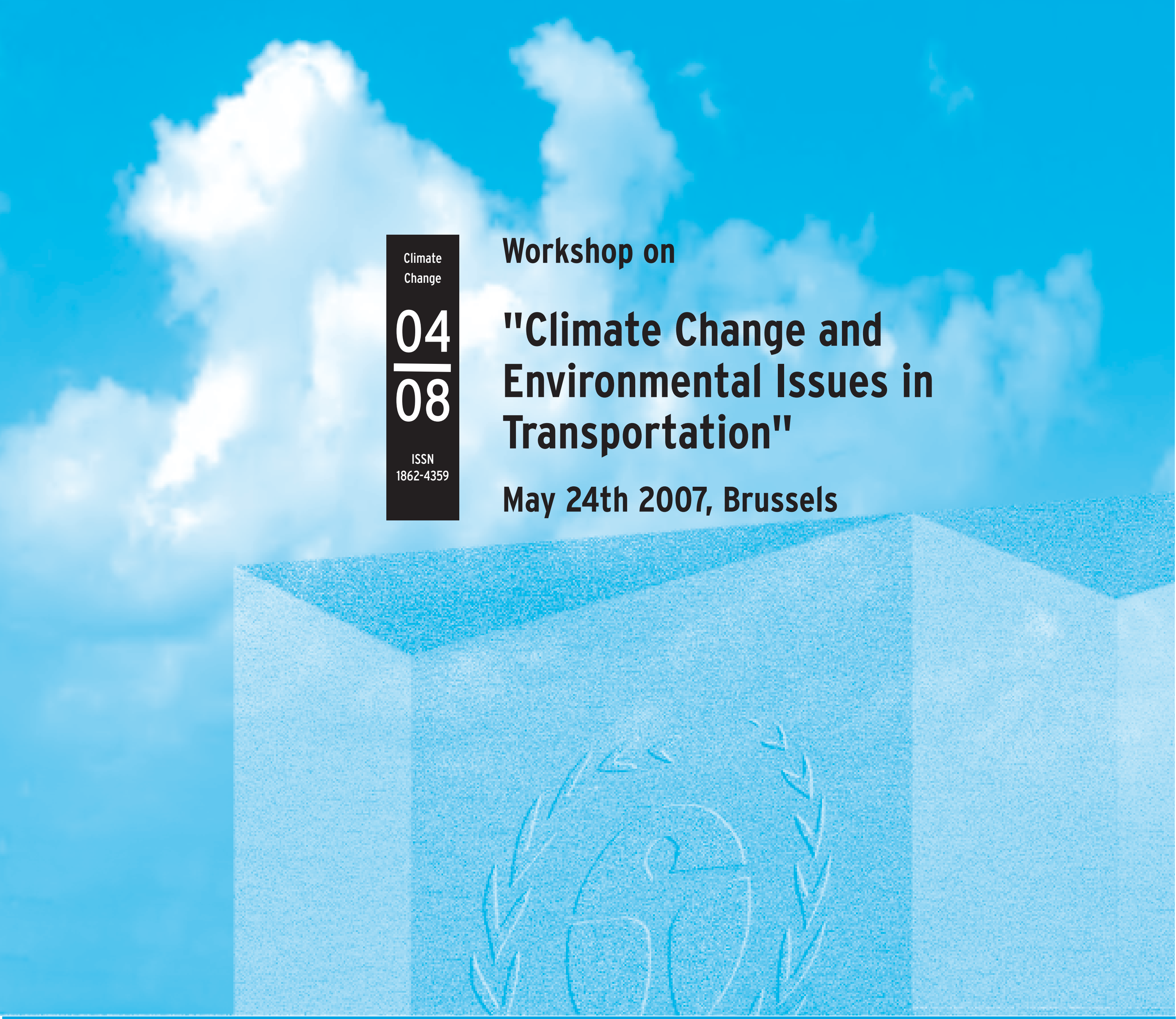
Climate Change



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Workshop on

"Climate Change and Environmental Issues in Transportation"

May 24th 2007, Brussels

Umwelt Bundes Amt

Für Mensch und Umwelt

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Workshop on

„Climate Change and Environmental Issues in Transportation“

May 24th 2007, Brussels

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Institut für Wirtschaftspolitik und Wirtschaftsforschung (IWW), Universität Karlsruhe (TH), Germany

Werner Rothengatter
Anselm Ott
Aaron Scholz
Carola Schulz

and

Edward Calthrop, David Gillen, Peder Jensen, Eleni Kopanezou, Anders Levermann, Markus Maibach, Hilde Meersman, Stefan Rahmstorf, Per Sandberg, Lee Schipper, David Thompson, Andreas Troge, Eddy Van de Voorde, Thierry Vanelslander

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06813 Dessau-Roßlau
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Dr. Hedwig Verron

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Foreword

The recent IPCC assessment reports on climate change and the economic assessments made by the group headed by Lord Nicholas Stern have led to a new round of scientific discussion and political debate. The messages are simple and convincing: Since the industrial revolution, climate change has had a strong man-made component which will have serious impact on the environment, on societies and on economies if things continue as they are now. There is a chance of slowing the increase in global warming if – on the basis of the 1997 Kyoto Protocol – concerted, worldwide action to drastically reduce greenhouse gas emissions such as CO_2 is taken soon . The Stern Review estimates that a stabilisation of greenhouse gas levels will cost around 1% of world GDP by 2050, whereas the cost of repairing the damage that will be done if no stabilising action is taken would come to at least 5%, under pessimistic assumptions even up to 20% of world GDP. This means that a policy of reducing greenhouse gases will not jeopardise the economy - on the contrary, it will make life less risky and less costly for future generations.

Against the background of the emerging public discussion and an increasing awareness in society of the long-term impact, the European Commission, as well as some of the member states, have announced significant commitments to reducing CO_2 emissions. The European Union has declared that it will reduce CO_2 emissions by 20% and that, if other developed countries join the initiative, a reduction of 30% by 2020 (base: 1990) will be set as a target. Germany has even announced a 40% reduction by 2020 (base:1990).

The industrial sector, including the power production industry, is the biggest producer of CO_2 in Europe, followed by private households (heating) and the transportation sector. The latter had a share of 25% of CO_2 emissions in 2005, a value which is set to increase due to the rapid growth of world-wide mobility and logistics. It is true that the transportation sector is of high economic relevance, as it enables international sourcing and distribution and a global exchange of intermediate products as well as the international mobility of business travellers and tourists. Nevertheless, it has a high potential for reduction and the extent to which this potential should be exploited by taking political action regarding the transportation sector must be discussed seriously.

