such a system is that it can use the existing transport infrastructure, i.e. the road network, and that it works both on demand and door to door. Vehicle availability is centrally administered and optimised. Vehicle capacity ranges from one to 20 seats, depending on the use of the vehicle. Systems like these can help to lower the costs of public transport since a large cost factor, the driver, is absent. This would also cut the external costs of mobility considerably, particularly local air pollution, noise pollution and the negative side effects of traffic jams. On balance, urban quality of life would rise substantially, which might also help to halt the trend towards decentralisation.

Furthermore, CTS could be a solution for social mobility problems. They provide a real mobility option for people that are not in a position to drive their own motor vehicle, such as the elderly and the handicapped. The advantages of CTS are also reflected in a high approval rating by the population. A survey by the CyberMove project found that 80% of the respondents would agree to use fully-automated vehicles, not least because it would eliminate the problem of finding parking in the centre of town.

Better traffic management and higher utilisation rates

Much less spectacular and visionary, but still future-oriented, is the use of satellite-supported navigation systems such as GALILEO, a joint venture between EU member states and the European Space Agency (ESA). They have the potential to substantially raise the efficiency of transport services in general and thus help to make mobility more sustainable in many areas. For example, costs related to traffic congestion could be lowered and fleet management in freight transport optimised (better capacity utilisation). Moreover, GALILEO has the potential to enhance traffic management in air and sea shipping, which would have a positive effect on safety for these two modes of transport. GALILEO can also accommodate greater train frequency and open up the potential for higher utilisation rates.

Timely inclusion in urban planning

Intelligent transport systems such as the visionary CTS and the soon-to-be-available GALILEO are examples of how new technologies can be used to respond to the challenge of rising transport volumes. Efficient implementation depends on active policy support and promotion (possibly by creating economic incentives to use transport systems outside peak hours). In order to leverage the possibilities of these systems, they must be included promptly and systematically at the appropriate stages of urban planning and development. This is the only way to eliminate the oft-cited bottlenecks in urban transport systems, for example, and to fully exploit the potential efficiency of new technologies.

The role of institutional capability

Limits of political management

Will and ability of social and political institutions is key

No matter how promising the opportunities presented by new technologies, the factors that will decide if and how rapidly technological options are implemented are more down-to-earth. The key to realising more sustainable mobility scenarios for the future lies in the will and ability of social and political institutions to actually introduce the necessary changes. Measures for demand management that are reasonable could meet major institutional resistance in their implementation since they imply substantial intervention into people's daily lives as well as significant economic distribution effects.

Consequently, social interest groups exert enormous pressure on political institutions to take decisions that will line up with their objectives. Industry representatives often allude to the feared negative effects on growth, competitiveness and jobs. The populace, too, can be strongly opposed to measures that aim to improve the sustainability of mobility and the quality of life. One example is the introduction of motorway tolls or an increase in fuel taxes. Resistance is particularly great when: (1) there is a clear differentiation between winners and losers under new measures, or (2) the planned measures would represent a substantial intervention into habitual behaviours and lifestyles.

Time dimension of effectiveness is an important determinant of decisions

Another problem of demand management is the time dimension of its effectiveness. As mentioned above, the short-term price elasticity of fuel demand, for example, is quite limited, since consumers need time to adjust their behaviour and lifestyle to the new relative price. Each individual may have the choice each day whether to commute by private car or by train. However, the framework for this decision has often been established sometime previously (e.g. through the choice of residential location). The same is true for overlying structures, such as the infrastructure available and the state of urban planning. In other words, solutions to mobility problems cannot be developed as if one is starting from scratch. Overcoming the forces of inertia at all levels is a very long-term enterprise.

Dividends reaped long after costs incurred

The policy dilemma is obvious: as a rule, the costs of demand-management measures are immediately tangible and immediately charged to government coffers. Furthermore, the depressing effects on growth in general can become evident relatively quickly, for example when policy demands that production and consumption move geographically closer together. The dividends reaped by demand-managing mobility policy, on the other hand, are evident later, sometimes much later. The reasons behind these dividends are not clear to every individual, nor is it easy to communicate to voters.

Need for global harmonisation and standardisation

Another fundamental problem is rooted in the fact that the external costs of mobility fall into the area of global generalities, and cannot be allocated to individual nations. One example is the CO_2 emissions from international aviation. It is precisely cross-border trade and cross-border integration of delivery chains that have driven the strong growth in transport volumes over the last 10 to 15 years, and illustrate the need to improve global harmonisation and standardisation.

The example of the European Union shows just how difficult such harmonisation can be. Ever since the union was formed, the diverse national standards have hampered the functioning of the common domestic market. Many of these discrepancies still exist today, and efforts to eliminate them have failed for decades due to the same short-term national interests.

Avoiding the free rider problem

Besides market efficiency gains, another issue advocating coordinated demand-management measures is the so-called free rider problem. Without harmonisation, it is possible for individual nations to keep their standards low, at the expense of others, in order to entice companies away from countries with higher standards (environmental and social dumping).

Conventional pollution – a success story

Results of a four-step strategy

Despite all the problems that arise when implementing demand-management measures, it should not be forgotten that there are also examples of real success. One of these is without doubt the reduction in conventional air pollution from transport activities in the European Union. The advances made so far have been based on a four-step strategy:

- Firstly, EU governments began to set emission standards for road vehicles at the end of the 1980s, which have been progressively tightened. This procedure forced automakers to fit new automobiles with the appropriate technologies.
- Secondly, automakers were required to explicitly guarantee that a vehicle could meet emissions standards over its entire normal life cycle. Moreover, special inspection and maintenance requirements to ensure the functionality of the new technologies were written into law.
- Thirdly, the appropriate fuels were made available to operate vehicles fitted with the new technologies.

- Fourthly, the additional costs of the new technologies were initially borne by the automakers, and then passed along to auto buyers and operators.

All of this has generally functioned quite well. The success is undeniable and experts believe that in the foreseeable future, conventional emissions will no longer pose a health threat. They see the remaining tasks as identification and elimination of old, non-standard vehicles.

Alternative scenarios for the future

Our above discussions were founded on the "business as usual" scenario (BAU). BAU scenarios generally serve as starting and reference points for scientific studies dealing with, for example, climate change (see IPCC, 2001) or sustainable mobility (see SMP, 2004).

Realisation of BAU scenarios is highly unlikely

BAU scenarios are basically formulated so that they do not make speculative assumptions about future trends, but are limited to extrapolating current trends (economic, technological, social) into the future. In this case, it means assuming, for example, that the new era of globalisation, with all its adverse side effects, will continue unchecked. It also assumes that no new political measures (such as the Kyoto Protocol mechanisms) will be taken, that consumer behaviour will not radically change, and that no pioneering technological innovation will reach the production stage or significantly penetrate the end-market.

While BAU scenarios are useful starting and reference points, they are clearly quite improbable. It is more likely that society will respond to the new challenges. One example is the first sign of reviving protectionism that could spread through countries that contain a high proportion of inhabitants who stand to lose out as a result of globalisation. This could well include the traditional industrialised nations of Western Europe, which suffer from transfers of jobs to the emerging economies of Southeast Asia and Eastern Europe. In addition to protectionism, terrorist attacks and devastating natural catastrophes could also interrupt or reverse current trends.

Three alternative scenarios from SMP

Arranging all possible future trends in all their conceivable permutations into scenarios would be so complex that it makes little sense. Nonetheless, it is helpful to list a small number of alternative scenarios showing the consequences of various proposed solutions. The following alternative scenarios should be viewed in precisely this light. First of all, we shall describe the three alternative scenarios from SMP.

Free market scenario

Increasing imbalance and underweighting of long-term implications

SMP's free market scenario assumes that the free flow of capital and goods across national borders will result in an increasingly homogenous global culture. Since the focus in this scenario is on financial returns, decisions that affect the transport sector are taken based solely on their ability to generate immediate financial revenues. Long-term implications are systematically underweighted in this scenario and the social gap between rich and poor widens at all levels.

Coordinated policy intervention scenario

Combination of intelligent urban planning, new fuel and propulsion technologies, and a fundamental shift in people's lifestyle and consumption habits

The coordinated policy intervention scenario assumes a series of exogenous shocks at the beginning of the 21st century that trigger collective, globally coordinated policies to counter the big sustainability problems. Such exogenous shocks could include oil shortages, as currently discussed in connection with the situation in Iran, but also a series of natural catastrophes on the scale of last year's Hurricane Katrina. With a clear mandate from the people, governments around the world would make a coordinated and concerted effort to tackle the socio-economic and ecological problems, using the entire spectrum of policy options available, including demand management by internalisation of external mobility costs and the broad and intensive promotion of innovative technologies. The combination of intelligent city planning, new fuel and propulsion technologies and a fundamental shift in people's lifestyle and consumption choices would result in a radical change in the way people and goods are transported.

Localisation scenario

Fragmentation and localisation of the global economy

The localisation scenario assumes a sudden halt to the current trend of global alignment of cultures, supported by phenomena such as the Internet or globally active companies, as individual countries begin to favour a stronger national identity at the beginning of the 21st century. Triggered by a greater need for security and the desire for national influence in economic, social and ecological affairs, the global economy becomes more fragmented and localised. Local communities pursue their own goals in the process and implement their own measures that are scaled to local conditions in order to achieve them.

Sustainable transport scenarios of the OECD

Environmentally sustainable transport (EST)

The alternative scenarios drawn up by the OECD (OECD, 1999) are considerably more concrete than those of the SMP. The starting point is to define the criteria that the transport sector must satisfy by 2030 in order to qualify as sustainable. These are defined solely in environmental protection terms. The OECD criteria for environmentally sustainable transport (EST) include:

- Nitrogen oxides: Total emissions of NOx from transport in 2030 should not exceed 10% of total emissions of NOx from transportation in 1990.
- Volatile organic compounds: Total emissions of VOCs from transport in 2030 should not exceed 10% of total emissions of VOCs from transportation in effect in 1990.
- Carbon dioxide: Total emissions of CO_2 from transport in 2030 should not exceed 20% of the total emissions of CO_2 in 1990.

Starting point assumes that the EST criteria must be fulfilled by 2030

In addition to the usual BAU scenario, which differs little from the SMP's scenario, the OECD research team also describes three alternative scenarios. The approach is completely different, and focuses on the achievement of concrete implications. In each case, the starting point assumes that the EST criteria must be fulfilled by 2030. Then it defines which measures are necessary to achieve this goal in different ways and what effects the implementation of these measures could have on the economic and social framework.

The high-technology scenario (EST1)

Fulfil the criteria without affecting transport volumes

The starting point for this scenario is the question of which technological innovations would be necessary in order to reduce the environmental effects of mobility to a level that would fulfil the EST criteria without reducing future transport volumes as projected by the BAU scenario. The following table lists the key characteristics of such a scenario according to the OECD's research team.

The high-technology scenario (EST1)*

MODE	scenario features
Light-duty road vehicles (including cars)	Almost all conventional vehicles would be replaced by electric vehicles of one of three kinds: battery-powered, fuel-cell-powered or hybrid combustion-electric.
Heavy-duty road vehicles	Almost all conventional vehicles replaced by hydrogen-based, fuel-cell-powered vehicles.
Rail	All electrified, light-weight systems with numerous technological improvements — regenerative braking, advanced control devices, etc.— and more efficient utilisation.
Inland and coastal shipping	Improved vessels, perhaps using hydrogen-based fuel cells.
Aviation	Hydrogen will be used as a fuel, in fuel cells or directly.
Electric power generation	Almost all electric power is produced without use of fossil fuels, mostly using renewable means.
Other	Noise is reduced through design features. Widespread use of information technology helps improve vehicle efficiency and utilisation.

* These summaries are very general and do not necessarily represent individual characterisations of the scenario

Source OECD, 1999

The researchers note that the implementation of this scenario would involve extremely high costs. A large part of these costs would be attributable to the production, processing and storage of hydrogen. Note particularly the high fuel consumption and the overall low efficiency of this process.

The capacity-constraint scenario (EST2)

Fulfil the criteria solely by means of demand management

This scenario assumes the technological level of the BAU scenario, with the result that all measures to achieve the EST criteria would have to be made exclusively in the area of demand management and reduction of transport activities. In general, efforts would be made to keep the effects on daily life in developed countries to a minimum.

The capacity-constraint scenario (EST2)*

MODE	scenario features
Private cars	Much lower use or no use of private automobiles, with reductions in use sustained by regimes of high levels of taxation of fuel, road use, and parking. Moped and motorcycles may also not be used.
Other passenger transport	Most passenger transport is by collective means, particularly using rail. There is much new supporting infrastructure — also for facilitation of non-motorised modes. Efficiency improved through logistical organisation.
Freight movement	Much less reliance on road vehicles, with more use of rail and, possibly, water-borne modes. Logistical reorganisation in place to avoid transport—reversal of trend to "just-in-time," for example, and load optimisation. Transport of goods also reduced by increasing the use of locally produced products and by reducing the volume of materials circulating per unit of GDP.
Aviation	Travel by air is very much reduced or negligible. Long-distance travel is mostly replaced by telematics.
Land use	Settled areas are redeveloped to the extent possible to reduce the need for motorised travel, particularly by increasing residential densities. Work practices are changed to the same end.
Telecommunications	There is much more use of teleworking and teleconferencing, and other activities that can reduce the need for travel, together with the necessary infrastructure.
Economic activity	Economic development and freight transport have been decoupled. However, the macro-economic projections of the BAU scenarios cannot be sustained, at least not without profound changes in the structure of the global economy sufficient to obviate simple comparison with BAU scenarios.
Other	A high level of public education and information is in place to sustain the reductions in activity. Several other activities are restructured, notably tourism and vacation-taking.

* These summaries are very general and do not necessarily represent individual characterisations of the scenario

Source OECD, 1999

Dramatic economic effects

The scenario characteristics summarised in the table above suggest the dramatic and sweeping changes that would be effected in the countries where it was realised. This is equally true for the transport of passengers and freight. The main objective is to reduce transport activities. Obviously, the economic effects would be enormous, but not exclusively adverse.

The optimum combination scenario (EST3)

The optimal combination of both extreme scenarios

This scenario assumes that the EST criteria can be fulfilled with an optimal combination of technological innovation and reduction in activity. The available options would be so combined as to maximise their social and economic efficacy (this does not involve optimisation in a technical, mathematical sense).

Focus tends towards reduction in demand

So although it is a compromise between the two extreme scenarios, the EST3 scenario also has dramatic implications: for example, the use of private automobiles would be scaled back to nearly 50% of the 1990 level. In this respect, the implied effects are closer to EST2 than EST1. The same is true for freight transport by truck.

The optimum combination scenario (EST3)*

MODE	scenario features
Private automobiles	There is a decrease in car ownership and use, but not as drastic as in EST2. More hybrid-electric cars are used than in EST1.
Other passenger transport	There is a focus on reducing long-distance travel, and on much greater use of non-motorised means together with supporting infrastructure. There is some emphasis on rail.
Freight movement	Large reductions in transport distances are evident, although not as much as in the EST2 scenario. Hydrogen may be widely used as a fuel, directly and in fuel cells.
Rail	Rail is all-electric, with high-speed modes and increases in efficiency.
Inland and coastal shipping	More efficient, less polluting vessels are used; hydrogen may be used as a fuel.
Aviation	Long-distance air travel is substantially reduced. Aircraft in use are more efficient, conventional types. Rigid airships may be used for shorter journeys.
Electric power for transport	This is made with great efficiency using high proportions of renewable fuels.
Land use	Modest changes in the form or settlements have been implemented to reduce the need for movement of people and freight.
Telecommunications	Extensive use is made of telecommunications to obviate travel and movement of goods.
Economic activity	Regionalisation of production occurs to avoid long-distance freight movement; volumes of production are reduced.
Other	Aggressive public education is required to sustain lower levels of travel.

* These summaries are very general and do not necessarily represent individual characterisations of the scenario

Source OECD, 1999

Balance of effort (BoE) analysis reveals differences between the transport of goods (focus on transfer) and passengers (focus on reducing demand)

The most striking differences compared to the two extreme scenarios are firstly, a greater use of public transport, and secondly, a much higher share of railways in total freight transport. In general, the EST3 scenario has a narrower focus on reducing activity and is less dependent on technological innovation. A differentiated, balance of effort (BoE) analysis further reveals systematic differences that the EST3 scenario assumes between the transport of freight and transport of passengers. The emphasis on passenger transport is more towards reducing transport activities than shifting demand to more environmentally friendly modes of transport (e.g. moving from road to rail). The opposite is true for freight transport. The third factor that was examined in terms of transport activities is the average capacity utilisation (the load factor) of vehicles in passenger and freight transport. This factor was found to have a relatively low significance in the overall context.

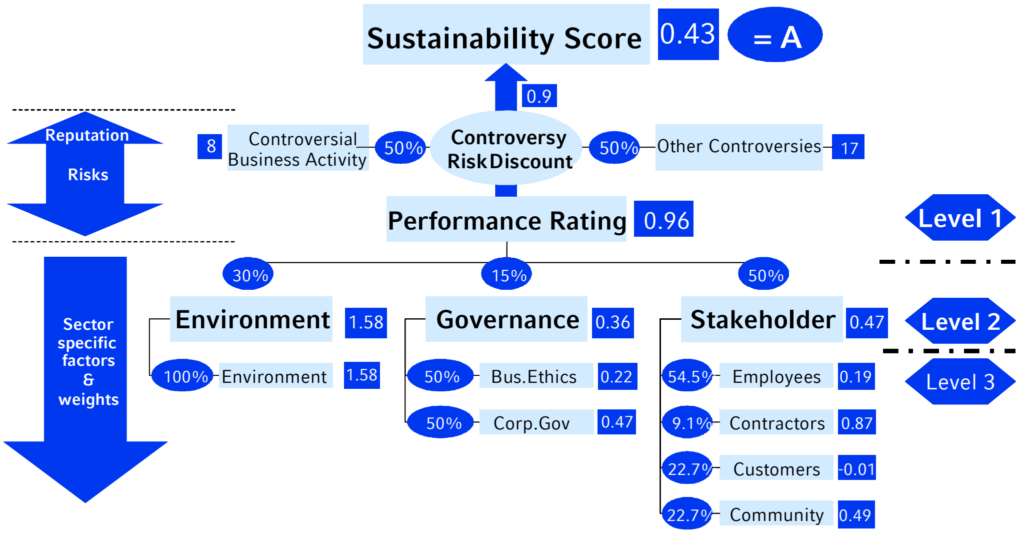
Sustainable mobility as reflected in our Extra-Financial Risk Ratings

Key determinants of the sustainability of the transport sector are included in our Extra-Financial Risk Navigator. This tool is generally used to assess companies in terms of non-financial factors, which are gaining in significance for the purposes of share valuation.

Sector-specific criteria reflect the varying non-financial demands on each sector

Early this year we modified the methodology of our Extra-Financial Risk Monitor: having previously used sector-specific weightings to achieve a certain amount of differentiation in our extra-financial evaluation of each sector, we have now added a series of sector-specific criteria designed to reflect the different demands on various sectors from a non-financial perspective (see our publication *Extra-Financial Risk Navigator – Focusing on sector-specific factors* dated 23 March 2006).

Structure of WestLB Extra-Financial Risk Ratings



Source WestLB Research, SiRi Group

Criteria specific to the transport sector relate almost entirely to the environment

We have now extracted sector-specific criteria in order to perform a more in-depth analysis of the transport sector. These criteria relate almost entirely to the environment. This reflects how the transport sector differs significantly from other sectors, precisely because of its adverse effect on the environment due to the products manufactured and services provided, as well as companies' potential responses to the associated challenges.

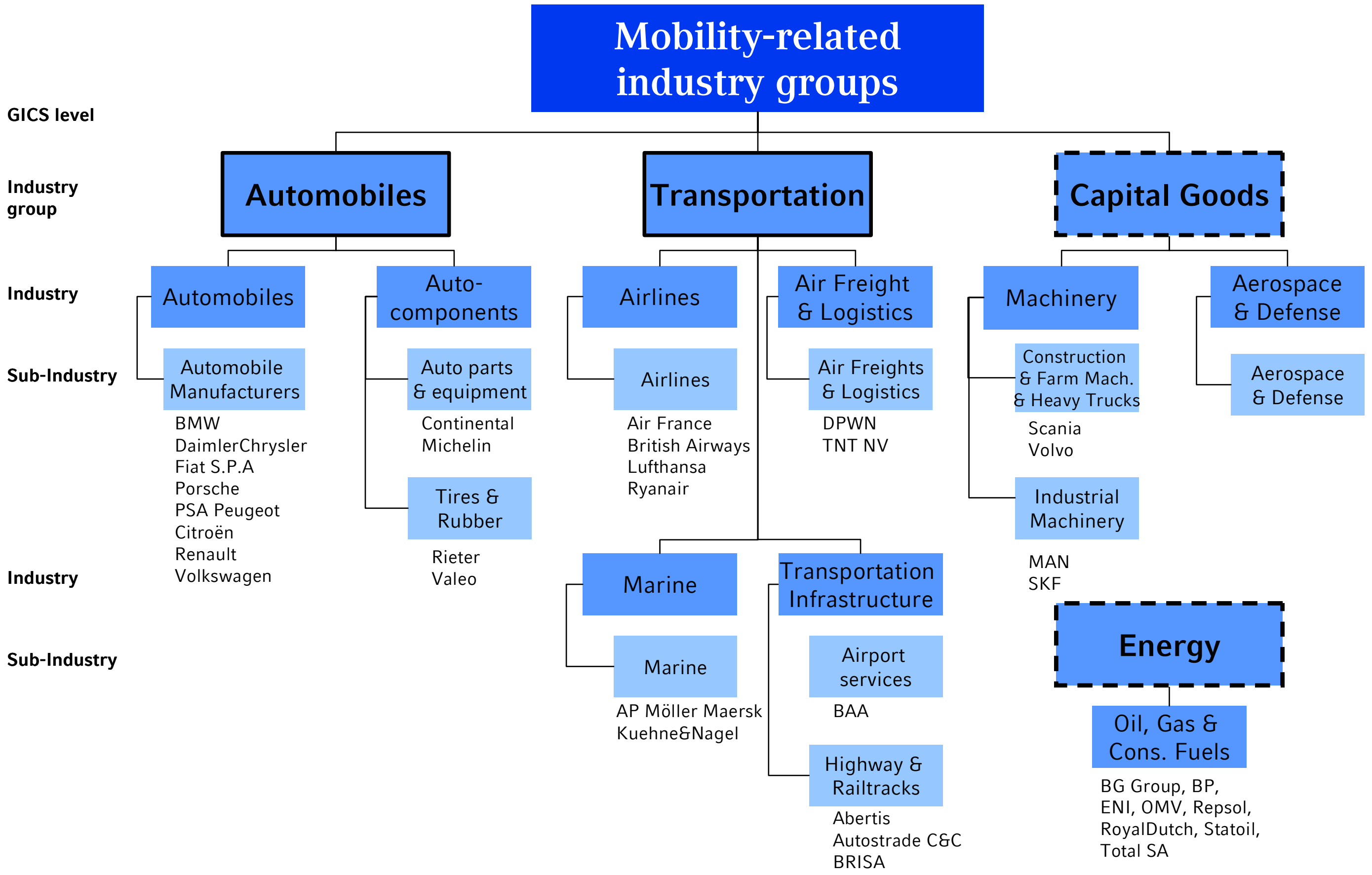
Overview of mobility-related sector-specific criteria

Automobiles & Parts	weight
Automobiles	
Passive car safety	1.05%
Product safety (EURO NCAP rating)	0.80%
Targets and programs to reduce CO2eq emissions of the fleet	3.80%
Average CO2eq emissions/km of the fleet	2.88%
Autocomponents	
Targets and programs to reduce the impact of product at the end of the life-cycle	1.91%
Targets and programs to reduce hazardous waste generation	1.91%
Targets and programs to reduce material consumption	1.91%
Targets and programs to phase out use of hazardous substances	1.91%
Data on hazardous waste generation	2.60%
Data on material consumption	2.60%
Transportation	
Airlines / Air Freight & Logistics	
Public position statement on transport and climate change	1.86%
Targets and programs to reduce emissions of transport means	2.80%
Targets and programs to reduce the noise characteristics of transport means	2.80%
Eco-efficiency of providing the service	2.72%
Marine	
Public position statement on transport and climate change	1.86%
Targets and programs to reduce emissions of transport means	2.72%
Eco-efficiency of providing the service	3.00%
Transportation infrastructure	
Targets and programs to reduce the noise characteristics of transport means	3.28%
Capital Goods	
Machinery	
Targets and programs to reduce the energy consumption of products	2.72%
Products beneficial to the environment	3.20%
Aerospace & Defence	
no real sector-specific criteria	
Energy	
Oil, Gas & Consumable Fuels	
Percentage of renewable energy sold	1.88%
Products beneficial to the environment	1.88%

Source WestLB Research, SiRi Group

We have now analysed the companies in our universe using these criteria and classified them according to the GICS sector structure.

Sector structure and classification of companies



Source WestLB Research, SiRi Group

Automobiles

In the Automobiles sector the focus is on the car as a product. We look firstly at the targets, programmes and data on CO_2 emissions relating to cars, and secondly at both active and passive vehicle safety.

Automobiles – overall rating and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)			
	Overall		Environ-	Gover-	Stake-	Passive	Product	CO2eq emissions of the fleet	
	Rating	Z score	ment	nance	holder	car safety	safety	Targets & prgs	Avg emis./km
weight			40%	15%	45%	1.05%	0.80%	3.80%	2.88%
Automobile Manufacturers									
BMW	A+	1.42	1.02	-0.06	1.75	0	100	40	50
DaimlerChrysler	A+	0.62	1.90	0.24	0.50	25	75	80	25
Fiat S.P.A	B++	-0.04	-0.10	1.00	0.13	0	0	0	100
Porsche	B+	-1.33	-0.10	-2.52	-1.61	50	50	40	0
PSA Peugeot Citroën	A++	2.37	1.98	0.85	2.28	75	75	100	100
Renault	A+	1.32	1.58	0.01	0.92	25	100	40	100
Volkswagen	A+	0.84	1.58	-0.51	0.87	25	100	80	100

Source WestLB Research, SiRi Group

Auto components

Component suppliers have a different set of criteria

The car as a product is a key focus for component suppliers, albeit from a different angle. Rather than CO_2 and exhaust emissions, the emphasis here is on the consumption of energy and materials, the use/production of hazardous substances in the manufacture of components, and how to dispose of the constituent parts of the car at the end of the product lifecycle.

Auto component suppliers – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)					
						Targets and programs on...				Data on...	
	Overall		Environ-ment	Gover-nance	Stake-holder	...end of life-cycle	...hazard. waste	...material consump.	...hazard. subst.	...hazard. waste	...material consump.
	Rating	Z score									
weight			**40%**	**15%**	**45%**	**1.91%**	**1.91%**	**1.91%**	**1.91%**	**2.60%**	**2.60%**
Tires & Rubber											
Continental	B++	-0.12	-0.02	-0.59	-0.06	40	0	40	0	0	0
Michelin	A+	0.86	0.62	0.43	0.83	100	80	0	40	0	0
Auto Parts & Equipment											
Rieter Holding Ltd	A	0.02	-0.18	0.66	-0.13	0	0	40	40	0	0
Valeo	A	0.44	0.54	0.39	0.08	40	40	0	80	50	0

Source WestLB Research, SiRi Group

Transportation

Using transport in an environmentally sustainable manner

If the focus of automobile manufacturers and their suppliers is on the car as a product, then it is the transport companies (in a narrower sense) as economic users of the various modes and systems of transport that bear significant responsibility for using transport in an environmentally sustainable manner. The main issues are climate change, reduction of noise and air pollution, and the ecological efficiency of the service provided.

Airlines and air freight & logistics companies – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)			
	Overall		Environ-ment	Gover-nance	Stake-holder	Statement on climate change	T&P to reduce... emissions	noise	Eco-efficiency of service
	Rating	Z score							
weight			**40%**	**15%**	**45%**	**1.86%**	**2.80%**	**2.80%**	**2.72%**
Airlines									
Air France	A	0.05	0.94	-1.27	0.86	100	40	40	75
British Airways plc	B++	-0.26	0.22	1.41	-0.20	100	80	40	50
Lufthansa AG	A	0.20	1.18	0.09	0.38	100	100	40	25
Ryanair Holdings Plc.	B	-2.05	-0.66	-0.74	-2.40	40	0	0	100
Air Freight & Logistics									
Deutsche Post World Net	A	0.24	0.46	-0.44	0.10	100	40	40	50
TNT NV	A+	1.43	0.78	1.83	1.24	100	40	0	50

Shipping companies – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)		
	Overall		Environ-ment	Gover-nance	Stake-holder	Statement on climate change	T&P to reduce emissions	Eco-efficiency of service
	Rating	Z score						
weight			**40%**	**15%**	**45%**	**1.86%**	**2.72%**	**3.00%**
Marine								
AP Moller Maersk	B	-2.25	-0.66	-2.03	-2.31	0	40	50
Kuehne & Nagel	B+	-0.67	-0.58	-1.35	-0.26	0	40	0

Source WestLB Research, SiRi Group

Under the GICS classification, transport infrastructure companies were likewise assigned to the transport sector. The focus here is on noise prevention.

Infrastructure companies – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)
	Overall		Environ-ment	Gover-nance	Stake-holder	Targets &Programs to reduce noise characteristics of transport means
	Rating	Z score				
weight			40%	15%	45%	3.28%
Airport Services						
BAA Plc.	A+	0.73	0.86	0.81	0.16	80
Highway & Railtracks						
Abertis	B++	-0.46	0.22	-1.46	-0.63	0
Autostrade Concessioni & Cost	A+	0.78	0.30	0.17	1.13	40
BRISA- Auto Estradas	B+	-0.64	-0.10	-0.67	-0.98	40

Source WestLB Research, SiRi Group

Manufacturers of commercial vehicles and aircraft

Scania, Volvo and MAN generate most of their sales from the manufacture of commercial vehicles; in 2004, for example, commercial vehicles accounted for 50% of MAN's sales, trucks constituted 68% and busses 6% of Volvo's sales, and Scania's Vehicle's & Services division contributed a hefty 92% of that company's sales. The Automotive division of conglomerate SKF contributed only 31% of group sales in 2004, but the group also has ties with the transport sector via other divisions – notably Industrial and Aero & Steel – which explains why we included it in our analysis.

Reducing the energy consumption of commercial vehicles

Under the GICS classification, however, these companies fall under the machinery sector. Consequently, the sector-specific criteria are quite different to those that pertain to automobile manufacturers and their suppliers. The only criterion of relevance to our topic of sustainable mobility is that of targets and programmes for reducing the energy consumed by the companies' products.

Manufacturers of commercial vehicles – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)
	Overall		Environ-ment	Gover-nance	Stake-holder	Targets &Programs to reduce the energy consumption of products
	Rating	Z score				
weight			40%	15%	45%	2.72%
Construction & Farm Machinery & Heavy Trucks						
Scania	A+	0.60	1.82	-1.50	-0.15	40
Volvo B	A+	1.42	1.90	0.54	0.57	40
Industrial Machinery						
MAN	B++	-0.35	0.86	-0.89	-0.76	40
SKF AB	A+	1.26	1.34	-0.18	1.13	40

Source WestLB Research, SiRi Group

Component suppliers have a different set of criteria

In similar fashion, EADS, Rolls-Royce and Thales have all been assigned to the Aerospace & Defence sector under GICS. At EADS, for example, the Airbus division (civilian aviation) generated 61.8% of group sales in 2004. At Rolls-Royce, Civil Aerospace accounted for 51% and Marine for 15% of group sales in 2004. At Thales, which specialised in the manufacture of electronic systems and equipment in the fields of aeronautics, marine and defence, the subdivision of products into civilian and military use, and hence the proportion of sales by use in each individual business unit, is not shown separately. However, there is also no criterion here of relevance to the issue of sustainable mobility.

Oil & Gas companies

In the context of sustainable transport it is imperative to have a look at the Oil & Gas sector too. Oil & Gas companies play a key role in the development, the production, and the distribution of alternative fuels. Within our extra-financial risk rating we consider two sector-specific criteria that have a direct link to this topic: Firstly, we rate the percentage of renewable energy sold (including alternative transport fuels) and secondly we evaluate the products of these companies which are beneficial to the environment.

Oil & Gas companies – overall ratings and sector-specific criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)	
	Overall		Environ-ment	Gover-nance	Stake-holder	% of renewable energy sold	Products beneficial to the environment
	Rating	Z score					
weight			**40%**	**15%**	**45%**	**1.88%**	**1.88%**
Integrated Oil & Gas							
BG Group	A+	0.81	-0.26	1.37	1.26	0	25
BP PLC	A	0.26	0.86	1.56	1.03	0	50
ENI	B++	-0.39	-0.90	0.81	0.31	0	50
OMV	A+	1.23	0.22	-0.14	2.24	0	100
Repsol YPF S.A.	A	0.29	0.22	0.54	0.68	0	75
Royal Dutch/Shell Group of Companies	B++	-0.29	0.06	1.30	1.48	0	75
Statoil ASA	A+	0.56	0.30	0.69	1.12	0	100
Total SA	B+	-1.10	0.06	1.15	-0.53	0	50

Source WestLB Research, SiRi Group

WestLB

Transport modes

Road

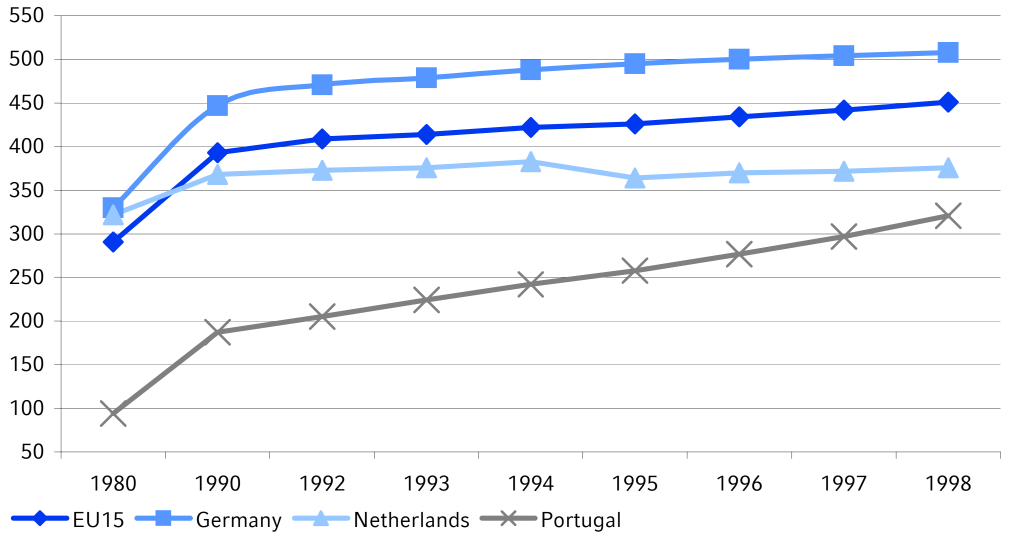
Road bears the lion's share of the overall external costs of transport. Infrastructure charging and regulation of emissions and fuel consumption are the two major policy options in this area. The global regulatory environment in which European companies have to operate will become much stricter. Companies should start accepting the unavoidable and take a more pro-active approach in adapting to the new conditions. Adaptation costs will differ strongly across OEMs.

And the winner is ...

The increasing significance of road transport

Most passenger and freight traffic nowadays is road-based. A so-called white paper by the European Commission has reported that road transport's share of total freight volume (including sea freight) is 44% (and the trend is upwards), and that of total passenger traffic no less than 79%. The main factor is undoubtedly the car, which has become a symbol of individual freedom and independence in modern society. Between 1970 and 2000 the number of automobiles in the EU nearly tripled from 62.5m to some 175m.

Number of passenger cars per 1,000 inhabitants, 1980-98

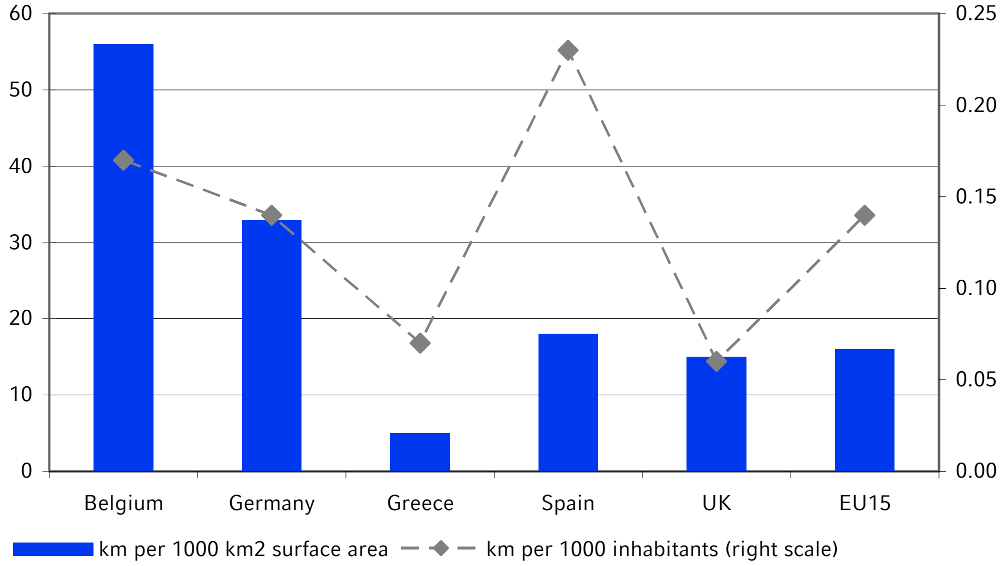


Source EC, 2001

Steep rise in motorway density in Europe

Although there are signs that growth in car registrations is slowing in the 'old' EU member states, more than 3m cars are still being added each year, and this number will undoubtedly increase considerably following the accession of the new member states. In the EU-15, 10 hectares of land are lost each day to new road construction. Building activity is especially high in structurally weak regions far removed from the EU's urban centres. This is noticeable above all in the later-acceding states such as Spain and Portugal. In those countries motorway density increased by a remarkable 43% between 1988 and 1998 – a period of just 10 years. The background is that improving road infrastructure is seen as one of the key ways to promote economic development. In the EU as a whole, the number of motorway kilometres tripled between 1970 and 2000.

Motorway infrastructure density in 2000



Source EEA, 2003

Competitive advantages of road transport

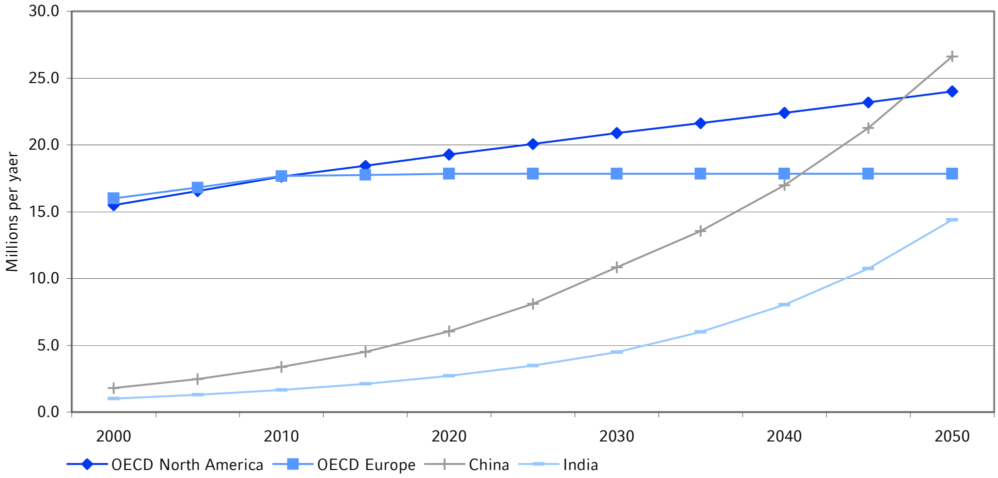
A large part of this growth is due to international freight traffic, which has boomed in the wake of the opening up of Eastern Europe. It is now estimated by the EC that road freight traffic will grow 50% between 2000 and 2010 in the absence of regulatory intervention in the meantime. Imbalances in the growth rates of different modes of transport indicate two trends. First, they show a preference for cars and trucks on the basis of their clear competitive advantages under current conditions in today's modern economy. One such advantage, for example, is their enormous flexibility, which is especially important given increased demand for on-demand and just-in-time deliveries. Second, the imbalances can be interpreted as a sign that the external costs of mobility are not allocated fairly and efficiently to the individual means of transport.