In the workshop on “Climate Change and Environmental Issues in Transportation” on May 24th, 2007, which was organised by the Federal Environment Agency of Germany, ten outstanding speakers presented ideas on how the responsibility of the transportation sector can be defined and quantified. Participants from the European member countries representing governments, parliaments, NGOs and universities discussed these ideas and suggested policy measures. This report summarises the workshop’s results. It concludes with an action list which is not only intended to be a guideline for the environmental policy of the EU and its member states, but also as a strong message to „unconverted“ countries such as the US, China or India. In this sense, the results of the workshop have a global perspective.

Prof. Dr. Andreas Troge

President of the Federal Environment Agency of Germany

1 Recommendations – Action List

Authored by Prof. Werner Rothengatter, Dr. Anselm Ott, Aaron Scholz, Carola Schulz, IWW, Universität Karlsruhe (TH)

1.1 Taking Responsibility

Transportation provides an interface for linking activities in space. Consumption patterns and life styles in advanced economies include a high share of local, regional, national and international mobility, with long distance mobility, in particular, growing at high rates. Logistics has developed into one of the most important economic sectors, ranking just behind services, trade and the automotive industries. Transportation and logistics have close links to high-tech industries such as communication technology and electronics which cause the transportation sector to show a dynamic economic growth significantly above the growth rate of GDP and makes a significant contribution to productivity and growth in other sectors. Due to this, it is often argued that the potential for applying reduction policies to the transportation sector is much lower than in other areas, e.g. power production or household heating. Furthermore, the investments which would have to be made to reduce CO_2 emissions by one unit in transportation are estimated to be substantially higher than in other sectors, which leads to two basic arguments that are often put forth for treating this sector with care when it comes to climate policy: First, a high risk of the destruction of spatial activity patterns and of economic loss due to the reduced levels of economic activity and, secondly, the lower efficiency of a cost unit invested in reduction measures compared to investments in other sectors.

Weighing theses arguments in the light of the global climate challenge leads to the following conclusion:

Integrating transport from the beginning in ambitious reduction strategies (30% less CO_2 by 2020 in the EU).

(1) Against the background of a high share of the transportation sector in global emissions (25% in 2003) and a dramatic increase world-wide (31% in 2030 according to IEA, 2005), it is important to **include the transportation sector in the ambitious reduction strategies from the beginning and to start with actions immediately**. A host of possibilities for reduction can be identified in the different areas of individual mobility as well as for freight logistics, which can be explored by setting suitable incentives for transport decision making and technology development.

Setting incentives right for flexible market conforming adjustments.

(2) It is not wise to confront every sub-sector in transportation with a fixed reduction target, e.g. the European (minus 30%) or the German (minus 40%) targets. It is economically more efficient to ensure comparable conditions and incentivesfor all sub-sectors and to let the market do the rest. This can be implemented using a phased process to allow technology and behaviour to adjust. From this baseline, one can begin with a first analysis of the mechanisms which have the potential to achieve a substantial reduction in greenhouse gas emissions and environmental impact. A first draft is shown in Figure 1. Reduction targets are set that define the issues for the impact areas of the transportation system, i.e. vehicle and fuel technology, infrastructure technology and transportation behaviour.

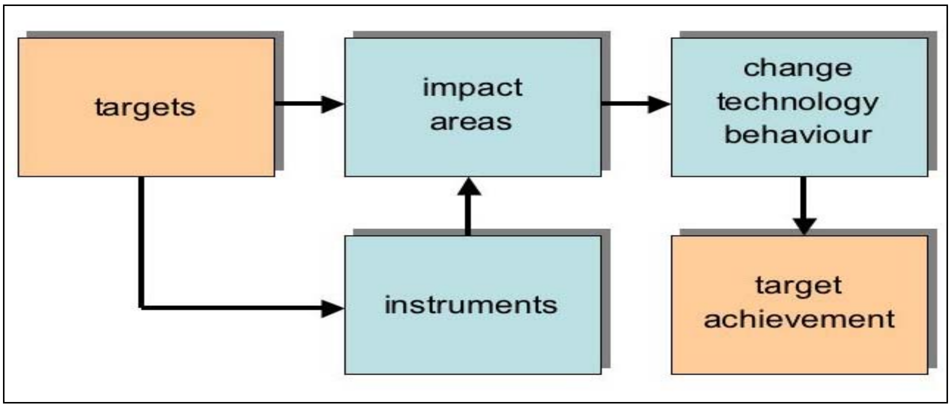

Figure 1: From environmental goals to target achievement

1.2 Analysing the areas of impact

If things continue as before, the transportation sector will substantially increase CO_2 emissions in the future. Therefore, contributing to ambitious reduction means much more than exploiting the technological potential which is known today. The scope of change has to go far beyond vehicle technology and must also include the provision of appropriate infrastructure and the adjustment of behavioural decisions in trip making and logistics.

Develop alternative technologies in the long run, exploit all potential of conventional technologies in the short and medium run.

(3) **Vehicle technology** provides a number of short-, medium- and long-term options. In the short term, optimised conventional propulsion techniques and hybrid engines can reduce fuel consumption by 15-20%. In the medium-term, vehicle components can be constructed according to **new performance requirements**. While, formerly, high speed, acceleration and high comfort moved vehicle technology in the direction of more horsepower, better air conditioning and heavy components, new development goals can be set for the engineers, such as lower weight, low-resistance tyres, energy-saving air conditioners and low fuel consumption.

In the long run, **alternative propulsion** technologies such as hydrogen-based fuel cells may replace conventional techniques, but there is still a long way to go until all the problems of hydrogen generation, distribution, tanks and use of platinum resources can be solved. Last but not least, **biofuel** production can be increased to reduce dependency on crude oil and to improve the CO_2 balance. But this option should be treated with care because it might lead to counterproductive results. More complete discussions and detailed analyses of the technological options are given in OECD (2007) and WBCSD (2004).

Demand management and modal shift, better use of ITS.

(4) **The provision of infrastructure** can be planned that environmentally friendly modes of transportation and transportation behaviour are supported, e.g. railways, inland waterways and coastal shipping (the motorways of the sea). Bottlenecks in the road network do not necessarily imply the need for capacity extensions of those roads. Demand management and modal shift might be environmentally preferable means of meeting transport demand. Furthermore, road capacity can be planned for lower speeds and designed to minimise the induced demand effects.

New types of fuel, such as natural gas, might need **new fuel distribution infrastructures**. Improving **information and communication networks** might also mean that communication networks must be changed fundamentally, as, for instance, they will be changed by the European satellite navigation system GALILEO, which is currently being developed. Using the potential of ITS can reduce capacity use by about 10%. Congestion externalities would go down more than proportional.

Changing values and new paradigms for adjusted mobility and logistics.

(5) **Change of behaviour** in the transportation sector is a key driver insofar as demand greatly influences supply, i.e. the consumer has to show a **willingness to pay for new energy-saving technology**. If the demand for environmentally friendly vehicles and transportation modes expands, planners will discover the need for suitable infrastructure. This means that powerful **feedback processes** can be induced once acceptance by the consumers is proven. Such reorientations of the demand side may be self-induced through a change of values in society.

Green movements and the **changing values** of younger generations may cause a trend shift in social values, e.g. in the way that high-powered, big and heavy automobiles are no longer the top prestige products of individual mobility. In the past, such self-induced processes were not powerful enough, which means that, for the foreseeable future, the necessary changes of behaviour may have to be induced and supported by state policies.

This includes individual mobility as well as logistics. A host of political instruments might be considered to influence these areas of demand. In the past, only modest attempts were made by the state to initiate policy measures for influencing transportation behaviour. The reason is that personal mobility is a highly valued good of consumers who don't like to experience too much state intervention and react as voters to environmentally ambitious plans of the ruling parties. Furthermore, the logistics sector has grown to be the third-largest economic sector after the service sector and the machinery/automotive product sector. The affected industries will put forward the arguments of economic loss and employment risk as soon as state interventions are considered. The worldwide reaction to the IPCC reports and the Stern Review indicate that there is a chance now to get consumers and the logistics industry on board with a global initiative to reduce greenhouse gases.

1.3 Designing the instruments

When it comes to CO_2 reduction, it is evident that concerted international actions which address all regions and all CO_2-generating activities are the first and best choice. The Kyoto Protocol can be regarded as the cornerstone of an international agreement on a global reduction policy including, for instance, emission trading systems. It is most essential to get the countries at the threshold of industrialisation, for instance, China, India or Brazil, on board as well as the developing countries. In future, the largest share of CO_2 will be emitted in these countries, and the greatest environmental problems will occur in the megacities of the Third World. Therefore, solutions which include the developing and newly-industrialised countries from the beginning will show the best long-term results.

A world-wide agreement on a CO_2 trading scheme or a carbon tax is currently not in sight but global reduction strategies have to start immediately if changes should be successful and efficient, following the Fourth Assessment Report of the IPCC issued in Valencia, November 2007. Therefore, further approaches like **standard settings** are needed for short- and medium-term results which are incomplete but would lead to primary reduction solutions. Furthermore, CO_2 does not cover all climate-relevant emissions and environmental policy also has to address further externalities such as particulate matter, sulphur, NO_x and noise. This leads to the conclusion that a host of instruments has to be evaluated to derive a second-best combination of instruments. We will summarise the instruments in the following categories:

- Emission trading systems,
- Regulatory measures and setting standards,
- Clean Development Mechanism (CDM) and Joint Implementation (JI),
- Taxation and tolls,
- Spatial planning, land use and urban policies,
- Infrastructure planning,
- Research, development and pilot projects,
- Mode-specific policies and logistics,
- Voluntary commitments and
- Information and advice to support behavioural changes.

Ideal solution: Global scheme of emission trading, minus 50% CO_2 reduction until 2050.

(6) **A global emission trading system** for CO_2 involving all countries and all emission activities would be the best solution. This would require a further development of the Kyoto Protocol towards an enhanced Kyoto treaty, signed by all countries and monitored by the United Nations. The following table presents the basic features of an efficient trading system on the left and the problems with existing systems, in particular by the European ETS which started in 2005, on the right hand side.

Features of a world-wide ETS for CO_2	Problems with the European ETS
Open cap and trade system with staggered reduction targets, with a goal of minus 80% for OECD countries by 2050	No fixed target, countries to decide to which extent they intend to achieve the reduction targets through the ETS
Auctioning off of emission rights, no grandfathering	Allocation of emission rights to the industries, only 10% auctioned off
All industrial sectors and households to be included	Restricted to power production and selected industries
No CO_2 arbitrage	CO_2 arbitrage possible through outsourcing of CO_2 intensive production
Fairness towards developing countries through an allocation mechanism on the base of allowable per-capita emissions	Fairness a question of negotiations, little willingness of newly-industrialised countries to join
Incentives for implementing best technologies for energy production and transport	Incentives for making windfall profits with suboptimal technologies

Table 1: A worldwide ETS: features and mistakes

An **optimal trading scheme** would require the establishment of an “emission bank” with the UN which would control the stock of certificates traded. Furthermore, the rules for auctioning and trading would have to be defined. Game-theoretical studies have shown that countries would accept this best solution if they could generally agree with the reduction targets and if there were no problems with dominance or leadership. This is not the case, however. Furthermore, there are additional greenhouse gases which are not included in the trading scheme (theoretically it could be extended to CO_2 equivalents; this would require an agreement on this indicator). And, last but not least, there are still problems with other environmental pollutants such as sulphur, NO_x, particulate matter and noise. Therefore, a **second-best strategy** is needed, which would partially replace the emission trading scheme in the short- and medium-term and would serve as a complementary scheme in the long-run such as regulatory measures and standards.

Necessity to support efficiency: regulation and standard setting to take the environmental lead.

(7) **Regulatory measures and set standards** are generally more easily accepted by consumers than taxation and tolls. This is because these instruments apply to every user in the same way and are regarded as fair and just. In general, the **Euro standard** for emissions has proven successful - the major deficiency consisted in not introducing equal standards for diesel engines and SI engines in Euro 4 and Euro 5. This may be corrected in Euro 6 which could **catch up with the higher Californian and Japanese standards** again.

One example is taken from the many existing regulations to show the effectiveness of an environmental policy. This is EU Directive 1999/30, which limits the **concentration of particulate matter (**since 2005) and NO_x (to be implemented in 2010). The problems agglomerations have in fulfilling this directive have led to a number of actions directed at vehicles with old Euro standards and at trucks. This generates a trickle-down effect, as many users will replace old cars to be able to access every region in an agglomeration by car.