Global prospects

Motor vehicle penetration rates will increase further worldwide

What does the future hold in store for road transport in a global context? Once again, the BAU scenarios of the Sustainability Mobility Project (SMP), which we have cited several times, offer some clues. This scenario assumes that the penetration rates of engine-driven vehicles will continue to rise worldwide. In some regions the growth rates in the number of automobiles and light-duty vehicles (LDVs) predominates; in others motorised two- and three-wheel vehicles are to the fore. If the current trends do in fact continue, vehicle density in the former Eastern Bloc countries is expected to exceed the current figure for the OECD countries in 2050. By contrast, motorisation rates in line with current levels for the European OECD countries are predicted for Latin America and China.

New light-duty vehicle sales by region



Source SMP, 2004

Making road transport more sustainable

87% of all external costs are attributed to road transport

The overall external costs of transport in Western Europe (EU-15 plus Norway and Switzerland) are estimated at €530bn a year, which is equivalent to about 8% of the GDP of those countries (see chart on p. 29). Of this amount, 58% is attributed to cars, 8% to LDVs and 21% to heavy-duty vehicles. These figure imply that road transport causes 87% of all external mobility costs. So it should be no surprise that political efforts to achieve greater sustainability in the transport sector focus on this mode. The goal of shifting freight traffic from road to rail has topped the agenda in this regard for decades. However, current trends show that we have not come any closer to achieving this goal. The original aim in the EU white paper on transport policy was to stabilise the share of road transport at its 1998 level by 2010. The date for hitting this target now threatens to recede even further into the future.

Demand management can work

However, it would be totally wrong to conclude, on the basis of the lack of success in this matter, that a policy of managing demand can never work. We have cited above the success of gradually tightening emission standards in lowering conventional motor vehicle emissions as an example of demand management actually working. In the following sections we consider in detail the current regulatory framework in which the automotive industry operates, and future steps in this field. However, there are other examples of necessary measures that politicians should be encouraged to implement if the goal of more sustainable mobility is to be attained. Undoubtedly, one such example is the experience gained in assisting diesel-driven vehicles in the EU – regardless of how one assesses the measure itself. It simply demonstrates that demand management does work in principle.

The important role of tax

Tax plays an important double role where demand for diesel vehicles is concerned, firstly through motor vehicle tax and secondly through fuel tax. As the table below shows, there is a significant link between the tax imposed on diesel fuel and the proportion of new registrations of diesel-powered vehicles in Europe.

Overview of the tax rate on diesel in Europe (€ cents)

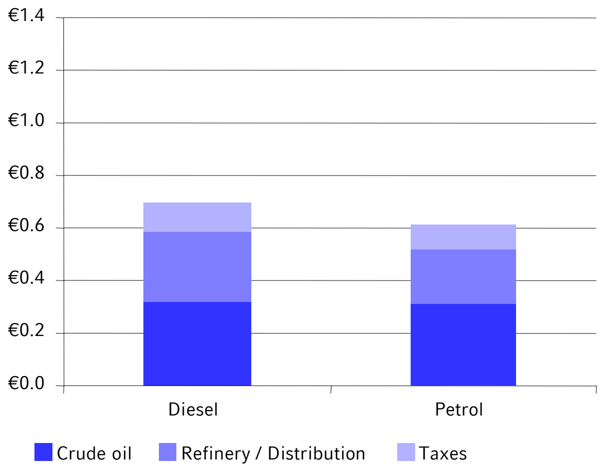
Country	Unleaded petrol	Diesel	Taxation Difference	Diesel share (2004) (%)	Vehicle tax CO_2-based
Austria	417	302	115	70.9	
Belgium	508	315	193	70.2	
Germany	655	470	185	43.6	
Denmark	539	406	133	24.2	X
Spain	396	294	102	65.4	
Finland	588	319	269	15.5	
France	589	417	172	69.2	
Greece	296	245	51	2.9	
Ireland	443	368	75	18.3	
Italy	542	403	139	58.3	
Luxembourg	442	253	189	72.5	
Netherlands	659	360	299	24.9	
Portugal	523	308	215	56.9	
Sweden	356	367	-11	8.0	
UK	688	688	0	32.6	X
European average	**509**	**368**	**142**	**48.9**	

Source ACEA, WestLB Research

A causal relationship between tax subsidies and the proportion of diesel-driven vehicles

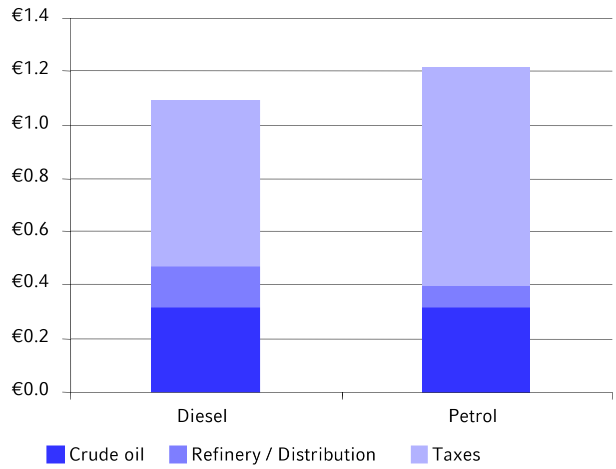
Basically, in countries in which diesel fuel enjoys only a slight or no tax advantage, the proportion of new registrations of diesel-driven vehicles is significantly lower. In the two countries that impose a CO_2-based motor vehicle tax, this has led to an increase in the share of diesel-powered vehicles, but Denmark and the UK are still well below the European average.

USA – diesel/petrol price comparison



Source WestLB Research, EIA, as of 08.12.2005

Germany – diesel/petrol price comparison

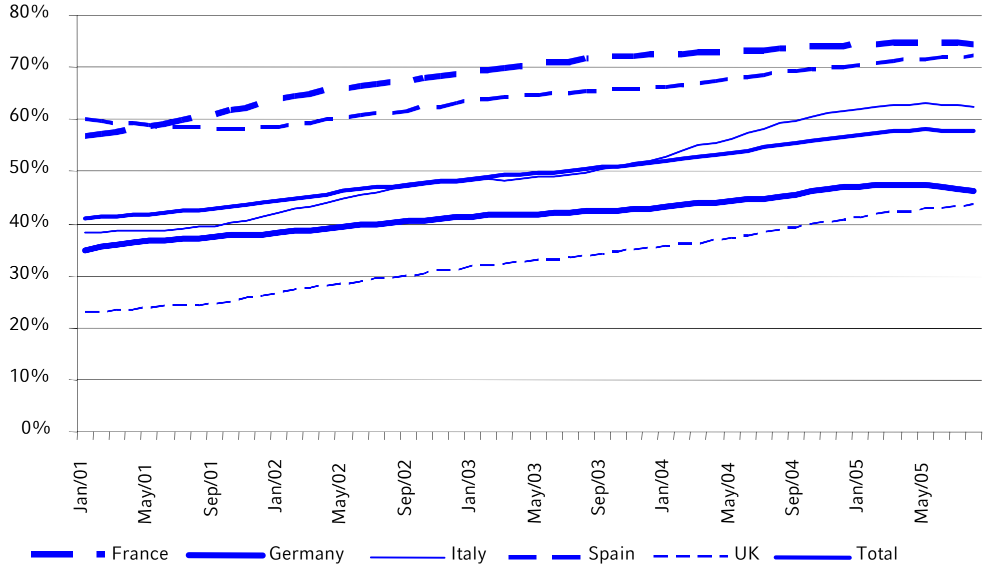


Source WestLB Research, MWV, as of 08.12.2005

25% is the critical level for the tax advantage of diesel

the share of new registrations of diesel-powered vehicles is significantly higher once the tax advantage of diesel exceeds 25%. However, the Scandinavian markets still have a below-average share of diesel-powered vehicles even though diesel fuel in Finland, for example, is 45.7% cheaper than petrol.

Diesel share of new registrations in Western Europe



Source Marketing Systems, WestLB Research

Moving towards gradually charging for the use of infrastructure

Road transport is significantly subsidised

The failure of politicians to achieve the goal of shifting freight traffic to rail shows that the argument that road transport is subject to an unfair competitive disadvantage given the subsidies for rail transport is clearly at odds with the empirical facts. The criticism levelled at state aid for rail traffic disregards the fact that road-based freight transport receives significant assistance, as the road infrastructure is provided in some cases at a zero marginal cost.

Road usage charges should fully reflect external costs

The political objective must therefore be to charge these infrastructure costs (e.g. in the form of road usage fees) to users step by step. It would make sense to include not only direct infrastructure costs in the calculation, but also the external costs of road usage such as the costs of air pollution, congestion and noise. However, this should then apply at the same time to all other modes of transport (regardless of whether privately or commercially used) in a suitable form. Only in this way could the desired efficient allocation effect be achieved. The following table gives some idea of the infrastructural and external costs of road-based freight transport.

External and infrastructure costs (euros) of a heavy goods vehicle travelling 100 km on a motorway with little traffic

External and infrastructure costs	Average range (€)
Air pollution	2.3 – 15.0
Climate change	0.2 –1.5
Infrastructure	2.1 – 3.3
Noise	0.7 – 4.0
Accidents	0.2 – 2.6
Congestion	2.7 – 9.3
Total	**8.0 – 36.0**

Source European Commission, 2001

Gap between prices and costs remains huge

Of course, some of these costs are already covered by the various taxes and charges levied on vehicles themselves, on fuel and on road usage (e.g. the motorway toll introduced in Germany in 2005). According to the EU white paper, actual charges average between €12 and €24 per 100 km. Accordingly, there is a considerable shortfall against actual costs of up to €36 per 100 km.

The ultimate aim of gradually increasing charges – whether these be road usage fees or through fuel taxes – is to reduce road transport volumes. If volumes are cut, the external costs of freight transport are automatically reduced and the gap between costs and prices charged closes further. The goal of efficient and fair pricing must be to establish a balance between costs and prices as quickly as possible.

Important role played by new technologies in levying charges

New information and communications technologies – for example, satellite-aided navigation systems such as GALILEO – can play an important role in connection with road usage fees. With their aid, user tariffs can be tailored to particular aspects – for example, to a vehicle's emission profile or road wear characteristics, to utilisation of vehicle capacity (number of passengers, or load factor) or to its contribution to congestion in travelling to a certain destination at a certain time. The German motorway toll system for heavy-duty vehicles introduced in 2005 is moving in this direction. It may be only a matter of time before it is extended to cover LDVs and cars.

Congestion accounts for a high proportion of overall external costs

It is noticeable that, aside from local noise pollution, which we will consider in detail in the following chapter, the external costs of overloading the traffic infrastructure account for a high proportion of the total external costs of road traffic. A traditional response to the problem of overstrained roads is to construct additional traffic infrastructure. Apart from the resultant external costs of land use, this is not always the best reaction in view of the problem of so-called induced demand. For example, if infrastructure measures improve traffic flows on a certain route, those drivers who previously responded to the congestion by choosing other routes or other times will adjust their behaviour in such a way that they now increasingly use the route on which traffic flows have been improved. This typical compensatory behaviour threatens to negate the positive effects of infrastructure measures. In many cases, therefore, a better response is to introduce road usage charges.

London congestion charge has been a success story so far

One example of this is London's congestion charge, which was implemented in the face of huge public resistance. One year after its introduction, delays caused by high traffic volumes in the city had fallen by 30% overall. Bus traffic in particular profited significantly in and around the zone that was subject to the congestion charge. Delays were cut by up to 60%, which created an additional incentive to switch to public transport. Traffic levels within the charge zone dropped 15% and the number of vehicles entering the zone during chargeable periods fell 18%.

Speed and acceleration differences an important factor

Another factor contributing to congestion is the differing speeds and rates of acceleration between vehicles on the roads. If all vehicles were to run at the same speed, it would not only substantially reduce the tendency of traffic to congest, but would also markedly improve traffic safety. One example of the sensible separation of traffic with different flow speeds are high-occupancy toll (HOT) lanes, which have been introduced on interstate highway no. 1 in San Diego. The charges to use these lanes range between US$0.50 and US$8.00 per trip. At six-minute intervals they can be adjusted in US$0.50 steps to the prevailing traffic situation to ensure unhindered, constant-speed traffic flow in the HOT lanes.

Smoothing traffic volumes by using intelligent traffic management systems

Modern technologies such as intelligent traffic management systems represent other possible means of smoothing traffic volumes and reducing congestion-related external costs. The Dutch Transport Ministry estimates, for example, that in the past 25 years the introduction of these systems alone has raised road capacity in the Netherlands by 5% and cut congestion by 15-20% (relative to the situation that would have applied had these measures not been taken).

Energy efficiency and emissions

Trends and projections

Conventional pollutants

Efforts have been made over many decades in developed countries to cut emissions of conventional pollutants; these include lead, carbon, particulate matter (PM), nitrogen oxides (NOx) and so-called volatile organic compounds (VOC). The greatest success to date has definitely been the universal introduction of unleaded petrol. As a result, the lead content of transport-related exhaust gases is now barely an issue in traditional industrialised countries. The advances made in abating other conventional types of emissions have also been significant, albeit considerably less spectacular.

A large part of the success is due to road transport

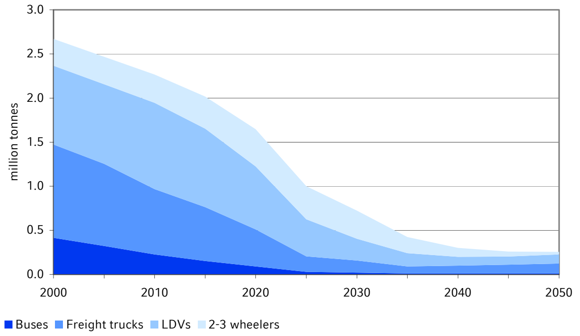
These successes are primarily attributable to developments in road traffic. For example, emission standards for motor vehicles have in some cases been tightened considerably, and technical conditions (e.g. installation of catalysts) have been created to ensure compliance. The higher demands thereby placed on vehicle fuels have resulted in such fuels being produced in large quantities and being widely available. A further emission-lowering effect came from the renewal of vehicle fleets in Eastern Europe in the second half of the 1990s.

The greatest challenge in the future is to reduce levels of particulate matter

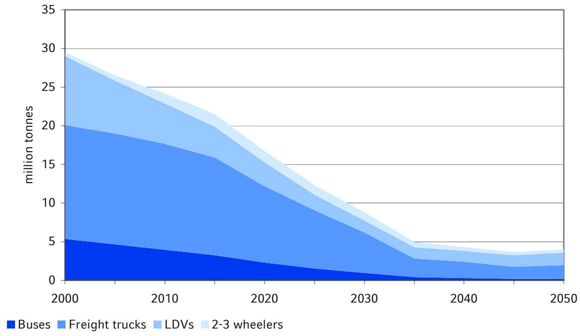
Despite the success achieved to date, further efforts are clearly required in connection with conventional emissions. One of the major challenges is undoubtedly to reducing PM levels in urban regions – a problem that has been intensified by, among other things, the increasing penetration of diesel in car fleets in Europe. However, looking ahead over the coming decades, there are grounds for optimism that these problems can for the most part be solved – at any rate according to the assumptions of the SMP's BAU projections, among others.

BAU scenario projections for selected conventional polluters

Total PM-10 emissions by mode



Total NOx emissions by mode



Source SMP, 2004

Greenhouse gas (GHG) emissions

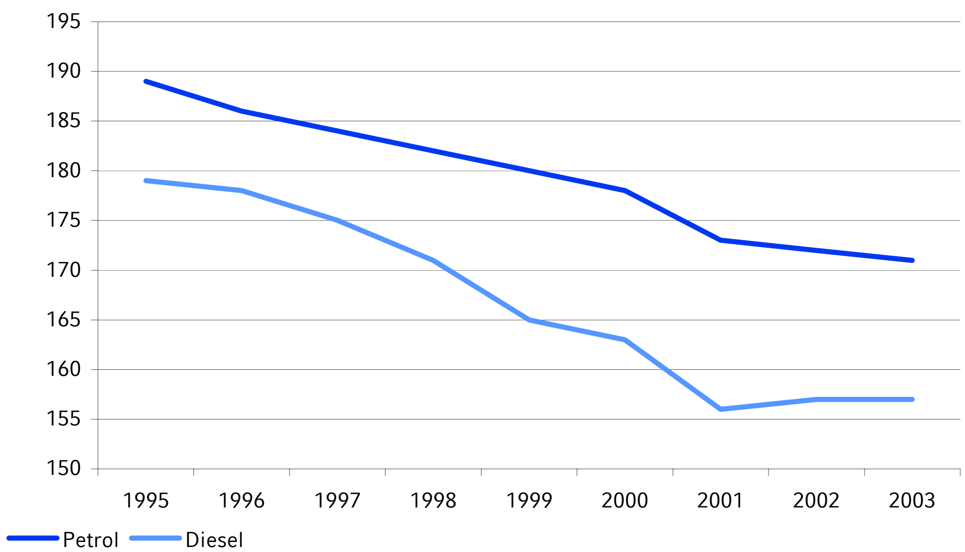
Kyoto targets can only be achieved if the CHG balance of the automotive sector improves significantly

In view of the success in cutting conventional emissions, it should be no surprise that the focus in road transport is on CO_2 emissions. The auto sector alone contributes about one-quarter of global anthropogenic GHG emissions. Many governments have in the meantime realised that it will be barely possible to hit the Kyoto targets unless further emission-restricting measures are taken in this field. Over a car's entire life cycle, 75% of all CO_2 emissions are caused by vehicle use, 19% by fuel production, 4% by production of materials and vehicle components, and 2% by final assembly. It is therefore clear that the most effective way to improve the GHG balance of cars – apart from lowering transport volumes in tonne- and person-kilometres – is to raise their energy efficiency and cut their specific CO_2 emissions.

Transport volumes are rising faster than vehicle energy efficiency

The basic problem facing the transport sector in general and the auto industry in particular is that transport volumes are rising faster than vehicle fleet energy efficiency. For example, average energy efficiency in Europe is improving year on year and CO_2 emissions of newly registered cars in the EU-15 countries have been lowered continuously. According to the EEA, CO_2 emissions from diesel vehicles fell by 12.3% between 1995 and 2003, and even those of petrol-driven vehicles fell by 9.5%.

Average CO_2 emissions of new passenger cars sold in the EU-15



Source EEA, 2006

Energy efficiency expected to increase by 18-29% by 2050 …

As a consequence, the EEA expects CO_2 emissions per passenger kilometre in the EU-15 to fall by nearly 4% by 2010. However, such a gratifying improvement due to the use of new technologies and alternative fuels would be offset by the expected strong growth in car transport volumes (+16.4% from 2005 to 2015). The SMP also assumes under its BAU scenario that car energy efficiency will improve markedly. It reckons that energy consumption per passenger- and tonne-kilometre for cars, including LDVs, will fall by 18% by 2050, and for heavy-duty trucks by as much as 29%.

… But transport volumes may rise by 123-241% in the meantime

However, it will clearly not be possible to offset increased energy requirements caused by rising transport volumes in the long term. Thus the SMP assumes in the reference case that transport volumes will grow 123% (autos) and 241% (trucks) during the same period. The consequence is that road transport GHG emissions sector will continue to rise strongly.

Regional differences

A further feature of the projection is the assumption of extraordinarily large regional differences. The projection assumes that the increase will be very high in the developing and newly industrialised countries while growth in the developed nations will be comparatively flat. This projection is based, first, on the assumption that transport volumes in newly industrialised countries such as China will grow at a much faster pace than in the USA or Western Europe. It further assumes that new technologies to improve energy efficiency in the developing and newly industrialised countries will to some extent be deployed only with a considerable time lag.

Car occupancy and lorry load factors decline

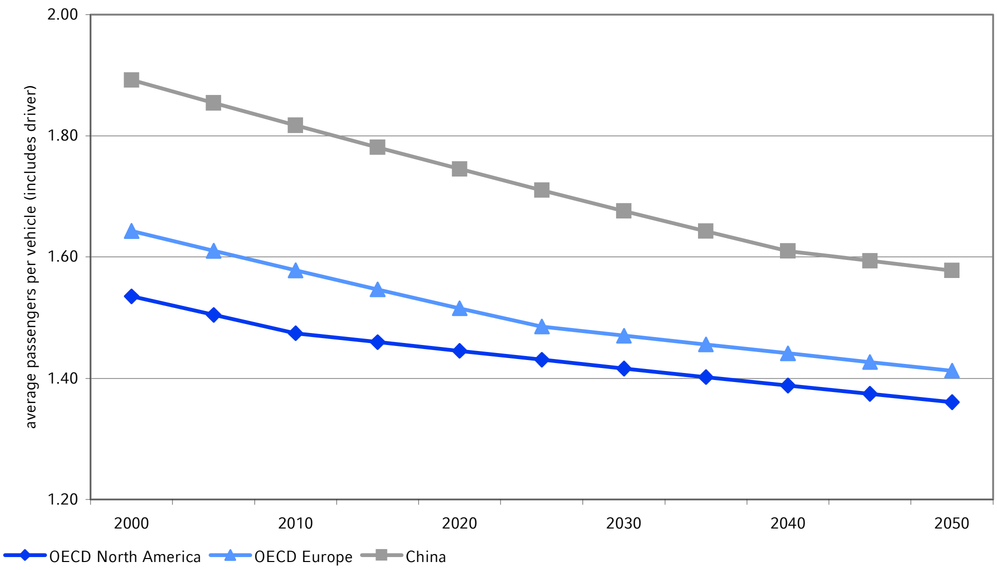
Falling occupancy and load factors offset increasing energy efficiency

Besides the main problem – namely the steep rise in transport volumes – a further factor in the developed countries to some extent negates the success undoubtedly achieved in improving the CO_2 efficiency of vehicles. This is the trend towards reduced occupancy and load factors in passenger and freight traffic. While no data are available covering all EU states, in the countries for which data exist the average occupancy rates for cars are well below the level attained 10 years ago.

More difficult to reconcile individual transport needs

The reasons are increasing car penetration rates (up from 305 to 380 cars per 1000 inhabitants during the 1990s), the declining average household size and the increasing decentralisation of urban regions. Among other things, changes in lifestyles caused by these trends mean that it is no longer as easy to reconcile individual transport needs as it was 30 or 40 years ago. The result is that each individual not only drives more kilometres by car, but that he or she does so with a lower number of persons per vehicle (indeed often alone).

Average LDV passenger 'load factor' by region



Source SMP, 2004

In truck-based freight traffic, load factors are also declining, albeit at a lower rate than in the case of cars. The general improvement in logistics operations, which has resulted in fewer journeys without freight, has been unable to alter this trend. The main reason for this development is that the higher transport costs caused by sub-utilisation of transport capacity are more than offset for example by greater flexibility and resultant savings in storage and production costs.

Virtually no scope to optimise utilisation rates given the flexibility requirements

New strategies in companies such as supply chain management and just-in-time and on-demand deliveries rigorously exploit these cost differences. The maximum possible flexibility demanded of transport firms by their customers simply gives them no room to optimise utilisation rates. In addition, the major retail groups have changed their distribution strategy. Instead of the former more decentralised approach, they now have a small number of large distribution centres, which has resulted in fleets with larger trucks and longer distances that the trucks have to cover.

Load factor-related road usage charges could be a solution

Politically, it is undoubtedly not easy to directly address the trend of falling car and truck utilisation rates, since these are ultimately the result of free market forces. In relation to the increase in incomes, it has become more affordable for people to have their own cars. As a result, the incentive to ensure full occupancy has tended to fall. Measures such as restricting access to fast lanes on motorways for vehicles without the required occupancy rate, while helpful, can ultimately only partially solve the overall problem. The starting point is to set the right economic incentives and to fully internalise external costs, an issue we have already discussed in detail. In the case at hand, this could be effected through road usage charges based on utilisation rates. Modern satellite-aided systems such as GALILEO could provide the technological basis for recording data and levying charges. Despite all the initial teething problems, systems such as the truck toll system in Germany show that the trend is indeed likely to move in this direction. The technical platform, for example, has been deliberately designed for cars as well.

Technology potential assessment

Promoting new technologies by means of standards and tax incentives

At present, the most widely used approach to achieve a balance between effectively paid transport prices and external costs is to promote the introduction of new technologies by setting standards and offering tax incentives. We will consider this in detail and discuss the impact of the current or imminent emission guidelines in Europe and the USA as well as the demand for cars with different drive transmission technologies and the resultant implications for the individual carmakers. However, before we do so, we consider it appropriate to discuss briefly once again the basis potential of new technologies with regard to the goal of higher energy efficiency and lower emissions.

New technologies that improve fuel efficiency are being applied in road transport. This is being carried out partly through the increased use of diesel engines for the passenger fleet (direct injection and common rail technologies) and other technological advances, such as the use of lightweight materials, advanced transmissions, and low-resistance tyres and lubricants. However, petrol direct injection has so far failed to significantly enter the market and currently remains but a promising technological improvement. Furthermore, hybrid drives have become available in small quantities in passenger cars and are more fuel efficient than conventional petrol engines.

The OECD's high-technology scenario is the starting point

The OECD's so-called high-technology scenario represents the starting point for our considerations (see p. 42). The question underlying this scenario is what technological innovations would be necessary to decrease the impact of mobility on the environment to a level that meets the OECD's criteria for an ecologically sustainable transport system without future transport volumes being lower than stipulated in the BAU scenario. If we look at road traffic, this gives rise to the following scenario features:

- Light duty road vehicles (including cars): Almost all conventional vehicles would be replaced by electric vehicles of one of three kinds: battery-powered, fuel-cell-powered or hybrid combustion-electric.
- Heavy-duty road vehicles: Almost all conventional vehicles replaced by hydrogen-based, fuel-cell-powered vehicles.
- Widespread use of information technology helps improve vehicle efficiency and utilisation.

The researchers point out that the costs incurred in implementing this scenario would be enormously high. A large part of the costs would be caused by the production, treatment and storage of hydrogen. Reference is made above all to the high fuel consumption and the overall low efficiency of these processes.

SMP's technology scenarios

The SMP has also assessed the abatement potential of new technologies. It first evaluated the different drive and fuel technologies individually with regard to their efficiency. It concluded that 'diesels and hybrid ICEs [internal combustion engines] fuelled with conventional gasoline and diesel fuel, or fuel cells fueled by with natural gas-derived hydrogen', can only slow, but not stop, the growth in road transport-related CO_2 emissions up to 2050. According to the SMP's analysis, only the use of 'carbon-neutral hydrogen in fuel cells and advanced biofuels in ICE-powered vehicles' would be able to fully compensate for the increase in emissions caused by the growth in transport volumes during this period.

Various drive and fuel technologies must be deployed at the same time in order to reduce CO_2 emissions

Accordingly, the SMP also takes the view that a significant abatement in CO_2 emissions can only be achieved by the simultaneous use of differing drive and fuel cell technologies. On this point, it is in complete agreement with the research team commissioned by the OECD. However, there are clearly differences in the technology mix proposed by the SMP and the OECD teams. This is mainly because the SMP's CO_2 reduction targets are less ambitious. The starting point for the OECD was the question as to what CO_2 level from an environmental point of view is feasible in the long term at all. One of the 'environmentally sustainable transport' criteria it therefore formulated was that transport-related CO_2 emissions should be at least 80% under the 1990 level by 2030.

By contrast, in its combined technology scenario, the SMP's target is merely that CO_2 emissions should return to the 2000 level by 2050. This would also clearly be a major success which would require a huge effort and cause enormous costs. The mix of measures proposed by the SMP to meet this target is as follows:

- The dieselisation of LDVs and medium-duty trucks rises to around 45% globally by 2030 (that is, to about current European levels).
- The hybridisation (gasoline and diesel) of LDVs and medium-duty trucks increases to half of all ICE vehicles sold by 2030.
- The quantity of biofuels in the total worldwide gasoline and diesel pool rises steadily, reaching one-third by 2050.
- Mass market sales of LDVs and medium-duty trucks with fuel cells using hydrogen derived from fossil fuels (no carbon sequestration) start in 2020 and rise to half of all vehicle sales by 2050.
- Hydrogen sourcing for fuel cells switches to centralised production of carbon-neutral hydrogen over the period 2030-2050 once hydrogen LDV fleets reach significant penetration at a country level. By 2050, 80% of hydrogen is produced by carbon-neutral processes.
- The additional energy efficiency improvement potential embodied in current vehicles is around 1.0% per year, but about half of this potential improvement is offset because of vehicle purchasers' preferences for larger and heavy vehicles. In developing countries, preferences relating to the mix of vehicles chosen by purchasers and the performance of these vehicles change somewhat, leading to an additional 10% average annual in-use improvement.
- Better traffic flow and other efficiency gains in road vehicle use lead to a further 10% reduction in emissions.

What conditions will have to be put into place before new technologies can be introduced on a large scale?

Our interim conclusion is that reducing the growth in fuel consumption and emissions and ultimately even lowering their absolute volumes do indeed appear technically feasible and attainable. However, the key question is what framework will be required to enable these technologies to be implemented. The broad-based introduction of some of these technologies has already begun (see hybrid vehicles). In the case of others, it will take decades before they attain the critical mass in market penetration required to actually cut emissions to the necessary extent.

Obstacles to implementation of fuel cells/hydrogen option

A traditional example is the widespread use of hydrogen in combination with fuel cells. This option plays a central role in the OECD and SMP scenarios. However, a host of obstacles will have to be overcome before this can finally be put into practice. For one thing, much still has to be done before appropriate vehicles are technically ready for mass production. In addition, reducing the CO_2 emissions arising from the production of hydrogen is hugely problematic, as is the question of providing the required hydrogen infrastructure.

Demand management action is unavoidable

In our opinion, it is quite clear that the intrinsic economic incentive for industry will not suffice to enable the process of introducing these new technologies to take place as quickly as possible and as quickly as necessary. Experience shows that the introduction of new technologies, or the further development of existing ones, requires state institutions (ideally of course on an agreed multilateral basis) to take action to manage demand to achieve the goal of sustainable mobility. Catalysts, particle filters for diesel vehicles and reductions in exhaust emissions are examples that demonstrate that tightening emission standards has supported the development and introduction of new emission abatement technologies in automobile construction, and will continue to do so. A further promising example of demand management is that more and more EU states have started to link their vehicle taxes to vehicles' CO_2 emission profiles.

Minimising transition costs

Even if the idea of steering demand is generally accepted – which the representatives of the various affected industrial sectors still find difficult to do – the question naturally remains as to how quickly and how extensively such measures should be introduced. A 'big bang' would not only result in enormous out-of-pocket costs, but would also involve considerable differences in how costs were shared among the various groups in society. Furthermore, if the goal of sustainable mobility is taken really seriously, transport volumes will also have to be cut back, which in turn would mean a loss of economic prosperity at least in the short term. In the long term, however, the loss of prosperity cited above all by lobbyists is not an argument against demand management if it succeeds is closing the undoubted gap between transport prices and external transport costs for all modes of transport. This transition should proceed as smoothly as possible – not least to ensure broad acceptance in society. However, we can no longer afford to delay taking steps very much longer as much of the damage caused by the non-sustainability of road transport is irreversible. This issue really represents one of the greatest tasks and challenges for politicians.

Closing the technology gap between the developed and the developing world

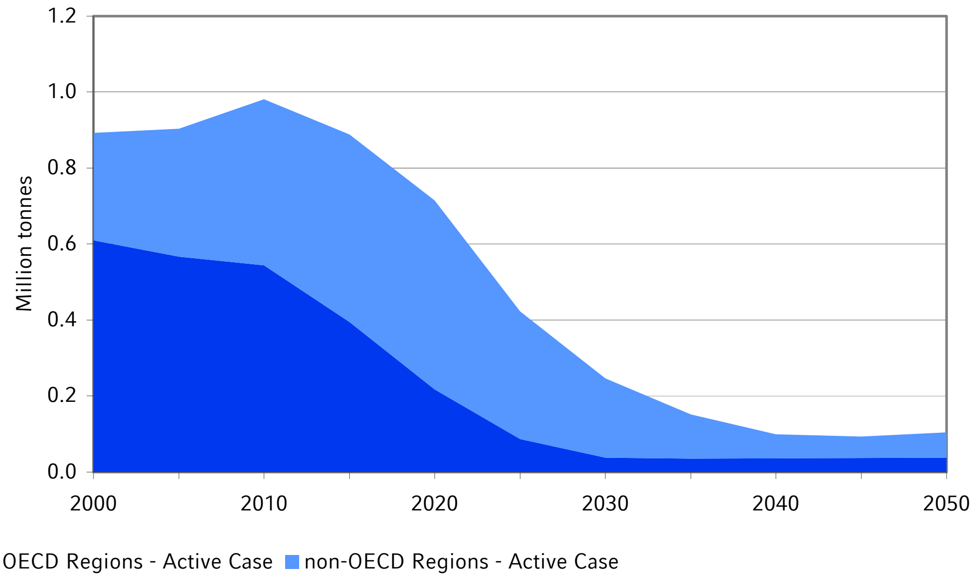
Time lag of 10 years

A particularly important aspect of this challenge is the technology gap between countries in the developed world and the newly industrialising and developing countries. For example, in its reference scenario, SMP assumes a time lag of 10 years before new technologies that have become established in the developed world can also be adapted and effectively implemented in the developing countries.

Economic growth has priority

Given the high contribution of newly industrialised and developing countries to the expected growth in transport volumes over the coming decades, this time lag is of considerable significance as far as achieving the goal of more sustainable mobility is concerned. However, as of today it is more than doubtful that this gap can be reduced faster than assumed in the BAU scenarios. For example, the priorities in the newly industrialised nations such as China are still focused on unbridled growth (= construction of additional road infrastructure) and more prosperity (= affordable vehicles) for the broad mass of the population. In addition, the environmental policies of these countries are likely to concentrate on improving local, conventional pollution. Monitoring compliance with newly introduced emission standards will probably prove especially difficult. It must therefore be assumed that conventional emissions in these regions will initially also rise for several decades before ultimately falling.

Total LDV PM-10 emissions by region



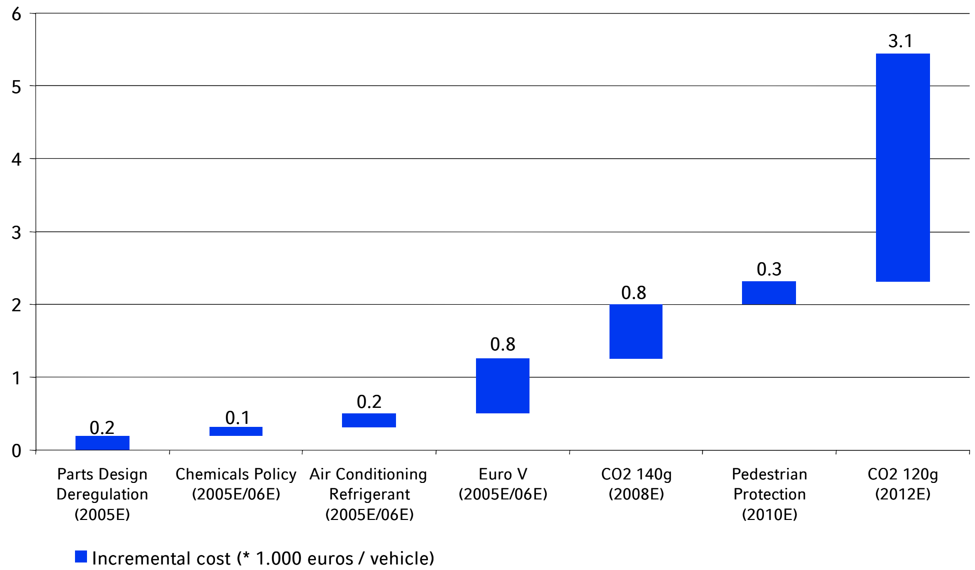
Source SMP, 2004

Regulatory framework as a major technology driver

Huge pressure on carmakers

The political focus on climate change and GHG emissions and the ever stricter standards with regard to conventional emissions of combustion engines are putting enormous pressure on carmakers to improve the energy efficiency and emission characteristics of their vehicles.

Incremental vehicle costs due to changes in regulatory environment in the EU



Source VDA

Do regulatory measures increase costs?

However, this does not give rise only to burdens, as the above description of the cost escalation caused by regulatory measures in the USA based on VDA estimates suggests. New market opportunities can also arise, as Toyota's success with the launch of hybrid vehicles demonstrates. After resisting for a long time, other manufacturers have now jumped onto this trend. However, they are at considerable competitive disadvantage to the market leader.

Measures to promote fuel-efficient vehicles around the world*

Fuel efficiency approach	Measures/forms	Country/region
Fuel economy standards	Numeric standard in mpg, km/L, or L/100-km	USA, Japan, Canada, Australia, China, Taiwan, South Korea
GHG emission standards	Grams/km or grams/mile	EU, California
High fuel taxes	Fuel taxes at least 50% greater than crude oil base price	EU, Japan
Fiscal incentives	Tax relief based on engine size, efficiency, and carbon dioxide emissions	EU, Japan
R&D programs	Incentives for particular technologies and alternative fuels	USA, Japan, EU
Economic penalties	Gas guzzler tax	USA
Technology mandates and targets	Sales requirement for ZEVs	California
Traffic control measures	Hybrids allowed in HOV lanes; ban on SUVs	Several U.S. States (hybrid HOV lanes) Paris (SUV ban)

* Note: This list is not exhaustive **Source** SMP, 2004

No international comparability of emission standards

Standards for conventional emissions, energy efficiency and GHG emissions, now exist in many regions of the world – for example in China, which is so important for sustainable mobility. Wherever standards exist, their tightening and extension are an ongoing issue. In regions without emission standards, there are efforts to introduce such standards taking other countries as a model. One problem of existing standards is the lack of comparability, which is due to different general political approaches, different test drive cycles and different emission units. Despite this lack of comparability, one can say that the strictest standards at present are in the EU and Japan.

Fuel economy and GHG standards for vehicles around the world

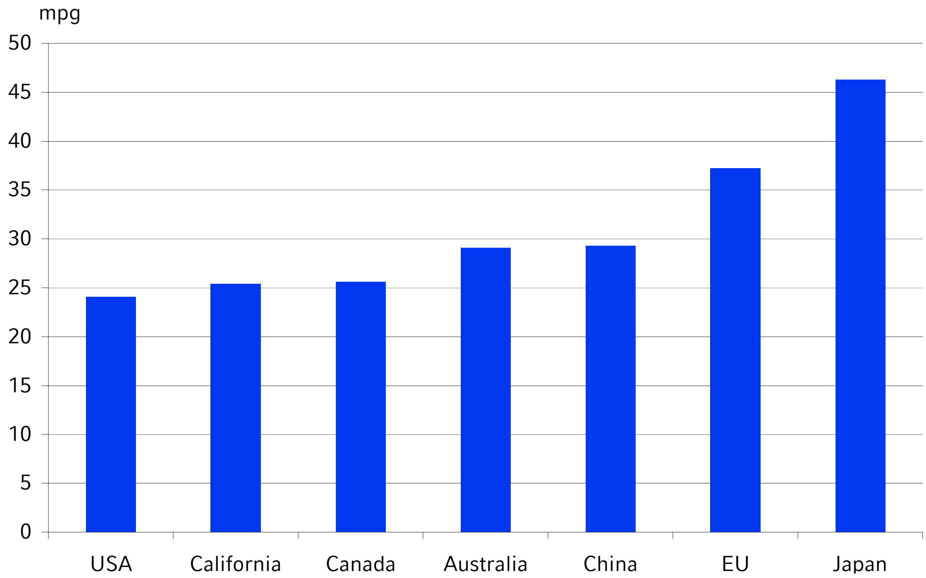
Country/region	Type	Measure	Structure	Test method[a]	Implementation
United States	Fuel	mpg	Cars and light trucks	U.S. CAFE	Mandatory
European Union	CO_2	g/km	Overall light-duty fleet	EU NEDC	Voluntary
Japan	Fuel	km/L	Weight-based	Japan 10-15	Mandatory
China	Fuel	L/100-km	Weight-based	EU NEDC	Mandatory
California	GHG	g/mile	Car/LDT1 and LDT2[b]	U.S. CAFE	Mandatory
Canada	Fuel	L/100-km	Cars and light trucks	U.S. CAFE	Voluntary
Australia	Fuel	L/100-km	Overall light-duty fleet	EU NEDC	Voluntary
Taiwan, South Korea	Fuel	km/L	Engine size	U.S. CAFE	Mandatory

[a] test methods include US Corporate Average Fuel Economy (CAFE), New European Drive Cycle (NEDC), and Japan 10-15 Cycle; [b] LDT1 and LDT2 are categories of light-duty trucks. **Source** SMP, 2004

Fuel economy and GHG emission performance of the US car and LDV fleet lags behind

Not surprisingly, the fuel economy and GHG emission performance of the US car and LDV fleet lags behind many other developed nations. And based on current policies this trend is expected to continue. The USA has the lowest standards in terms of fleet-average fuel economy rating in the developed world, and the highest GHG emission rates based on the EU testing procedure. The new Californian standards have narrowed the gap between the USA and the EU, but they are still less stringent than the EU standards. The new Chinese standards are more stringent than those in Australia, Canada and the USA, but they are less stringent than those in the EU and Japan.