The EU Commission has decided to set the target for CO_2 emissions of cars to 120 g/km in the year 2010 (10 g/km of the reduction may be achieved by extended shares of biofuel). In 2006 the average CO_2 emission of newly registered cars in Europe was around 160 g/km which implies a reduction of 40 g/km within the next three years to fulfil the target. It has to be considered that car stocks are recycling only slowly and vehicle kilometres in Europe are still growing, so that overall emissions will be only be slightly dampened. Furthermore, the way of implementation the target will strongly influence the overall reduction result. The Commission has published a plan in December 2007 which is based on a purely administrative approach. Car manufacturers have to pay penalties which relate to the average fuel consumptions of their fleet. The German industry and policy makers are complaining that the plan is unfair because it disadvantages the producers of bigger cars. At the same time it provides little incentives to reduce fuel consumption of small cars and might motivate consumers to use their old cars even longer.

Complementary actions: clean development mechanism, joint implement-tation, global environment facility.

(8) The **Clean Development Mechanism and Joint Implementation** option of the Kyoto Protocol offer some flexibility, as they allow the export of reduction activity to countries in which the reduction in CO_2 emissions can be achieved with a lower financial investment. This can have undesired and desired effects. Of course it lowers the motivation of producers in industrialised countries to invest in reduction policies domestically because

investments in a developing country may be much more effective. This could imply that emissions in industrialised countries would continue to grow - an effect which can be observed in the European power production industry. On the other hand, **modern technology would be exported** to developing countries, which would then be enabled to make considerable progress in the use of clean production technologies.

Until now, the transportation sector has not been extensively used clean development mechanism (CDM) and joint implementation (JI), both of which were developed in the context of the Kyoto Protocol. Integration of the transportation sector would particularly foster the second type of impact. Currently, used vehicles which no longer fulfil the relevant Euro emission standards are exported to non-EU countries with lower standards. CDM and JI could create **incentives to at least retrofit used vehicles with reduction technology**, e.g. catalysts or particle filters for diesel engines.

The **Global Environment Facility** (GEF) was established by the World Bank, the UNDP and the UNEP in 1991. GEF addresses, beside others, climate change issues and could be used to fund pilot projects in developing countries.. It could be extended to invest in sustainable transportation technology and to serve as a catalyst for similar investment activity in developing countries.

Effective short run instruments: taxes, tolls and charges.

(9) **Taxation and tolls** are classical instruments used by the state to intervene in the transportation sector. The impact of a trading scheme for CO_2 emissions, for instance, could also be achieved through an international agreement on carbon taxation. **Fuel taxes** based on the purchase of gasoline or diesel fuel could serve as proxies; they have already proven to be effective at influencing the behaviour of consumers and producers. In high tax countries such as the UK, the Netherlands or Germany, the elasticity of passenger transport demand to fuel price increases is relatively high. A problem in Europe is the high range of taxes, which stimulates fuel arbitrage. Internationally operating trucks in particular fill their tanks in low tax countries such as Luxembourg, which has become a trucking hub because of its low fuel tax. Tourists also follow this behaviour and contribute to distortions in the European transportation markets. A convergence of the taxation ranges is necessary if fuel taxes are to be used as an instrument in the reduction of carbon emissions.

Vehicle taxation has often been rejected in scientific studies because it is not related to traffic activity and is a fixed cost which might encourage an even more intensive use of the infrastructure. It is true that there is little influence of vehicle tax on mileage. But there is a high influence of a differentiated vehicle tax on the choice of technology. A low vehicle tax for vehicles with better environmental attributes of would be a strong incentive to buy new technology, while a high vehicle tax for vehicles which don't meet certain standards would contribute to taking such vehicles out of circulation.

Infrastructure usage fees can be differentiated according to the environmental performance of the vehicles. This is applied to the motorway tolls for heavy goods vehicles in the EU. The revised Directive 2006/38/EG now allows a range of 100%. This generates strong **incentives to buy environmentally friendly technology**. One can observe, and this is true for Switzerland, Austria and Germany, that the differentiation of the toll led to a jump from Euro 3 to Euro 5/Euro 5+ (used in Germany for vehicles which fulfil NO_x and particulate matter emission targets beyond Euro 5). For the future, an integration of external costs into the chargeable cost pool is being considered and has to be decided on in 2008. This would create additional incentives for better organisation of loads and fewer empty runs by trucks, as well as the use of alternative modes of transportation. An extension of infrastructure usage fees to light-duty commercial vehicles and cars would be a consequent follow-up, which would create similar effects reducing mileage. **City congestion tolls** in London and Stockholm highlight the positive effects of reducing urban bottlenecks and environmental harm.

Transport policy not a good instrument for correcting wrong land use policy.

(10) **Spatial planning, land use and urban policies** are instruments for influencing the generation and distribution of traffic and the possibility of using alternative traffic modes. As a matter of fact, **transportation policy is generally not able to correct the mistakes** which have been made in land use policy. For a long time, the planning of industrial and residential settlements followed short-term market rules which led to spatially dispersed structures, generating a lot of traffic and favouring the car as a mode of transportation.

Changing these structures will take decades, but will prove very effective. In a number of European cities, one can observe that the trend of moving outside the centre has stopped and that net migration is becoming positive again. This has many reasons, some of which have to do with traffic, its costs and the accessibility of cities from the suburbs by car. **Stopping the car-oriented spatial development policy** has already resulted in significant impact and encourages more emphasis to be placed on this instrument, which can only work in the long term, but is highly effective, in particular in the mega-cities of the third world. Tolls on urban traffic can contribute to accelerating this process.

Change in paradigm: infrastructure extension primarily to foster environmentally friendly modes and better management.

(11) **Infrastructure planning** is a long-term instrument for influencing transport activities and guiding them towards better environmental efficiency. One means of inducing a change in transportation behaviour is to offer more desirable alternative modes in order to divert transportation activity to public transportation, railways, waterways and coastal shipping. In this sense, it is necessary to **limit the capacity of environmentally problematic modes** such as roads and to refrain from automatically planning road extensions as soon as bottlenecks and congestion show up. In the absence of a viable pricing framework, congestion is the only means of controlling the development of road transportation. Of course congestion has very large economic costs and a number of undesired effects, also on the environment. But these can be reduced through the use of appropriate technology (e.g. automatic stopping of engines, laying out engines for lower speeds).

A general strategy for infrastructure extension is to **disconnect it from the development of the presumed demand** for roads and air traffic and to develop plans with a view to the effective demand which is expected after taking action in traffic management and pricing. This would imply advantages for public transport.

Research and technology development: alternative technology and comprehensive pilot projects for sustainable cities and transport patterns.

(12) **Research, development and pilot projects** are necessary to explore the possibilities offered by innovative technologies. While conventional technologies such as hybrid propulsion have considerable potential to reduce emissions, it is obvious that **in the long run, a basic change will be inevitabl**e for two reasons: First of all, the increasing shortage of fossil energy resources makes it necessary to develop alternative propulsion techniques and alternative fuels. Secondly, the increasing call for the transportation sector to contribute to the ambitious reduction targets will induce further searches for fundamentally different techniques which will enable coming generations to enjoy mobility.

With regard to fuel, the present state of knowledge suggests an increase the production and use of biofuel. It is obvious that this cannot induce a radical change because the production capacity of bio power plants will be limited. But it will contribute to a mix of renewable energy sources if biofuels are produced by waste and pre-processing. Other technologies are vehicles powered by solar energy or fuel cells. While the respective technologies have been researched to some extent, producing these technologies at acceptable prices still presents a big challenge. At present, such innovative technologies are more than 10 times more expensive than comparable conventional technologies. Performing more **pilot projects** to test new technologies under real-life conditions will bring more insight on the potential of innovative solutions.

Exploit potential of railways: better organisation and interoperability are the keys.

(13) **Mode-specific policies and logistics** require particular expertise in the areas addressed and a consideration of the overall market effects. One example is the **railway sector,** which is, in principle, more environmentally friendly than road or air transportation. A first observation is that this is true on average but not for every segment. As soon as the trains are less occupied and driven by old diesel engines, rail service can be more polluting than buses or trucks. A second observation is that the performance of railway companies is not only dependent on the infrastructure, which is usually provided by the state, but also on the **organisation of infrastructure managers and railway companies**. The traditional state-owned enterprises usually show a low level of efficiency and market performance. Commercially oriented railway companies will do better, but will not automatically apply environmentally efficient technology, i.e. they might prefer used diesel engines to expensive – possibly hybrid - electric locomotives. Therefore, providing incentives through a **differentiated track charging scheme** which includes environmental bonus-malus components will be necessary, and is made possible, in principle, by Directive 2001/14.

Special problems of environmental policy occur in the sectors **aviation, maritime shipping and inland waterway shipping**. Partially due to international agreements, these sectors are excluded from fuel taxation. Therefore, solutions have to be found, for instance an **integration into the EU Emission Trading System (ETS)**. A directive for including aviation in the ETS is being prepared but shows several weak points as are exhibited on the right-hand side of Table 1. Further problems in aviation are NO_x and water vapour which cause the contrail and cirrus problems. In **maritime** and inland waterway shipping, the pollution problems are increased by the use of low-quality fuel with a high sulphur content and illegal practices of bilge water disposal.

Logistics is a growing economic sector in developed countries which, on the one hand, organises the spatially distributed workflows of production as well as the distribution and sourcing processes in space. On the other hand, **contract logistics** is a more and more integral part of the intelligent organisation of workflows themselves and participates through integrating value-added services. In the past, this has led to an increase in transportation activity because transportation was cheaper than other logistic management objects like warehousing. As a consequence, logistic intelligence concentrated on replacing high-cost components of the logistics chain with transportation. In the future, the intelligence of this sector can be used to reduce vehicle miles and emissions drastically by **giving logistics managers new challenges**. This needs to be accompanied by higher costs of infrastructure use and a higher cost of transportation activity through taxes or emission certificates.

Voluntary commitments to accompany hard instruments.

(14) **Voluntary commitments** can support and partly replace public actions. The environmental performance of products is increasingly becoming a sign of high technology and high quality. Environmental technology is an innovative field of product and process development and will have a lot of potential on the world market due to the growing problems in the Third World. Ideally, the environmental characteristics of products and services would **foster competition** between companies. This would boost the effects which can be achieved by state-controlled taxes and regulation policies alone.

There are examples of promising initiatives regarding the development of reduction strategies for companies, for instance BP, SBB and Hydro.

One negative example is the voluntary commitment of the European automobile industry to reduce the CO_2 emissions of newly registered cars to 140 g/km from 1995 to 2008 which would have been 25% below the average emissions of 1990. In 2006, the average emissions of newly licensed cars in Germany were 172.5 g/km (KBA, 2007), whereas the average in Europe was only 161.4 g/km (Frankfurter Rundschau Aktuell, 2007). More than ten years after signing the voluntary commitment and with only two years left to go, it can be expected that the objectives cannot be achieved. This example shows that the government should always have instruments up its sleeve in case voluntary commitments fail.

It also underlines that non-fulfillment of voluntary commitments might lead to administrative over-reactions (see item (7))).

2 Climate change and necessary responses

2.1 Climate change: challenges for the economy and the transportation sector

2.1.1 Some basic facts on global warming

Compiled by Prof. Anders Levermann, Prof. Stefan Rahmstorf, Potsdam Institute for Climate Impact Research

The core findings of climate research have been so well confirmed in recent decades that they are now generally accepted as fact by climate researchers. These core findings include the following:

1. The atmospheric CO_2 concentration has risen strongly since about 1850, from 280 ppm (a value typical for warm periods during at least the past 700,000 years) to 380 ppm.

2. This rise is entirely caused by human activity and is primarily due to the burning of fossil fuel, with a smaller contribution due to deforestation.

3. CO_2 is a gas that affects climate by changing the earth's radiation budget: an increase in its concentration leads to a rise in temperatures close to the Earth's surface. If the concentration doubles, the resulting average global warming will likely be between 2 and 4°C (the most probable value is around 3ºC).

4. Since 1900, global climate warmed by approximately 0.8°C. Temperatures in the past ten years have been the highest since the recording of measured temperatures began in the 19th century and for many centuries before that.

5. Most of this warming is due to the rising concentration of CO_2 and other anthropogenic gases.

These findings are based on decades of research and thousands of studies. The extraordinary consensus reached is seen in the statements of many international and national professional bodies which have extensively and critically assessed the scientific evidence. In addition to the well-known reports by the IPCC, there are public statements by the National Scientific Academies of all G8 countries, the American Geophysical Union (AGU), the World Meteorological Organisation (WMO), the scientific Advisory Council on Global Change (WBGU) of the German government, and many others. These organisations have come to the same key conclusions again and again.