2002 fleet fuel economy averages for new vehicles



Source PEW, 2003

Below, we consider only the regulatory framework in Europe and the USA. One reason is that they are the two most important markets for European carmakers. A further reason is the function as pioneers and model that European standards for example have for newly industrialised and developing countries have or will probably have in the future. Last but not least, it would clearly go beyond the scope of this study to consider the entire global situation. The following comments are based on *Squaring the Circle*, the study we published in December 2005.

Regulatory environment in Europe

Europe has two different emission reduction standards: Euro 4/5 and the ACEA voluntary agreement

Europe has two different emission reduction standards, Euro 4/5 and the ACEA voluntary agreement. Whereas Euro 4 and Euro 5 regulate the vehicular emission of nitrogen oxide (NOx, leading cause of acid rain and smog), hydrocarbon (HC, precursor of smog) and particle emissions (PM, precursor of smog and hazardous to health via inhalation), the ACEA voluntary agreement is strictly a CO_2 reduction measure. The ACEA voluntary agreement calls for a Europe-wide CO_2 emission reduction to 140 g/km by 2008. Measures of compliance and non-compliance with the ACEA voluntary agreement have yet to be clarified.

CO_2: ACEA voluntary agreement

Reducing CO_2 emissions in all newly registered vehicles to 140 g/km by 2008

The ACEA members (BMW, DaimlerChrysler, Fiat, Ford, GM, Porsche, PSA, Renault, VW) have committed themselves to reducing CO_2 emissions in all newly registered vehicles in Western Europe to 140 g/km by 2008. The ACEA agreement is structurally different from the US CAFE requirement in that it does not address requirements at the manufacturer level, which makes it difficult to gauge the successful implementation of the measure in practice in the European automotive industry.

The ACEA's emission target entailed a reduction in the CO_2 level from 185 g/km to 140 g/km between 1995 and 2008. According to our calculations, the volume-weighted average was around 167 g CO_2/km in 2004 compared to the European Commission's

2003 reported value of 163 g CO_2/km and the ACEA's measurement of 161 g CO_2/km. Assuming a linear emission trend, CO_2 emissions must be reduced at an annual rate of 2% in order bring the level down from 185 g/km to 140 g/km. Between 2002 and 2003, however, the emission improvement rate was a mere 1.2%. For the ACEA target to be achieved, therefore, the annual improvement rate would have to increase to 2.8% in subsequent years.

ACEA voluntary commitment not feasible under current conditions

Lack of progress is due to the increasing weight and engine power offered

In our view, it won't be possible to achieve compliance with the ACEA voluntary commitment of 140 g CO_2/km. The main reason for the current and the expected lack of progress is the increasing weight and engine power offered on new passenger cars. Given that these trends continue, a significant improvement in CO_2 emissions in the coming three years seems unfeasible, which is all the more true with regard to the EU's objective of 120 g of CO_2/km. The European Commission is currently reviewing the options available to further reduce CO_2 emissions from passenger cars. Air conditioning, for example, is not yet incorporated in fuel-efficiency tests.

Putting the ACEA agreement into the overall climate change context

Further steps required going well beyond the 140 g/km target

Scientific studies (see IPCC, 2001) have shown that GHG emissions in western countries would have to be cut by 60-80% by 2050 to ensure that the rise in temperatures relative to the pre-industrial age does not exceed 2°C. This means that GHG emissions would have to be lowered by 2.0-3.5% year after year. On the assumption that urban traffic increases by 2% a year, vehicle CO_2 efficiency would have to rise each year by 4-5%. This is well above the rates implied by the ACEA agreement and even higher than the rates actually achieved. Accordingly, further steps would have to be taken going well beyond the 140 g/km target.

The Euro 5 standard

All diesel engines have to be fitted with particle filter

Euro 5 is an emission standard for vehicle type approval in the EU. The Euro 4 standard came into effect in 2005. A proposal for Euro 5 has been submitted by the European Commission, although its final form is still unclear. It could even be introduced by 2008. The commission's current proposal envisages a 20% reduction in NOx emission from diesel engines to 200 mg/km. It should be possible for small cars to conform with this ceiling with engine technical modifications, but from mid-sized cars upwards it will require an exhaust gas treatment system. In addition, all diesel engines will have to be fitted with particle filters, which are intended to cut soot particulates emissions by 80% to 5 mg/km. Besides the reduction levels of pollutant emissions, the main differences between Euro 5 and 4 concern the definition of vehicle categories and prescribed test cycles.

Euro 5 regulations are more stringent – but not as strict as expected

Reduction will be difficult to achieve for smaller, more fuel-efficient engines

The new regulation prescribes a NOx reduction of only 20% to 200 mg/km for diesel engines compared to speculation of up to 70% in the run-up to Euro 5. This limit was intended to ensure compliance through improved engine performance. Because NOx reduction technology is not yet fully developed, the European Commission has recently proposed not setting the reduction target below 200 mg/km. This reduction will be difficult to achieve for smaller, more fuel-efficient engines in particular as they will be subjected to a significantly higher workload in the required driving cycle. The reduction of particulate emissions by 80% to 5 mg/km poses a greater challenge. Since a particulate filter is indispensable for this target to be achieved, it may well be required on all diesel-powered vehicles. Today's filters can reduce particulate emissions by 97%, so the new ceiling should not be a problem – at least from a technical standpoint.

For petrol engines, the new Euro 5 standard stipulates a 25% reduction of NOx and HC emissions to 60 mg/km and 75 mg/km respectively, which should be far less difficult – and less expensive – to achieve than the new diesel standards.

Targeted vehicle categories

SUV demand should be significantly reduced

In contrast to Euro 4, the Euro 5 requirements also apply to passenger vehicles with a kerb weight in excess of 2,500 kg. Under Euro 4, these vehicles were classified as light commercial vehicles. This regulation favoured SUVs in particular. Now that Euro 5 has closed this loophole, demand for this vehicle class should be significantly reduced.

Longer test period

Besides the reduction of emissions, the new test period also presents new challenges for manufacturers. Previously, manufacturers provided a vehicle emission warranty of 80,000 km. The emission test period has now been extended to 160,000 km. The associated difficulties should not be underestimated, in our view. Some modern diesel engines are no longer able to conform to the prescribed emission limits after only 50,000 km. This is due to impurities within the engine that accumulate over time and hinder combustion. Extending the durability period to 160,000 km places exorbitant demands on combustion robustness, which is very difficult to achieve with today's technology.

Regulatory environment in the USA

Manufacturers in the USA are subject to a fuel consumption limit

In contrast to the European market, manufacturers in the USA are subject to a fuel consumption limit. The Corporate Average Fuel Economy (CAFE) regulation provides for separate standards for passenger cars and light commercial vehicles. In addition to the CAFE regulation, which controls the fuel consumption of manufacturers' fleets, the USA has the Tier 2 emission regulation and other state regulations (e.g. those issued by the state of California). The Tier 2 regulation sets ceilings for the emission of NOx, HC and particulates.

The recently passed US Energy Bill has set more stringent standards for CAFE; however, this is based on a new classification of light commercial vehicles. Ultimately, this new regulation will have a greater effect on manufacturers of smaller vehicles than on those of larger vehicles, and will thus tend to affect European/Asian manufacturers more than US manufacturers.

CO_2: CAFE requirements

If the fuel consumption limit is exceeded, penalty payments are imposed

The CAFE regulation governs the maximum allowed fleet fuel consumption by manufacturer. If the fuel consumption limit is exceeded, penalty payments are imposed. The calculation of fuel consumption is volume weighted, and vehicles with alternative drive concepts (e.g. hybrid technology) generate positive compensatory effects. The CAFE requirements for passenger cars (weighing less than 6,000 lbs) call for 27.5 miles per gallon (mpg) (equivalent to 8.6 litres/100 km) and are not especially demanding. Still, in the past Porsche and BMW were unable to fulfil this target. The recently passed US Energy Bill will not change the 27.5 mpg limit. In contrast, the limits for light commercial vehicles (weighing between 6,000 lbs and 8.500 lbs) will, on average, gradually be raised from 22.2 mpg in 2007 to 24.5 mpg in 2012. Vehicles with a kerb weight in excess of 8,000 lbs are exempt from the CAFE regulation. Neither Porsche nor BMW managed to fulfil this standard in 2004.

Tightening standards will mean that the industry will have a much higher hurdle to clear

Tightening this standard will mean that the industry will have a much higher hurdle to clear – and this will include European manufacturers as well. As opposed to today's method of calculation (volume-weighted average fuel consumption), the new regulations provide that average fuel consumption values are to be calculated according to vehicle category. This is based on a vehicle's footprint (not its weight). Vehicles weighing more than 8,000 lbs (e.g. the GM Hummer) are not taken into account.

CAFE standards for passenger vehicles

mpg	2000A	2001A	2002A	2003A	2004	2005E	2006E	2007E
CAFE target	**27.5**	**27.5**	**27.5**	**27.5**	**27.5**	**27.5**	**27.5**	**27.5**
Industry-wide average	28.5	28.8	29.0	29.5	29.1	30.0	30.2	30.0
DaimlerChrysler	27.9	27.9	27.7	29.7	29.7	28.7	29.0	29.1
Volkswagen	28.8	28.5	29.5	29.8	28.7	28.8	28.5	29.5
BMW	**24.8**	**25.0**	**26.2**	**26.8**	**26.3**	**26.9**	**27.1**	**26.9**
Porsche	**24.3**	**23.7**	**23.9**	**24.1**	**23.3**	**24.4**	**23.7**	**23.9**

Source NHTSA, WestLB Research estimates

Easier for manufacturers of large vehicles to observe the limits

According to the new regulation, light commercial vehicles are divided into six categories; these have to achieve between 21.3 mpg (for the largest vehicle) and 28.4 mpg (for the smallest vehicle). Thus, in future the penalty payments will not be calculated on the basis of the average values of 2 categories but on 7. It is therefore easier for manufacturers of large vehicles to observe these limits, as the heavier vehicles do not negatively affect the average value of all vehicles; instead, they have to merely observe the limit within their respective category.

The penalty payments are calculated using the number of unit sales and the amount by which the standard is missed: each 0.1 mpg by which the standard is missed is multiplied by a penalty of US$5.50 times the number of unit sales. For Porsche, this figure amounted to €3.5m in 2003.

It is possible to accumulate credits for years in which the standards have been surpassed, which can then be used in the three subsequent years in case the standards are not met. However, this has never been the case for Porsche.

Tier 2 and LEV II

Main difference is the sequence in which the standards will be introduced

There are two emission standards in the USA: the national standard Tier 2 (issued by the Environmental Protection Agency) and the LEV II standard (issued by the California Air Resources Board). The standards are increasingly being brought into line with each other, and the main difference is the sequence in which they will be introduced. Whereas the implementation of Tier 2 will be completed by 2010, the LEV II standards will come into effect as early as in 2007. LEV II will apply in California and states in the northeastern USA (New York, Pennsylvania, etc.).

Petrol, diesel and other engine technologies must observe the same emission standards

In contrast to the Euro 4/5 regulations, the Tier 2/LEV II regulations do not distinguish between the various engine technologies. Thus, petrol, diesel and other engine technologies must observe the same emission standards. The Tier 2 regulation has been in effect since 2004 and will be fully implemented by 2010. The Tier 2/LEV II regulation provides for significantly more stringent guidelines with regard to NOx than the

European guidelines. As diesel vehicles will most likely have to be equipped with a particulate filter and SCR system, their projected compliance costs will be considerably higher than those in Europe. The costs for petrol engines will also rise but not at the same pace as for diesel engines. However, in contrast to Euro 4/5, the Tier 2 regulation allows vehicles to be subdivided into eight classes. The way in which the individual vehicles are classified is left up to the manufacturer as long as the fleet emission exceeds the limit of 0.07 g NOx/mile. As in the case of Euro 5, the test cycle here has also been extended from 80,000 to 120,000 miles.

Two divergent strategies – consumption and emission optimisation

Complying with the Euro 5/Tier 2 standards leaves the manufacturers with far fewer alternatives

Compared to the CAFE requirement of 140 g CO_2/km, complying with the Euro 5/Tier 2 standards leaves the manufacturers with far fewer alternatives. Since the Euro5/Tier 2 standards regulate NOx, CH, CO_2 and PM emissions, the petrol engine enjoys a technical advantage here. Segregated standards have been established for diesel and petrol technologies, resulting in a relatively narrow scope for technological upgrades. By contrast, the ACEA voluntary agreement in no way stipulates how the industry-wide average emission rate of 140 g CO_2/km is to be complied with, be it through engine technology upgrades (diesel, hybrid, etc.), model mix or fuel optimisation. Compliance cost estimates are very difficult and imprecise at best because of the number of assumptions involved.

The introduction of diesel direct injection with common rail injection technology has contributed the most to reducing CO_2 emissions in Europe (pump-nozzle injection system). More far-reaching measures include variable valve timing (VVT), exhaust gas recirculation systems, SCR systems, new transmission concepts, etc. All of these measures entail additional costs and can in combination reduce CO_2 emission ratings, based on our analysis, by up to an estimated 50% for petrol engines and 40% for diesel.

Potential of conventional technologies to reduce CO_2 emissions – most important steps, based on 2000

Measure	CO_2 reduction potential (%)	Additional costs (€)	Comment
Fuels			
Roll-on tyres	3-5	0-20	Already marketed
Low-viscosity oil	1-5	0-30	Already marketed
Engine			
Petrol direct injection, incl. exhaust recirculation	10-13	150-200	E.g. VW FSI, Mitsubishi GDI
VVT and electromechanical valve actuation	15-20	240-470	
Downsizing / turbocharger	5-7	200-270	Volkswagen TSI
Transmission			
Automated gearshift	3-5		
6-speed automatic transmission	1-3	170-340	
Variable transmission	5-10	85-340	30%-70% vs. conv. transmissions
Weight reduction			
Aluminium	5-8	0-375	Max. 20% of kerb weight
Plastics	5-8	60-1800	Max. 20% of kerb weight
Propulsion system			
Diesel-powered vs. petrol engine	8-13	150-620	25%-30% consumption reduction but CO_2 disadvantage
Start/stop function, mild hybrid	8-10	800-960	Valeo, Continental
Summary			
Petrol engine with direct injection	35-49	230-1320	Base value of est. 175 g CO_2/km
Diesel engine with direct injection	23-41	240-1360	Base value of est. 150 g CO_2/km

Source WestLB Research, Kolke, National Research Council

Petrol technology is able to achieve a higher CO2 emission reduction potential versus diesel

The costs associated with CO_2 reduction are very similar for both engine technologies. A CO_2 emission reduction of 35%-49% for petrol engines with direct injection should cost about €230-1,320 per vehicle. In terms of cost, petrol technology is able to achieve a higher CO_2 emission reduction potential than diesel. We estimate that additional unit costs for a CO_2 emission reduction of 23%-41% for diesel engines run to approximately €240-1,360. As diesel technology is already fairly advanced (direct fuel injection, common rail), any further emission savings potential is limited.

Emission savings potential of hybrids is similar to that of conventional technologies

By contrast, current compliance costs for a 40% CO_2 emission reduction in a hybrid system are estimated to be approximately €240-€1,500. From a technological standpoint, the emission savings potential is similar to that of conventional technologies, with newer model series commanding a greater market share (assuming the relevant government requirements are formulated accordingly). However, tax breaks for US hybrid engines will certainly make it difficult for diesel technology to capture a significant market share, as is already the case in Europe for example. Given the uniform tax rate for diesel and petrol, however, the success of hybrid vehicles will depend on regulations targeting other toxic emissions. Although the revised energy bill removes some of the tax incentives for hybrid vehicles, diesel engines remain significantly and expensively disadvantaged under the Tier 2 standard.

Propulsion technology options

Conventional technologies

For the next 10 years, it is likely that manufacturers will continue to focus on making the design of diesel and petrol engines more efficient. The main areas of attention are likely to be light-weight bodywork systems, exhaust gas after-treatment systems, engine designs and transmission designs.

High investment required for diesel vehicles can only be justified in combination with a more favourable tax regime

Nowadays, diesel engines consume around 30% less fuel than a conventional petrol engine. However, a diesel motor costs about 30% more to manufacture. For this reason, our calculations suggest that the diesel powertrain for a mid-sized vehicle costs roughly 9% (or €900) more to manufacture than a petrol engine. This additional cost is passed on to customers and our investigations indicate that a mid-sized car costs between 8% and 12% more than a comparable petrol-powered vehicle. Consequently, the higher level of investment required can only be justified in combination with a more favourable tax regime for diesel vehicles. In Europe, car manufacturers have managed to generate a perceivable benefit for their customers by utilising the advantages of diesel technology in combination with a favourable regulatory environment and the lower tax on mineral oil, and have thereby artificially increased demand. Although in Europe the diesel engine is regarded as the key technology for reducing CO_2 emissions, a higher proportion of diesel vehicles in the USA would be entirely due to demand and not to regulations.

Squaring the circle

Trade-off between public health impacts and climate change

Due to the unique performance characteristics of combustion engines (both petrol and diesel), it is not possible to reduce all emission outputs through improved engine efficiency alone. While the diesel engine is more efficient (approx. 15%-35% exhaust gas recirculation) than its petrol counterpart (approx. 10%-30%), resulting in lower fuel consumption and reduced CO_2 emissions, it produces much higher emissions of PMs, HC and NOx. For policy makers, this can result in a trade-off between public health impacts and climate change.

Comparison of emission levels between diesel and petrol engines

Vehicle type	Engine type	Kerb weight (kg)	CO_2 emissions (g/km)	NOx emissions (mg/km)	Particle emissions (mg/km)
BMW 320i	Petrol	1,435	178	32	0
BMW 320d	Diesel	1,505	153	222	2
Golf 2.0 FSI	Petrol	1,242	182	29	0
Golf 2.0 TDI	Diesel	1,281	146	239	2

Source KBA, WestLB Research

More difficult and more costly to meet Euro 5 standards for diesel engines

However, as the carbon content of diesel fuel (energy density of 35.3 MJ/L) per unit volume exceeds that of petrol (energy density of 32 MJ/L), the diesel engine's superior fuel efficiency does not lead to a disproportionately high reduction in CO_2 emission levels.

CO_2 emissions: petrol vs. diesel

Conventional petrol engine fuel consumption	7 l/100 km or 166.8 g CO_2/km
Fuel economy of Euro 4 diesel engine	approx. -30%
Smaller CO_2 reduction due to CO_2 emissions	approx. +15%
Particulate filter increases consumption	approx. +2%
NOx after-treatment increases fuel consumption	approx. +5%
Reduced CO_2 emissions of a Euro 5 diesel engine	approx. 5%-10%

Source WestLB Research

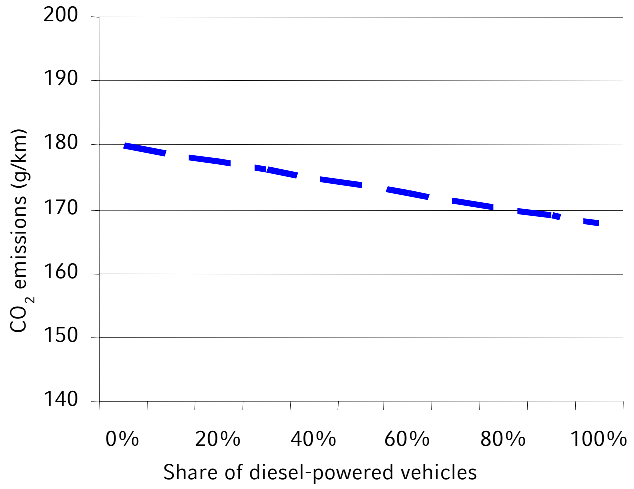
Although the European automobile industry considers diesel engines to be the key technology for reducing CO_2 emissions, it will be more difficult and more costly to meet Euro 5 standards than for petrol engines. Transforming a diesel engine into a 'clean' powertrain calls for expensive and sophisticated after-treatment technologies (DeNOx catalytic converters, particulate filters).

Would a 100% diesel share be a solution?

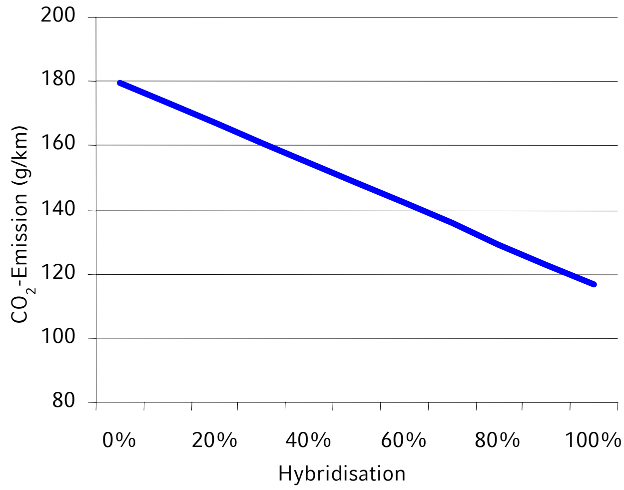
Diesel-powered cars sold in the German market emit 7.2% less CO2 on average than petrol-driven vehicles

Diesel-powered cars sold in the German market emit 7.2% less CO_2 on average than petrol-driven vehicles. The average CO_2 emission of a diesel car in Germany is 167.6 g CO_2/km compared to 179.7 g CO_2/km emitted by cars running on petrol. The increase in the proportion of diesel cars from around 35% in Germany (in 2001) to its current figure of around 49.7% reduced CO_2 emissions by only about 1% (based on a constant mix ratio (WLBe). Even if the share of diesel-powered cars were 100%, the level of CO_2 emissions in Germany would still be 167.5 CO_2/km (it is currently 173.7 g CO_2/km), only 3.6% lower than it is now. As this would still exceed the limit of 140 g CO_2/km, this would therefore not be an effective solution to the problem.

CO_2 emissions – dependence on diesel share



CO_2 emissions – dependence on hybridisation



Source WestLB Research

Hybrid technology

Difference between full and mild hybrid models

A hybrid design is based on the idea of combining at least two different types of drive. Generally it combines a petrol combustion engine and an electric motor. This leads to additional costs for the electrical motor, the transmission system and the engine management system. Toyota places the additional cost to consumers at €4,500, while Volkswagen assumes a figure of between €2,500 and €3,000. Besides Toyota (currently available: Toyota Prius, Toyota Highlander, Lexus RX400h), Honda (Honda Civic IMA, Honda Accord, Honda Insight), Ford (Ford Escape, Mercury Mariner) and GM (GM Silverado and Sierra) also offer hybrid technology in production vehicles. Toyota and Ford offer full hybrid models, while Honda and GM have mild-hybrid models.

The difference between full and mild hybrid models lies in the degree of hybridisation, i.e. how powerful the alternative source of motive power is (in this case the electric motor) compared to the main powertrain. In the case of the continental system fitted to the GM Silverado, the electric motor does not have any drive function, merely a start function. As a result, the degree of hybridisation is zero, which makes it similar to a start/stop system.

Features of hybrid technology

	Additional retail sales cost (US$)					
	Small cars	Mid-sized/ large vehicles	Light truck	Heavy truck	Performance gain (%)	Change in fuel consumption (%)
Start/ stop	600	640	640	--	0	7.5
Light hybrid tech.	1,250	1,385	1,450	1,625	10	12.5
IMA	1,620	1,790	--	--	15	20
Fully hybrid tech.	3,320	3,920	3,700	4,100	15-20	20

Source US Department of Energy

Opportunities for hybrid technology

Between 7% and 10% market share potential in the USA by 2008

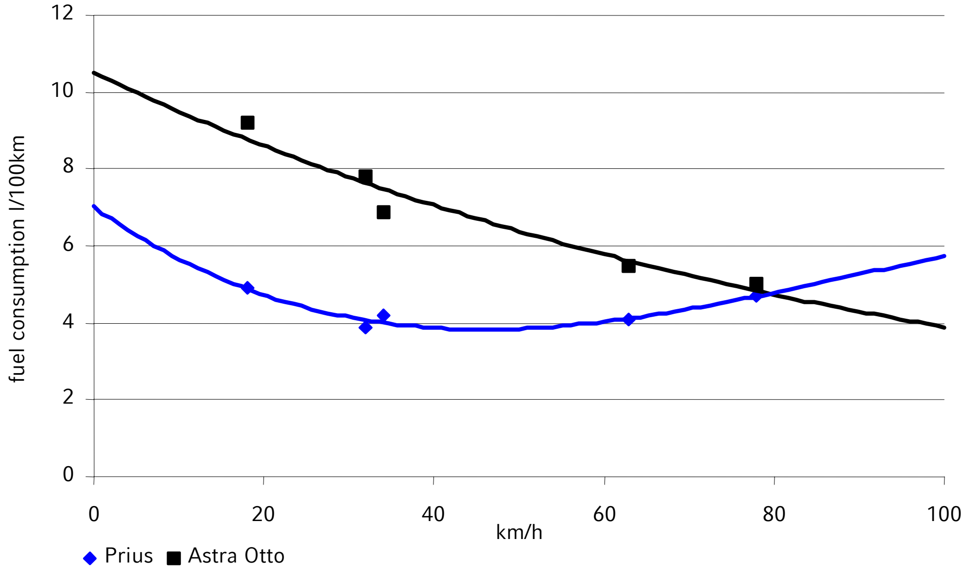
The US Department of Energy estimates that between 7% and 10% of vehicles sold in the USA will have hybrid technology by 2008 (1.2m-1.7m vehicles) and that this figure could be around 15%-20% (2.6m-3.4m vehicles) by 2012. Toyota has plans to sell between 350,000 and 400,000 hybrid vehicles by 2006 and 1m by 2010, which would correspond to a market share of between 12% and 15%. This would put Toyota in line with the US Dept. of Energy's forecasts. Estimates regarding the hybrid market share in Europe differ widely. We do not expect it to exceed 5% by 2010. However, this depends primarily on the whether or not this technology is available to European manufacturers. Toyota estimates that it is 3-5 years ahead of the competition. Accordingly, the European manufacturers' first competitive hybrid vehicles are unlikely to reach the market before 2008, which tallies with the product planning at VW and DCX.

Disadvantages of hybrid technology

Drawbacks in long-haul driving

European manufacturers frequently refer to the drawbacks of hybrid technologies in long-haul driving. The higher vehicle weight resulting from the hybrid system leads to higher fuel consumption in driving cycles, with relatively high average speeds because the electric motor is hardly used and therefore only represents ballast. Accordingly, European manufacturers are expecting to see even greater differences in future customer behaviour. In urban areas with relatively low average speeds (less than 80 km/h), hybrid vehicles are likely to win a very large market share, wheras in rural areas (with high average speeds in excess of 80 km/h) diesel-powered vehicles will probably be able to further expand their share of the market.

Comparison between hybrid drive and petrol engine at different average speeds



Source Volkswagen, WestLB Research

Alternative fuels

One big advantage of alternative fuels is that they do not contain sulphur

The use of alternative fuels is just as important for cutting emissions as engine innovations or exhaust gas treatment systems. One big advantage that alternative fuels enjoy over conventional diesel or petrol is the cleanness of the combustion process, since they do not contain sulphur, for example. Many EU member states have introduced incentives to promote low-sulphur fuels, with the objective of reducing the sulphur content of fuels to a maximum of 50 ppm by 2005 and to a maximum of 10 ppm by 2009. A reduction in the sulphur content of petrol and diesel fuels is expected to have a large impact on exhaust emissions as it will enable the introduction of more sophisticated after-treatment systems.

The second big advantage of alternative fuels, more precisely of biofuels, is their lower net carbon impact

The second big advantage of alternative fuels, more precisely of biofuels, is their lower net carbon impact. Biofuels are made from biomass, which absorbs carbon while growing. They thus represent a lower carbon route to transport fuels. However, they are not carbon neutral due to emissions of greenhouse gases and pollutants produced during cultivation of the biomass. The benefits of current biofuels, in terms of reduced greenhouse gas emission, are thus smaller than their share in consumption. Additionally, with petrol and diesel becoming cleaner, the emission advantage of alternative fuels is getting smaller.

Advantages and disadvantages of different types of alternative fuel

Alternative fuel	Advantages	Disadvantages
Natural gas	• Very low particulate emission compared with diesel • Low NOx emission compared with advanced diesel engines • Zero sulphate and SO2 emissions	• More complex refuelling system • 4 times larger tank size requirement • Engine efficiency in bus operation is • approximately 20% lower than that of the diesel engine • Lean burn NG engines often have problems with methane emissions, but at very low NOx emission levels
Alcohols	• High octane number • Low NOx emission • Zero sulphate and SO2 emission • Low evaporative losses	• cold start problems • Increased aldehydes • More corrosive than hydrocarbons • Larger fuel tanks • Safety and handling problems
Dimethyl ether	• Little modification to the diesel engine required • Very low particle emission • Zero sulphate and SO2 emission • Lower engine noise • Low NOx levels without after-treatment	• Lower viscosity • The injection system needs to be developed
Biodiesel	• Higher cetane number • Good lubricity • Zero sulphate and SO2 emission • Particulates of lower toxicity (same mass emission)	• Their corrosion properties • Lower heating value • Higher freezing point • Increased NOx emission • Increased odour

Source EEA, 2006

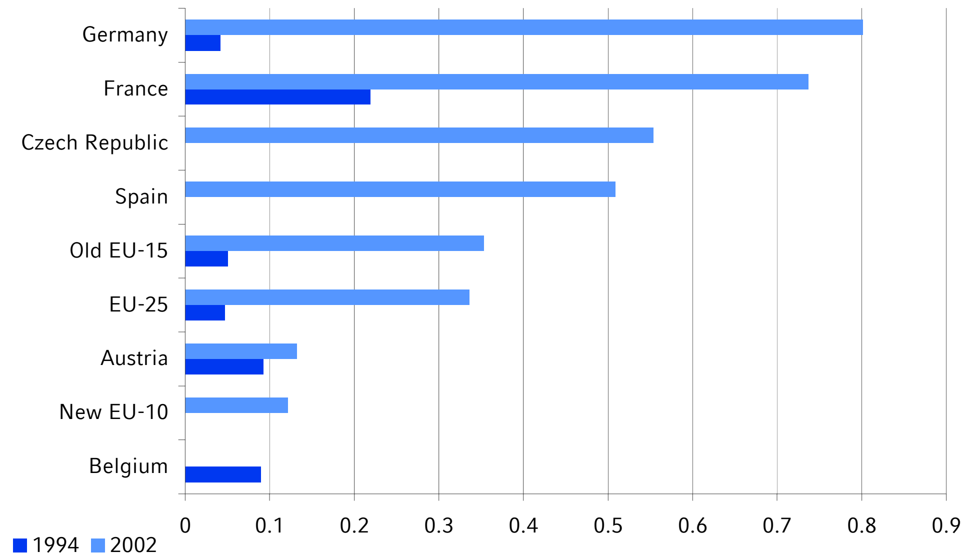
Biofuels also require large areas of land, potentially having a negative effect on biodiversity

Biofuels also require large areas of land for production and compete with both other land uses (e.g. agriculture), potentially having a negative effect on biodiversity, and with other uses of biomass, such as fuel for heat and power plants. Being among the few alternatives to petrol and diesel, biofuels are also considered important for the security of transport energy supply. In the medium term, there is an expectation that more advanced production processes for biofuels will be developed which will allow a broader range of plants to be used and which will improve the efficiency of the biomass-to-fuel conversion process. In the long run, biomass could serve as feedstock for the production of hydrogen for fuel cells.

Market penetration of biofuels and other alternative fuels is still rather low

The market penetration of biofuels and other alternative fuels is still rather low. Biofuel production for 2004 equals about 0.7% of total road transport fuels consumed (based on energy content). In 2004, Germany was the leading biodiesel producer (54% of production), whereas Spain was the main bioethanol producer (66%). Note that the EU biofuels target is set for biofuel consumption, not for production. The share of biofuels in overall fuel consumption is increasing, although currently reported shares are below the targets of the Biofuels Directive.

Share of biofuels in transport (%)



Source EEA, 2006

Strong influence of tax regime in each country

According to targets set out by the EU, alternative fuels will account for an ever greater share of the market and thus be able to gradually replace traditional fuels. How these quotas are to be met, whether by mixing or via monovalent (natural gas) or bivalent (natural gas and petrol) drives, has yet to be specified, and will be very heavily influenced by the tax regime in each country.

EU targets for alternate fuels

(%)	2010	2015	2020	2020 – new proposal
Biofuel	5.75	7	8	15
Natural gas	2	5	10	10
LPG	0	0	0	5
Hydrogen	0	2	5	n.a.
Overall quota	**7.75**	**14**	**23**	**>30**

Source Volkswagen, European Commission

Tax incentives include exemption from mineral oil tax in Germany and from the London congestion charge

One major obstacle for the introduction of alternative fuels, besides the technical ones, is the price of those fuels compared with conventional fuels. Tax incentives have thus been instituted to achieve the above target figures for each of the fuel types. For example, biodiesel is exempt from mineral oil tax in Germany until 2009 (47 cent/litre) whereas natural gas, while having the same calorific value, is taxed about 80% less than petrol and about 70% less than diesel. Another tax incentive is contained in the London congestion charge, which exempts vehicles powered by natural gas. The introduction of a carbon tax, differentiated according to content of fossil fuel, could dramatically alter the position of alternative fuels and boost its implementation.

Well-to-wheel analysis

Alternative fuels and conventional engine technologies can make a significant contribution to cutting emissions, but they can only represent an initial step. This is because the combination of processes leads to a variety of problems that have to be taken into consideration. Firstly, engine technology (tank-to-wheel) makes the greatest contribution in the usage of the vehicle. However, the energy and CO_2 balance prior to the combustion of the fuel (well-to-tank) cannot be neglected. The objective is to optimise the different possible combinations of combustion process and fuel.

Hybrid combination of a hydrogen combustion engine generates the greatest energy efficiency improvement

Joint Research Centre (JRC) calculations suggest that hybrid technology brings around a 25 g CO_2/km reduction in emissions. According to these calculations, the hybrid combination of a hydrogen combustion engine generates the greatest energy efficiency improvement (-100% GHG emissions), which is ahead of that of a combined natural gas (CNG) combustion engine (-34% GHG emissions), followed by the diesel engine (-21% GHG emissions).

Tank-to-wheel analysis – scenario 2010E

Engine / fuel combination	Consumption (l/100km)	GHG* emissions (as equivalent to g CO_2/km)	Change since 2002 (petrol engine) Energy (%)	GHG* (%)
Petrol engine (conv. fuel injection)				
Petrol	5.90	140.3	-15	-16
Petrol with admixture of ethanol (95/5)	6.00	140.2	-15	-17
CNG bi-fuel	5.98	110.4	-14	-34
CNG	6.00	110.8	-14	-34
Hydrogen (gas)	5.21	0.5	-25	-100
Hydrogen (liquid)	5.21	0.5	-25	-100
Petrol engine (direct fuel injection)				
Petrol	5.84	138.8	-16	-17
Petrol with admixture of ethanol (95/5)	5.94	138.7	-16	-17
Diesel engine (direct injection and particle filter)				
Diesel	5.00	133.2	-20	-21
Bio diesel	5.49	138.8	-20	-17
Diesel with admixture of Bio-diesel (95/8)	5.02	133.9	-20	-20
BTL-Diesel	5.24	129.0	-20	-23

* Greenhouse gas

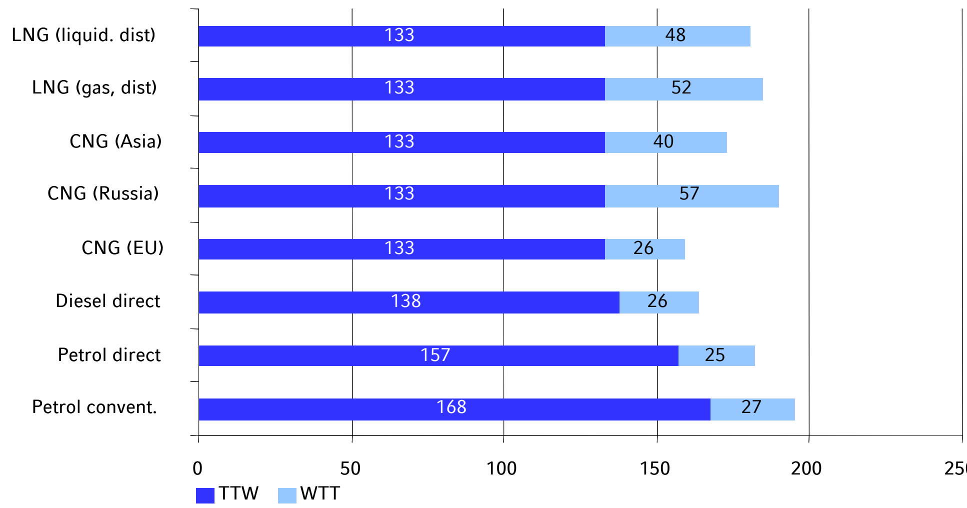
Source JRC/EUCAR/CONCAWE

Wheel to tank changes the picture

Natural gas becomes far less attractive as soon as transportation routes become too long

However, the above approach only represents one factor in the equation. The second factor analyses the energy and GHG efficiency of the fuel with regard to manufacture, transportation and storage. The figure below shows the combined figures for the currently available technologies. It can be seen that natural gas becomes far less attractive as soon as the transportation routes become too long. However, it should be noted that well-to-wheel analysis only targets the greenhouse gas effect and does not deal with other emission problems like acidity, toxicity, etc.

Well-to-wheel analysis (g CO_2/km)



Source JRC, Eucar, Concawe

Granting tax breaks for additives in diesel and petrol will permit the admixture targets to be achieved

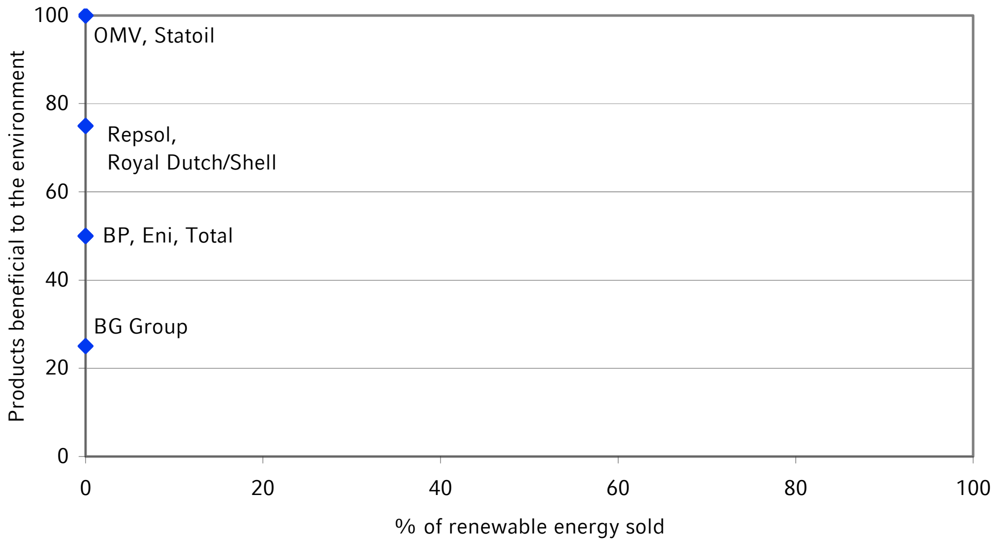
Granting tax breaks for additives in diesel and petrol will permit the admixture targets to be achieved, in our view. Recently, there has also been evidence of great activity with regard to the penetration of natural gas-powered vehicles. At the current crude oil price, these alternatives appear attractive enough to offset the fact that natural gas-powered vehicles consume more fuel. We assume that both natural gas engines and hybrid systems will not capture any significant market share during the period we have examined (up to 2008) and we have therefore not included them in the following cost analysis.