Points 1. – 3. show that a further increase in CO_2 concentration will lead to a further rise in global mean temperature (Fig. 2). For a range of plausible assumptions on future emissions, this rise will be in the range of 1.4-5.8 ºC (from 1990 to 2100).

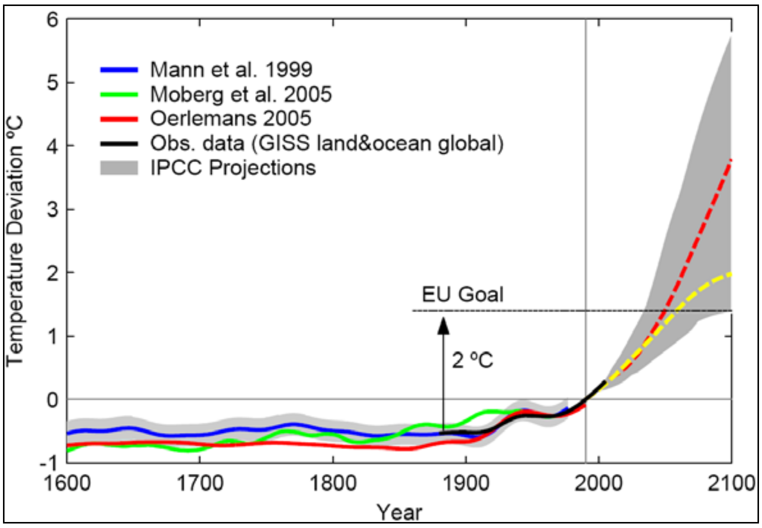

Figure 2: IPCC projections of global mean temperature in the 21st century

Note: The grey band shows the full range of scenarios; red and yellow are two examples (B1 and A2). The EU target of 2 ºC is also shown.

For comparison: the last major phase of global warming was at the end of the last great Ice Age (about 15,000 years ago); it involved a global warming of ~5ºC over a time span of 5,000 years. Unchecked anthropogenic warming could reach a similar magnitude over a fraction of this time – and, of course, starting from an already warm climate.

2.1.2 Impact and risks

Compiled by Prof. Anders Levermann, Prof. Stefan Rahmstorf, Potsdam Institute for Climate Impact Research and Carola Schulz, IWW, Universität Karlsruhe (TH)

Whether this warming is to be considered a "dangerous" climate change cannot, of course, be determined by scientists alone as it depends on a societal value judgment on what is dangerous. However, science can help determine the risks that arise from such unprecedented warming. Amongst the most important risks are the following:

- **Sea level rise and loss of ice sheets.** Over the course of the 20th century, global sea level increased by 15 - 20 cm. Currently, the sea level is rising at 3 cm per decade, faster than projected in the scenarios of the Third Assessment Report of the IPCC. By 2100, the rise will likely be less than one meter, but even if warming is stopped at 3 ºC, the sea level will probably keep rising by several meters in subsequent centuries as a delayed response. Coastal cities and low-lying islands are at risk. What would now be considered a once-in-a-century extreme flood in New York City (with major damage including flooded subway stations) would statistically occur about once every 3 years if the sea level were just 1 meter higher.

- **Loss of ecosystems and species.** Global temperatures would reach a level which has not been seen for millions of years and the rise would happen much too quickly for many species to adapt. A large share of species - some studies suggest up to one third of all species - could already be doomed to extinction by the year 2050. Life in the oceans is not only threatened by climate change but also by the equally serious problem of the ongoing global ocean acidification which is a direct chemical result of our CO_2 emissions.

- **Risk of extreme events.** In a warmer climate, the risk of extreme flooding events will increase since warmer air can hold more water (7% more for each ºC of warming). Droughts and forest fires are likely to increase in some regions, as is currently occurring in the Mediterranean region and in southern Africa. Hurricanes are expected to become more destructive. An increase in the energy rather than the frequency of hurricanes in response to rising sea surface temperatures is suggested by models and existing data. A number of recent studies have shown that the observed rise of sea surface temperatures in the relevant areas of the tropics is primarily due to global warming rather than a natural cycle.

- **Risk to water and food supplies.** While the total global agricultural production may not decline in a warmer climate, many poorer and warmer countries can expect reductions in yields due to water shortages and weather extremes. The water supply of major cities like Lima will be threatened when mountain glaciers disappear.

- The **economic consequences** of climate change are the focus of the Stern Review (2006) and the IPCC Climate Change Report of 2001. Figure 3 gives an overview of the estimated losses as a percentage of global GDP as a function of global warming. There is a consensus that increasing magnitudes of climate change will lead to higher losses, but that small increases in average global temperatures may entail positive or negative effects.

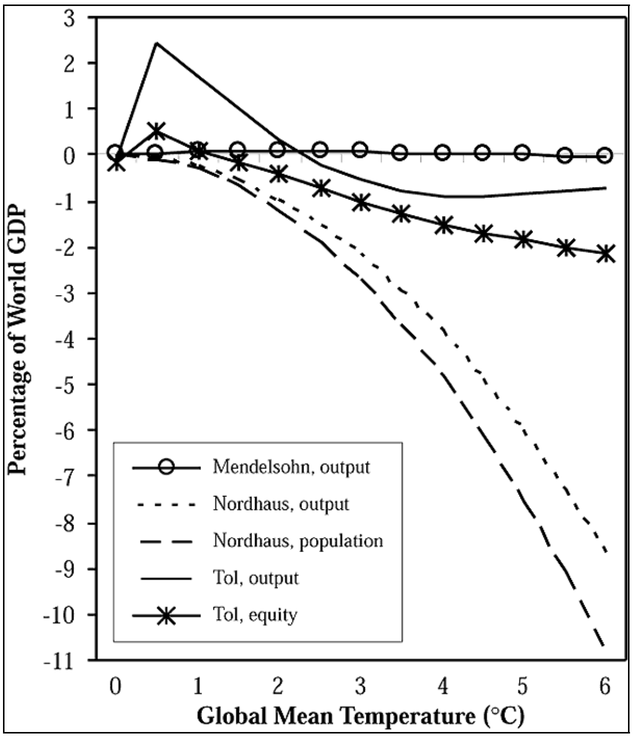

Figure 3: Monetary impact as a function of the level of climate change

Source: IPCC (2001), Task group II: Impact, Adaptation and Vulnerability

These are only examples – the exact consequences of such a major change in climate are difficult to predict, and surprises are likely.