Alternative fuel profiles of Oil & Gas companies as reflected in our extra-financial risk ratings

Two sector-specific criteria relating to alternative fuels

In the context of sustainable transport it is imperative to have a look at the Oil & Gas sector too. Oil & Gas companies play a key role in the development, production, and distribution of alternative fuels. Within our extra-financial risk ratings we consider two sector-specific criteria that have a direct link to this topic: Firstly we rate the percentage of renewable energy sold (including alternative transport fuels), and secondly we evaluate the products of these companies that are beneficial to the environment.

Alternative fuel profiles of Oil & Gas companies as reflected in our extra-financial risk ratings



Source WestLB Research, SiRi Company

Disappointing results overall

The results are quite disappointing in our view. They show that although companies are involved in many promising projects and contribute to the development of alternative fuel technologies in many ways, they have not been able to increase the share of alternative fuels to a significant level. Furthermore, seven of the eight companies considered do not disclose any meaningful data on this item, which leaves us no option but to give zero out of 100 possible points here. BG, the worst rated company with respect to the items under consideration, is the one exception: the company states that the percentage of renewable energy it sells is zero. In the following we give some examples about the companies' activities in the product area.

On top: OMV (100 points)

OMV developed AdBlue technology for heavy-duty commercial vehicle diesel engines

OMV committed itself to a mixture of biological components in mineral oil products (approximately 2.5%) by October 2005. By 1999 most of OMV's fuels already complied with the EU Fuels Directive for 2000 and 2005, the most environmentally friendly being SuperPlus iMotion (the first fuel with a sulphur content below 10ppm) and OMV eco diesel. In 2002 OMV was the first to launch a super gasoline (95 octane with less than 30 ppm sulphur) in Austria. OMV's refinery in Germany has been producing sulphur-free diesel fuel since 2002, and since 2004 its entire diesel fuel production has been sulphur-free. Sulphur-free fuel increases the energy efficiency of an engine and fuel savings of up to 4% over the life of an engine. OMV developed AdBlue technology for heavy-duty commercial vehicle diesel engines. This technology breaks down NOx into nitrogen and water, thus reducing NOx emissions and saving up to 7% fuel compared with today's state-of-the-art engines.

Company is developing lubricants that reduce fuel consumption and have to be replaced less often

OMV is also developing lubricants that reduce fuel consumption and have to be replaced less often. A lot of these products are based on rapeseed oil or synthetic esters. OMV biosegarol is a biodegradable lubricant for chain saws that has achieved the Austrian eco-label. OMV is striving for lower sulphur content in the field of fuel oil. Since 1990 its extra-light fuel oil has contained only 0.1% sulphur. OMV is developing low-emission burners for light fuel oil that reduce NOx emissions by 30%.

OMV promotes the use of combined natural gas (CNG) for individual traffic, operating 17 CNG filling stations in Austria. The company also reports that it has a 5% share in the research centre Hydrogen Center Austria. Its refinery in Schwechat produces approximately 100 tons of hydrogen per day.

Above average: Repsol (75 points)

Several initiatives aimed at developing clean fuels

According to its 2004 CSR report, Repsol is involved in several initiatives aimed at developing clean fuels. In 2000 the company started producing gasoline based on bioethanol, obtained by fermenting cereals. In addition to this, there is a pilot programme for using biodiesel in city buses and using bioethanol-derived ethyl-terbutil ether (ETBE) as a gasoline additive.

About average: BP, ENI, Total (all 50 points)

BP

Several of BP's businesses are involved in reducing GHG emissions to tackle climate change by developing cleaner fuels for sustainable transport. The group has increased its sales of liquefied natural gas (LNG), which releases less carbon per unit of energy than oil or coal when consumed. It is exploring the potential for low-carbon bio-fuels, and has continued the roll-out of BP Ultimate, a low-sulphur fuel that reduces emissions.

ENI

ENI has continued R&D in its Refining & Marketing division on the development of refined products (gasoline, diesel fuel and lubricants) with high quality and low environmental impact. In this area the new BluDiesel, a virtually sulphur-free fuel for diesel engines, has been launched, and marketing of a new high-octane fuel has begun. An innovative 'fuel economy' lubricant has been developed at commercial level. Moreover, the R&D unit is building MultiEnergy services stations that sell traditional liquid fuels (petrol, diesel and BluDiesel) and low/zero-emission gaseous fuels (methane, LPG and hydrogen for testing), and have a recharging area for electrical vehicles.

Total

Total states that it aims to work on hydrogen-based substitutes for conventional fuels and is striving to develop alternative solutions. It has, among other things, created a hydrogen competency centre in Berlin, where in 2002 it built one of Europe's first hydrogen fuel-stations.

Lagging behind: BG (25 points)

Focusing on gas

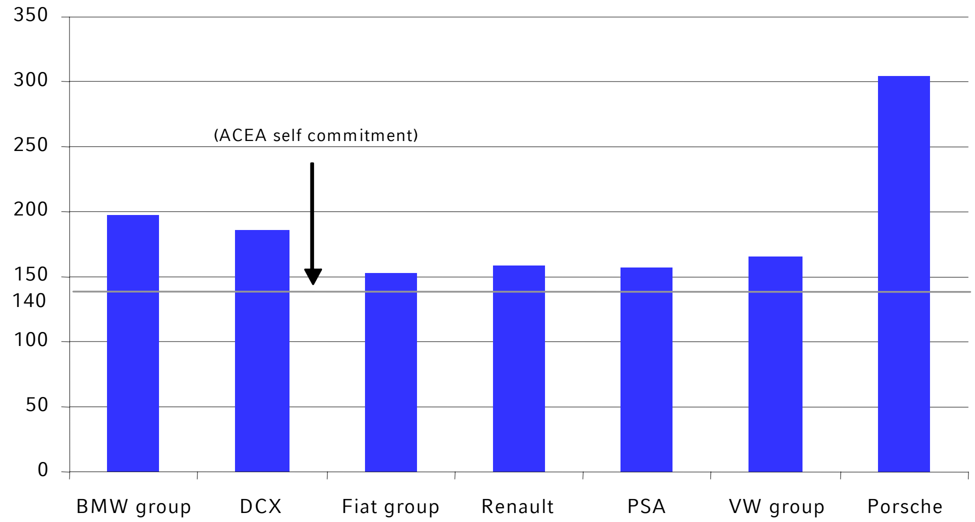
BG states that it considers gas, as the cleanest fossil fuel, to be beneficial as there is an environmental benefit where it replaces coal and oil. *"With our expertise in all parts of the gas chain we are well placed to contribute to society's efforts to balance the need for affordable energy with environmental considerations by facilitating access to gas as an alternative to higher carbon content fuels."*

Manufacturers' CO_2 profiles

ACEA's voluntary commitment will not be achieved by 2008

In our view, the ACEA's voluntary commitment will not be achieved by 2008. In particular, the German manufacturers will probably not be able to meet the prescribed ceiling figures. However, since the definitive targets for each of the manufacturers are not known it is impossible to calculate the cost implication of their non-compliance. In order to be able to analyse the various scenarios it is therefore necessary to know manufacturers' CO2 profiles.

CO_2 emissions by manufacturer, as at 2004 (g CO_2/km)



Source WestLB Research

The CO_2 profiles of the manufacturers

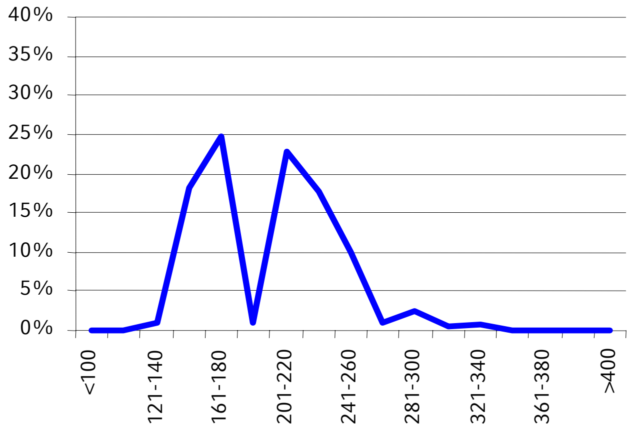
Crucial for scenario analyses with regard to the proportion of diesel-powered vehicles and unit sales volumes

The CO_2 profiles of individual manufacturers are crucial to generating scenario analyses with regard to the proportion of diesel-powered vehicles and unit sales volumes. Focusing mainly on emissions allows meaningful statements to be made about the volume distribution of individual engines and the difficulty and cost intensity that is involved in the future reduction of CO_2 emissions. For example, the distribution aspect allows the conclusion to be drawn that a uniform reduction of CO_2 emissions across all manufacturers by, say, 20% is easier for BMW than for DCX and easier for Renault than for Fiat, even though the absolute CO_2 emissions would permit a contradictory conclusion to be drawn.

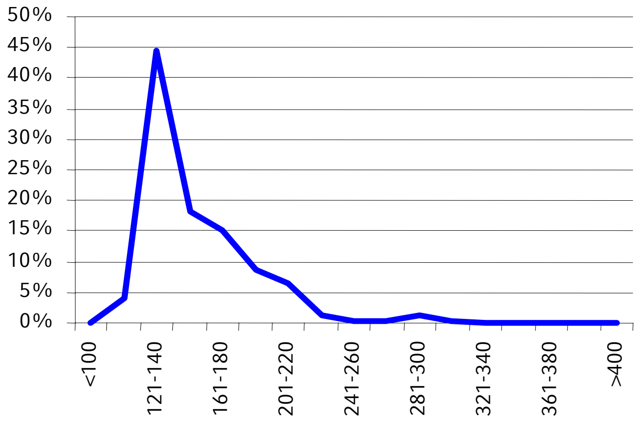
BMW does not offer a single vehicle whose CO_2 emission is less than 140 g/km

In the case of BMW, the 1 and 3 series diesel engines clearly stand out (first peak of the profile curve). These engines have CO_2 emission levels of 140-180 g CO_2/km. Currently, BMW does not offer a single vehicle whose CO_2 emission is less than 140 g/km. In contrast, DCX's Smart boasts an emission value of less than 140 g CO_2/km. So 20% of the vehicles DCX sells in Western Europe already have CO_2 emission values below 140 g CO_2/km. However, the upper medium-sized and luxury sedan models (E-, S-, M- and R-Class) have a significantly negative impact.

BMW – volume-weighted CO_2 emissions (g CO_2/km)



Fiat – volume-weighted CO_2 emissions (g CO_2/km)



Source WestLB Research

Fiat has the most favourable product portfolio

The profiles of the mass manufacturers are quite different. In particular, Fiat's strong focus on the sale of sub-compacts is clearly recognisable. Fiat has the most favourable product portfolio in this respect, and 48% of its vehicles already have CO_2 emission values of less than 140 g CO_2/km. For Renault and Volkswagen, the Mégane family and the Golf platform are highly important in terms of both number of units sold and CO_2 emissions. This leads to only 10% of Volkswagen's sales volume having CO_2 emissions that are already below the 2008 limit of 140 g CO_2/km. For PSA and Renault this figure is already 12% and 25% respectively. On top of this, VW's Golf platform emits 141-180 g CO_2/km, and thus 69% of its overall unit sales fall into this emissions category. To change this, VW's only option is to diversify its product portfolio to include smaller cars and to increase its share of diesel-driven vehicles. As VW's share of diesel cars in Europe is already more than 50%, it will be very difficult for the company to reduce its CO_2 profile.

Extremely difficult for Porsche even to come close to achieving ACEA targets

The Porsche engine with the lowest CO_2 emission still reaches a level of 229 g CO_2/km. The Cayenne family has CO_2 emission values ranging from 324 g CO_2/km to 385 g CO_2/km. However, the kerb weight of the Cayenne's basic version alone comes to 2,235 kg. With its current product portfolio it will therefore be extremely difficult for Porsche to be able to achieve emission levels that even come close to ACEA targets.

Costs per manufacturer

ACEA commitment represents a lower cost barrier to some manufacturers than the Euro 5 standard

According to our calculations, the ACEA commitment represents a lower cost barrier to some manufacturers than does the recently proposed Euro 5 standard. By 2008 BMW's product costs are expected to increase by €632m. Additional compliance costs, not counting the ACEA voluntary agreement, amount to an estimated €235m overall, or €195 per vehicle. In terms of the potential impact on the EBIT margin, this effect is roughly equivalent to that of higher raw material costs in 2005. Our estimate indicates an EBIT of €4,180m for 2007E, and this implies an earnings decline of 15.1%.

Incremental compliance costs for emission regulations (€ per vehicle)

Manufacturer	Total cost (€m)	Total cost per vehicle	Euro 5	ACEA	Tier 2	CAFE
BMW	632	523	141	329	52	2
Renault	466	187	132	55	0	0
Porsche	181	2,357	52	2,132	64	108
PSA	555	164	122	42	0	0
Fiat	284	161	109	52	0	0
DaimlerChrysler	1,186	684	136	335	211	3
VW Group	1,131	220	122	85	13	0

Source WestLB Research

Example 1: BMW – Premium translates into a higher amount of CO_2 exhaust

High average vehicle weight and high diesel share

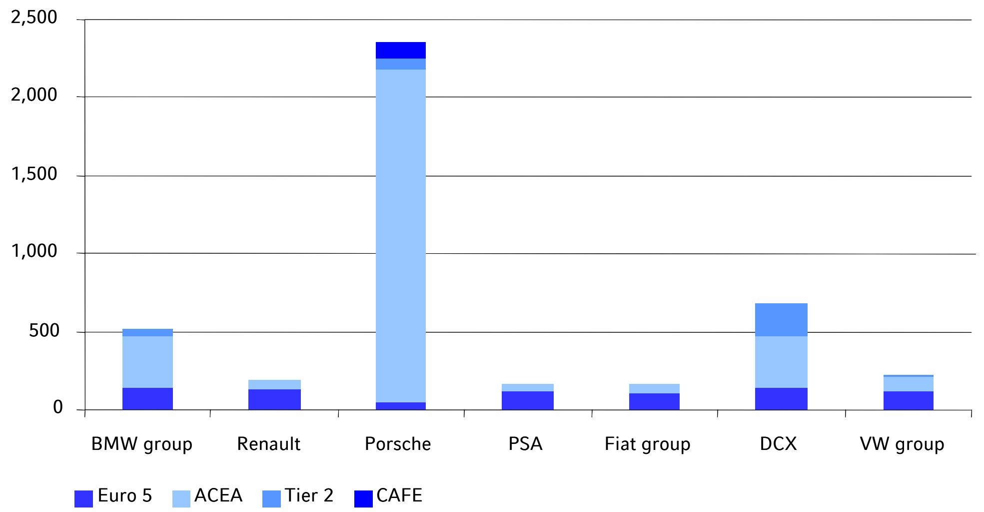
Two trends are very apparent at BMW: a heavy average vehicle weight (high mix share in the full-size and upper mid-size classes) and high diesel share (in some cases upwards of 75% per segment). BMW already has the highest share of Euro 4-compliant engines. However, the cost impact of ensuring that the segment and diesel mix fall within the prescribed Euro 5/Tier 2 and CO_2 requirements is negative.

Example 2: Volkswagen – High diesel share and lowest fitment rate of particulate filters

Our estimated compliance costs for VW are the highest for any mass manufacturer

Volkswagen has the highest average diesel share of all mass manufacturers (roughly 50%). In addition, only an estimated 48% of Volkswagen's models are standard-equipped with particulate filters. As a result, our estimated compliance costs for VW are the highest for any mass manufacturer, with a double negative impact on the cost base likely due to the high diesel share and low percentage of standard-equipped particulate filters.

Incremental cost burden by emission standard (€/vehicle)



Source WestLB Research

Example 3: Porsche – Meeting CO_2 limit is not feasible

Costs per vehicle of €2,357 are the highest

As expected, Porsche's costs per vehicle of €2,357 are the highest. The average CO_2 emission is 305 g/km. The Porsche Cayenne's CO_2 emission of an estimated 350.9 g/km is particularly detrimental to the manufacturer's profile. Diesel technology would be of little avail as the base value is simply too high to even begin to approach the CO_2 limits in the USA and Europe. The use of hybrid technology appears to be a plausible solution under the circumstances, as Porsche ranks high among the advocates of CAFE and its vehicles have a very positive impact on the average CAFE figure in the USA, particularly the gas mileage requirement of 22.2 mpg for SUVs in 2008, rising to 24.5 mpg by 2012.

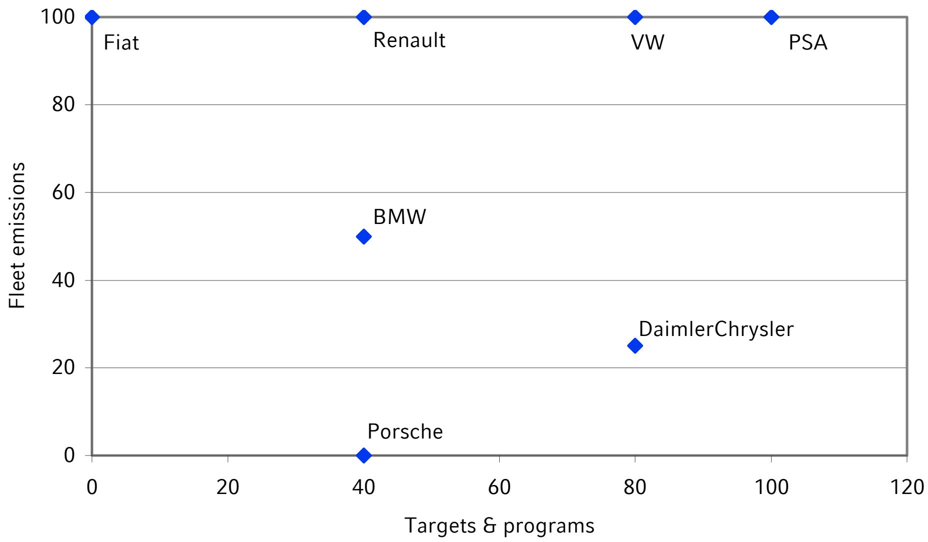
Company CO_2 profiles as reflected in our extra-financial risk ratings

OEMs

Extra-financial risk criteria

CO_2 emissions are included as a sector-specific criterion in our extra-financial risk ratings (see also p. 47). The carmakers' targets and measures aimed at cutting CO_2 vehicle emissions are evaluated. In addition, the average CO_2 emissions of the entire fleet – weighted by the numbers of the respective models – are taken into account as a rating criterion.

CO_2 profile of car manufacturers as reflected in our extra-financial risk ratings



Source WestLB Research, SiRi Company

PSA is industry leader

PSA Peugeot Citroën must be cited as a positive best-practice example in management. For example, PSA publishes not only its own programmes (such as start and stop systems, particle filters, energy efficiency improvements), but also the concrete targets (included timeframes) that the company has set itself in various fields. PSA has, for example, set itself the goal of selling a total of 1.7m vehicles that emit less than 120g CO_2/km by the end of 2006.

DCX: focus is on improving conventional combustion engines

DaimlerChrysler states that the core goal of its environmental strategy is to attempt to cut fuel consumption and CO_2 emissions. In the short to medium term the focus is on improving conventional combustion engines and, in the medium to long term, on developing new, alternative drive systems such as fuel cells. Between 1990 and 2004, new vehicle fuel consumption was lowered by 29% – 4 percentage points more than in the VDA's self-commitment. The powertrain strategy aims to cut the consumption of current petrol and diesel engines by 10-20%. The strategy involves developing hybrid drive systems and fuel cells, which DCX describes as a 'vision for emission-free mobility of the future'. With more than 100 transporters, buses and cars powered by fuel cells and tested by customers worldwide, DCX currently has the largest and most diverse fuel cell fleet of all the carmakers in everyday use. In addition, DCX promotes and supports the development of environmentally compatible and largely CO_2-neutral fuels. The 'fuel roadmap', for example, covers improvements in conventional fuels as well as synthetically produced fuels based on gas, biomass and hydrogen. Finally, DCX wants to use innovative technologies to lower emissions from vehicle production and use.

Remarkably, DCX views reducing traffic volumes as an effective means of reducing emissions

Besides the factors already mentioned, DaimlerChrysler's environmental concept includes delivery traffic and logistics. The aim is to keep CO_2, pollutant and noise emissions caused by delivery traffic as low as possible. According to DCX, the most effective means of achieving this is to lower traffic volumes. This is to be achieved above all by developing and implementing efficient traffic and logistics concepts that seek to improve vehicle load factors, achieve shorter routes and make use of rail and ships.

VW's strategy to develop a sustainable mobility concept covers the ongoing improvement of conventional engines and fuels, the development of alternative concepts (e.g. synthetic fuels based on gas and CO_2-neutral SunFuels based on biomass), support for newly industrialised countries in the use of ecologically efficient technologies, and driver training to promote fuel-saving driving techniques.

In the 'programmes and CO_2 reduction targets' category, DaimlerChrysler and VW thus receive above-average ratings, although both companies are awarded slightly lower scores because of a lack of concrete time targets. BMW, Porsche and Renault receive only mid-table ratings because of their lack of targets.

Commercial vehicle manufacturers

No concrete targets at all

MAN, Scania and Volvo, the three commercial vehicle makers in our research universe, are each awarded 40 out of 100 possible points on the sector-specific criterion 'targets & programmes to reduce the energy consumption of products' (see p. 49). One of the principal reasons for their comparatively low scores is the lack of any concrete targets in all three cases. MAN states that it is aiming to minimise consumption and emissions with regard to engines and turbines. It has not published any concrete targets. Scania refers to a series of programmes designed to lower fuel consumption and emissions. The primary goal is to offer engines with the best possible combination of fuel efficiency and environmental characteristics. Low fuel consumption in conjunction with unchanged good engine performance is the aim. In emission abatement, Scania does not rely on particle filters. Instead, it is looking to improve the engine combustion process to make Scania engines run as cleanly as possible. On the conversion from Euro 1 to Euro 4, fuel efficiency was markedly improved. In its P, R and T series, Scania was able to cut fuel consumption by up to 3% thanks to improved aerodynamics, softer control of engine auxiliaries, and lighter vehicles.

For trucks that are used over long distances and generally drive at constant speeds, aerodynamics plays an important role in fuel consumption – as does vehicle weight. In recent years, Scania has managed to lower the average weight of a 4-Series truck, for example, by a good 400kg. In addition, it is making increasing use of new electronic systems. These can be used, among other things, to improve fuel efficiency and lower emissions. However, Scania has published no concrete targets.

Volvo: focus remains on diesel engines

At Volvo, improving fuel efficiency is also at the very top of the agenda. In the past 20 years Volvo has achieved an 85% reduction in emissions, while fuel consumption and CO_2 emissions have been cut by 30% in the same period. While Volvo continues to focus on diesel engines, it has also made substantial progress with regard to alternative engine types and fuels. In view of its high energy efficiency, the company is concentrating on dimethyl ether, which can be produced from alternative raw materials. Volvo publishes no concrete targets on reductions in fuel consumption.

Transport companies

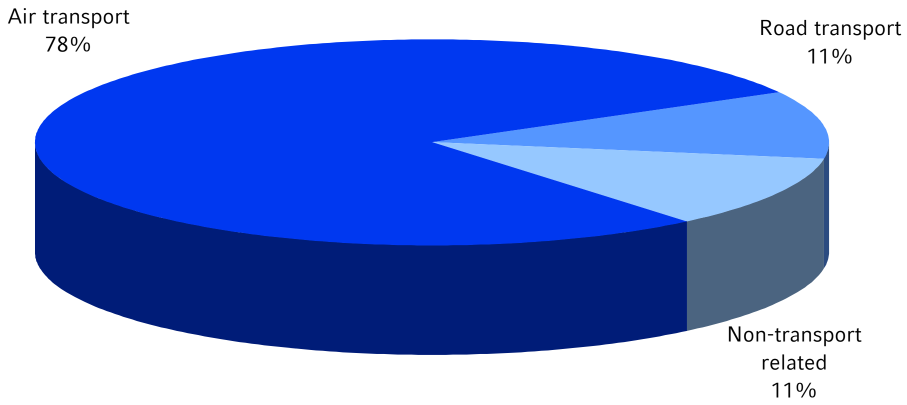
For the two transport and logistics companies in our research universe with a high proportion of road transport activities – Deutsche Post World Net (DPWN) and TNT – CO_2 emissions are included in the ratings on the basis of three criteria: (1) statement on climate change, (2) targets and programmes to reduce emissions, and (3) eco-efficiency of service. In this field, both companies are awarded 190 out of 300 possible points (see p. 48).

DPWN states that climate change is a top priority of its environmental policy

DPWN's website includes a section on climate change in which the company clearly accepts its own responsibility as a producer of CO_2 emissions. Emissions data for the entire group are published in this section. In addition, the company has stated that a top priority of its environmental policy is to counter the causes of climate change. Besides using new technologies, the group is relying on raising the efficiency of its operations. The DPWN subsidiary DHL recently started offering 'green products' in Germany, Scandinavia and Switzerland – for example the 'green parcel', which is transported in a climate-neutral manner. This means that the resultant CO_2 emissions are offset by investments in climate protection projects.

CO_2 emissions of DPWN

CO_2 emissions in 2004, total*: 7,7m tonnes



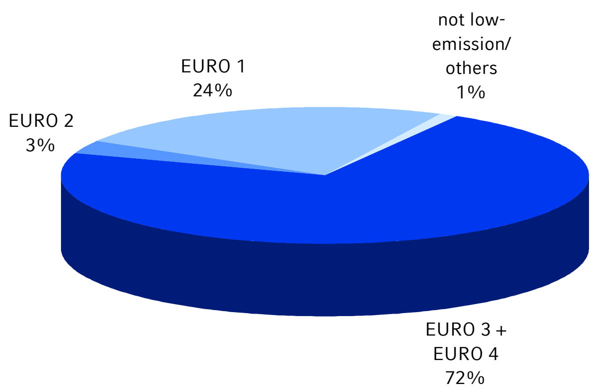
*representing between 53% and 75% of worldwide turnover

Source DPWN

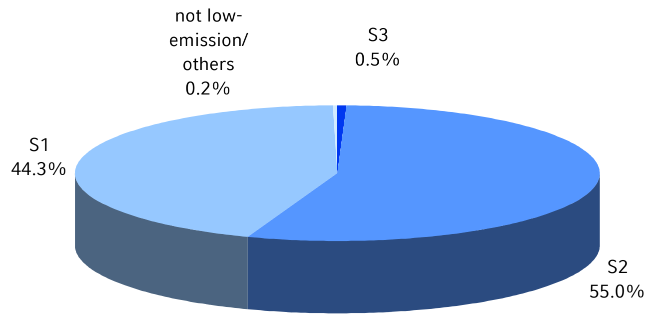
DPWN: numerous pollution-abatement programmes

On its internet site, DPWN publishes a great deal of information and details on diverse programmes to reduce the emissions of its fleet. These range from using modern, energy-saving technologies and promoting a more environmentally-friendly driving style, to developing alternative traffic concepts. In its aircraft and vehicle fleet operations, DHL aims to maximise efficiency by using fuel-efficient engines streamlined bodies and alternative fuels, by regular maintenance, by raising load factors, by route optimisation and by training drivers in fuel-saving techniques. On the road, DHL is currently testing alternative drive technologies at several locations worldwide with over 200 vehicles. In addition, delivery staff still frequently cycle or walk the 'last mile' (in more than 40% of delivery districts in Germany). Its 2003 environmental report contained concrete targets up to 2005; more recent data were not available.

Emission categories for cars and delivery vehicles ...
(as of 2001: approx. 52,000 cars and delivery vehicles 3.5t)



... and for trucks> 3.5t
(as of 2001: approx. 4,000 delivery vehicles > 3,5t)



Source DPWN

TNT: no concrete targets

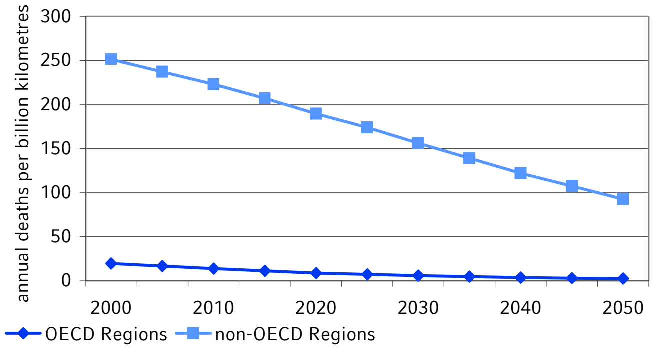
TNT publishes emission reduction programmes. The group-wide clean driving strategy covers four steps to cut emissions; these range from the acquisition of clean means of transport and the use of new technologies and fuels to cooperation with UNEP. However, once again there are no concrete targets.

Safety

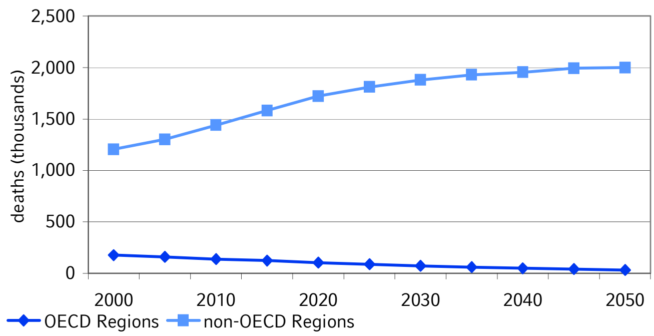
1.2m road accident fatalities in 2000

In 2000, some 1.2m people died as a result of road accidents, while 20m suffered injuries, 7.8m of which were serious. The World Health Organisation (WHO) estimates that road accidents will rise to become the third most frequent cause of death by 2020. Road accidents are above all affecting young people in developing and newly industrialised countries, and accident rates are continuing to rise in these countries. However, even in Europe more than 100 people die from road traffic accidents every day, and here too it is young people in particular who are most affected: road accidents are the most frequent cause of death in the 5-29-year age group. The SMP's BAU scenario assumes that the frequency of road-related fatalities and serious injuries will decline in developed countries – in both relative and absolute terms.

Average road-related fatality rates by region



Total road-related fatalities by region



Source SMP, 2004

Fatalities and serious injuries in both newly industrialised and developing countries may rise for many years to come

By contrast, the total number of road-related fatalities and serious injuries will continue to grow sharply for a while in the newly industrialised and developing countries. The increase will then start to flatten from about 2020 (see chart, right-hand side). The projection is based on the assumption that vehicle density (degree of motorisation) will increase considerably in these countries as incomes rise sharply. The growing numbers of cars will initially come up against an infrastructure that is not designed to cope with such growth. For example, there are frequently no pavements or bicycle tracks – which, given the still large numbers of pedestrians and cyclists, leads initially to sharply rising accident rates among these groups in particular. Accordingly, those groups that rely on these modes of movement – the elderly, children and the disabled – are disproportionately affected. This issue thus has a fairness dimension.

Improved infrastructure, more experience and higher vehicle safety are slowly gaining the upper hand

The long-term flattening out of the growth rate of fatalities and serious injuries is attributable in part to flatter growth rates in vehicle penetration. In addition, the combination of improved infrastructure, greater experience of road traffic and increased vehicle safety standards will slowly gain the upper hand. Over the entire period, this is reflected in a continuous decline in the fatality rate per kilometre driven (see chart at left).

Of course, infrastructure, behaviour and new vehicle technology are significant issues not just in the newly industrialised and developing countries. They are generally the most important determinants of road traffic safety, and even in developed nations there is still huge scope for improvement in all areas. The division between developed and developing countries is thus only gradual in nature.

Road infrastructure

Infrastructure features that raise accident risk

Road infrastructure influences road safety in several respects. In the first place, as already mentioned, the separation of pedestrians, cyclists and motorists is an important safety criterion. Studies show that the risk of injury is greatest where, on comparatively low speed limits of 60-70 km/h, there are wide differences in speeds of movement (frequent braking and accelerating, differences in the speeds of various traffic participants) and traffic flows are characterised by many opportunities to change direction (intersections, turning lanes) and by oncoming traffic.

Basically the same conditions maximise the risk of death under higher speed restrictions of 80-100 km/h too.

The key role of speed

Thus speed plays a major role, and this of course is no surprise. What does surprise us is a statement by the WHO characterising speed as the most important single determinant of safety in road transport systems. The huge significance of speed limits is obvious. It is also beyond dispute that they can increase traffic safety on roads in general, and on motorways in particular.

Monitoring compliance with speed restrictions is crucial

For example, the 100 km/h speed limit imposed in Hesse during the second oil crisis in the 1980s resulted in a 25-50% cut in traffic fatalities. The European Commission reports that, in France, heightened monitoring of compliance with speed limits has by itself led to a 21% drop in traffic accident-related deaths. This latter example brings us automatically to the next most important determinant of safety on the roads: the behaviour of road users. The above examples show that imposing rules of behaviour and, more particularly, monitoring compliance can play a significant role in road safety.

Road user behaviour

A tripling of controls could cut the death rate by 17%

Estimates assume that speed limits are disregarded by one-half of road users if police enforcement and control is low (see SUNflower, 2002). The Netherlands offers an example. In 2000, according to the SUNflower project, about one-third of the speed limits on main roads were ignored by road users. That year, the police issued some 3m speeding tickets. Given, a total of 7m persons with driving licences in the Netherlands, this represents a rate of 0.43 ticket per driving licence holder. Thus, if one wanted to cut the number of ignored speed limits from 33% to 10%, the issue rate of speeding tickets would have to be increased to 1.5 per person in purely arithmetical terms. This in turn means that one would have to more or less triple the level of enforcement and control of speed limits in the Netherlands compared to 2000. With regard to Sweden, it was concluded that such a level of control would cut the number of road-related deaths by 17%.

Other types of behaviour that endanger road safety

Driving too fast is of course only one of the many types of behaviour on the part of road users that endanger safety on the roads. Apart from speeding, the most important include failure to wear seat belts, failure on the part of motorcyclists and pillion passengers to wear helmets, and driving under the influence of alcohol or drugs. All areas of improper behaviour naturally offer scope for saving lives and avoiding injuries if stricter rules are introduced and compliance is monitored more rigorously. However, the limits to this approach are set by its level of acceptability to society.

New vehicle technology

Regulation and customer needs are the driving factors

New technologies that improve vehicle safety are currently being driven above all by two trends: increasing regulation and increasing demand on the part of customers for safety features. With regard to the distinction between active vehicle safety (safety of the driver and passengers) and passive safety (safety of others outside the vehicle), automobile manufacturers are certainly improving the former in response to increased customer requirements, and they also see this as a key opportunity to differentiate themselves from their competitors. By contrast, passive safety tends to represent a reaction to tighter statutory standards.

NCAP ratings

For example, the safety ratings developed by the European New Car Assessment Programme (NCAP) are increasingly being cited as important buy arguments. However, weaknesses in this area (e.g. due to defective design or quality problems of certain components) can quickly damage reputations and have a negative impact on financials.

Leading carmakers and suppliers have recognised that vehicle safety is becoming ever more important, and are therefore positioning their products or individual brands in a strategically appropriate way to profit from this trend.

To improve active and passive vehicle safety, manufacturers basically have the following options:

- Improve the impact characteristics of car bonnets.
- Equip vehicles with active safety features such as airbags, night-vision equipment, adaptive headlights, active brake support, run-flat tyres and so-called advanced driver assistance systems (see details below).
- Increase the distance between the radiator grille and engine to better absorb the shock of impact in the event of an accident.

The latter must in turn be seen in connection with the demand that vehicles be designed bigger, particularly longer. Generally, passenger and driver safety is a function of vehicle mass, vehicle geometry and the available crumple zone.

Making cars lighter and longer

The realisation that large, high-weight vehicles provide better protection for occupants than small, low-weight vehicles is already fairly widespread. This is frequently reflected in the motives of buyers of large limousines or SUVs, for example. While the preference for large vehicles is understandable from an individual standpoint, it has a considerable drawback in the case of accidents involving other vehicles or pedestrians. The drawback is the considerably higher accident risk for non-passengers. It is vehicle weight rather than vehicle size that impairs passive safety. Indeed, studies show that a larger vehicle of the same weight may improve the safety of its passengers without decreasing that of non-passengers. The general direction that vehicle development will have to take to raise road traffic safety is clear: vehicles will have to become larger, in particular longer, with similar – or, ideally, lower – weights (larger crumple zone between grille and engine).

Using lighter materials offers other safety advantages

Of course, this goal can only be achieved if lighter materials are used. As a rule, these are markedly more expensive than those normally used in automobile construction (above all, steel). Besides optimisation of vehicle size, using lighter materials also offers a number of other safety-relevant side-effects. They can be used to improve vehicle performance and handling, and to shorten braking distances.

Advanced driver assistance systems (ADAS)

Linking various systems and functionalities

Current developments in ADAS show the efforts being made to link various systems and functionalities by means of sensors and of information and communications technology. The discernible, highly promising steps in this direction could ultimately lead not only to considerably greater safety in road traffic, but also to more even traffic flows and a more efficient use of the available road infrastructure (less congestion). The following are some examples of ADAS:

- **Vehicle diagnostics:** These include rollover warning systems, roll stability control and road surface monitoring (loss of traction alarms). Smart tyres are another example. As tyres are the only connection between vehicle and road, it is obvious that they play a key role in improving active vehicle safety. In recent years, tyres have been fitted with pressure sensors as standard features. These lower the risk of tyres bursting and help tackle the general problem of tyre pressures that are often too low and thus impair vehicle safety and efficiency. In addition, smart tyres are able to monitor contact with the road surface, enabling systems such as ABS and ESP to be linked.

- **Driver support and monitoring:** Speed alert systems are an example. They inform the driver of a recommended speed, having regard to traffic conditions (infrastructure, traffic density, other parameters). They also provide warning signals when the vehicle approaches a bend, the end of a tail-back or unfavourable road surface conditions (e.g. snow, ice, surface water). Other examples are systems that support drivers in keeping to their lane (avoidance of unintentional lane departure or changing lanes (e.g. blind spot warning). These features can considerably reduce the risk of accidents, especially on motorways. Systems that serve to warn against running into the back of another vehicle (e.g. stop & go and active cruise control) also fall into this category. These systems automatically maintain sufficient distance to the next vehicle and accelerate automatically if traffic permits. Driver drowsiness detection and warning systems are another example.

- **Intersection safety:** These systems are designed to increase safety at intersections – at points where accident risk is high – by supplementing vehicle diagnostics and vehicle support systems with roadside-to-vehicle or vehicle-to-vehicle communications systems.

Only 6% of all accidents are generally not within the reach of new technologies

How much potential do these new technologies offer as far as reducing road traffic accidents is concerned? Experts estimate that only 6% of all road traffic accidents are generally not within the reach of new technologies. Studies such as that conducted by the SUNflower project show that improvements in passive vehicle safety in the 1980s and 1990s cut the number of fatalities among drivers and passengers by 15-20% (SUNflower, 2002). The basis for the study was the three EU states with the lowest death rates in the EU (Sweden, Netherlands and UK). There remains plenty of scope for further improvements. Koornstra (2003), for example, estimates that the introduction of new active and passive safety systems will lower death rates in the coming decades by a further 40%.

Safety gains in part negated by changed behaviour

For all the euphoria surrounding the huge potential offered by new safety systems, a few words of warning appear appropriate. In many areas, considerable technical hurdles still have to be overcome. Even if one is confident that these will be mastered, a question mark must be placed over optimistic estimates. The reason for this is people's typical behavioural response to technical innovations that enhance vehicle safety, also known as risk compensation. Such innovations alter the behaviour of vehicle users in such a way that some of the intended improvement in safety is lost. Safety belts offer a simple example. It may be assumed that drivers who wear their seat belts tend to behave more aggressively in road traffic, and that as a result some of the additional safety potential offered by belts is lost.

Safety profiles of OEMs' vehicle fleets as reflected in our extra-financial risk ratings

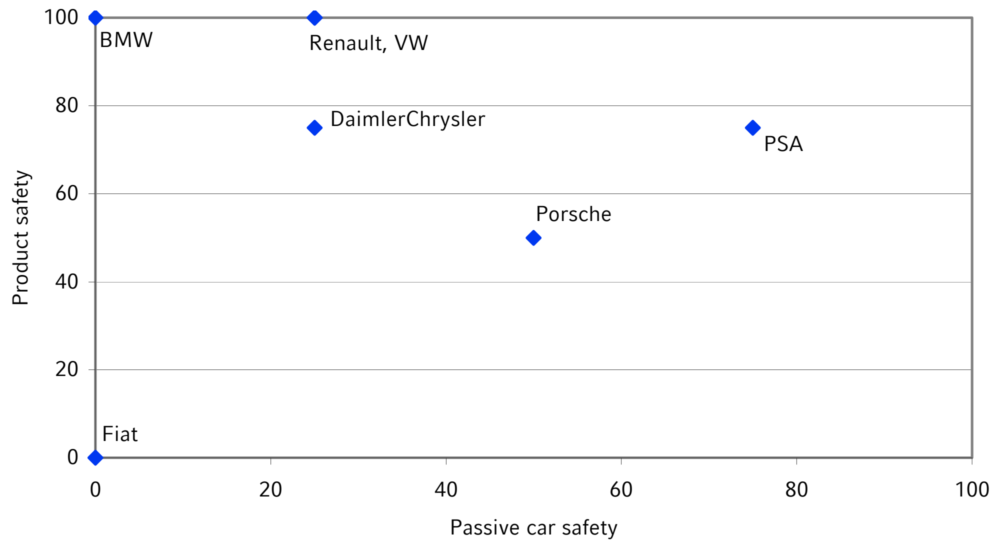
Two sector-specific criteria on vehicle safety

The safety profiles of current vehicle fleets are important criteria for our extra-financial risk ratings of the European automakers (see p. 47). Two sector-specific criteria are included in the rating of so-called product safety – which is simply the evaluation of the active safety of the current fleet on the basis of the NCAP ratings – and passive car safety.

PSA fares best in active/passive mix

According to the European NCAP ratings, BMW, Renault and Volkswagen are among the leading carmakers in product safety. PSA Peugeot and DaimlerChrysler receive above-average ratings. BMW and Fiat come out worst with regard to passive vehicle safety (i.e. pedestrian safety). Even the results for DaimlerChrysler, Renault and VW are below average, while Porsche is at least in line with the sector average and PSA Peugeot has an above-average rating.

Safety profiles of car manufacturers as reflected in our extra-financial risk ratings



Source WestLB Research, SiRi Company

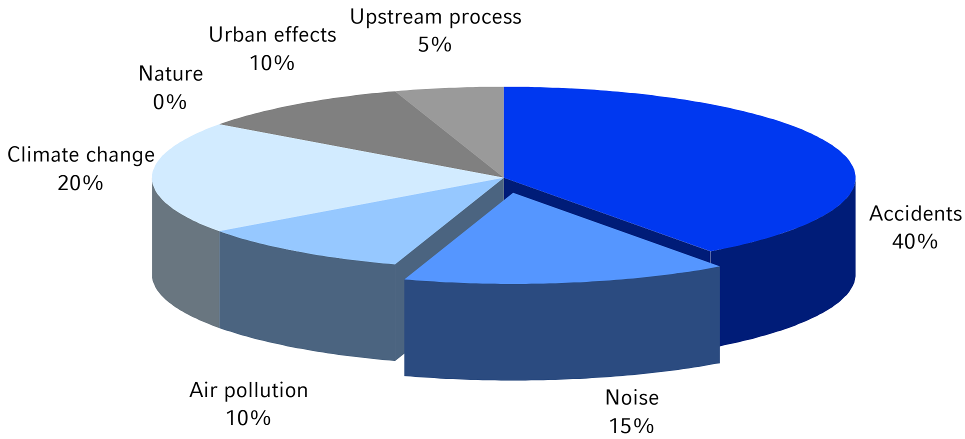
Noise

Road-related traffic noise is expected to increase

Noise the epitome of a local public good

Noise is the epitome of a local public good, as opposed to a global public good such as 'climate'. Transport-related noise generates external costs that cannot be effectively lowered by either voluntary measures or pure market mechanisms. The share of these costs in the overall external costs of road traffic is extremely significant. For example, if one takes the marginal costs of car passenger transport as a basis, the share of noise pollution according to Infras/IWW is 15%. Thus it comes third after accidents (40%) and climate change (20%), but – remarkably – ahead of local air pollution (10%).

Marginal external costs of passenger transport by car – share by cost category (max case with total marginal costs of €1.9)



Source Infras/IWW, 2000

Traffic volumes are the main driver of noise pollution

Traffic volumes are of course the main driver of road-related noise pollution. This applies especially in urban zones. Other important determinants are speed and traffic flow profiles. At higher speeds (over 80 km/h), tyre noise, for example, accounts for most of the noise level. By contrast, at lower speeds (25-35 km/h) and in the context of more frequent accelerating and braking, vehicle engine noises (including air intake and exhaust systems) cause the most noise. The latter characterises the noise profile on, for example, roads in residential areas and on roads that are overloaded and therefore congested (stop-and-go traffic).

Noise pollution will increase further

In BAU scenarios (e.g. those of the SMP), it is generally assumed that road-related noise pollution will continue to grow in the coming decades. This is hardly surprising given that traffic volumes are expected to increase steeply, especially in newly industrialised and developing countries. Much of the increase in noise levels will occur in urban areas and will be favoured largely by factors resulting in an overloading of traffic infrastructure.

Offsetting factors

Congestion avoidance, sound protection walls, road surfaces and drive technologies

Of course, there are also some factors that can help lower the rise in noise pollution or mitigate its impact. These include tightening vehicle noise emission regulations and infrastructure measures. There is certainly potential in monitoring compliance with regulations and in sanctions against non-compliance. Infrastructure measures mean constructing noise abatement walls and using quieter road surfaces, which will also play a major role in the future. However, measures that help to avoid congestion or smooth traffic flows also help to contain the rise in road-related noise pollution. In vehicle technology, innovations in drive systems (e.g. hybrid drives and fuel cells) are most geared to making a significant contribution to noise abatement. However, progress in tyre technology and vehicle body aerodynamics could also have a positive impact on noise emission levels.

Noise profiles of infrastructure providers as reflected in our extra-financial risk ratings

Rating of motorway operators

Noise aspects are incorporated into our extra-financial risk ratings as a sector-specific criterion only for infrastructure providers. In the road transport sector it is motorway operators that are affected. Autostrade and BRISA are rated at the same level on the criterion 'targets & programmes to reduce noise characteristics of means of transport'; both receive 40 out of a possible 100 points (see p. 48). Albertis, by contrast, fares extremely badly and receives no points.

Autostrade: noise abatement 'at the source'

Autostrade is doing research and working on a number of measures aimed at lowering road noise. As well as constructing noise protection walls in sensitive areas, the company has turned its attention to reducing noise 'at the source'. For example, Autostrade is testing special surfaces and noise protection systems at tunnel entrances that absorb noise better. The company generally supports concepts that help reduce the negative impact of roads on the environment. In this connection Autostrade is, for example, developing automatic payment systems to cut congestion and thus help lower vehicle petrol consumption. However, the company has not published any concrete noise reduction targets.

BRISA and Abertis

In the case of its rival BRISA, there are only indications that noise protection walls are being built along roads. We have no information on other programmes or specific targets. Albertis provides no information at all on noise protection.

Use of materials

Materials consumption is increasing and will continue to increase

Materials consumption will increase significantly

Increase in vehicle production is the dominant factor

The consumption of materials required in the manufacture of road-based vehicles will continue to grow strongly if the assumptions contained in the BAU scenarios prove correct. The main driver is the assumption regarding the expected strong rise in the vehicle population. Even if the share of recycled materials is maximised, demand for primary materials will grow. Ultimately, the rise in recycling rates will not be able to keep pace with the rise in vehicle production.

Demand for individual materials

Demand for ferrous metals will climb from 42m to 65m tonnes a year by 2050

Ferrous metals and aluminium are among the materials whose consumption is expected to rise strongly. In its BAU scenario, the SMP assumes that consumption of ferrous metal products will initially remain constant at about 42m tonnes a year up to 2030, thanks to increasing substitution by light metal products, but will afterwards rise to over 65m tonnes by 2050. Over the whole period, the volume of recycled materials is estimated at a constant 35m tonnes. Accordingly, the need for primary material will grow from an initial 7m tonnes to some 30m tonnes at the end of the period.

Rise in aluminium consumption will be smoother

As a result of the substitution effect touched on above, the growth in aluminium consumption should be smoother. In its projections, the SMP assumes that the current volume of some 5m tonnes a year will climb to 16m tonnes in 2030 and 32m tonnes in 2050. In this connection, it is assumed that recycled aluminium – in contrast to ferrous metals – will be unable to account for a significant share of aluminium production during the period covered by the projection. This is due mainly to the length of the life cycles of road vehicles, which is estimated at 17.5 years on average. Despite an assumed recycling rate of 90% for new vehicles, the fact that the number of cars with appreciable amounts of aluminium is currently very low means that the supply of recycled materials will vary widely for a long time (e.g. in 2030 78% for ferrous metals vs 42% for aluminium).

Further increases in materials consumption driven by special factors

Other materials for which a significant increase in consumption is predicted are copper, lead and nickel. Besides the general rise in the number of vehicles, this is mainly due to the trends towards additional electrical and electronic equipment. The expected strong increase in demand for platinum group metals (PGM) is also driven by special factors. It is based largely on the assumption that, as emission standards are tightened worldwide, the demand for catalytic converters will rise sharply.

Total energy impact of materials use

The question of materials consumption is significant from another perspective as well. For example, GHG emissions caused by the production of the materials required in vehicle production depend to a very large extent on how high the proportion of recycled materials is. This is highly important in, for example, the very energy-intensive production of aluminium. To produce aluminium from recycled materials, only a fraction of the energy is required.

The central role played by vehicle weight

Marked increase in vehicle weight

Apart from the expected sharp increase in vehicle numbers, the expected changes in average vehicle weight also play a key role in the projected consumption rates of materials. In this regard too, the trend is moving in the wrong direction – at least if the goal is more sustainable mobility. In the past 30 years the average weight of LDVs in Europe has grown by some 30%. In the USA the average weight in the same vehicle class initially fell 21% during the same period, but climbed back up to its 1975 level in 2003.

Trend towards increasing equipment levels is an important driver

The trend towards increasing vehicle weight manifests itself in two ways. First, the average weight within the individual vehicle classes is rising. Second, the market share of vehicle classes that have higher average weights (e.g. SUVs) is rising. The main reason for the increase in weight in vehicle classes is that vehicles are being fitted with more and more equipment, and with technologies designed to improve safety, comfort, emissions and performance. The increase in weight caused by additional equipment also makes it 'necessary' to put more powerful engines into vehicles, which raises the weight even further. The use of lighter materials and savings resulting from improved vehicle design has only partly offset the resultant weight increase.

Still plenty of scope for reducing weight

There still appears to be plenty of scope for lowering weight by using lighter materials. For example, a study commissioned by the European Aluminium Association demonstrates that overall vehicle weight could be cut by 28-36%. The study took account not only of the use of lighter materials but also of second-round effects such as the use of smaller and lighter engines.

Vehicle weight also plays an important role in vehicle safety and energy efficiency

Vehicle weight is of course of crucial significance, and not only in terms of materials consumption and the related problem of disposal at the end of the product life cycle. It also plays an important role in active and passive vehicle safety and in energy efficiency and thus GHG emissions. According to one rule of thumb, a 10% reduction in vehicle weight can lower fuel consumption by 5-7%, provided however that engine performance is adjusted downwards to the lower vehicle weight. Without such an adjustment, the saving would still amount to 3-4%. On average, 25.3kg of CO_2 per kilogram of reduced weight can be saved in this way (see IPAI, 2000).

Use of recycled aluminium is able to improve the overall energy efficiency balance significantly

Another point of significance for the energy balance is how the lighter materials used to lower vehicle weight have been produced. We return to the above example of aluminium production. Studies show that 45% of the potential energy saving that can be achieved if aluminium instead of conventional materials is used during a vehicle's entire life cycle is wiped out by the highly energy-intensive process of aluminium production. One solution to this problem would be to raise the proportion of recycled materials in aluminium production. The expected share of 42% cited above would mean a fall in the lost saving potential from 45% to 10-30% (see SMP, 2004).

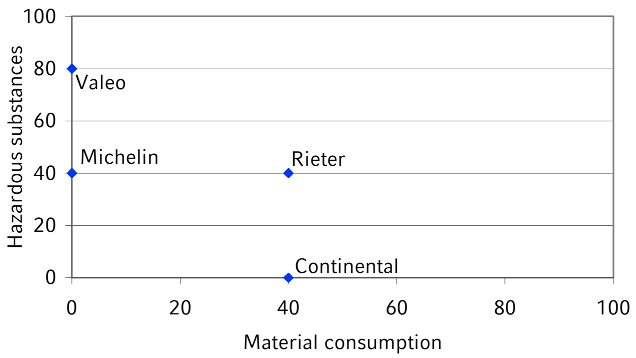
Materials use profiles of component manufacturers as reflected in our extra-financial risk ratings

In all, six criteria are taken into account in the rating

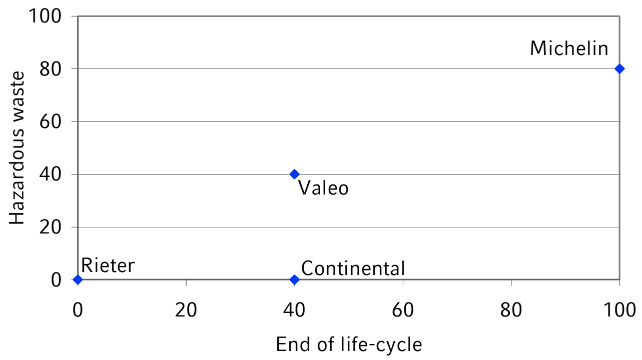
In our extra-financial risk rating, criteria relating to materials use are taken into account above all for component supplier companies. Besides materials consumption in the narrow sense, the use and production of harmful substances during the manufacture of components is also relevant, as is the disposal of vehicle parts at the end of the product life cycle. In all, the assessment takes account of six criteria (see p. 48). It is striking that the four companies we have identified as important have huge shortcomings when it comes to providing data on materials consumption and dangerous waste materials. Apart from Valeo, which at least publishes information on hazardous waste and receives 50 out of 100 points for doing so, all companies are awarded zero points in this area. By contrast, in the 'targets & programmes on …' area comprising four criteria in total, the picture is very mixed as the following chart shows.

Materials use profiles of component manufacturers as reflected in our extra-financial risk ratings

Upstream



Downstream



Source WestLB Research, SiRi Company

Michelin and Continental ratings based on end-of-life-cycle criterion

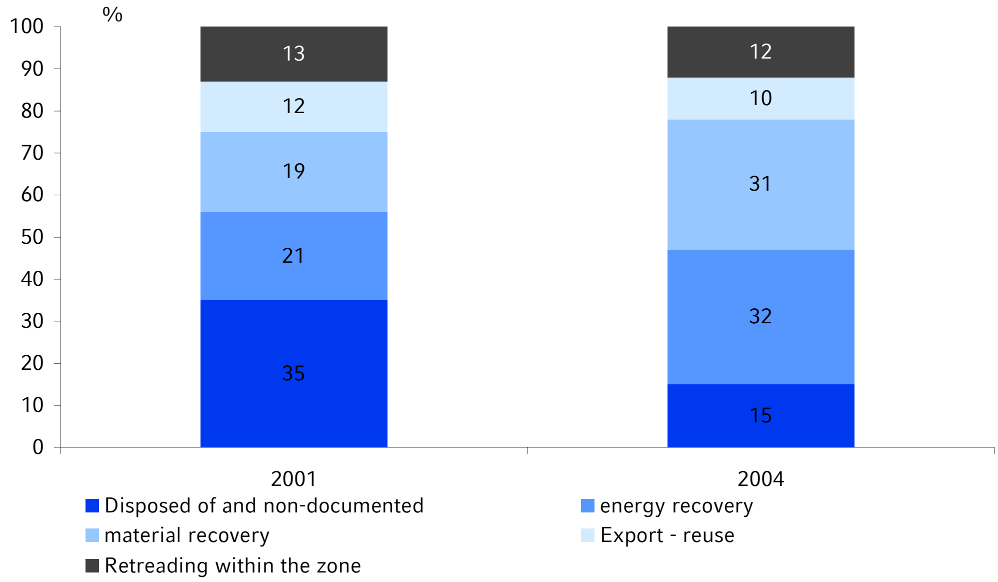
Demand for rubber expected to grow strongly

As an example, we have taken the end-of-life-cycle ratings of the two major European tyre manufacturers. The background is as follows. Rubber is one of the materials for which the SMP expects significantly higher consumption in the coming decades. It is not so much synthetic rubber produced from oil that is causing concern, but rather natural rubber gained from the juice of the rubber tree, which grows only in certain regions. At present, the tyre industry consumes nearly 70% of all natural rubber worldwide. The sharp rise in road-based freight traffic implies that demand for truck tyres will grow so sharply that it cannot be covered by the available supply of natural rubber. This means that the share of synthetic rubber will have to increase in the future to satisfy the additional demand. Recycling of old tyres could also become much more important.

Is recycling of old tyres becoming increasingly significant?

In Europe, some 2.5m tonnes of old tyres reach the end of their useful life each year. Until recently, most of them ended up in landfill. More recently, old tyres have been disposed of in different ways in national markets. Individual states have introduced regulations (e.g. France, Benelux, Portugal and Scandinavia) or are preparing to do so (Spain, Italy). Other countries are leaving tyre disposal to market forces (Germany, Austria, Switzerland, UK). Large numbers of old tyres in Germany are recycled to recover energy (2004: over 50%). Tyres no longer end up on dumps. In Europe, the share of tyres than ended up in landfill or were not pursued statistically dropped by 4 percentage points to 21% between 2001 and 2004; most go to Eastern European countries.

Recycling of old tyres in Europe-25: 2001 vs 2004
(share of total volume)



Source Michelin

Ratings of the two leading European tyre manufacturers

For our evaluation under the extra-financial risk rating of the two leading European tyremakers Michelin and Continental, an important point is the extent to which the companies set targets and draw up programmes that deal with the end-of-life-cycle issue – in other words, that ensure either that waste is reused or recycled, or that products and materials are developed that can be easily replaced/reused or have the lowest possible impact on the environment.

Continental

For the tyremaker Continental, REG – the tyre disposal company set up by the parent company in 1992 – is responsible for disposing of old tyres as required by law. In addition, REG develops and implements ecologically sensible recycling technologies as an alternative to storage in landfill. This includes using natural resources carefully while at the same time achieving economic costs of disposal. No specific targets are published, which results in only a mid-level ranking.

Michelin

Continental's French competitor Michelin has committed itself to the goal of the EU directive that no old tyres may be stored in landfill after mid-2006. In the US market the company participates in the tyre recycling initiative supported by the Rubber Manufacturers Association.

Related stocks in the small cap segment

Interesting small cap stocks related to traffic efficiency enhancement

INIT

Innovation in Traffic Systems (INIT) develops and markets fleet management, fare management and on-board vehicle systems for the transportation industry. The company's main product is called MOBILE, a modular, flexible system that integrates software and hardware components. Init markets its Intelligent Transportation Systems (ITS) products throughout Europe and the USA. The company is listed on the Frankfurt stock exchange (Prime Standard).

Interesting small cap stocks that might benefit from rising sales of hybrids

iQ Power

iQ Power is involved in the development and commercialization of electrical power sources and energy management technologies. The company develops technologies for the automotive industry and other industries. iQ Power's primary technology relates to a smart automotive starter battery, which contains several proprietary features. The company is listed on Nasdaq's OTC segment.

Interesting small cap stocks related to alternative fuels

ADM

Archer-Daniels-Midland (ADM) procures, transports, stores, processes, and merchandises agricultural commodities and products. The company processes oilseeds, corn, milo, oats, barley, peanuts, and wheat. Archer-Daniels-Midland also processes products which have two end uses, including food or feed ingredients. In Europe, ADM is active in Germany as a producer of biodiesel from plant oil, and operates or has plans for three plants with a total capacity of 875,000 tpy from end 2006. 500,000 tons of annual capacity is already on stream. The company is listed on the NYSE and is a member of the S&P500 index.

Bunge

Bunge is an integrated global agribusiness and food company spanning the farm-to-consumer food chain. The company processes soybeans, produces and supplies fertilizer, manufactures edible oils and shortenings, mills dry corn and wheat, manufactures isolated soybean protein, and produces other food products. Bunge has primary operations in North and South America. In Europe Bunge benefits twofold from the expected increased consumption of biodiesel, as an operator of plant oil mills and of large biodiesel production plants in Germany. Together with its French partner Diester Industrie Bunge operates the 60:40 joint venture 'Diester Industrie International (DII)', which is one of the largest European biodiesel producers. The company is listed on the NYSE.

Biopetrol Industries

Biopetrol Industries manufactures and distributes biodiesel and pharmaceutical grade glycerol. The company's customers include the mineral oil industry and trade, large fleet operators, public transport operators, agriculture, and the construction industry. Biopetrol plans to increase its current biodiesel production capacities five-fold by Q3 2007 and thus establish itself as one of the Top 5 European biodiesel producers. The company is listed on the Frankfurt stock exchange (Entry Standard).

EOP Biodiesel

EOP has been listed since September 2005 in Entry Standard on the Frankfurt stock exchange. The company is a biodiesel producer and plans to add 100,000 tpy of biodiesel capacity to its existing 32,500 tpy plant as of the beginning of 2007. EOP has an oil-pressing mill and primarily targets the refinery industry.

Abengoa	Abengoa offers engineering and construction and recycling services, and produces alcohol. The company builds and integrates information systems, builds and operates conventional and renewable energy generating plants, offers aluminum, zinc, and salt cake recycling services, builds water and waste treatment plants, and manufactures ethyl alcohol from vegetable products. The company is listed on the Madrid stock exchange.
D1 Oil	D1 Oil develops bio diesel fuel. The company has plantation rights to cultivate the crop jatropha curcas. D1 Oils operates in Africa, India, and the Asia Pacific region. The stock is listed on AIM in the UK.
Biofuels Corporation	Biofuels Corporation is developing biodiesel processing plants in Seal Sands, Middlesbrough, on the northeast coast of England. The stock is listed on AIM in the UK.

Aviation

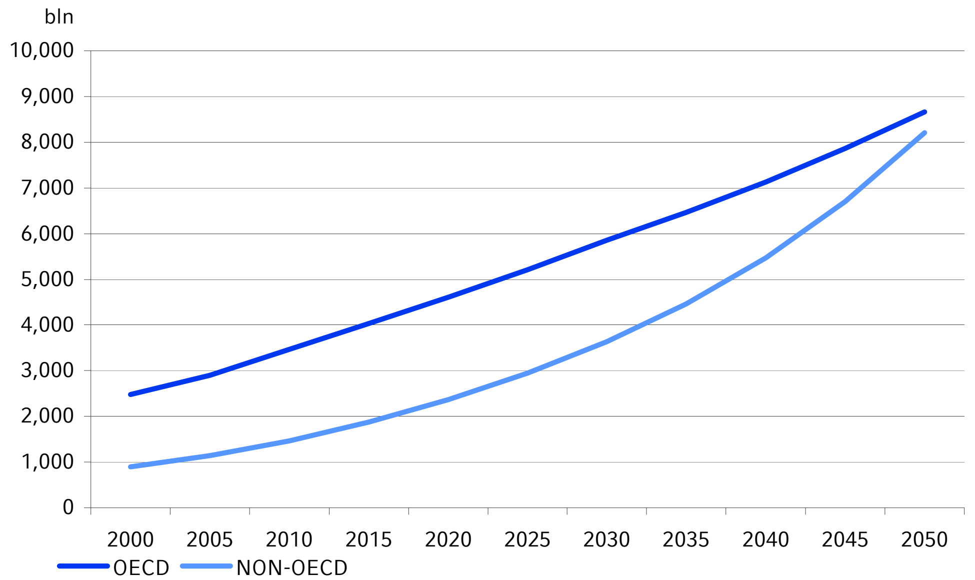
Aviation is by far the fastest-growing form of transport; budget airlines in particular have posted soar-away rates of growth in recent years. An increasing proportion of freight is also being transported by air, and this trend is set to continue over the years ahead. The flipside is that aviation is also the form of transport that causes the greatest environmental impact. Flying offers the most 'climate intensive' connection between two places. Noise pollution and exhaust fumes are also problems, especially close to airports. And measures like energy efficiency improvements, noise reduction and regulatory intervention are in danger of being ineffective in light of the rapid growth in the industry.

Up, up and away…

The fastest-growing form of transport

Aviation is the fastest-growing form of transport. The International Air Transport Association (IATA) calculates that total passenger traffic (measured in RPK: revenue passenger kilometres) worldwide jumped by about 14% in 2004. The trend in air freight is similar. Although the market is still experiencing extreme price pressure, IATA figures show that goods transport grew by about 12% in 2004. In a recent development, it is not only perishable goods like flowers, lobsters, shrimp, fruit and vegetables that are being conveyed by air, but also leather goods and textiles.

Air: total passenger km



Source SMP, 2004

Stable long-term growth trend

Low-cost carriers and Asian growth creating additional demand

Besides the fact that flying is simply the quickest connection over long distances, the main reasons for this strong increase in demand are that flight prices are falling steadily, while prosperity is growing among broad swathes of the population. Over the long term, there is a clear correlation between air traffic and global economic growth. The long-term average growth rate for aviation is about 2.5 times economic growth. In addition to this basic trend, there are currently a number of special factors that are taking growth potential temporarily even higher. First and foremost, these are the proliferation of budget carriers and the speed of aviation growth in Asia/Pacific and the Middle East. But direct and indirect state subsidies are also a key factor. Airports and aircraft constructors receive direct subsidies and special credits, while aviation also gets a massive boost from the special tax status of kerosene and international flight tickets and the opportunities for duty-free shopping, e.g. on flights into and out of the EU.

Passenger growth within Europe to average around 5.1% until 2009

Medium-term – i.e. in the period to 2009 – the IATA expects passenger growth within Europe to average around 5.1%. This average growth rate is likely to continue to be overshadowed to an extent by the growth in long-haul flights, e.g. to North America (5.3%), Asia/Pacific (5.9%) and the Middle East (6.6%).

Global growth in passenger and freight volumes

%	Passengers		Tonnes of freight	
Route	2005	CAGR 2005-2009E	2005	CAGR 2005-2009E
Europe – North America	5.0	5.3	5.1	4.6
Trans-Pacific	7.4	5.8	6.6	6.0
Europe – Asia/Pacific	6.8	5.9	6.9	5.7
Europe – Middle East	8.4	6.6	7.0	5.1
Europe – Africa	6.4	5.7	5.0	4.5
Within Asia/Pacific	8.7	6.8	8.5	8.5
North America – Latin America/Caribbean	5.2	4.6	4.4	3.7
Within Europe	5.7	5.1	5.1	4.1
Within Latin America/Caribbean	4.6	4.2	3.0	5.0
Middle East – Asia/Pacific	8.9	6.7	13.7	8.8
TOTAL INTERNATIONAL	6.7	5.6	6.8	6.3

Source IATA, 2004

The same trend is reflected in demand for new aircraft: Airbus and Boeing both expect the existing fleet to more than double over the next 20 years.

Structural trend: Network vs. direct routes

Boeing expects more direct routes …

Even though their assessments of prospects for the broad market are very similar, Airbus and Boeing have very different opinions about the expected future structure of aviation. Boeing expects future growth to be very much concentrated on direct, non-stop routes. As passengers want to reach their destination airports as quickly as possible without the hassle of changing planes, the US company believes that airlines will make increased use of medium-sized aircraft so they can offer an attractive mix of popular direct routes.

… while Airbus believes in network solution

Airbus essentially agrees that growth in air travel will lead to a big increase in the number of direct routes on offer. However, in light of the increasing urbanisation of the world's population, the European constructor reckons that the bulk of passenger growth will continue to be handled via central hubs. As airport capacity in fast-growing big cities is generally limited and infrastructure measures take a very long time to implement, Airbus sees a strong trend towards the use of large aircraft. It therefore anticipates very high demand for mega-jumbos like the A380, at around 1,250 units by 2023.

Expected market trend by product category

Airbus share	2003A	2023E	CAGR 2003-23 (%)
Passengers	10,838	21,759	3.5
Single aisle	8,347	15,111	3.0
Small twin aisle	951	2,173	4.2
Medium twin aisle	1,510	3,213	3.8
Large (A380)	30	1,262	20.6
Boeing share	**2004A**	**2024E**	**CAGR 2004-24 (%)**
Regional	2,520	5,648	4.1
Single aisle	10,248	20,474	3.5
Twin aisle	3,024	7,766	4.8
747 and larger	1,008	1,412	1.7
Total	16,800	35,300	3.8

Source EADS, Boeing

Trouble in the skies – environmental impact of aviation

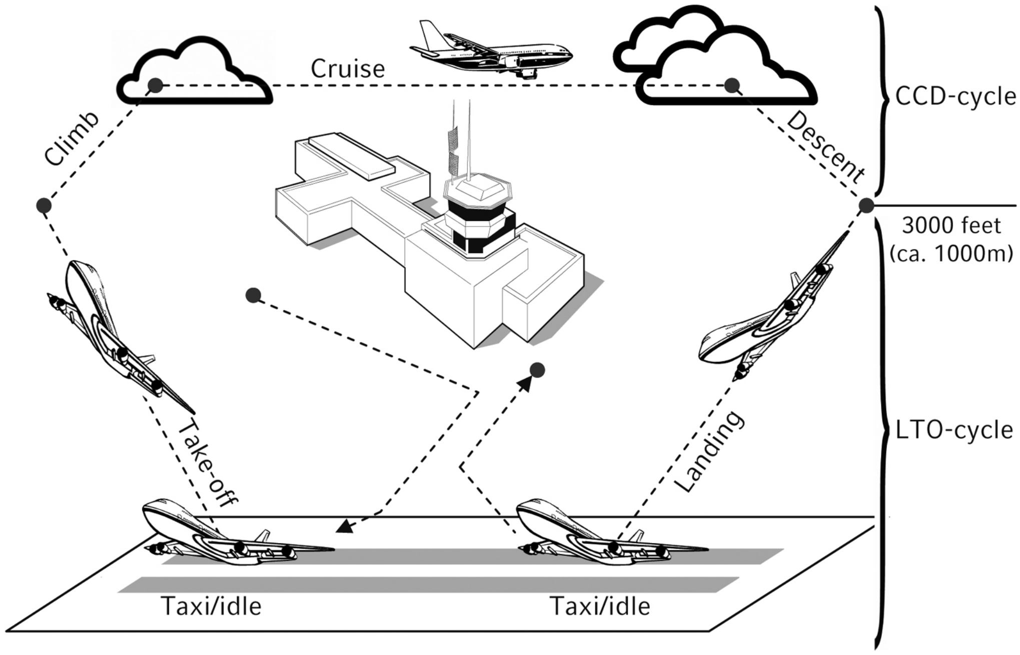
Aviation is one the fastest-growing consumers of energy

The strong growth of this sector also goes hand in hand with a sharp increase in the damage to the environment resulting from aviation. Aviation is one the fastest-growing consumers of energy, currently accounting for around 12% of global energy consumption for transport. Under the SMP reference scenario, this share is forecast to rise to more than 18%. The emissions caused by aviation will also increase further, in proportion to the rise in total energy consumption. This will outweigh the positive effects of expected efficiency gains.

Each particular combination of aircraft type and engine type has its own emissions profile

The emissions caused by aviation consist principally of carbon dioxide (CO_2), nitrogen oxides (NO_X), carbon monoxide (CO), hydrocarbons, (water) steam, sulphur oxides (SO_X) and aerosol particles. Each particular combination of aircraft type and engine type has its own emissions profile. The emissions at landing and take-off (LTO) are not the same as those during the normal flight phase (climb/cruise/descent, CCD). Hydrocarbons escape mainly while the engines are working at low capacity, whereas NO_X is formed particularly during landing and take-off but also while the aircraft is cruising, i.e. at high thrust (high temperatures and high pressure in the engines). CO_2 and steam are created by the burning of kerosene in proportion to fuel consumption.

Aircraft operation: landing/take-off (LTO) and climb/cruise/descent (CCD) cycle



Source ADV, 2003

Emissions in the sky two to four times more harmful than at ground

It is also particularly problematic that the harmful exhaust gases are emitted directly into the atmosphere. Transport aircraft generally fly at an altitude of 8-12 km (30,000-40,000 feet), i.e. in the upper troposphere and the lower stratosphere. At these levels, according to IPCC estimates, greenhouse gases are two to four times more harmful than at ground level.

Changing climate more 'effectively'

Flying is the most climate intensive connection between two places

Aviation offers the most 'climate intensive' connection between two places. According to the key 1999 report from the IPCC's international climate researchers, the share of aviation in the man-made greenhouse effect was around 3.5% in 1992, and this share was expected to increase to 15% or more by 2050. In the EU-15 alone, CO_2 emissions caused by aviation rose by 62% between 1990 and 2003 (EU-25: 73%) and now account for 13.6% of total emissions from transport (including international flights, but excluding maritime transport). In the UK, aviation accounted for 13% of total CO_2 emissions, and the Department of Transport expects this figure to rise to 31% by 2030.

Focusing on CO_2 emissions falls too short

However, more recent studies show that focusing on CO_2 emissions alone falls too short. We also need to look at other changes in the atmosphere caused by aircraft, for instance the concentration of steam, ozone, methane and aerosols, changes in cirrus clouds and those resulting from vapour trails, which also have a negative impact on the climate. The high cirrostratus clouds and vapour trails alone can contribute more to global warming on a localised level than all other greenhouse gases caused by humankind. Although there has still been very little research into these effects, recent estimates from the IPCC put the total climate impact of aviation at two to four times that of the CO_2 effect alone. In the EU, the sector's share in the total greenhouse effect is likely to rise to 8-24% by 2020 – depending how growth in the sector actually pans out, how successful the emissions reduction efforts are, especially in other sectors, and how high the 'CO_2 multiplier' actually is.

Aviation's contribution to climate change

Emission of...	Effect	Estimated total contribution to man-made climate change, global average
CO_2	global greenhouse gas effect	2%
NO_X	triggering greenhouse gas ozone	1–2%
NO_X	reducing greenhouse gas methane	– 0.5% to –1%
Particulate matter	Contrails	0.5–1%
Particulate matter	Cirrus clouds	~4.5% (0.5%–9%)
Total		~9% (4%–12%)

Source IPCC, 2001

Nitrogen oxide emissions at high altitude

More climate effects through NOx emissions …

Even though aviation causes only 1.3% of global NOx emissions, these emissions nonetheless merit particular attention. Studies have shown that at high altitudes – between 8 and 12 km – nitrogen oxides promote the formation of the greenhouse gas ozone. At the same time, methane, an even more dangerous greenhouse gas, is reduced. The extent to which these two effects cancel each other out is unknown. However, scientists believe that the net effect on the climate will be greater than nil.

Vapour trails and cirrus clouds

The energy economy of the earth's atmosphere is heavily influenced by clouds. In general, clouds reflect the rays from the sun, having a cooling effect. They also reflect long-wave radiation back to the earth, warming its surface. Which of these effects prevails at any particular time depends in part on the optical thickness of the clouds.

… and vapour trails

Vapour trails are linear cirrus clouds caused by aircraft. Only under certain atmospheric conditions are the steam emissions of an aircraft engine visible as vapour trails. They form when the atmosphere is sufficiently cold. The exact threshold temperature below which vapour trails form depends on the aircraft's altitude, the ambient humidity, the fuel and the aircraft's performance. If the air is sufficiently humid, persistent vapour trails form which can last from a few minutes to hours; 10% to 20% of all flights take place in such a sufficiently humid atmosphere. Over Europe, averaged out over the year, linear vapour trails cover around 0.7% of the sky during the day, according to calculations by the German Aerospace Centre. At night, when vapour trails have a more intense warming effect, the coverage is about a third of this.

In terms of quantifying the climate effect, there remains a great deal of uncertainty, as there is too little reliable information on the average level of coverage and on the average optical thickness of vapour trails. Far too little is known about the changes to cirrus clouds caused by aviation either. What is certain is that both effects can vary extremely widely from location to location. Overall, however, a warming effect is assumed here too.

Noise

Another detrimental effect

Another significant detrimental effect of aviation is noise. In areas around airports in particular, the noise created by aircraft taking off and landing, taxiing, the use of APUs (auxiliary power units), engine tests and aircraft maintenance is enormous. A Boeing 747-400 taking off causes a noise level of around 100 dB(A) at 300 m. An Airbus 230 comes in slightly lower than this (at around 95 dB(A)).

Due to a range of measures fewer people are exposed to aircraft noise, ...

A range of measures have been taken which have significantly reduced the noise created by individual aircraft. Technical improvements alone have brought down noise levels of aircraft by an average of 20 dB since jet aircraft were introduced in the late 1950s. Combined with flight restrictions and improved route planning, this has resulted in a significant reduction in the number of people exposed to aircraft noise over the last ten years: according to estimates, in 1998 around 30 million people were exposed to a day-night noise level of over 55. Of these, 3.5 million were subject to a day-night noise level of over 65. These figures have now fallen to 20 million and 2.3 million respectively.

Extra-financial risk rating of airport infrastructure providers

With respect to our extra-financial risk rating, BAA is the only airport infrastructure provider covered. The company frankly states that it is primarily government policy that influences how BAA tackles air noise. BAA's objectives include:

- Encouraging the manufacture of quieter new aircraft and engines by influencing government standards and aircraft manufacturers.
- Rewarding the use of quieter aircraft through differential landing charges.
- Improving compliance with quieter operating practices, including a charging scheme for noise limit breaches.
- Keeping noise-sufferers better informed.

Within our extra-financial risk rating BAA receives 80 out of 100 points for its targets and programmes to reduce the noise characteristics of transport means.

Sustainable mobility profile of airport services providers as reflected in our extra-financial risk rating

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)
	Overall		Environ-ment	Gover-nance	Stake-holder	Targets &Programs to reduce noise characteristics of transport means
	Rating	Z score				
weight			**40%**	**15%**	**45%**	**3.28%**
Airport Services						
BAA Plc.	A+	0.73	0.86	0.81	0.16	80

Source WestLB Research, SiRi Company

... but this trend is likely to break

However, this downward trend is very unlikely to continue in the future. Firstly, the potential for technical improvements – for jet aircraft at least – appears to be largely exhausted. And secondly, conurbations are often expanding ever closer in the direction of airports. In addition, there is now an ever-increasing number of flights to and from smaller airports as well. Budget carriers, in particular, have moved to such airports for cost reasons, and, because of capacity problems and restrictions at large airports, smaller airports are more and more likely to become destinations for larger airlines as well in future. This will mean, however, that the noise is distributed across wider areas. At the end of the day, what is likely to be decisive in increasing noise levels is simply the predicted sharp growth in air transport.

Exhaust fumes – local emissions

Emissions on the ground stress environment close to airports

As well as suffering from noise pollution, people living in close proximity to airports and the local environment are also particularly heavily impacted by exhaust gases such as nitrogen oxides and sulphur oxides, volatile organic compounds (VOCs), carbon monoxide and particulate matter.

Scientific findings show that NO_X and ozone, along with ultra-fine particles, are responsible for a rise in respiratory illness among certain sections of the population. Nitrogen oxide and VOC emissions are key factors in the formation of surface ozone – the main component of smog. In addition, nitrogen oxides and sulphur oxides contribute to the formation of acid rain and eutrophication.

But those emissions are caused not just by aircraft

The harmful emissions are caused not just by aircraft but also by other vehicles at airports (passenger buses, mobile lounges, tankers, towing vehicles, etc.), as well as vehicles used for transport to and from the airport (cars, buses, trains, etc.). To these must be added the emissions from stationary generators. The sharp increase in air transport will also bring with it an increase in these additional activities. The trend of linking up different transport modes at airports will further add to the local issues. The connection with rail, however, could ease this problem somewhat.

Fuel dumping

Fuel dumps contaminating soil?

Often, fuel dumps are blamed for polluting soil next to airports. However, the aviation industry denies that. The demands made on an aircraft's engine are greater when landing than when taking off. In order to be able to make engines and brakes lighter, long-haul aircraft with large fuel capacity have a much higher maximum permissible take-off weight than landing weight. The lower total weight means that, over the course of a year, hundreds of tonnes of kerosene are saved per aircraft.