2.1.3 How to avoid dangerous climate change

Compiled by Prof. Anders Levermann, Prof. Stefan Rahmstorf, Potsdam Institute for Climate Impact Research

In the United Nations Framework Convention on Climate Change (UNFCCC) of 1992, almost all the nations of the world committed themselves to preventing a "dangerous interference" with the climate system. To avoid the most dangerous consequences of climate change, the European Union has decided to halt global warming at below 2ºC above pre-industrial temperatures (EU limit, see Fig. 2). To reach this goal, the carbon dioxide concentration in the atmosphere needs to be stabilised below 450 ppm (possibly after exceeding this value for a limited time).

To achieve this, global CO_2 emissions need to be roughly halved by 2050 compared to the level of 1990. Carbon cycle feedback makes this number incalculable, and the actual value is likely to be between 40% and 70%.

According to latest economic modelling results (see Edenhofer et al. (2006), as well as the Stern Review (2006)), this can be achieved with minimal costs (less than 1% lower GDP by 2100) by induced technological innovation, including increased energy efficiency and renewable energy technologies (wind, biomass, solar). Detailed scenarios for the required energy transition have been worked out by the Advisory Council on Global Change of the German government and others.

2.1.4 European Policy on Transport and Environment

Compiled by Dr. Eleni Kopanezou, Head of Unit Clean Transport and Urban Transport, DG TREN and Carola Schulz, Universität Karlsruhe (TH)

2.1.4.1 Sustainable Mobility

Mobility has been essential for the ever closer integration of Europe and its communication with other parts of a globalised world. The demand for transportation has grown by 2.8% per year for goods and 1.9% per year for passengers since 1995. Transportation is a major contributor to **economic growth and competitiveness**. The transportation services sector employed about 8.2 million persons in the EU-25 in 2004 and accounted for a turnover of approximately 850 billion Euros. The EU is a leading provider of transportation services, equipment and technology. EU companies control 30% of worldwide air transport and 40% of the maritime fleet. Transportation equipment accounts for 16% of EU exports. However, the growing demand for transportation also results in increasing congestion and adverse environmental impact. Transportation policy is also closely linked with energy policy since transportation accounts for 71% of all oil consumed in the EU.

The **main environmental** challenges for transportation policy are related to:

- Excessive dependence of transportation on oil with its impact on the reliability of supply
- CO_2 emissions from transportation with the associated impact on climate change
- Emissions of pollutants from vehicles along with their impact on health

A **multifaceted approach** needs to be taken both to ensure an efficient transportation system and to limit the environmental impact of transportation. All modes must become more environmentally friendly, safe and energy-efficient, and the increasing demand for transportation services should be re-directed, where appropriate, towards more environmentally friendly modes. The efficient use of different modes in co-modality will result in an optimal and sustainable use of resources in line with the renewed Sustainable Development Strategy. European transport policy takes a holistic and multi-modal approach and aims to increase the share of "Green Propulsion" in all modes throughout the whole transportation sector.

Transportation systems have evolved over many decades within each EU member state. The next step is an **integration of the national transport systems** to allow for the European dimension of the continent and the single market that the European Union represents. In practice, this often involves a major re-structuring of the regulatory framework, such as rail liberalisation, or substantial investment in technological programmes, such as railway signalling systems (ERTMS) or air traffic management (SESAR).

Specific steps are required to address environmental concerns, in particular climate change.

2.1.4.2 European policy framework

The overall objective of European transport policy is competitive, secure, safe, and environmentally friendly mobility. Several recent strategy documents for the transportation and energy sectors outline the framework and propose a number of concrete political actions.

- The **mid-term review of the White Paper on Transport** of June 2006 aims to disconnect the development of sustainable mobility from negative effects, in particular from the impact on the environment. It proposes improving the efficiency of all transport modes, whether used on their own or in combination and modal transfer to rail and waterway transportation, when more efficient from an overall perspective as well as the deployment of intelligent transportation systems and innovation in all fields of transportation. An intelligent toll system should contribute to a more efficient use of existing infrastructure and thereby reduce congestion and pollution. The satellite navigation system GALILEO should contribute to improving traffic and logistics management.

- The Commission is preparing a new **Green Paper on Urban Transport**. This Green Paper will look at new approaches to encouraging the use of energy-efficient transport solutions, including public transportation, car-sharing and non-motorised modes of transportation. The Green Paper will most likely be adopted by the Commission in September 2007.

- The Commission is considering a new initiative on the **promotion of the market development of clean and energy efficient vehicles** by public procurement. It could be based on an inclusion of life-time costs for energy, CO_2 emissions, and pollution into the awarding criteria for vehicle procurement. A Commission proposal is expected before the end of 2007.

- The **Energy Efficiency Action Plan** of October 2006 addresses transportation as a key sector. It proposes a number of concrete measures**,** with the overall objective of a 20% improvement in energy efficiency by 2020. This objective has been endorsed by the March 2007 Spring European Council. An integrated approach addresses all actors, including motor and tyre manufacturers, drivers, fuel suppliers and infrastructure.

- The January 2007 proposal of the Commission for a new **European energy policy** has the core objective of reducing greenhouse gas emissions from energy consumption in Europe by 20% by 2020. This objective has been endorsed by the March 2007 Spring European Council. Improvement of energy efficiency in transportation and a long-term vision for energy technology development are some of the main objectives.

- **Research and technological development programmes** in transportation and energy have had a strong focus on clean and energy-efficient technologies. This will be continued by the Seventh Framework Programme of the European Union for the 2007-2013 period.

2.1.4.3 Sector-specific measures

2.1.4.3.1 Road

While the EU as a whole has reduced its emissions of greenhouse gases by just under 5% during the 1990-2004 period, the **CO_2 emissions from road transportation** have increased by 26%. The bulk of transport-related CO_2 emissions (84.2%) originates in the road sector and, despite initiatives taken in recent years (e.g. voluntary agreements, technical standards, labelling, taxation of fuels), emissions are still increasing, and are predicted to continue doing so.

- **EC strategy for reducing the CO_2 emissions of cars** (1995): The basis of the strategy are voluntary commitments by the car industry, consumer information through fuel efficiency labelling, and fiscal measures to promote fuel-efficient cars.