Experts say No

In emergencies (e.g. because of technical problems or if a passenger falls ill), long-haul aircraft can dump fuel prior to an unscheduled landing in order to reduce the weight of the aircraft to its maximum permissible landing weight. The aircraft in question is also allocated particular air space, where possible over an unpopulated or sparsely populated area. The prescribed minimum altitude is 1,500 m, but usually fuel is dumped at an altitude of 4 to 8 km. The aircraft must not fly in closed loops and its speed must be at least 500 km/h. The kerosene is reduced to a fine mist by the turbulence behind the aircraft. Even on a windless day, it is calculated that just 8% of the fuel dumped at the minimum altitude of 1,500 m, with a ground temperature of 15°C, reaches the ground. So for a minimum speed of 500 km/h, ground distribution can be calculated at 0.02 g per m^2, which equates in volume to a champagne glass of kerosene spread over an area of 1,000 m^2. When wind speeds are low, the resulting mixing with air means almost all the dumped fuel evaporates before it reaches the ground. So, despite the use of sensitive analysis procedures, no pollution from fuel dumping has yet been found in plant or soil samples, according to DLR.

Strategies to reduce the negative impact of aviation

A reduction in the number of flights seems not to be the goal

As a reduction in the number of flights cannot be expected in the near future, discussion of possible strategies to reduce the negative environmental impact will focus in particular on technical measures, such as improving energy efficiency, and on regulatory measures, such as including aviation in emissions trading systems, charging systems or noise restrictions.

Improving fuel efficiency

Steady improvements in fuel efficiency prevent exorbitant increases in consumption

Globally, aircraft currently consume around 170 million tonnes of kerosene a year. That equates to between 5% and 6% of world oil production. According to estimates by the German Aerospace Centre, consumption is currently rising at an average annual rate of 5%. It is mainly the ongoing replacement of old, inefficient aircraft with new, more efficient models which is preventing this increase in consumption from being significantly higher. For instance, the specific fuel consumption of the Lufthansa fleet has been reduced by 70% since the 1970s. By 2012, the group is seeking to achieve a further reduction of 40% against 1991; a 25.2% reduction had been attained by 2001.

Measures to improve energy efficiency

Three crucial factors

The IPCC puts the improvement in energy efficiency from 1960 to 2000 at 70% and expects further improvements of 1-2% per year in the future. Energy efficiency per available seat kilometre is determined by the following factors:

- **aerodynamic efficiency**, specified as the gliding ratio during cruising – this is estimated to have improved by approximately 15% since the 1960s.

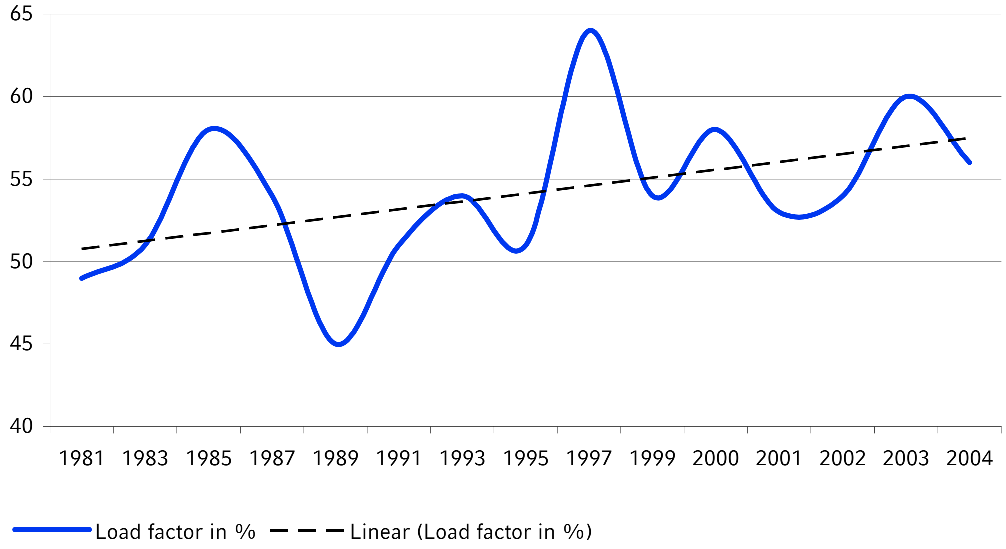
- **weight efficiency**, expressed as the ratio of payload to maximum take-off weight (MTOW) or as the ratio of operating weight to MTOW. The rates of improvement here were relatively small over the period in question. Improvements in material weight have often been offset due to the fact that planes have been fitted with more and more technical equipment and greater seating comfort. In more recent times, the increasingly popular method of 'tinkering' – i.e. the loading of additional fuel for the next flight – has also added further weight.

- **engine efficiency**, expressed as specific fuel consumption. This improved by an average of 40% between 1959 and 1995. The technical potential here therefore seems to have been largely exhausted for the moment. A new generation of jet engines which use turbo-fan technology points to further significant savings potential. They will first be used as standard on the A380. However, the lower fuel consumption is paid for in terms of higher weight. Fuel efficiency can also be improved through simple measures such as regular maintenance.

Operational factors also important

Operational factors – such as the load factor, route management, queuing, weather conditions and delays – also have a role to play. However, these factors are generally left out of calculations of average energy intensity.

Load factors in air freight transport
(figures are average for all European carriers)



Source AEA, 2005

Efficiency gains – not as great as is claimed?

IPCC's 'yardstick' of 70% efficiency gains neglects the low emission piston-engined planes of the 60s

The calculations of the IPCC are often used as a yardstick when looking at efficiency in aviation. But they leave out of the equation the fact that the beginning of the 1960s saw the start of the switchover from propeller planes to jet engine technology, then in its infancy. A study by the National Aerospace Laboratory (NLR, 2005) shows that the introduction of jets initially led to a massive increase in fuel consumption. But the last piston-engined planes used until 1965 would hold their own in terms of energy consumption against today's jets. Significantly lower fuel prices (kerosene can be produced much more cheaply than the aviation petrol needed for propeller planes) and 40%-80% faster flight speeds were what drove out the more environmentally friendly piston-engined aircrafts.

Another fact which has been found to be problematic is that the IPCC used the DH Comet 4 as a reference aircraft for its calculation – an aircraft type which was hardly used and which also had relatively high fuel consumption. Taking the first successfully used jets, like the Boeing 707, produces an efficiency improvement figure for today's jets of only 55%, as against the IPCC's figure of 70%.

Using these results, in conjunction with an analysis at macro level which, instead of the frequently used linear efficiency curves, assumes more realistic power curves – i.e. steadily diminishing efficiency gains – the NLR calculates a reduction in average fuel consumption per seat kilometre of only 43% since 1960. Since 1955, when most aeroplanes were piston-engined, fleet-wide fuel consumption has declined by only 23%. The efficiency gains expected in future are therefore likely to be lower than the 1.2-2.2% per annum forecast in most studies.

Technical solutions for noise reduction

Newest jet generation: turbo-fan technology …

Various measures have been taken in recent years to curb aircraft noise emissions. A breakthrough came with the latest generation of engines, which use turbo-fan technology. When these turbo fans are in operation, only part of the air which has been sucked in and precompressed is fed into the combustion chamber. The majority flows around the core of the engine and muffles the jetwash emerging from the combustion chamber. This flow cushions the meeting of the jetwash and the ambient air, greatly reducing engine noise.

Depending on the size of the aircraft, modern engines have bypass ratios of 5:1 to 8:1, meaning that much more air bypasses the combustion chamber than travels through it. The hope is that bypass ratios for future generations of engines can be upped to 10:1 or more, which would cut noise and energy consumption further. Modern jets are about 30 dB quieter than their first-generation counterparts of comparable capacity. As a 10 dB reduction halves the level of noise, this development means that sound levels have been cut by almost 90%.

… and operational measures

As with energy efficiency, there are also operational measures that can curb noise pollution, including special procedures, technologies and routings on the ground. These include noise abatement departure and approach procedures. Such procedures usually involve careful selection of high lift devices and engine power settings in order to reduce noise under or to the side of the aircraft during take-off or landing.

Hurdles to emissions reductions

Trade-offs

As we stated earlier, efficiency gains are not linear. If we look at other emissions as well as CO_2, it is plain that the simple equation 'more efficient technology = fuel savings = lower emissions' does not work. The TALON II TM combustion chamber, for example, was designed to slash NO_X emissions. However, the 25% cut in NO_X emissions versus the baseline figure came at the expense of smoke emissions rising from 30% to 93% of the ICAO limit. It is a similar story with the dual annular combustor (DAC), where the 30% and 67% reductions in NO_X and smoke emissions versus the baseline had to be offset against higher hydrocarbon and carbon monoxide output – up 15% and 130% respectively.

Diverging interests hampering optimum solutions for energy technology

These trade-offs also reflect the differences between the interests of the various parties involved. This means that for the aviation industry, aircraft speed is another important factor in design alongside fuel efficiency. Furthermore, technical conditions at airports or interior design considerations can play a decisive role in overall aircraft design. For instance, according to calculations carried out by Dalhuijsen and Singerland, the new Airbus A380 could have been up to 11% more fuel-efficient than is currently planned, given an optimal wing form; airport conditions led to a sub-optimal solution (in terms of energy efficiency).

Substitution of old technologies is a slow process

Further major hurdles to reducing emissions are the long lifespan of aeroplanes (usually more than 25 years) – which, obviously, is a positive thing in terms of lifecycle analysis – high capital costs and slow approval procedures for new technology (there are often more than ten years between development and entry into operation). A significant reduction in emissions could therefore be achieved by taking old aircraft out of service, but economic factors often militate against scrapping aircraft which are still functioning.

Even if estimated energy efficiency gains of 1-2% a year are realistic, these will be outweighed by growth in demand for air transport of 4-6% a year. A continued increase in energy consumption and in the environmental impact resulting from aviation will be the consequence.

Regulatory intervention

Efficiency gains wiped out by rising number of flights – regulatory measures thus needed

All the results point in one direction: however good the efficiency gains, they are constantly being wiped out by the rising number of flights. If we are serious about diminishing the implications of air travel for the environment and public health, there is no choice but to tighten up regulation. The measures that keep cropping up – some of which have been introduced locally – include adding aviation to the emissions trading system or levying higher fees and taxes.

Standards currently in place

The International Civil Aviation Organisation (ICAO) – a special organisation of the United Nations – is responsible for regulating international aviation. The prime purpose of ICAO certification standards is to ensure that the best of proven technology is incorporated into the aircraft design.

Emission certification standards

ICAO Annex 16, Volume II to the Chicago Convention, regulates aircraft engine emissions of NO_X, CO, hydrocarbons and smoke, for a reference landing and take-off (LTO) cycle below 900 m in altitude (3,000 feet). Specific rules also apply to the dumping of aircraft fuel (fuel jettisoning). Annex 16 limits do not address aircraft greenhouse gas emissions of CO_2, water vapour and SO_2.

The ICAO has also tightened up international limits on NO_X emissions three times in the last decade. The CAEP/4 standard reduced allowable NO_X by 16% – at an engine pressure ratio of 30 – for new or derivative engine designs after 2003. This standard replaced the CAEP/2 standard, which reduced the NO_X previously allowed to be emitted by 20%. In 2004, the ICAO Council endorsed the CAEP/6 recommendation for an additional NO_X stringency increase. This new standard will be applicable to new engines certificated after 2008 and is 12% lower than the existing (CAEP/4) standard.

Standards on NO_X at altitude on the way

Past efforts regarding NO_X technology development have concentrated on the reduction of NO_X during the landing and take-off cycle. Concerns about the impact of NO_X at altitude and its effect on climate change have, however, led to the development of programmes to identify technologies that reduce NO_X not only during the LTO cycle, but also during the cruise phase.

Regulations on noise

In 1971, the ICAO brought out regulations on noise emissions from civil aircraft, Volume I of Annex 16 to the Chicago Convention. This has been updated on several occasions. Since 2006, the new 'Chapter 4' limit has applied for approvals of new aircraft, which, across the three measures, is a total of 10 dB(A) below those in Chapter 3.

Noise data on modern passenger aircraft with noise permits, according ICAO Annex 16, Chapter 3

Jet-engined aircraft

Type of aircraft	MTOW (in t)	Number of engines	Number of seats (Max)	Noise level acc. to chap. 3 ICAO Annex 16 (in EPNdB) take-off	cruise	landing
B 747-400	386	4	524.0	99.0	98.3	103.3
MD 11	280	3	410.0	94.9	95.9	103.8
A 340-200	254	4	440.0	94.4	94.8	97.3
B 777-200	243	2	440.0	93.3	95.8	99.4
A 330-300	212	2	440.0	91.6	97.4	98.6
B 767-300	185	2	345.0	93.2	97.0	100.2
A 300-600	165	2	375.0	90.0	97.2	99.1
A 310-300	153	2	280.0	91.5	96.0	98.6
B 757-200	109	2	231.0	84.8	93.1	95.0
A 321-100	83	2	220.0	85.4	94.5	95.4
A 320-200	74	2	180.0	86.6	94.8	96.0
B 737-500	52	2	132.0	84.0	89.0	97.0
Avro RJ 85	44	4	112.0	84.3	88.4	97.3
Fokker 100	43	2	109.0	83.4	89.3	93.1
Canadair RJ	23	2	50.0	78.6	82.2	92.1

Piston-engined aircraft

Type of aircraft	MTOW (in t)	Number of engines	Number of seats (Max)	Noise level acc. to chap. 3 ICAO Annex 16 (in EPNdB) take-off	cruise	landing
Saab 2000	23	2	58	79.1	86.7	87.9
ATR 72-200	22	2	74	86.5	84.7	94.1
Fokker	20	2	58	81	85	96.8
Dash 8-300	19	2	56	85	87.3	98.7
ATR 42-300	16	2	50	82.6	83.8	96.8
Dash 8-10	16	2	37	79.8	86.1	97.5
Dornier	14	2	33	81.7	84	92.7
Saab 340	12	2	37	77.3	86	90.8
Embraer	11	2	30	81.2	83.5	92.3

Source Flight International Airliners of the world, 1995

ICAO's Balanced Approach consists of identifying the noise problem at an airport and then analysing the various measures available to reduce noise using four principal elements, namely:

- reduction at source;
- land-use planning and management;
- noise abatement operational procedures; and
- aircraft operating restrictions.

Night-time operational restrictions

Night-time restrictions with adverse effects

Among the operating restrictions of a partial nature, night-time limitation measures are increasing, particularly in Europe. Night-time operational restrictions can take a variety of forms and may even go as far as completely banning night operations. Such restrictions often have an adverse economic impact.

- The introduction or revision of night-time operational restrictions may result in limiting the capacity of airports, which could create an obstacle to the maintenance and further development of regional and global route networks, increasing traffic congestion during non-restricted periods.
- It could also discriminate against or even eliminate services that depend on air operations at night, such as global and regional next-day delivery services, home-based charters and freight services. Further, airport night bans in one region may result in a corresponding export of noise to other regions. For instance, night curfews in Europe inevitably increase night operations in the Asia-Pacific region as most flights to Europe depart from Singapore, Bangkok or Delhi around or after midnight, to arrive in the morning at Paris, London or Frankfurt airports.

Emissions trading

ETS regarded as efficient instrument for addressing climate change externalities

The strong increases in aviation volumes have attracted considerable attention. A response has been a discussion on the introduction of economic instruments to reduce emissions, especially via emission trading in CO_2 quotas. An approach based on emissions trading may provide an efficient and cost-efficient instrument for addressing the externalities associated with climate change.

Many open questions

The European Commission launched a policy paper in 2005 which sparked a debate with other European institutions on including air travel in the European emissions trading system. The Commission aims to put forward a legislative proposal by the end of 2006. A consultant study published by the Commission shows that the impact of inclusion of international aviation in the EU ETS depends on the scope of flights to be included; the treatment of the climate impact of non- CO_2 effects; and the way emission allowances are distributed.

- **Extending certificates to non-CO_2 emissions:** CO_2 is not the only greenhouse gas released into the atmosphere during air travel. The latest estimates indicate that nitrogen oxides, other particles and condensation trails have two to four times the impact on the climate of CO_2. But including these effects in emissions trading would entail vastly more data, that is not easy to get, and creating some common metrics, increasing the burden of administration. If this is not possible, there would be a need to develop mechanisms to deal with the non-CO_2 effects.

- **Allocation regional or on EU level**: Due to the fact that international aviation has been regulated for a long time, the sector should be more homogenous than others and thus be better suited to harmonised allocation than stationary sources. Besides, international aviation is not subject to the EU Burden Sharing Agreement, which enables a higher degree of centralisation.

- **Allocation procedure**: Assuming that air transport would be included in 2008, allocation would be undertaken under current rules, i.e. minimum 90% for free. This raises the issue of allocation method and base year. As the sector is highly dynamic, with new companies entering the market, the definition of new entrants creates a serious barrier to the application of grandfathering to aviation. More practical problems include reliability and availability of entity-specific emissions data, which is a prerequisite for grandfathering.

- **Benchmark year**: Economic fluctuations and other effects mean that newer, more efficient technologies are not introduced in linear fashion, in the aviation industry in particular. Besides, many new airlines have entered the market in recent years. The case is often made, therefore, that using a single benchmark year (1990) is unfair, and that setting a benchmark period instead would even things out somewhat.

- **Volume available for allocation**: As for other sectors, discussion centres on setting this volume so as to reduce emissions by 8% versus the baseline year in phase I (2008-2012) and 15-30% by 2020.

Scale of impact on prices depends on many factors

In all variants studied, emission reductions will foremost take place in other sectors due to the higher marginal abatement costs in the aviation sector. The industry will therefore probably be buying emissions rights more than selling them. The scale of the impact on ticket prices crucially depends on the cap set for emission allowances distributed to the aviation sector. The study concludes that if a cap was set at the 2008 emission level, the impact on ticket prices in 2012 would be modest.

Impact on volumes expected to be limited

Finally, the impact on transport volumes depends on the elasticity of demand for tickets. Low-cost airlines will therefore be more affected than higher cost airlines, with business class being a segment where price elasticity is lower. But even within this group, the effects will vary. Those airlines with more intra-EU travel will be more affected than those that have a higher proportion of intercontinental travel. One possible consequence of the bias would be leakage. Airlines may adapt their flight paths to minimise the distance flown in EU airspace, which could result in longer flight distances and an overall negative impact on fuel use and emissions.

Later inclusion could bring unwanted side effects

Further more, if these issues cannot be settled soon, it looks questionable whether aviation can be included in the first phase of emissions trading (2008-2012) at all. Later inclusion, however, could bring unwanted side effects, as well as delaying emissions cuts. There is a danger that airlines could refrain from making significant efforts on emissions reduction, e.g. by carrying out renewal investment, during the benchmark period in order to keep the benchmark figures as high as possible.

Levying charges

Emissions-related charges expected to have greater impact on emissions than ETS

The inclusion of aviation in the EU ETS will give the aviation sector incentives to reduce its CO_2 emissions, but these incentives will remain relatively limited. A significant finding so far has been that, for any given reduction target, emissions-related charges (or taxes) have a greater impact on airline operating costs and demand for air travel than, for example, open emissions trading. For the reduction targets assumed in the ICAO analysis the costs of CO_2-related charges (or taxes) would range from approximately $47bn to $245bn annually and would be largely achieved through dramatic fare increases.

Kerosene tax, …

In addition, aviation still enjoys a zero-tax rate for fuel, with a few exceptions (domestic flights in the Netherlands for example). This distorts the transport market. A kerosene tax on intra-EU flights is legally possible. Two reasons motivate a tax linked to fuel consumption: first, greenhouse gas emissions are closely linked to fuel consumption and second, the current exemption of kerosene from tax represents a subvention discriminating against the other transport sectors. Combining kerosene tax with emission-related LTO fees would have a direct effect on real emissions, as it is during take-off and the landing that most emissions occur.

… tax linked to emissions, or…

Even more efficient would be a tax linked to all emissions. The revenue that could be raised from emissions charges based on a bundle of relevant indicators introduced worldwide is comparable to that from a kerosene levy. If it could indeed be implemented around the world, the environmental effect would be better because a number of different types of emission would be included. It is far more realistic that such charges might be brought in on a regional basis; under this scenario emissions charging would be far superior to a kerosene tax. The effect on behaviour and the revenue would be higher, as there would be much less scope to dodge a specifically calculated emissions charge than a kerosene levy.

Examples of charges for selected flight distances and aircraft types

Aircraft	Avg. Number of seats	distance class (km)	CO2 charge (€)	NOx charge (€)	contrail charge (€)	Sum = Standard charge	Charge per passenger (national, €)	Charge per passenger (international, €)
Boeing 737	123	200	152	77	168	397	4.8	2.4
		400	254	145	280	679	8.2	4.1
		500	269	151	297	717	8.7	4.3
		1,000	476	238	524	1,239	15	7.5
		2,000	900	415	991	2,305	28	14
Airbus A300	259	200	295	186	325	806	4.6	2.3
		400	501	355	552	1,408	8.1	4
		1,000	922	550	1,016	2,488	14.3	7.2
		2,000	1,710	891	1,882	4,483	25.8	12.9
		4,000	3,342	1,613	3,679	8,634	49.8	24.9
		8,000	6,930	3,338	7,630	17,898	103.1	51.6
Boeing 747	377	200	574	469	632	1,674	6.6	3.3
		400	1,030	1,046	1,134	3,210	12.7	6.4
		1,000	1,765	1,518	1,943	5,225	20.7	10.3
		2,000	3,225	2,381	3,550	9,156	36.2	18.1
		4,000	6,237	4,297	6,867	17,400	68.9	34.5
		8,000	12,793	8,714	14,085	35,593	140.9	70.4

Source Brockhagen and Lienemeyer, 1999

... or stopping the VAT privilege via ticket tax

Besides, there is no justification for keeping the VAT privilege that the aviation industry has enjoyed for decades. Introducing ticket taxes may turn out to be easier than the factual introduction of VAT on international air tickets, and the purpose is more or less identical. There is unlimited policy freedom in this area – some member states such as the UK and France have already introduced such taxes.

Noise-related airport charges

Current ICAO policy on noise-related charges is based on the principle that the charges levied should not have a fiscal aim and should recover no more than the costs associated with alleviating or preventing noise. In general, the basis for user charge costs is defined as the full cost of providing the required airport services and facilities. In the context of noise-related charges this can include the costs of noise monitoring, of insulating houses against noise and of purchasing houses and land in areas adversely affected by noise.

Airport NO_X charges

Increasing number of airports in Europe implement NO_X charges

In response to regulatory obligations and political pressures, an increasing number of airports in Europe feel compelled to implement NO_X charges. This is typically done by making aircraft engine NO_X emissions a constituent part of the airport landing fee. With some airlines being charged and others receiving rebates, the sum total of the combined incentives would normally be zero, so that the scheme is revenue-neutral for the airport. Although revenue-neutral charges generally tend to have modest cost impacts for the industry, the differential effect on individual airlines can be substantial, based on their fleet composition, age and utilisation. In addition, the environmental benefits of NO_X charges are very uncertain.

Examples from the industry

Climate change

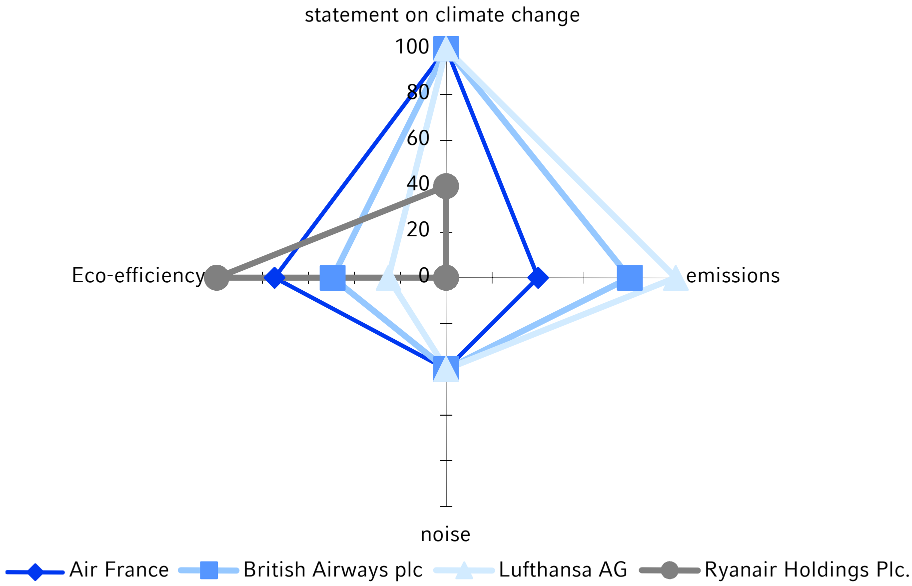
Public statement on climate change …

One factor used in our Extra-Financial Risk Navigator in light of the problems outlined above is whether a transport company is tackling the issue of climate change at all and whether it has issued a statement on the subject (see p. 48). They need to show not only that they judge climate change to be a relevant issue, but also that they recognise their responsibilities as a stakeholder and polluter, and are prepared to act on this responsibility.

… delivered by all airlines except Ryanair

Apart from the budget carrier Ryanair, all of the airlines have made such declarations. Air France has a number of initiatives researching the impact of air travel on climate change and ways in which it can be reduced. British Airways' long-term strategy aims to increase the fuel efficiency of the fleet and support developments in emissions trading. Lufthansa's website describes various issues in relation to transport and climate change, stressing the company's own responsibility for reducing emissions and declaring climate protection to be a central objective in its environmental protection efforts. Lufthansa is also supporting a range of scientific studies into climate change. Although Ryanair says it aims to reduce CO_2 emissions, partly by switching from older, less fuel-efficient planes, it makes no explicit statement on climate change.

Sustainable mobility profile of airlines as reflected in our extra-financial risk rating



Source WestLB Research, SiRi Company

Noise and air pollution

Lufthansa is sector leader

Lufthansa is the sector leader in reducing air pollution. Energy-saving activities aimed at conserving resources, protecting the climate and reducing costs are at the heart of its operational environmental protection measures. Lufthansa is also supporting a range of scientific studies, particularly research into the climate and noise pollution. The company's objectives include cutting the fleet's specific fuel consumption by 33% between 1991 and 2008 and 38% by 2012 (there are separate targets for the Passage, Cargo and Thomas Cook divisions). The focus here is on fleet renewal. A process of constant renewal brought the average age of the entire Lufthansa fleet down from 8.4 to 8.1 years in 2005. Lufthansa is therefore one of the world leaders in terms of modernity and environmental friendliness, and the introduction of the Airbus A380-800 from 2007 will only improve this. The most efficient plane in the Lufthansa fleet is the A330-200 used by Thomas Cook UIK, which consumes 2.67 litres per 100 passenger-km. (For details on the fleet including specific fuel consumption see appendix.)

The Lufthansa fleet made 706,560 flights in 2004, covering more than 22 billion tonne-km. Despite that, specific kerosene consumption continued to fall, owing in particular to improved fuel efficiency and increased utilisation. Passenger flights in 2004 burned just 4.29 litres per 100 passenger-km. By end-2004, specific fuel consumption had been cut by 31.7% versus 1991 levels – 96% of the way to the target for 2008.

Lufthansa fleet – environmental figures

Environmental figures		2004	2003	% change
Energy consumption				
Fuel consumption, total	tonnes	6,524,818	5,955,566	9.6
Fuel consumption, traffic	tonnes	1,373,720	1,226,536	12.0
Fuel consumption, cargo	tonnes	6,524,818	6,441,084	1.3
Fuel consumption, specific, traffic	l /100 pkm	4.29	4.31	-0.5
Fuel consumption, specific, cargo	g/ tkm	185	185	0.0
Emissions				
CO2 emissions	tonnes	20,579,279	18,783,853	9.6
CO2 emissions, specific, traffic	kg/100 pkm	10.815	10.88	-0.6
NOx emissions	tonnes	96,018	89,639	7.1
NOx emissions, specific, traffic	g/100 pkm	49.5	50.9	-2.8
CO emissions	tonnes	15,744	14,413	9.2
CO emissions, specific, traffic	g/100 pkm	8.6	8.8	-2.3
Unburned hydrocarbon (CH4) emissions	tonnes	2,253	2,338	-3.6
Unburned hydrocarbon (CH4) emissions, specific, traffic	g/100 pkm	1.0	1.1	-9.1

Source Lufthansa

Target is tied to reducing emissions of specific pollutants and curbing noise pollution close to airports

This target is tied to simultaneously reducing emissions of specific pollutants and curbing noise pollution close to airports. As well as employing new technologies (including, for instance, an optimised reserve fuel process to minimise fuel consumption and pollutant emissions by calculating fuel requirements more precisely), Lufthansa also states that it is trying to cut fuel use via measures like optimising flight routings, smoothing out take-off and landing cycles, and varying flight speeds to make the most of wind conditions. It is also involved in R&D into the options for minimising noise onboard and from aircraft, although it does not publish specific noise reduction targets. Finally, the company's environmental protection strategy includes creating smart transport concepts in collaboration with rail and local transport operators, improving group-wide energy management, improving internal and external communications on the environment, and building and improving the group-wide environmental database.

British Airways above sector average

British Airways has also a better than average record on emissions reduction. Back in the late 1990s, it set itself the target of improving fuel efficiency by 30% from 1990 levels by 2010. Fuel efficiency was already up 27.4% by 2004/05, so BA is 90% of the way there. If the target is reached ahead of schedule, BA plans to set itself new, more demanding targets. Fuel consumption is now down to 3.8 l/100 passenger-km. This means the company has already surpassed the target for 2008 which various airlines agreed at the March 2004 Geneva Aviation and Environment Summit. In terms of local air pollution, BA is concentrating above all on reducing nitrogen oxide (NO_x) output. As with noise pollution, BA is striving for the balanced approach supported by the ICAO (International Civil Aviation Organisation). This means that, as well as adopting technical methods of cutting emissions at source, changes to take-offs, methods for planning land utilisation and regulation of night flights are also included. BA publishes concrete data per airport on noise pollution and nitrogen oxide levels. There are no specific targets for these, however.

BA fleet – data on specific fuel consumption

Fleet	fleet (end 2005)	capacity (seats)	Range (km)	Fuel consumption (Imp. gallons/h)	avg. utilisation (hours/day)	introduced in	avg. age (years)
Longhaul flights							
Boeing 747-400	57	351	12,584	2,813	13.4	1989	10.4
Boeing 777-200A	3	219	8,499	1,672	10.9	1995	8.5
Boeing 777-200IGW	24	224	10,448	1,823	13.0	1995	6.6
Boeing 777-200ER	16	274	13,859	1,823	12.4	2000	4.1
Boeing 757-200	13	180	3,432	923	8.1	1990	10.7
Boeing 767-300 (short/long haul)	21	252/181	5,467/9,304	1,199/1,279	11.6/8.0	1990	11.7
European+domestic flights							
Airbus A319 (Note 2)	33	126	1,859	590	8.7	1999	4.1
Airbus A320-100/200	27	150	1,622/3,285	657/665	6.4	1988	12.9
Airbus A321	6	194	3,692	590	8.1	2004	0.0
Boeing 737-300	5	126	1,865	671	10.0	1998	15.4
Boeing 737-400	19	147	2,285	671	9.3	1991	12.1
Boeing 737-500	10	110	2,096	596	10.0	2000	12.4
Avro RJ100	16	110	1,603	714	6.7	1997	5.2
BA connect fleet (European+domestic)			(naut. miles)	(kg/engine/hour)			
Embraer RJ145	28	50	1,500	559	7.5	1999	4.5
British Aerospace 146-100,200/300	4/1	95/110	1,100	470/480		1995/2000	17.8/14.4
de Havilland Canada DHC-8	10	50	1,180	450	8.0	1996	8.0

Source British Airways

Air France

Although Air France publishes programmes for the reduction of air and noise pollution, it places its emphasis on fleet renewal and environmental management. The company also says that it supports extending the European emissions trading scheme to the transport sector, its aim being that companies that observe emissions targets will not be penalised. This is evidently also the reason why Air France has not yet set itself any quantitative targets for either emissions or noise pollution. Because of this, Air France only comes out below average in both categories.

Air France KLM fleet – environmental figures

		2004/05	2003/2004	% change
global aircraft emissions*	CO_2	24,147	23,081	4.6
	NO_X	120	115	4.3
	CO	13	14	-7.1
	HC	3.4	3.8	-10.5
of which low altitude emissions ('LTO cycle')**	CO_2	1,592	1,560	2.1
	NO_X	6.7	6.4	4.7
	CO	5.8	5.9	-1.7
	HC	1.1	1.1	0.0

* excl. Subsidiaries, except KLM cityhopper
** including all subsidiaries, except transavia.com

Source Air France/KLM

Ryanair

Ryanair states on its website that its entire fleet has fulfilled EU stage 3 noise requirements since April 2002. In order to reduce emissions and noise, it is replacing old aircraft with new. The old Boeing 737-200 is gradually being replaced by the new B737-800 model. The corporate policy of serving under-utilised airports and raising the load factor is also good for emissions. The company is vehemently opposed to emissions charges, saying that it would restrict access to air travel for less well-off sections of society – the airline's main target group. However, it does not give any detailed figures on environmental protection or any concrete targets.

Rail

It would be impossible to discuss sustainable mobility without touching on rail transport. Rail's greatest attributes are that it is environmentally friendly and efficient in terms of capacity, energy, space and time. This applies equally to passenger and freight transport. No other transport system offers as much transport volume capacity at such a low (external) cost. From a social perspective, rail contributes to sustainable development, particularly to social equity in terms of the access to mobility that it provides, and its high safety standards.

A sustainable sector that's not valued…

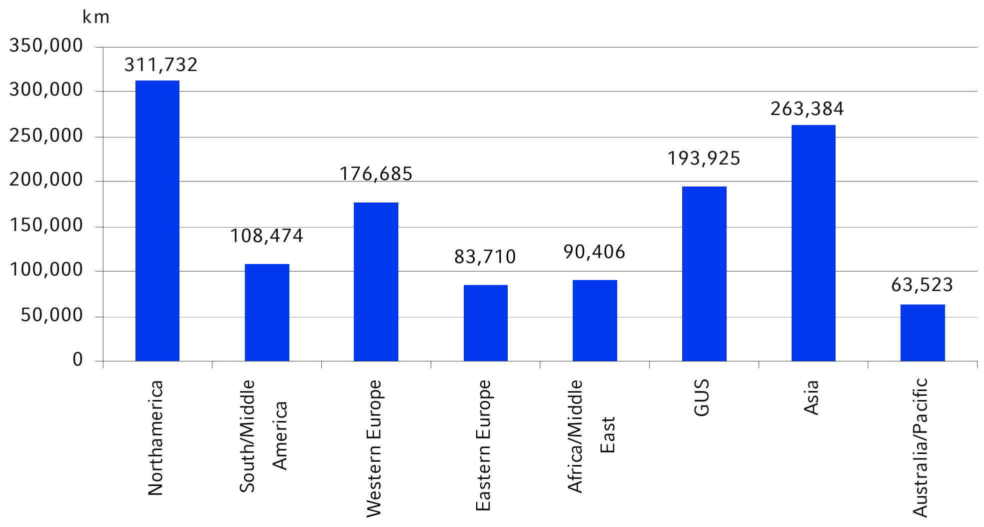
Environmentally friendly and efficient

It would be impossible to discuss sustainable mobility without touching on rail transport. Rail's greatest attributes are that it is environmentally friendly and efficient, and above all an alternative to the overloaded road system for freight transport. A SOFRES survey found that 79% of Europeans questioned felt that a modal shift in freight transport from road to rail was inevitable.

All the same, rail is continuing to lose market share in Europe

But despite this, the momentum has continued to move in the opposite direction in Europe. In the last 30 years, an average of 600 km of track have been closed each year, while new road building over the same period has run at about 1,200 km p.a. Between 1970 and 1998 the share of the goods market carried by rail in Europe fell from 21.1% to 8.4% (down from 283 billion tonnes per kilometre to 241 billion), even though the overall volume of goods transported rose spectacularly (EC, 2001). While the key routes between the big centres have been upgraded, uneconomic routes were withdrawn. Above all, due to the increasing urbanisation and the fact that more and more people are concentrated in high density regions, railway lines were closed down in whole regions and substituted by road transport. In these regions, public transport is almost exclusively provided by buses. It now transpires that some of the stretches of track that have been axed could have fulfilled important link functions as Europe grows closer together and transport volumes continue to rise.

Rail infrastructure worldwide

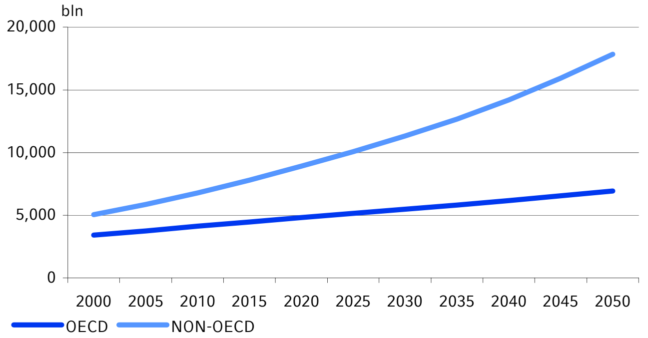


Source Vossloh

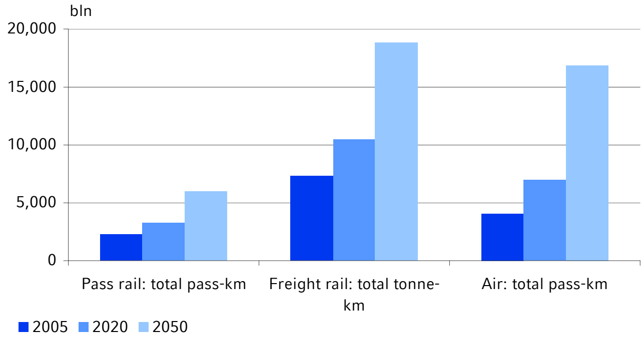
It is not just in passenger transport, but also in freight, that rail has lost significant market share in Europe. According to the EEA, between 1970 and 1998, the proportion of the total freight volume conveyed by rail shrank from 21.1% to 8.4%. And the decline was not only in relative terms: the total volume fell from 283 billion tonne-km to 241 billion tonne-km.

By contrast, rail transport gained market share in the USA over the same period, currently accounting for some 40% of total freight volume. A study commissioned by the WBCSD forecast substantial growth for rail transport volumes over the next 40 years, concentrated in non-OECD countries.

Rail (passenger/freight): total passenger & tonne km



Rail (passenger/freight) vs. Air (passenger)



Source SMP, 2004

In order to revitalise this form of transport in Europe as well, the European Commission has now agreed a package of measures supporting rail, which centre on liberalising competition.

High efficiency at low cost

The advantages of rail are obvious: it is highly efficient in terms of capacity, energy, space, time, etc.

Rail has some key advantages over other forms of transport, the most important being its efficiency in terms of capacity, energy, space and time. This applies equally for passenger and freight transport. No other transport system offers as much transport volume capacity at such a low (external) cost. From a social perspective, rail also contributes to sustainable development, be it in regard to the high safety standards or the social justice in access to mobility.

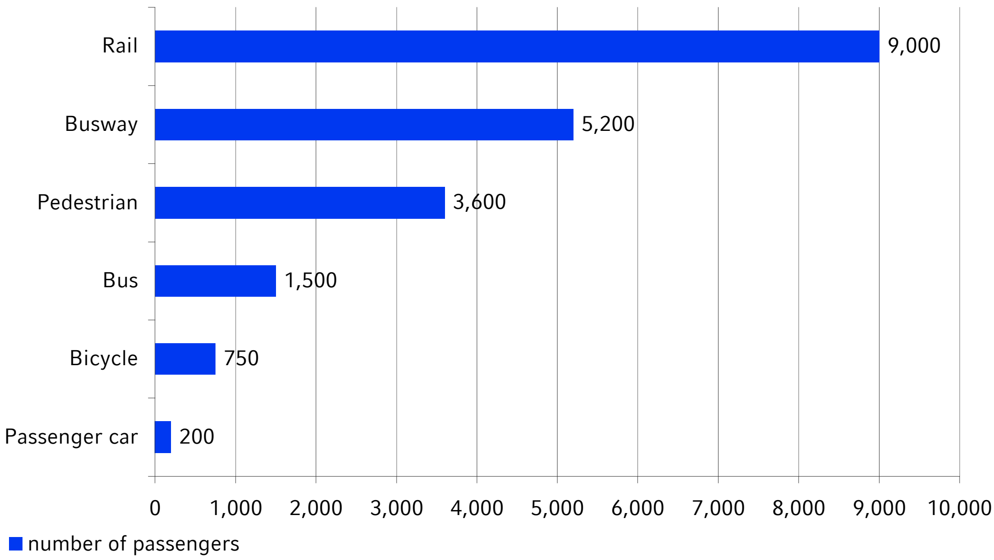
Capacity

Theoretical studies backed by empirical evidence show that an urban rapid transit system can move about 60,000 passengers in one direction in the space of an hour. Conveying the same number in cars would require a street 200m wide (around 57 lanes), or around 80m (some 23 lanes) in the case of motorways (UIC, 2002). Even if passengers switched to buses, the carriageway would still need to be seven lanes wide.

Making optimum use of the infrastructure

During the last few years, railway companies have been able to increase capacity by implementing organisational and technical measures. By separating slow public and freight transport from the high-speed (passenger) trains it has been possible to reduce mutual obstructions. Additionally, the employment of electronic train traffic control and supervision system has enabled a reduction in the distance between two trains so that more trains can use the same lane in a specific time period. Last but not least, the intensity of utilisation has been increased significantly by speeding up the trains in general, which was possible by improving the speed-restricted zones or removing bottlenecks, etc.. These measures could even be extended in the coming years.

Capacity per hour per metre width of infrastructure



Source UIC, 2002

Closing down of rail lines has been counterproductive from a trans-European perspective

What has been counterproductive, however, is that, particularly in rural areas, an increasing number of railway lines have been closed in the last few decades in Europe. Of the thousands of kilometres of lines which have been closed to traffic, or even dismantled, there are branches and lines which today would have been extremely useful for coping with saturation on parts of the rail network. With an interoperable trans-European network gradually being put together and traffic growth expected to rise, it is necessary to look again, from a truly trans-European perspective, at how the networks are organised and how they can be better integrated. The rail market shows the greatest potential for growth over long distances. Successful reorganisation means making optimum use of the existing capacity.

Safety

Safety

The high capacity offered by rail also comes with an extremely low risk of accidents. This risk has been reduced further in recent years as safety standards have been tightened. Across the EU-15, the number of people killed on the railways dropped from 1,107 in 1990 to 764 in 1995. For the purpose of comparison, some 43,500 people died in road accidents in 1996 alone. The number of rail accidents fell from 165 to 98 over the same period. Between 1990 and 1998, the number of rail accidents per billion passenger-km across the EU averaged 0.72, versus 13.8 on the roads. However, rates are higher in developing countries.

Social factors

Social equity

Another positive aspect of rail transport is its contribution to society: it is the most efficient way to grant large swathes of the population access to mobility, both for people and for goods, and in rural and urban areas alike. This is especially the case in developing countries, where private modes of transport are not that well developed. But in industrialised countries too, rail contributes to social equity, as it is open to the population at large. As a transport mode rail enables the very groups that are limited in their ability to use private transport means (e.g. cars) to travel – particularly children and young people, the elderly and infirm and those with disabilities, but also poorer people who cannot afford their own vehicles – to get access to vital services (e.g. health and education) and to participate in social activities.

For rail to retain its social function, it is imperative that it remains accessible to everyone

Industrialised nations have promoted this side ever since the birth of rail, when the railways came under the control of the state or were at least part-financed by it. In recent years, however, some of this has been lost with the growth in private transport. Trains have been axed and lines closed. For rail to retain its social function, it is imperative that it remains accessible to everyone, even in less economically attractive regions, such as rural areas. But it is precisely here that the axe has fallen. Developing countries, meanwhile, often lack the money to invest in a comprehensive rail network in the first place.

Flexibility

Flexibility is not one of rail's strong points

In terms of flexibility – another form of efficiency – however, rail ranks a long way behind other modes of transport, notably roads. Rail is therefore at a disadvantage in industrialised countries, where the majority of the population has access to private transport.

The lack of interoperability between different rail systems can often act as a barrier; it has been possible for quite a while for lorries and, by and large, cars to travel right across Europe, but this is still not feasible for trains, owing to differences in electrification and signalling systems.

Low costs

Intermodality with other forms of transport is therefore imperative if proper use is to be made of the efficiency benefits of rail within a sustainable transport concept. This is especially important as the external costs are considerably lower compared to other motorised forms of transport.

External costs

Rail is responsible for only 2% of external costs caused by transport

A study by INFRAS/IWW estimated the average external costs of passenger transport in Europe in 1995 (excluding congestion) at €85 per 1,000 t transported on the roads, against €20 per 1,000 t on the railways. For freight transport, the costs were put at €88 and €19 respectively. The marginal external costs per passenger km are estimated to be three to five times higher for road transport than for rail; the factor for freight transport is between three and four, depending on the type of vehicle and circumstances. The share of rail in overall external transport costs is estimated at 2%, compared to a cumulated share of cars, LDVs, and HDVs of 87%.

Climate change

Environmentally friendly form of travel

Travel has become one of the largest causes of global warming due to its emissions of the greenhouse gas carbon dioxide (CO_2). Train journeys, however, are the environmentally friendly way to travel. Per passenger, a long-distance train journey creates just under one-third of the CO_2 emitted by a car and 70% less than an aeroplane.

And although rail's CO_2 profile is already far better than that of other forms of transport, rail operators have made concerted efforts in past years to reduce CO_2 emissions even further. Deutsche Bahn, for example, has reduced CO_2 emissions per passenger-kilometre by over one-quarter since 1990 and aims to reduce these by at least another 15% by 2020.

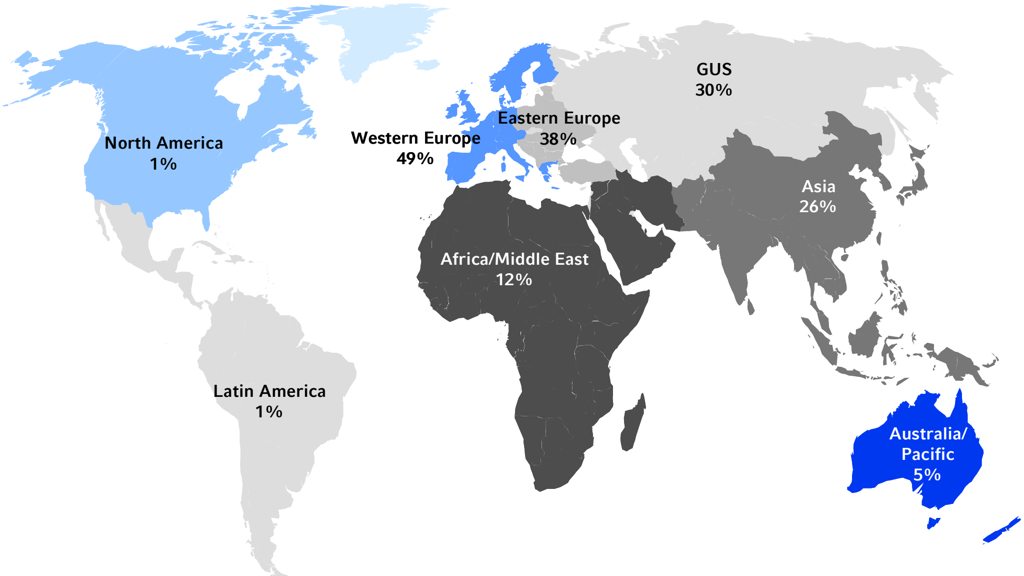
The key way to reduce CO_2 emissions (assuming transport volumes remain constant) is to employ energy-efficient technologies and increase transport capacity per unit of weight as well as capacity utilisation. Intermodal systems can also help to lower CO_2 output.

Employing energy-efficient technologies

Main energy sources are diesel and electricity

The majority of rolling stock is powered by electricity or diesel engines. Worldwide, the lion's share of the energy used by locomotives – 59% – is diesel, while 27% comes from external sources and is stored as electricity, and 12% – mainly in China – is derived from coal. There are major variations between individual countries as to which forms of energy are used. US and Canadian trains mainly run on diesel, while 78% of Japanese trains and 61% of Europe's rolling stock are electrically powered.

Level of electrification worldwide



Source Vossloh

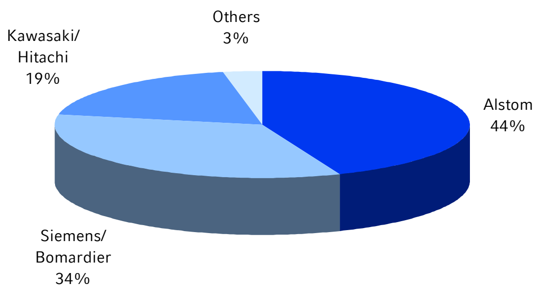
Hybrid locomotives are an alternative

Electrically powered trains are especially suitable for using energy from low-emission sources such as hydroelectric and wind power. Fuel cells are being considered as an additional energy source for diesel locomotives. They would enable the main diesel engine to be shut down when the locomotive is stationary but needs energy. Diesel locomotives are left on idle for an astonishingly large proportion of their operating time. A recent study into the work cycle of the Canadian railroads estimated the proportion of idle time at 54-83% of overall operating time. Using fuel cells as additional engines or hybrid add-ons would therefore cut the operating time of diesel engines considerably and help significantly reduce CO_2 emissions. The USA and Canada are already testing some of these hybrid locomotives.

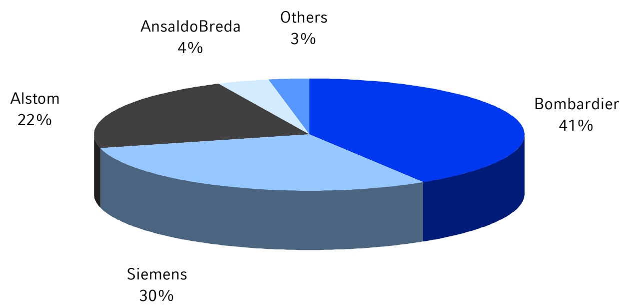
Aerodynamics and weight affect energy efficiency

The energy consumption of high-speed trains can also be reduced by using aerodynamic design. Air resistance accounts for some 50-70% of total resistance in this segment. In local transport, however, the process of accelerating and braking is the key element in the energy profile, so to improve energy efficiency, the plan is to reduce weight, for example by using lighter materials.

Market share high-speed trains, global



Market share electrified locomotives Europe



Source Vossloh

ICE 3 as an example

ICE 3, which is manufactured by the Siemens, Alstom and Bombardier consortium, is an example of how energy can be saved. It has a lightweight aluminium construction, optimum aerodynamics and the option of recovering power during braking, thanks to its higher number of axles than ICE 1 or 2. At 40% seat utilisation, its energy consumption was lowered to 2 litres of fuel per passenger/100 km. In the case of Hamburg's new DT 4.5 underground trains, lightening the construction and using energy-efficient components achieve energy consumption of 0.9 kWh per passenger kilometre, compared with the international average of approx. 1.1 kWh/pkm.

Efficiency improvements from innovative braking systems

A further example of how technical innovation can improve the environmental profile is a compressor developed specifically for the rail industry. It produces the compressed air used by braking systems and other pneumatic equipment in a particularly quiet, low-vibration and easily maintainable way, which is up to 20% more energy-efficient than conventional solutions. Using this new technology can save 25% in weight. Specially coated pistons mean the compressor can also work without any oil lubrication, so there is no need to cool and change oil.

Life cycle analysis in terms of energy consumption

Siemens Transportation Systems (STS) has analysed the entire life cycle of a newly developed series of metro trains for Oslo in terms of energy consumption. The analysis reveals that most energy is consumed by traction and auxiliary power units (95% over a 30-year life span), with 4.46% spent on obtaining and processing the raw materials used in the manufacturing process. By using 50% secondary aluminium, the energy consumed in manufacturing could be significantly reduced to just slightly more than the value for stainless steel. Although stainless steel is a little heavier, it is the better option for heat insulation. Reducing weight and enhancing propulsion technology are the most effective measures. STS's research also revealed further improvement potential.

Alstom & Siemens – overall rating and transport-related criteria

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)	
	Overall		Environ-ment	Gover-nance	Stake-holder	T&P to reduce end of life-cycle impact	Products beneficial to env.
	Rating	Z score					
weight			**40%**	**15%**	**45%**	**1.88%**	**3.00%**
Heavy Electrical Equipment							
Alstom	B+	-1.32	-0.90	-0.25	-1.22	40	50
Industrial Conglomerates							
Siemens	A	0.1555	-0.179532	0.61867	0.79309	na	75

Source WestLB Research, SiRi Company

Improving efficiency by increasing transport capacity per unit of weight

Double-decker cars: higher capacity for same energy consumption

Another way of reducing energy consumption per transport kilometre is to increase train capacity, which is easily achieved in both passenger and freight transport by using double-decker cars. This a favourite option in the USA. In Japan, Rail East's E1 double-decker, high-speed trains have 40% more seats, without increasing the weight of the trains. Similarly, the TGV Duplex operated by France's SNCF has 40% more seating capacity at no greater energy consumption than comparable single-decker TGVs.

Intermodal transport

Rolling highways

The clever combination of rail and road traffic – for example, in the form of so-called 'rolling highways', whereby entire trucks are transported by train – can significantly reduce CO_2 emissions, particularly in freight transport. In Switzerland alone, almost 370,000 consignments in 2001 were diverted from road to rail and transported over the Alps by Hupac and Ralpin. This has saved 91,000 t of CO_2 per year (as at September 2001). By 2007, this amount should rise – not least due to the opening of the Lötschberg tunnel – to 230,000 t of CO_2 p.a.

Suitable hubs are key

However, intermodal transport often lacks suitable hubs. Progress has been made in the last few years, especially in industrialised nations: numerous Park & Ride systems have been set up to transport passengers; a wide variety of transport systems have been linked to each other at and near major railway stations; and some high-speed trains stop at airports. Shopping centres, designed as meeting places and to raise the appeal of public transport, are increasingly being incorporated in larger train stations. However, the success of the various constructions varies from country to country.

Toxic emissions

The debate particulate matter has well and truly put the spotlight on the risk of local emissions, which can damage people's circulatory systems and respiratory tracts and cause cancer. Due to the higher population density, the same amount of pollutants causes far more harm to health in inner-city areas than in regions far from conurbations.

Electrically powered trains have a far better toxic profile

This is another area where electrically powered trains offer significant advantages over lorries and cars, and not just because low-polluting energy sources can be used for fuel. At the same time, with traditional power stations the pollution is emitted much further away from the majority of inhabitants (e.g. due to high chimneys and locations outside conurbations). This reduces toxic concentrations for individuals considerably. These days, the large-scale filter systems in power stations are already much better at removing air pollutants and particles from emissions than many passenger car exhaust systems.

Rust particle filters reduce toxic emissions from diesel locomotives

The use of diesel locomotives, especially in inner city areas and tunnels, is of course the weak spot of rail transport with respect to its environmental sustainability profile. Toxic emissions, however, can be significantly reduced by using higher-quality diesel, biodiesel or biogas, or at the very least rust particle filters. Toxic emissions from biodiesel are half as low as from traditional diesel. The downside of this is that there is very little chance of a significant swing towards biodiesel given the current supply and demand situation.

In the USA, strict regulations on operating diesel engines in the context of clean air targets are forcing rail companies and their suppliers to find new ways of reducing toxic emissions. SCRRA and Union Pacific have started testing the use of natural gas with the aim of slashing NOx emissions. Some countries have recently started encouraging the use of diesel fuel with a lower sulphur content.

World's first biogas train running in Sweden

In June 2005, the world's first biogas train came into operation in Sweden: two Volvo gas engines have replaced the old diesel engine of the renovated Fiat railcar. France's SCNF now intends to conduct research into converting the propulsion units of its X 73500 TER diesel trains into gas engines. Trenitalia Cargo is planning to develop a prototype locomotive powered by hydrogen.

Deutsche Bahn is opting for particle filters

Deutsche Bahn AG announced in 2004 that in future, it would only buy diesel locomotives fitted with rust particle filters. It also planned to fit particle filters to its existing fleet, and where this was technically impossible, would replace the locomotives' engines with environmentally friendly versions. The diesel locomotives it is putting into service include Vossloh's Am 843, which is used for shunting, track laying and freight transport. They are fitted with special silicon carbide filters that remove about 99% of rust particles 20-300 nanometres in size. Over an average working life of 30 years, this equates to a total reduction of about 40 tonnes of environmentally damaging fine dust. These locomotives already meet strict emission standards that are unlikely to become binding in Germany for another five to ten years.

Noise levels

Noise is one of the most serious environmental problems…

Noise has become one of the most serious environmental problems in heavily populated industrial nations such as Germany, but also in conurbations in developing countries. Traffic noise is a particular nuisance to city dwellers. According to a study by the German Federal Environment Agency, almost 60% of Germans feel road noise is a nuisance. The figure is about 32% for complaints about airplane noise and about 20% for train noise.

… with high external costs

The external costs of noise arise from the reduction in land value and the noise-induced risks to health. In terms of external costs per passenger kilometre, rail travel comes out about 30% better than private travel and more or less the same as air traffic. Buses, however, are four times better. In terms of freight transport, the external costs of noise for road travel are about 50% higher than for rail, whereas transportation by ship is far cheaper.

Technology can significantly reduce noise pollution

Noise pollution is particularly high in the vicinity of freight depots, so choice of location and design of transfer stations play a key role. But the rail tracks and trains themselves also offer potential for significantly reducing ambient noise. The options include building noise insulation walls; employing noise insulation material such as hard rubber inserts between rails and sleepers; smoothing uneven rail surfaces, which are responsible for a significant part of overall noise emissions; using lightweight wheel systems and absorbers to mitigate the wheel noise directly at its source; and installing quieter braking systems.

In the USA, systems for checking the condition of wheel sets are mandatory for inter-state-used cars (UIC, 2002). In Germany, the TSI directive (technical interoperability specifications), which was passed in November 2004 and enacted in mid-2005, has introduced binding limits on noise emission for conventional rolling stock. Acoustic quality management is intended as a procedure for regulating the client-manufacturer relationship in acoustic matters and identifying acoustic weaknesses in a vehicle early in its development. But the main potential for achieving even greater cuts in rail traffic noise comes from combining the various measures in a sensible way.

Deutsche Bahn intends to reduce rail noise by 50%

Deutsche Bahn has set itself a target of cutting rail noise by about half by 2020, compared with 2001's figures. As part of the European noise mitigation project 'Noemi', Deutsche Bahn has tested various sound insulation measures on high-speed tracks. The technical innovations include actively controlled current collectors, which can help reduce noise by up to 10 dB(A), equivalent to halving the noise emissions perceived by humans (see chart on p. 25). Since autumn 2004, the Berlin S-Bahn has been equipped with 1,000 of the most modern trains. In order to further reduce noise during approach and braking, DB is considering using anti-vibration material and noise aprons covered in noise-insulating plastic foam.

The SNCF has opted for wheel/rail contact measures to reduce rail noise pollution. Almost without exception, new vehicles are fitted with 'quiet' disc brakes, whereas the noise from older passenger and freight wagons with block brakes is reduced by switching to brake pads made of grey iron on composite and sintered materials. However, products capable of providing the necessary braking power need to be developed for heavy freight trains on routes crossing the Alps.

ContiTech and SKF are developing noise-insulated suspension

ContiTech, a business unit of Continental, and SKF have developed new bogie suspension for freight wagons, which is based on rubber components and should vastly reduce noise emissions. It is also expected to bring other advantages, such as safer steering and lower maintenance costs.

Waste products

Recycling rate raised to over 90%

With the issue of waste products also key in rail traffic, efforts are being made to improve the recyclability of the materials used, including fluids and wearing parts. It is estimated that over 90% of a standard train can be reused. Alstom has developed a comprehensive recycling concept for the DT 4.5 diesel train. Its key points are that it uses recyclable components and low-emission materials, such as biofibre composites. The recycling rate has risen to 94.3%, compared with its predecessor's 90.8%. The issue 'Targets and programs to reduce the impact of product at the end of the life-cycle' is also part of our Extra-Financial Risk rating (see table on p. 49).

Land use and biological diversity

The expansion of transport infrastructure, combined with increased transport services, poses a major threat to biological diversity. Noise, light and air pollution, as well as waste water, compromise and/or destroy the natural environment of many creatures. Land use is an indicator of the impact of transport systems on biodiversity. Again, this is an area where rail compares relatively favourably with other transport forms. While the direct and indirect land use of rail is estimated to be 3 ha/km, it is 7.5 ha/km for motorways. The external costs per passenger created by the destruction of the environment and landscape for rail are just less than one-third of those for cars. For freight transport, the external costs per tonne/km are 17% of those for road transport. Shipping causes similarly high 'biodiversity costs'.

Rail also comes out far better than road traffic in terms of the risk of accidents when crossing lines. To protect animals that could be get caught up crossing tracks, many countries have now erected fences with special crossing points for animals.

Marine

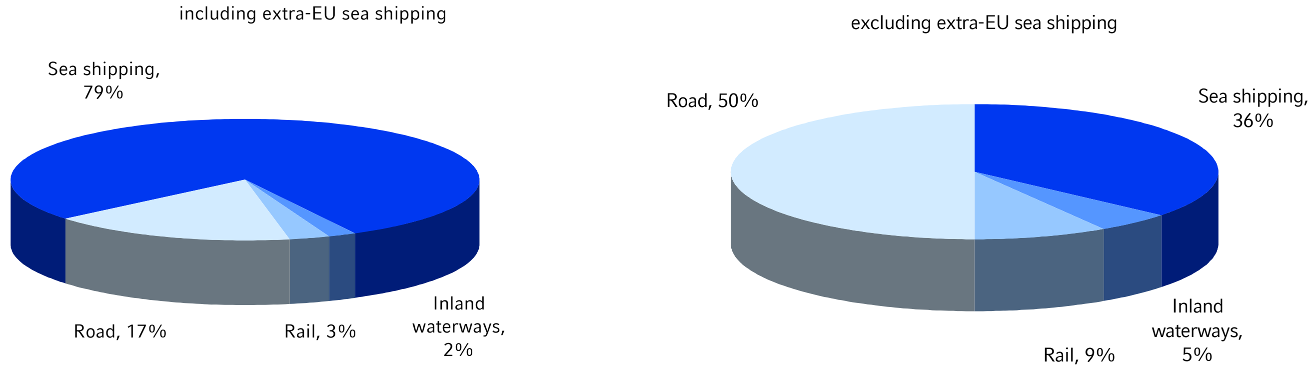
If we consider the proportion of total transport volumes that shipping accounts for, it is staggering how little attention this industry attracts with respect to sustainable mobility. Maritime shipping is one of the most efficient forms of transport, able to convey large quantities of goods across long distances at relatively low cost. It is also one of the safest modes of transport today, and has the potential to be one of the most environmentally friendly too. The lack of regulation leaves the door wide open to misconduct. It will be very difficult to achieve effective multilateral agreements in this area, so companies are likely to keep their mostly defensive approach for now.

Steaming ahead

Shipping is the backbone of freight transport

Shipping is the backbone of freight transport: around 90% of all consumer goods globally travel by ship. 95% of US goods imports, for example, come by sea. Estimates for the EU-25 show that it accounts for almost 80% of the total transport volume (in tonne-km), including shipping to and from non-member states. It is, however, extremely difficult to pinpoint international freight volumes owing to inadequate registration. But even if we exclude extra-EU transport, sea shipping still makes up some 36% of EU-25 freight volumes, with inland waterways accounting for about 5%.

Current shares of freight transport volume (tonne-km), by mode, EU25



Source EEA, 2006

Fastest growth in container shipping

UNCTAD (the United Nations Conference of Trade and Development) puts the value of goods transported by cargo vessel at about $380bn, corresponding to around 5% of global trade. In terms of weight, the global sea freight volume for 2004 is estimated at around 6.76 billion t; with freight transport travelling about 4 billion miles in all, that makes 27,635 billion tonne-km, up 4.3% on the previous year. Marine freight volumes are estimated to have nearly quadrupled since 1965, and growth rates averaging 1-4% are anticipated for the coming years. Container ships are expected to enjoy the biggest increase in the years ahead, at 8-9% p.a. They have steadily grown their share ever since being introduced in the 1960s. The volume of trade passing through container ports reached around 303 million TEUs (20-foot equivalent units) in 2004, a 9.6% jump on the previous year, with 122.4 million TEUs or 40.4% visiting ports in developing countries.

World seaborne trade in ton-miles, selected years (billions of ton-miles)

Year	Oil			Iron ore	Coal	Grain*	Five main dry bulks	Other dry cargoes	World total
	Crude	Products	Crude plus products						
1970	5,597	890	6,487	1,093	481	475	2,049	2,118	10,654
1975	8,882	845	9,727	1,471	621	734	2,826	2,810	15,363
1980	8,385	1,020	9,405	1,613	952	1,087	3,652	3,720	16,777
1985	4,007	1,150	5,157	1,675	1,479	1,004	4,480	3,428	13,065
1990	6,261	1,560	7,821	1,978	1,849	1,073	5,259	4,041	17,121
2000	8,180	2,085	10,265	2,545	2,509	1,244	6,638	6,790	23,693
2001	8,074	2,105	10,179	2,575	2,552	1,322	6,782	6,930	23,891
2002	7,848	2,050	9,898	2,731	2,549	1,241	6,879	7,395	24,172
2003	8,390	2,190	10,580	3,025	2,810	1,273	7,454	7,810	25,844
2004	8,910	2,325	11,235	3,415	2,965	1,325	8,065	8,335	27,635

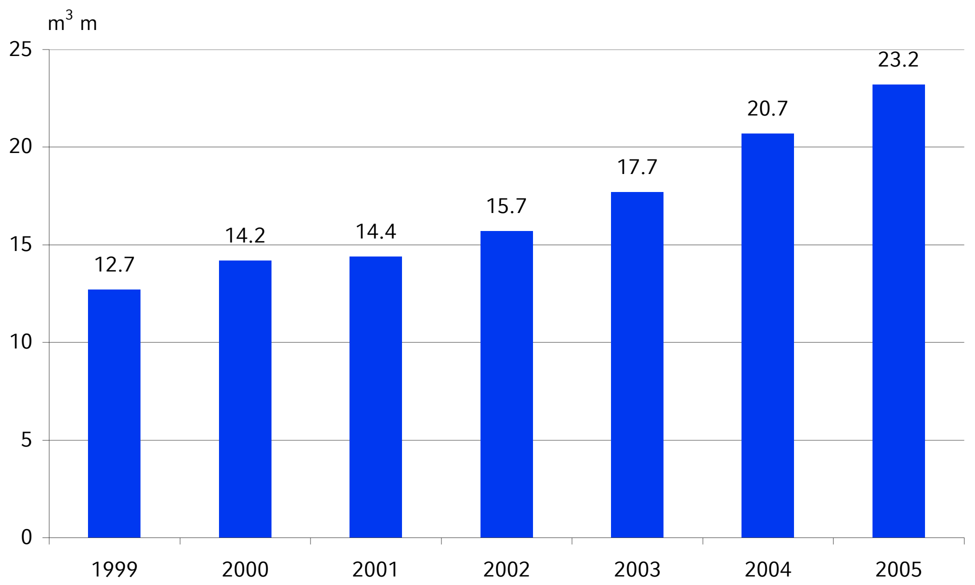
* Includes wheat, corn, barley, oats, rye, sorghum and soya beans

Source Fearnleys Review, 2004

Special trend: trade in liquefied natural gas

Worldwide trade in liquefied natural gas (LNG) is expected to grow particularly fast. According to estimates by Drewry, it is set to roughly triple to 340 million t by 2015. At the end of 2005, 131 LNG tankers were under commission – this equates to almost 90% of the existing fleet. Natural gas can be deep-cooled and transported in liquid form where it would be unprofitable to construct pipelines or the geography makes it impractical. The biggest single market is Japan, where around 43% of the total volume traded globally is consumed. But in Europe too, LNG structures are being expanded in light of the growing problems with Russian gas trading. At the same time, the costs of liquefaction and transport have fallen steadily over recent years.

Global liquefied natural gas tanker capacity



Source FTD, Drewry Shipping Consultants

The shipping industry should not be underestimated as an employer either; in all it employs more than 1.25 million people around the world. This does not include all those involved in coastal trading.

The structure of the shipping industry

Flags of convenience

Even though the overwhelming majority of the global shipping fleet belongs to companies and individuals in OECD states, only 52% of ships flew an OECD state flag in 1999. More than two-thirds of all ships go under flags of developing and emerging countries.

The world's leading flags as at 1 January 2001

Controlled tonnage (according to the headquarters of the controlling shipping line)	No. of ships	Ship size (GRT m)	Registered flag	No. of ships	Ship size (GRT m)
Greece	3,484	85	Panama	5,538	113
Japan	3,803	70	Liberia	1,529	51
Norway	1,92	39	Bahamas	1,218	31
USA	1,905	31	Malta	1,466	28
China	3,054	27	Greece	1,175	26
Germany	2,195	25	Cyprus	1,427	23
Hong Kong	669	20	Norway/NIS*	1,731	22
South Korea	1,42	18	Singapore	1,112	21
UK	1,041	14			
Russia	3,672	14			
Denmark	853	14			

*NIS = Norwegian International Ship Register

Source ISL, 2001

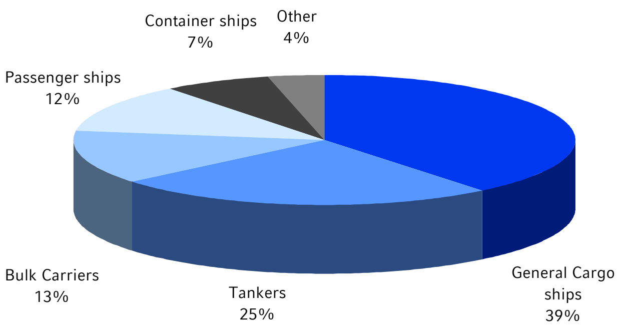
International standards are often flouted

By registering a ship in a particular country, it becomes subject to the sovereignty of that state. This country is then responsible for monitoring observance of international environmental and safety standards. The flag state also lays down the employment law conditions that must be complied with and is authorised to levy income tax on earnings made with the ship. The scope to freely choose a flag state (known as open registration) means that international standards are often flouted, which can bring considerable competitive advantages for ship owners. A raft of international agreements have therefore been reached, enabling port authorities of various states to check that ships docking in their ports comply with international standards, and to impound them if necessary until shortcomings are rectified.

Structure of the global commercial fleet

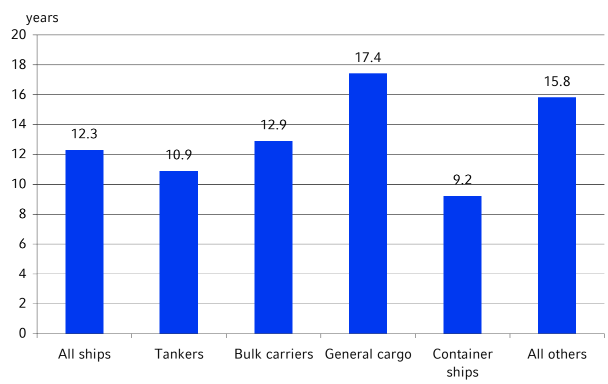
At the start of 2005, the global commercial shipping fleet consisted of 46,222 freight and passenger ships (almost 600 million gross tonnes), up 4.5% year-on-year. Traditional freighters (general cargo vessels and roll-on-roll-off freighters) accounted for the largest slice of this, at 18,150, followed by tankers at 11,356. Also registered were 6,139 bulk carriers (for dry mass goods), 5,679 passenger ships, 3,139 container ships and 1,733 ships of other types. They had an average age as at the start of 2005 of 12.3 years, although 27.3% of vessels were over 20 years old.

World trading fleet by ship types (2005)



Source Lloyd's Register Fairplay January 2005, quoted in ShippingFacts

Age distribution of the world merchant fleet



Source UNCTAD 2005

Container ships steadily growing in significance

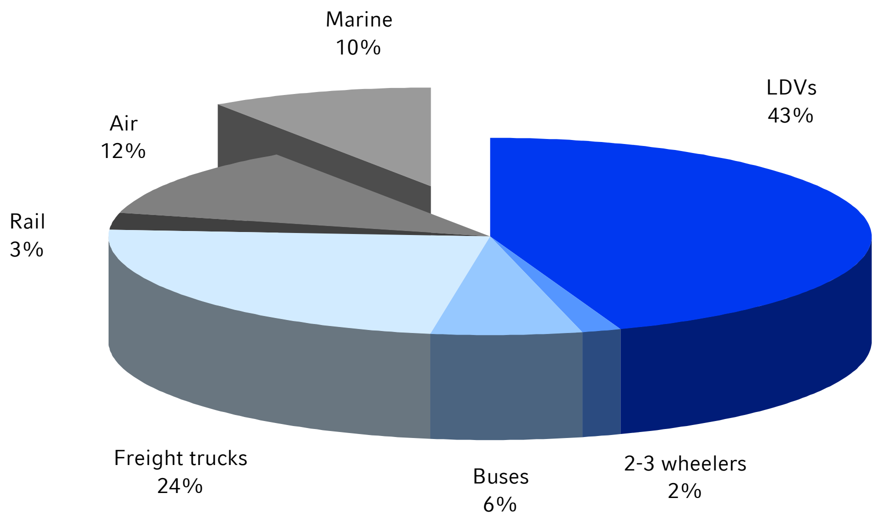
Measured by tonnage, tankers and bulk freighters lead the way. But container ships, which had moved up to almost 11% of the global commercial fleet by end-2004, are closing the gap. Since they first appeared in the 1960s, container ships have not only gained steadily in significance, they have also revolutionised the face of shipping. Containers are now the standard unit for transported goods; nearly all goods can be freighted in them. At end-2004, the loading capacity of the worldwide container fleet was around 7.6 million TEUs, and the number of big container ships (over 4,000 TEUs) is constantly growing. The biggest now carry over 8,000 TEUs.

Shipping and sustainable mobility – the “disguised captain” fails

The safest and most environmentally friendly form of transport

Maritime shipping is frequently described as the safest and most environmentally friendly form of long-distance transport. It is indeed much more energy-efficient than aviation, which emits up to 100 times as much CO_2 per tonne of freight. It also comes out well by comparison with roads. For instance, a study for the British government compared the energy consumption of different forms of transport. It found that the average energy consumed transporting goods by lorry was between 0.7 and 1.2 megajoules/t-km. By contrast, a 3,000 dwt coastal ship travelling at 14 knots consumes about 0.3 mj/t-km, and a medium-sized container ship travelling at 18.5 knots about 0.12 mj/t-km.

Year 2000 World Transport Energy Use by Mode - All Fuels



Source SMP, 2004

Safety has continually improved

Safety at sea has also improved constantly over recent decades. The Lloyds Register of Shipping shows that accident rates per year and per thousand ships, as well as in absolute terms, have fallen continually since the 1980s. They are now below 100 a year. However, we should point out that the number of ships actually sunk is far lower than the number of reported losses. A majority of these losses are in fact only insurance write-offs following large-scale damage. At the same time, the number of significant pollution events has dropped considerably. The picture is similar for insurance claims for third party liability. The number of crew members falling victim to an accident has declined substantially in recent years, despite constant increases in the size of the fleet.

Despite that, the environmental impact is considerable

Despite these positive factors, modern maritime transport attracts a lot of criticism. Shipping causes environmental damage which in some instances represents a serious threat, and which is also largely avoidable given the opportunities that exist to improve ships’ environmental profiles. For example, not all tankers are double-hulled yet – a precaution that greatly reduces the danger of hazardous substances like oil leaking in the event of an accident. Especially on the high seas, ships still often use cheap, unrefined grades of oil, with a serious environmental impact. Ships travelling on the high seas are also permitted to discharge any kind of waste (except plastics and oil), and they make full use of this scope. In addition, employment conditions and safety measures on board ships flying flags of convenience rarely live up to modern standards.

Out of sight and under-regulated

A major factor behind this is that shipping – even more so than aviation – tends to take place out of sight of the population (although the fact is often overlooked that about 70% of shipping traffic travels within 400 km of the coast, where it contributes severely to local environmental damages). Not only has this encouraged irresponsible behaviour on the part of individuals; for a long time, the need for regulation was not taken seriously either. Shipping is therefore significantly under-regulated compared with other modes of transport.

International law is lagging a long way behind on reducing the environmental burden

A further problem is that the high seas – like the skies – are a so-called global public good, with national sovereignty only extending a few miles from the coast. And even here, states often have their hands tied by international law when it comes to implementing their own environmental and navigational standards. It is always hard to reach legally binding international agreements, but this is especially true in the area of environmental protection and the protection of water and coasts in particular. Another complicating factor is that many ships travel under flags of poor countries that rely on flag fee incomes and often have neither the interest nor – for example, because of political instability – the ability to push through higher standards.

Example: phasing out single-hulled oil tankers

The main international legislative bodies in this area are the International Maritime Organisation (IMO) and the UN Convention on the Law of the Sea (UNCLOS). They have initiated various new laws in recent years designed to protect the seas. Implementing internationally binding agreements, however, is an extremely long haul and often involves clashes with the powerful shipping lobby. One example of this is the phasing out of single-hulled oil tankers. It took the Exxon Valdez tanker accident off the coast of Alaska in 1989 – the biggest accident of its kind in the history of the USA – for the US government to agree to outlaw such ships. It was another ten years, after the single-hulled oil tanker Erika sank off the coast of France, before the IMO also decided to ban single-hulled tankers. The target date for the phase-out was initially set at 2015, but it was brought forward to 2010 following the 2002 Prestige spill – the fourth such incident off Spain’s Galician coast in 30 years. The largest single-hulled oil tankers were phased out in 2005.

If marine transport is to play an essential role within a sustainable mobility concept, much tighter, internationally binding regulations are needed. However, the make-up of the IMO means it is not ideally placed to bring this about: countries’ voting rights are apportioned according to shipping tonnage, meaning that those in which the shipping industry has a loud voice hold sway.

Pollution of the seas

Marine conditions continue to deteriorate

Despite intensified measures taken at both international and national level to protect the seas in recent years, marine conditions continue to worsen. Considerable progress has been made in certain regions, but overall, the ongoing expansion and increasing frequency of various human activities is heightening the pressure on the marine environment. The greatest damage is to coastal ecological systems and stems from pollutants, fertilisers and sediment particles.

Even though around 80% of the damage to the marine environment comes from land, shipping also contributes around 12% – a considerable amount. Given the steady increase in sea transport volumes, this percentage – and especially the damage in absolute terms – will continue to rise if no steps are taken to prevent it.

Discharges and emissions into the sea

Little regulation of discharges of toxins into the sea

There is still very little regulation concerning the discharge of pollutants into the sea. Except for oil and plastic, rubbish of all kinds may be dumped by ships of all kinds into the sea. This has grave consequences for the sea itself and for coastal regions. Moreover, despite legal regulations, oil spills continue to occur. The use of toxic chemicals in ship paint, for example, and the release of ballast water are further problems.

Oil spills

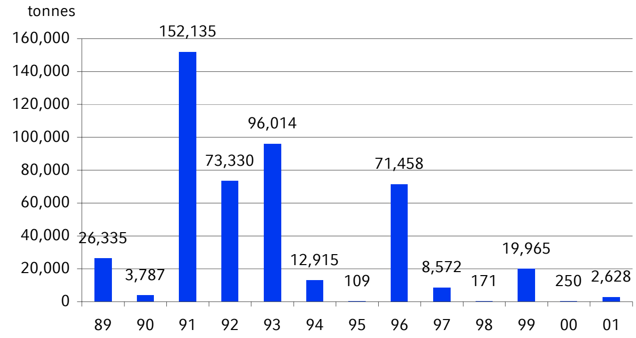
Oil spills cause widespread ecological and social damage

Images of oil-smeared water birds after tanker accidents are familiar to most of us. This kind of environmental catastrophe has enormous negative fallout for the environment as well as the people living in the coastal regions affected. Fishing and tourism all but cease for a certain period, and then coastal clean-up requires huge sums of money (for example, ExxonMobil has spent $900m to date repairing the damage caused by the capsized Exxon Valdez tanker off the Alaska coast in 1989, and another $100m could follow). Not least, such accidents cost the lives of thousands of marine plants and animals. Usually, the consequences can be felt for decades, partly because oil can never be completely cleaned up – in the Exxon Valdez case, the site still holds around 100 million tonnes of oil. Sunken tankers often continue to leak oil into the sea, and the chemicals used in the clean-up are not always benign.

46% of oil seepage into the world's seas is due to shipping

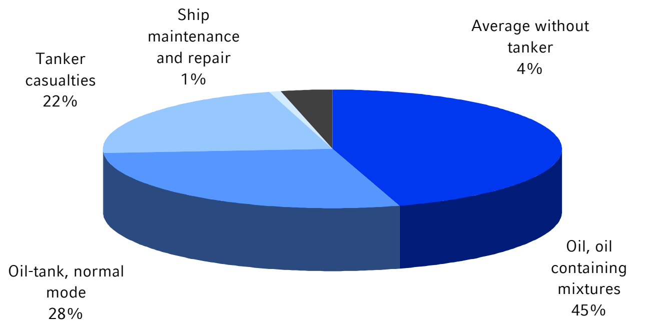
However, large tanker accidents like the Exxon Valdez disaster are only responsible for about 10% of the world's water pollution by oil. According to a study by the US National Research Council, around 46% of oil seepage into the world's seas is due to shipping – largely from accidents or deliberate discharges. Many ships discharge illegal bilge oil (a mixture of water, oil, grease and other toxins that collect in the holds) into the water before they reach harbour, as this is far cheaper than the official bilge disposal in port. Bilge oil accounts for around 10% of annual oil pollution in the world's seas. The WWF estimates that at least 300,000 sea birds on the east coast of Canada alone perish each year due to discharges of bilge oil. Even during normal ship operation, there are occasions when oil seeps into the water due to maintenance and repairs, operating faults or leaks. While these amounts are small, they add up, especially around ports and in busy shipping lanes.

Volume of accidental tanker oil spills (above 7 t per spill)



Source EEA, 2003

Oil discharges from shipping (total: 555,000 t p.a.)



Source GAUSS, 2000, OECD, 1997

That said, oil discharges have been cut by 60% since the 1970s, with the greatest improvement coming in the last 15 years. One contributing factor has been the prohibition on discharging oil. Another has been the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC Convention), which was initiated in 1990 and ratified in 1995. In addition, the USA outlawed single-hull oil tankers following the 1989 Exxon Valdez disaster, and the IMO followed suit several years later.

Ratio of oil (cargo and bunkers) discharged into the sea to total quantities carried by sea

(Million tonnes)	2000	2001	2002	2003	2004
Annual quantity of oil carried by sea	2,027	1,997	2,000	2,135	2,280
Annual quantity of oil spilt	0.012	0.008	0.067	0.042	0.015

Source IMO

Ship paint

Toxic chemicals kill more than undesired micro-organisms on the ship's hull

Ship paint is another factor that causes environmental damage. Toxic chemicals are intended to keep the hull free of marine organisms that would otherwise burrow into it, damaging the structure and raising energy consumption due to frictional resistance. Chemicals were developed in the 1960s that can kill off all the organisms on the hull. The problem is that these chemicals seep into the water, for instance tributyltin (TBT), used in toxic antifouling paint, collects in sediment on the ocean floor. It retains its toxicity and, as it works on hormones, can contribute to gender reversal in snails. The concentration of tin in marine organisms (organotin) has been rising steadily since the 1970s and represents a health risk for humans at the top of the food chain.

Hapag-Lloyd testing silicon paint

The International Maritime Organisation (IMO) issued a ban on paints containing toxic TBT in 2001, and a regulation to this effect for container ships will enter into force on 1 January 2008. In anticipation of the regulations, Hapag-Lloyd has been using environmentally safe underwater paint for a couple of years. The company recently tested a new silicon paint for container ships with a smooth surface that reduces friction resistance, cutting fuel consumption and emissions by 6%. It does not leak pollutants into the sea, making it considerably safer for the environment than conventional paints. After a successful test phase, more ships are being treated with this paint. Möller Maersk, another shipping company, also ceased using paints containing TBT in 2002. Today, 75% of the Möller Maersk fleet is free of TBT; over 10% of vessels carry no biocides at all.

Ballast water

Alien invaders

One of the largest marine pollutants is, astonishingly, sea water. The uncontrolled discharge of ballast water brings foreign organisms into distant ecosystems, where, given the right conditions, they can have a destructive effect on biological diversity and cause considerable economic hardship. For example, a type of jellyfish brought from US waters has so devastated the anchovy population of the Black Sea that fishermen have reported a decline in the catch from 700,000 t each year to just 70,000 t. Indeed, alien invasives can be as damaging as oil spills, and their effects much more persistent.

Atmospheric emissions

Emissions of CO_2, SO_2 and NO_X are climbing steadily

Recent studies show that shipping is responsible for roughly 7% of CO_2 emissions from transport, or approximately 2% of global CO_2 emissions (see EEA, 2006). Furthermore, around 7% of all SO_2 and 11-12% of all NO_X emissions can be attributed to shipping, and the trend is rising. Over the last few years, not only has the number of ships risen significantly, so too has their size and average speed, and hence their energy consumption. In consequence, atmospheric emissions are also increasing.

Inferior fuels are more polluting

Nearly all commercial ships are powered by diesel engines. The largest engines ever built are used in huge ocean-going steamers and can have up to 14 cylinders and cubic capacity of up to 1,000 litres. However, poor-quality fuels can be used to drive the engines. The largest ships (EPA category 3) are driven by bunker oil, the cheapest and lowest-grade fuel available. In contrast to higher-grade, refined fuels such as diesel, petrol and kerosene, bunker oil retains high concentrations of toxic impurities that have long been prohibited in most other industrial and consumer applications. Even where diesel is used, it is often the cheapest kind, and emissions pass unfiltered into the atmosphere.

Particles emitted when these fuels are burnt contribute to global warming, acid rain and health problems for people and animals living near major ports. As marine transport volumes rise, the threat to ecosystems and the health risks for coastal inhabitants will also rise.

MARPOL is not much help

Annex VI of the International Convention on the Prevention of Pollution from Ships – MARPOL – was signed in 1996 and came into force in May 2005. However, the standards are so weak that they will do little to reduce ship emissions long-term. First, the fuel standard is still highly unsatisfactory. Second, the engine emission standard will be unable to make a lasting improvement in air quality: the latest technologies available for shipbuilding could slash emissions by up to 90% of the level currently permitted by the standards. The US EPA estimates that ship emissions will rise another 6% by 2020 and 13% by 2030.

Marine CO_2 reductions by technical measures

Measures	Fuel/CO_2 savings potential	Subtotal [1]	Total [1]
New Ships			
Optimised hull shape	5 - 20%		
Choice of propeller	5 - 10%	5 - 30%	
Efficiency optimised	10 - 12% [2]		
	2 - 5% [3]	14 - 17% [2]	5 - 30%
Fuel (HFO to MDO)	4 - 5%	6 - 10% [3]	
Plant concepts	4 - 6%		
Fuel (HFO to MDO)	4 - 5%	8 - 11%	
Machinery monitoring	0.5 - 1%	0.5 - 1%	
Existing Ships			
Optimal hull maintenance	3 - 5%		
Propeller maintenance	1 - 3%	4 - 8%	
Fuel injection	1 - 2%		
Fuel (HFO to MDO)	4 - 5%	5 - 7%	4 - 20%
Efficiency rating	3 - 5%		
Fuel (HFO to MDO)	4 - 5%	7 - 10%	
Eff. rating + TC upgrade	5 - 7%		
(HFO to MDO)	4 - 5%	9 - 12%	

(1) Where potential for reduction from individual measures is well documented by different sources, potential for combination of measures is based on estimates only
(2) State-of-the-art technique in new medium-speed engines running on HFO
(3) Slow-speed engines when trade-off with NOx is accepted

Source IMO, 2000

Local emissions

Ecosystems under pressure from acid rain and eutrophication

SO_2 emissions from ships have been estimated to be at 4.5-6.5 million t p.a., and NO_X emissions at around 5 million t p.a. (see IMO, 2000). SO_2 and NO_X are responsible for acid rain, which has detrimental effects on land ecosystems. More recent studies show that the NO_X carried in the atmosphere contributes to eutrophication in coastal regions and at sea. The atmospheric introduction of NO_X can do lasting damage to the balance of regional ecosystems, particularly in areas where a lack of nitrogen inhibits biological production. Since efforts are being made to reduce SO_2 and NO_X emissions on land, shipping is likely to make up an increasing percentage of these emissions as long as international shipping is excluded from emissions-reduction programmes.

Shipping is now Europe's largest source of SO_2

This has become increasingly clear in the EU over the last few years, where shipping has become the largest source of SO_2 emissions. Directive 2005/33/EC (EC, 2005h) sets a limit of 1.5% (15,000 ppm) sulphur in fuels that can be used in the Baltic Sea and the North Sea. The same limit applies to passenger ships that regularly serve EU ports. From 2010, the maximum sulphur content of fuels for inland ships and for ocean-going ships at anchor in European ports will be lowered to 0.1% (1,000 ppm). The internationally recognised MARPOL Annex VI, which came into effect in May 2005, sets a sulphur limit of 4.5% (45,000 ppm). Its effects will therefore be extremely limited: the average sulphur content of fuels used in marine operation is already just below 3.0% (29,900 ppm).

Technical options to reduce emissions

As countries strive to reduce these emissions by 2010 in order to comply with the Long Range Transboundary Air Pollution (LRTAP) convention, it is far cheaper to do so on ships than on land. The costs are estimated at €300m p.a. for ships and €2.4bn p.a. on land. Europe-wide, this would bring the overall cost down from €7bn to €4.9bn.

Slow-speed, two-stroke diesel engines are standard for medium-sized and large tankers, bulk carriers and container ships. These run on cheap heavy oil, which is more environmentally damaging than other fuels. Depending on its origin, heavy oil contains up to 5% sulphur. Lower sulphur content can involve costs of around €20 per tonne and percentage point. Heavy oil with reduced sulphur content can be used without altering the engines. Marine diesel, which EU regulations stipulate must have a maximum sulphur content of 0.2%, is still mainly used by modern ferries and cruise liners.

There are a range of technical options available to reduce NO_X emissions. The addition of urea can reduce NO_X emissions by 90-95% in a selective catalytic reduction process. This costs €29,000-46,500 per MW, and the technology raises running costs by around €2 per MWh. Cheaper processes do not curb NO_X emissions to the same extent (HAM technology: 70-80%, exhaust reductions: around 60%, direct water injection: 20-50%, firing optimisation: 25%, injection of a fuel-water emulsion: 10%).

Possible solutions

Solutions to manage the adverse environmental impact...

A number of countries are already implementing various solutions to manage the adverse impact of shipping on the environment. These generally involve granting discounts on shipping fees, with their size dependent on compliance with specific environmental standards. The imposition of a tax on marine fuel and CO_2 emissions has also been discussed in the past.

...e.g. levying fees for using the sea

The WBGU (see WBGU, 2002) is currently debating the imposition of a charge, with the primary objective being to bring about a reduction in marine pollution. The aim is to create an incentive to take steps – especially on the technological and environmental management fronts – designed to reduce the adverse impact of shipping on the marine environment. This includes environmental damage which is only indirectly related to marine pollution – specifically CO_2 and SO_2 emissions by ships. Possible methods for levying fees include waterway and port charges, a tonnage tax or user fees (the WBGU's preferred option).

- **Discounts for tankers with separate ballast tanks or double hulls:** In Sweden, for example, discounts are granted on port and waterway charges to ships whose SO_2 and NO_X emissions fall below the limits stipulated in Annex VI to the MARPOL convention.

- **Green Award system:** The Green Award system certifies ships which satisfy specific requirements relating to technology, management and human resources. Certified ships are granted discounts of varying levels in certain ports in the Netherlands, Portugal, South Africa, Spain, the United Kingdom and lately also in Hamburg. So far, however, the certification system only covers large tankers and other very big ships.

  The Environmental Passport is a similar certification system. This certificate has been issued since 2001 by Germanischer Lloyd (a private German ship classification society recognised by the authorities) and testifies to the implementation and observance of all operational and technical measures employed onboard ships to protect the environment. These include, for example, exhaust emissions reductions, use of underwater paints free from tributyltin (TBT) and ballast water management.

- **Charges on fuel or CO_2 emissions**: A levy on marine fuels as a way of promoting environmentally friendly ships is mainly being discussed as part of a move to raise a general CO_2 levy. The effect of a charge on heavy oils in terms of controlling pollution would probably depend largely on the size of the charge. However, a charge of this kind raises certain practical issues; it would only be possible to avoid loopholes if the charge was introduced globally, for example.

- **Charging via the tonnage tax**: Since the income tax payable by ship owners is levied by each flag state and there is strong tax competition between states, there is scant chance of a charge raised through the relatively low income tax levied on earnings generated from shipping (tonnage tax) being sufficient to change behaviour or generating enough revenue.

- **Imposition of user fees**: The fee proposed by the WBGU is principally based on ships' tonnage and engine power. The distances covered do not come into play for reasons to do with collection. Measures to reduce environmental damage and increase safety are considered in detail as quality shipping measures and attract a bonus when calculating charges. A catalogue compiled by GAUSS (Association for applied environmental protection and safety in sea shipping) is proposed for the recording of quality shipping measures. It comprises 19 criteria subdivided, for bonus calculation, into three differently weighted categories (shipping company policy and management; ship design, construction and fitting out; and ship management and technology).

Companies and sustainable shipping

The sustainable mobility profiles of shipping companies is reflected in our extra-financial risk ratings via three sector-specific factors: firstly, the general statement on climate change, secondly, the presence and quality of targets and programs to reduce emissions, and thirdly, the eco-efficiency of the services delivered by the companies. The two companies within our rating universe that have the relevant GICS classification are AP Moller Maersk and Kuehne & Nagel. As the following table show, both companies do not perform extraordinarily well. In particular, both have no statement on climate change and receive only 40 out 100 possible points for their targets and programs to reduce emissions.

Sustainable mobility profiles of shipping companies is reflected in our extra-financial risk ratings

	WestLB Sustainability Rating (Z scores)					Sector specific criteria (raw scores)		
	Overall		Environ-ment	Gover-nance	Stake-holder	Statement on climate change	T&P to reduce emissions	Eco-efficiency of service
	Rating	Z score						
weight			**40%**	**15%**	**45%**	**1.86%**	**2.72%**	**3.00%**
Marine								
AP Moller Maersk	B	-2.25	-0.66	-2.03	-2.31	0	40	50
Kuehne & Nagel	B+	-0.67	-0.58	-1.35	-0.26	0	40	0

Source WestLB Research, SiRi Group

Möller Maersk

Möller Maersk has also taken a series of measures designed to improve the environmental sustainability of its activities. These include using a waste heat recovery system, which helps reduce energy consumption by up to 10%. New lubricant systems for cylinders not only help cut lubricant consumption but also lower particulate emissions by 25%. According to Möller Maersk, the fleet's SO_X emissions currently average 2.7%; the company is also testing the use of fuels with sulphur content below 1.5% at present. The fleet is also being fitted out with NO_X-efficient technology; for example, 80% of vessels have been equipped with new slide-type fuel injection valves which cut NO_X output by up to 26%. Advanced computer systems for logistics management and policies for steady running, weather routing, ocean currents, etc. should also boost the efficiency of transport and help cut emissions. Furthermore, all new ships have specially protected oil tanks, helping to reduce the risk of oil discharges in the event of accidents at sea, and management of ballast water and waste is now standard practice at Möller Maersk.

Hapag-Lloyd

In the above table, Hapag-Lloyd Container Line, the container ship division of TUI Group, is missing, because of its GICS classification (Hotels, Restaurants & Leisure). It thus has different sector-specific assessment criteria. The company is a leading supplier in the global door-to-door container transport industry. The company handles complex logistics packages along the transportation chain, delivering a comprehensive range of services. Hapag-Lloyd recognises that freight transport causes environmental pollution. Consequently, the company is, by its own admission, endeavouring to keep the environmental impact of its services to a minimum. Hapag-Lloyd has put in place a combined quality and environmental management system (QEM system) in accordance with quality standard ISO 9001 and environmental standard ISO 14001. The certification encompasses the entire product – global door-to-door container transport services – and covers all locations worldwide. The company also focuses on using modern technologies, developed in conjunction with universities and major mechanical engineering companies. The collaboration aims to further reduce fuel consumption and hence emissions from global shipping operations whilst simultaneously boosting engine reliability and efficiency. All newly constructed container ships put into service for Hapag-Lloyd since 1997 meet the requirements of the Environmental Passport. Hapag-Lloyd is also involved in the Clean Cargo Group, a section of the US organisation Business for Social Responsibility (BSR), which lobbies for greater sustainability in international transport.

WestLB

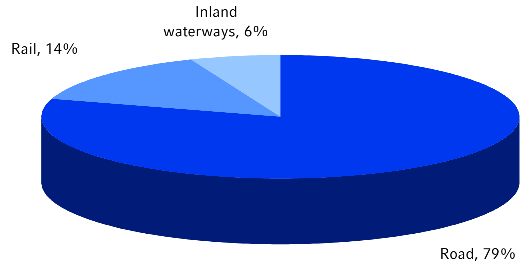
Appendix

Appendix

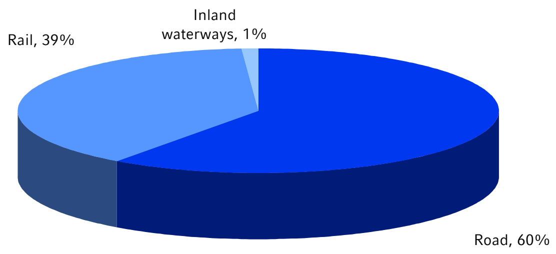
Mobility facts in tables & pictures

Modal share of freight transport volume in % (tonne-km), 2003

EU15



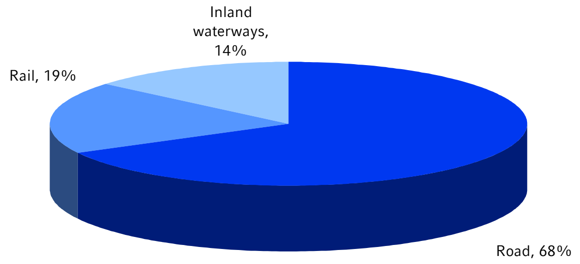
EU10



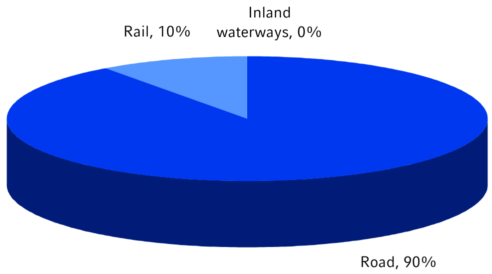
Source EEA 2006

Modal share of freight transport volume in % (tonne-km), 2003

Germany



UK



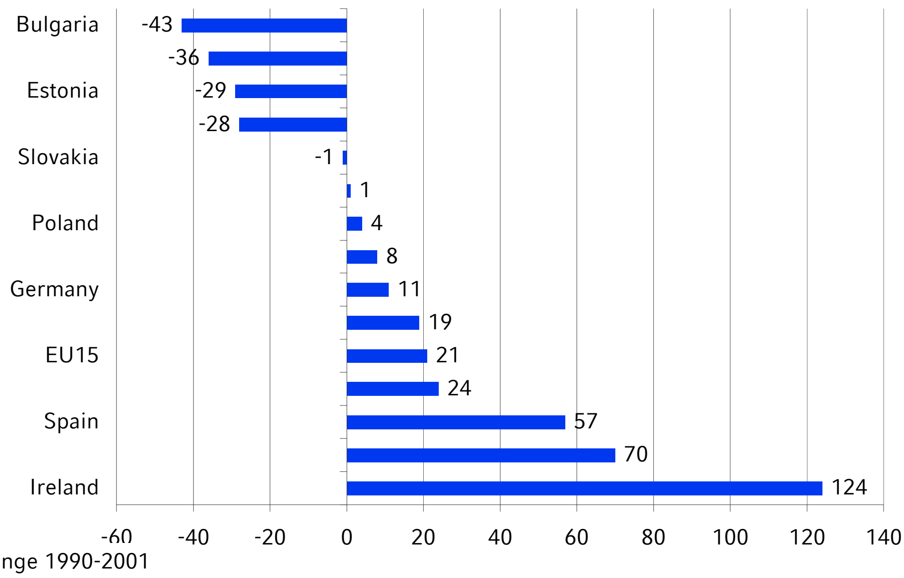
Source EEA 2006

National infrastructure quality (WEF rankings)

Rank	Overall infrastructure quality	Railroad infrastructure development	Port infrastructure quality	Air transport infrastructure quality
1	Denmark	Japan	Singapore	Singapore
2	Singapore	Switzerland	Netherlands	USA
3	Germany	France	Denmark	Germany
4	Switzerland	Germany	Hong Kong	United Arab Emirates
5	France	Denmark	Germany	Hong Kong
6	USA	Hong Kong	Finland	Denmark
7	Finland	Singapore	United Arab Emirates	France
8	Hong Kong	Finland	Belgium	Finland
9	Austria	Netherlands	France	Netherlands
10	Canada	Malaysia	USA	UK
11	Iceland	Belgium	Iceland	Australia
12	Japan	Korea	Japan	Japan
13	United Arab Emirates	Canada	Malaysia	South Africa
14	Malaysia	Czech Republic	New Zealand	New Zealand
15	Luxembourg	Taiwan	Canada	Malaysia
16	Sweden	Sweden	Taiwan	Canada
17	Belgium	Austria	Sweden	Belgium
18	Netherlands	USA	Norway	Austria
19	Australia	Luxembourg	Korea	Sweden
20	Taiwan	Ukraine	Estonia	Taiwan

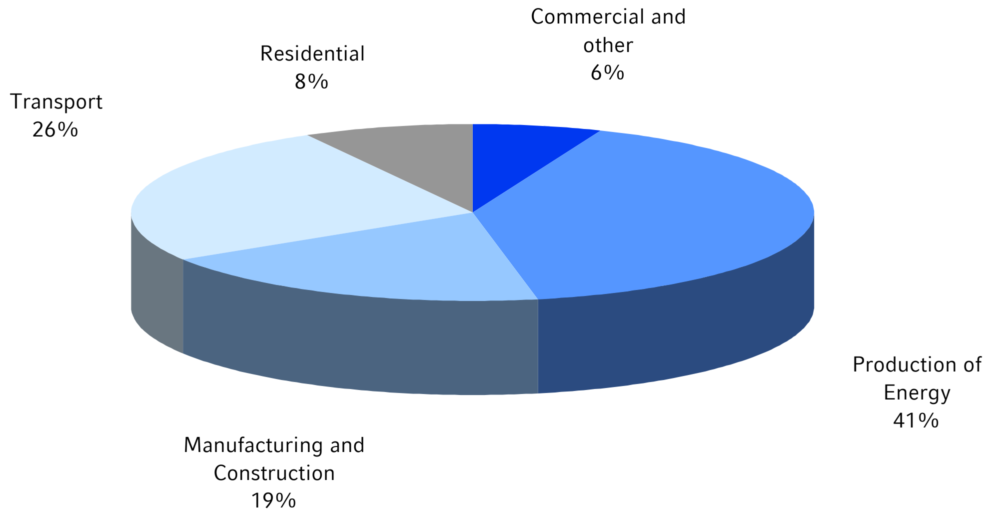
Source WEF, 2005

Change in total GHG emissions from transport



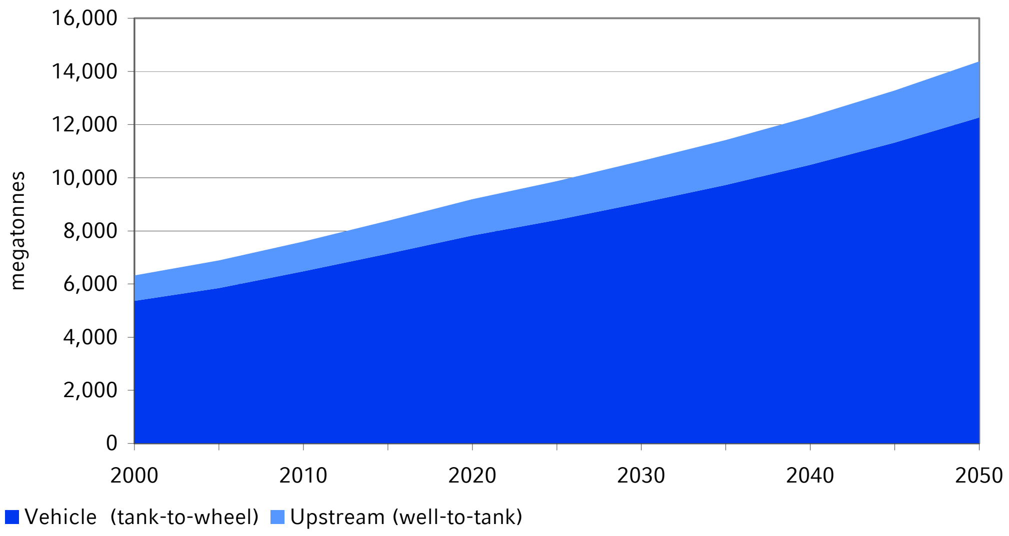
Source EEA, 2003

Share of worldwide CO_2 emissions from the combustion of fuel, by sector (1998)



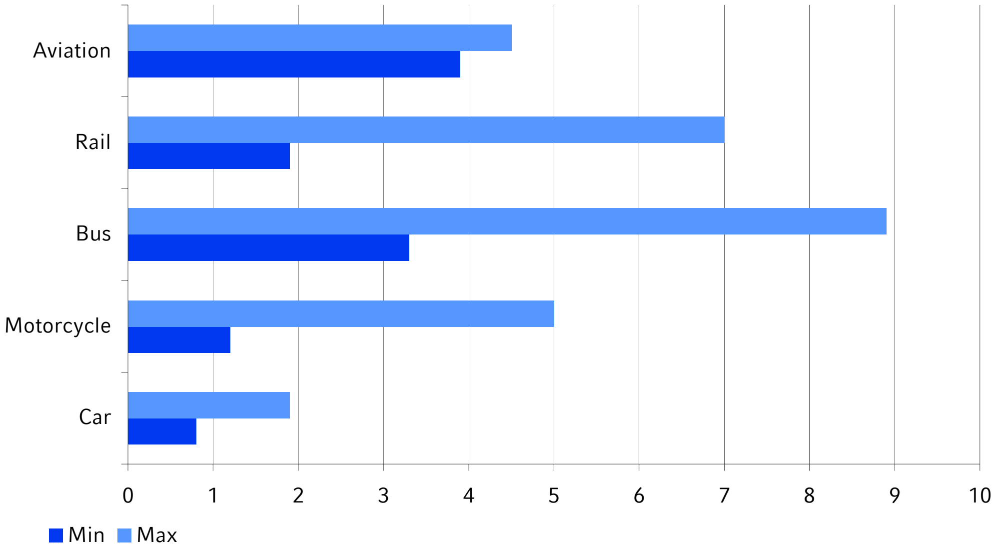
Source IEA, 2000

World Transportation Vehicle and Upstream (WTW) CO_2-equiv Emissions



Source SMP, 2004

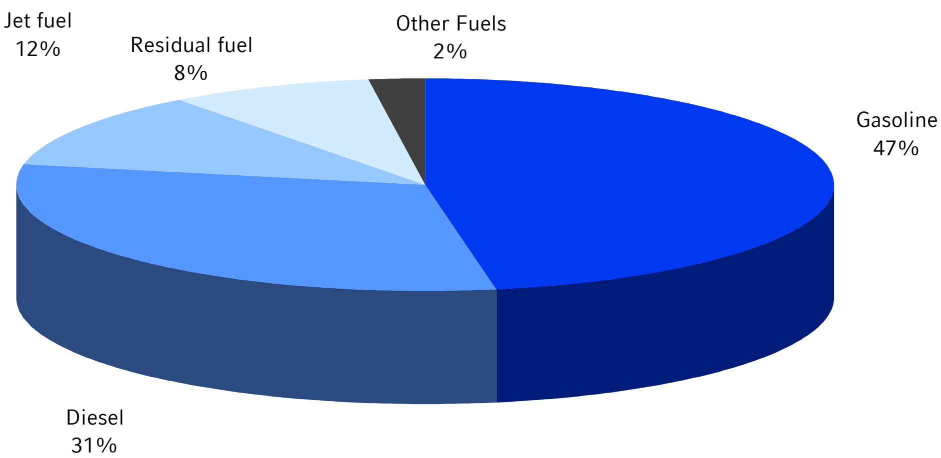
Marginal external costs of passenger transport by cost category and transport mode*



* EUR per 10 vehicle-km for road and rail, EUR per vehicle-km for aviation

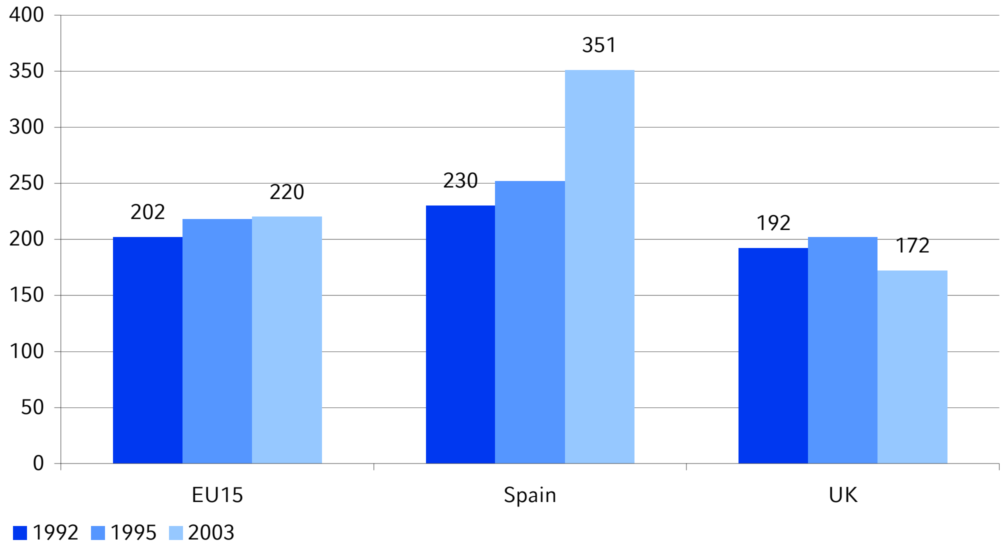
Source Infras/IWW, 2000

Year 2000 World Transport Energy Use by Fuel



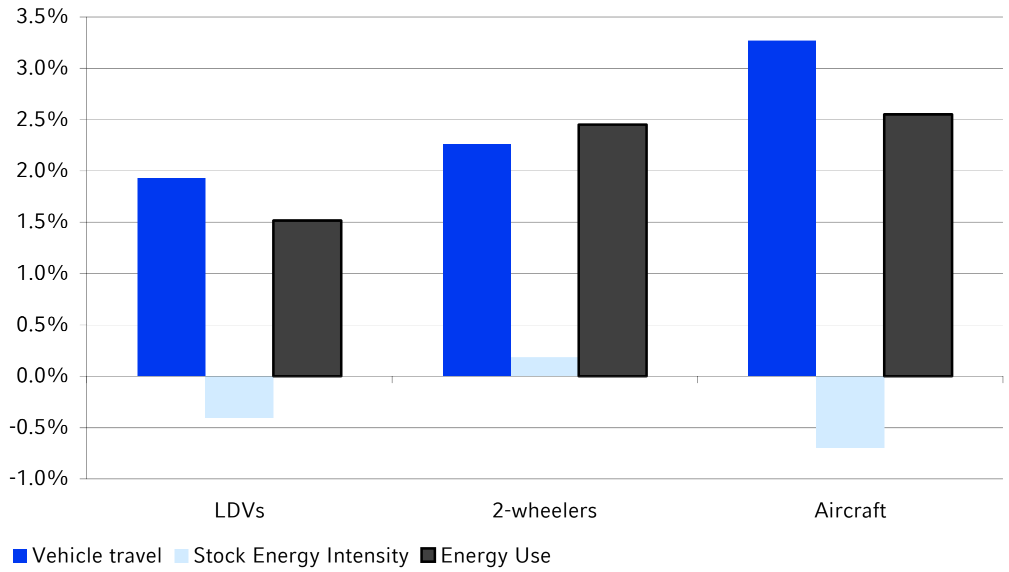
Source SMP, 2004

Trends in freight transport intensities (tonne-km/1000 EUR GDP)



Source EEA, 2006

Decomposition of World Energy Use by Passenger Mode, 2000-2050: Change due to Change in activity and change in intensity



Source SMP, 2004

Lufthansa fleet – data on specific fuel consumption

Fleet	Operator	Fleet (31/03/06)	capacity (seats)	Range (km)	introduced in	spec. fuel cons. l/100 pkm
Medium-/long-haul flights (intercontinental)						**3.98**
Boeing 747-400	DLH	30	390	12,200	1989	4.22
Airbus A 340-600	DLH	10	345	14,260	2003	4.12
Airbus A 340-300	DLH	29	247	11,500	1993	3.99
Airbus A 330-300	DLH	10	221	10,000		4.19
Airbus A 330-200	DLH/TCX	2	229	11,000		4.29/2.67
Boeing767-330ER	CFG					2.87
Short-/medium-haul flights (continental)						**4.30**
Airbus A 300-600	DLH	14	280	3,900		5.25
Airbus A 321-100/200	DLH	26	182	4,200	1994	4.76/4.93
Short-haul flights (continental)						
Airbus A 320	DLH/TC/CFG	36	150	3,200		5.60/3.03/2.86
Airbus A 319	DLH	20	126	3,400	1996	6.25
Airbus A310-300	DLH	5				5.90
Boeing 737-300	DLH	33**	123	2,500	1986	7.10
Boeing 737-500	DLH	30	103	2,500	1991	8.11
Boeing 757-300	TCX/CFG	11				2.95/2.78
Boeing 757-200	TCX/CFG	16				3.00/2.83
Cityline (Regional)						
Avro RJ85	CLH	18	93	2,400	1994	9.71
CRJ700	CLH	20	70	2,400	2001	7.83
CRJ100/200	CLH	42	50	1,850	1992	8.72
ATR42-300	EWG					7.03
ATR42-500	KIS/EWG/DLA	15				9.56/9.22/8.19
ATR72-500	DLA	8	64	900		6.34
ATR72-200/500	EWG	6	64	900		6.11
BAE 146-200	EWG	6				10.24
BAE 146-300	EWG	4				10.58
CRJ200	DLA/EWG	17				9.72/9.11
DHC8-300	AUB	n.a.				7.94
DHC8-400	AUB	n.a.				6.83
Fokker 50	KIS	n.a.				7.98
Cargo (long-haul)			**Loading cap. (m^3)**			**g/tkm**
Boeing MD 11F	GEC	14	455	7,700		167
Boeing MD 11SF	GEC	5	455	7,700		
Boeing 747-200 B/F	GEC					199

Source Lufthansa, 2006

Extra-Financial Risk Navigator – Assessment of the transport & transport related companies

GICS sector	Index membership		WestLB Extra-Financial risk assessment							
	STOXX	STOXX	overall		Environment		Governance		Stakeholder	
Company	600	DJSI	Rating	Z score	Rating	Z score	Rating	Z score	Rating	Z score
Automobiles										
Automobiles										
Automobile Manufacturers										
BMW	x	x	A+	1.42	⬀	1.02	⇨	-0.06	⇧	1.75
DaimlerChrysler	x	x	A+	0.62	⇧	1.90	⇨	0.24	⇨	0.50
Fiat S.P.A	x		B++	-0.04	⇨	-0.10	⬀	1.00	⇨	0.13
Porsche	x		B+	-1.33	⇨	-0.10	⇩	-2.52	⇩	-1.61
PSA Peugeot Citroën	x		A++	2.37	⇧	1.98	⬀	0.85	⇧	2.28
Renault	x		A+	1.32	⇧	1.58	⇨	0.01	⬀	0.92
Volkswagen	x		A+	0.84	⇧	1.58	⬂	-0.52	⬀	0.87
Autocomponents										
Tires & Rubber										
Continental	x		B++	-0.12	⇨	-0.02	⬂	-0.59	⇨	-0.06
Michelin	x	x	A+	0.86	⬀	0.62	⇨	0.43	⬀	0.83
Auto Parts & Equipment										
Rieter Holding Ltd			A	0.02	⇨	-0.18	⬀	0.66	⇨	-0.13
Valeo	x		A	0.44	⬀	0.54	⇨	0.39	⇨	0.08
Transport										
Airlines										
Airlines										
Air France	x	x	A	0.05	⬀	0.94	⬂	-1.27	⬀	0.86
British Airways plc	x		B++	-0.26	⇨	0.22	⬀	1.41	⇨	-0.20
Lufthansa AG	x		A	0.20	⬀	1.18	⇨	0.09	⇨	0.38
Ryanair Holdings Plc.	x		B	-2.05	⬂	-0.66	⬂	-0.74	⇩	-2.40
Air Freight & Logistics										
Air Freight & Logistics										
Deutsche Post World Net	x		A	0.24	⇨	0.46	⇨	-0.44	⇨	0.10
TNT NV	x	x	A+	1.43	⬀	0.78	⇧	1.83	⬀	1.24
Marine										
Marine										
AP Moller Maersk	x		B	-2.25	⬂	-0.66	⇩	-2.03	⇩	-2.31
Kuehne & Nagel	x		B+	-0.67	⬂	-0.58	⬂	-1.35	⇨	-0.26
Transportation infrastructure										
Airport Services										
BAA Plc.	x	x	A+	0.73	⬀	0.86	⬀	0.81	⇨	0.16
Highway & Railtracks										
Abertis	x		B++	-0.46	⇨	0.22	⬂	-1.46	⬂	-0.63
Autostrade Concessioni & Cost	x		A+	0.78	⇨	0.30	⇨	0.17	⬀	1.13
BRISA- Auto Estradas	x		B+	-0.64	⇨	-0.10	⬂	-0.67	⬂	-0.98
Capital Goods										
Machinery										
Construction & Farm Machinery & Heavy Trucks										
Scania	x		A+	0.60	⇧	1.82	⬂	-1.50	⇨	-0.15
Volvo B	x	x	A+	1.42	⇧	1.90	⬀	0.54	⬀	0.57
Industrial Machinery										
MAN	x	x	B++	-0.35	⬀	0.86	⬂	-0.89	⬂	-0.76
SKF AB	x	x	A+	1.26	⬀	1.34	⇨	-0.18	⬀	1.13
Aerospace & Defense										
Aerospace & Defense										
EADS NV	x		A	0.05	⇨	0.38	⇨	0.01	⇨	0.24
Rolls Royce	x	x	A+	0.60	⇧	1.82	⇨	0.43	⇨	0.46
Thales	x		B+	-1.03	⇨	-0.18	⇨	-0.40	⇨	-0.14

Source WestLB Research, SiRi Company, DJ STOXX

Extra-Financial Risk Navigator – Assessment of the transport & transport related companies (Cont'd)

GICS sector	Index membership		WestLB Extra-Financial risk assessment							
	STOXX	STOXX	overall		Environment		Governance		Stakeholder	
Company	600	DJSI	Rating	Z score	Rating	Z score	Rating	Z score	Rating	Z score
Consumer Services										
Hotels, Restaurants & Leisure										
Hotels, Resorts & Cruise Lines										
Kuoni Group			B++	-0.14	⬀	1.02	⬂	-0.97	⬂	-0.77
TUI	x		B++	-0.12	⬀	0.70	⇨	-0.40	⇨	-0.24
Energy										
Oil, Gas & Consumable Fuels										
Integrated Oil & Gas										
BG Group	x		A+	0.81	⇨	-0.26	⬀	1.37	⬀	1.26
BP PLC	x	x	A	0.26	⬀	0.86	⇧	1.56	⬀	1.03
ENI	x		B++	-0.39	⬂	-0.90	⬀	0.81	⇨	0.31
OMV	x		A+	1.23	⇨	0.22	⇨	-0.14	⇧	2.24
Repsol YPF S.A.	x		A	0.29	⇨	0.22	⬀	0.54	⬀	0.68
Royal Dutch/Shell Group of Companie	x		B++	-0.29	⇨	0.06	⬀	1.30	⬀	1.48
Statoil ASA	x		A+	0.56	⇨	0.30	⬀	0.69	⬀	1.12
Total SA	x		B+	-1.10	⇨	0.06	⬀	1.15	⬂	-0.53

Source WestLB Research, SiRi Company, DJ STOXX

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Distribution of ratings as of 4 April 2006

Coverage universe	Count	Percent	Inv. Banking relationships*	Count	Percent
Buy/Add	129	44	Buy/Add	24	63
Hold	117	40	Hold	13	34
Sell/Reduce	45	15	Sell/Reduce	1	3

* Companies from which WestLB AG or an affiliate or subsidiary has received compensation for investment banking services within the past 12 months.

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