- **Supporting the market development of biofuels**: a policy package on European energy policy (10 January 2007)

- **Tolls for heavy goods vehicles:** The Eurovignette Directive (2006/38/EC amending 1999/62/EC). The Directive also provides for other regulatory fees, such as urban congestion or a pollution charge.

- **Pollutant emissions from vehicles**: successive EURO standards (EURO I-VI)

2.1.4.3.2 Rail

Rail is the transport mode with the lowest emissions, and its emissions are falling. It is a longstanding objective of European transport policy to promote the use of rail transportation for both passengers and freight. A modal shift towards rail could contribute to reducing the steadily growing CO_2 emissions of the transportation sector. Therefore, enabling rail to compete with road and air is a priority. Emphasis is being put on **liberalisation** and on **interoperability** across borders, which will enable rail transporters to improve efficiency, and thereby compete with road transportation more effectively.

The **ERTMS system** will enhance interoperability between national networks, which is a pre-requisite for effective long-distance rail operations. The EU is investing considerable public funds into this system and accompanying its roll-out with the necessary regulatory framework.

2.1.4.3.3 Sea and inland waterways

The transportation of goods by sea and inland waterway is more energy-efficient than by road and air. Most of the EU's external trade (71.7% in 2004, by weight) is transported by sea. However, the relative proportion of air pollution from ships is rising. Unless more actions are taken, they are set to emit more than all land-based sources combined by 2020 (land-based sources are subject to more stringent regulation). The Commission will continue efforts in the International Maritime Organisation to achieve more stringent emission standards for pollutants.

Maritime policy is in the process of being re-designed. A debate was set in motion by the Commission's Green Paper on a future EU maritime policy to develop an integrated maritime transport strategy around a "**common European maritime space**".

River transportation could be improved by modernising and integrating it into efficient multi-modal logistics chains. The **NAIADES programme** formulates an action plan for this purpose.

2.1.4.3.4 Aviation

Aviation emissions are growing quickly and have a greater adverse effect on global warming than emissions on the ground. Although aviation greenhouse gas emissions are small compared to total greenhouse gas emissions (i.e. 3.6% of EU-25 in 2004), they are growing rapidly and are expected to continue doing so. A legislative proposal to bring aviation into the EU emissions trading scheme was presented by the Commission in December 2006.

The EU programme for the modernisation of air traffic management in Europe, SESAR, is a major initiative which will support the sustainable development of air transportation. Environmental sustainability is one of the key objectives of SESAR.

2.1.4.3.5 Multi-modal measures

- **Charging**: A report will be presented by the Commission, in the context of the Eurovignette Directive, by June 2008 on the impact of internalising external costs for all modes of transport.

- **Improving transportation efficiency** and Information Technology for transport and logistics: E.g. Satellite navigation system GALILEO, forthcoming Logistics Action Plan.

- **Commission funding policy for the trans-European transport network (TEN-T)**: Each new infrastructure programme is subject to a strategic environmental analysis and each individual project must also be assessed regarding its environmental impact.

- **Development of technologies to reduce environmental impact**: The 7th Research and Technological Development Framework Programme includes strategies for "The Greening of Air Transport" and "The Greening of Surface Transport".

2.2 External cost of transportation and climate change

2.2.1 The climate change challenge: strategies in the transportation sector

Compiled by David Thompson, UK Department for Transport,
Aaron Scholz and Carola Schulz, Universität Karlsruhe (TH)

The role of Transportation in productivity and growth

In 2003, around 24% of worldwide CO_2 emissions from fuel combustion were caused by the transportation sector (Figure 4). Its share is highest in the more developed countries, but developing countries have the highest emission growth rates. Within the last decade, the share of transportation has increased in all regions of the world (OECD, 2007).

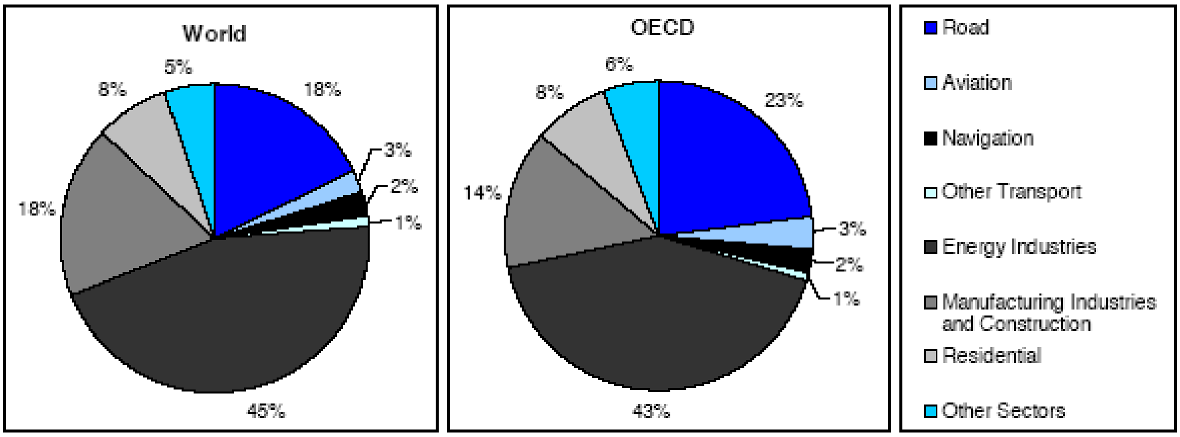

Figure 4: Transportation's share of CO_2 emissions from combustion in 2003 in percent

Source: IEA, 2005

The transportation sector plays a significant role in the climate challenge of the century, but enhanced mobility is also essential to continued economic progress – especially in developing countries (key dilemma). Molina and Molina (2002) summarise the relationship between transportation, economy and the environment as illustrated in Figure 5. Transportation facilitates economic growth in a variety of ways, such as the production of vehicles and fuel, expenditures for the provision of infrastructure and transportation services. Different studies have proven that economic growth requires the availability of reliable, safe, secure, efficient and affordable transportation services. On the other hand, economic growth stimulates an increased demand for transportation services which impacts the environment. If unchecked, economic and environmental impact of transportation might restrain further economic growth through congestion, decreasing reliability, etc. Therefore, an overall approach which considers environmental (and social) issues as well as economic impact has to be chosen. Transportation should be treated in the same way as every other sector when it comes to reduction policies; it should not be preferred, but also not discriminated against.

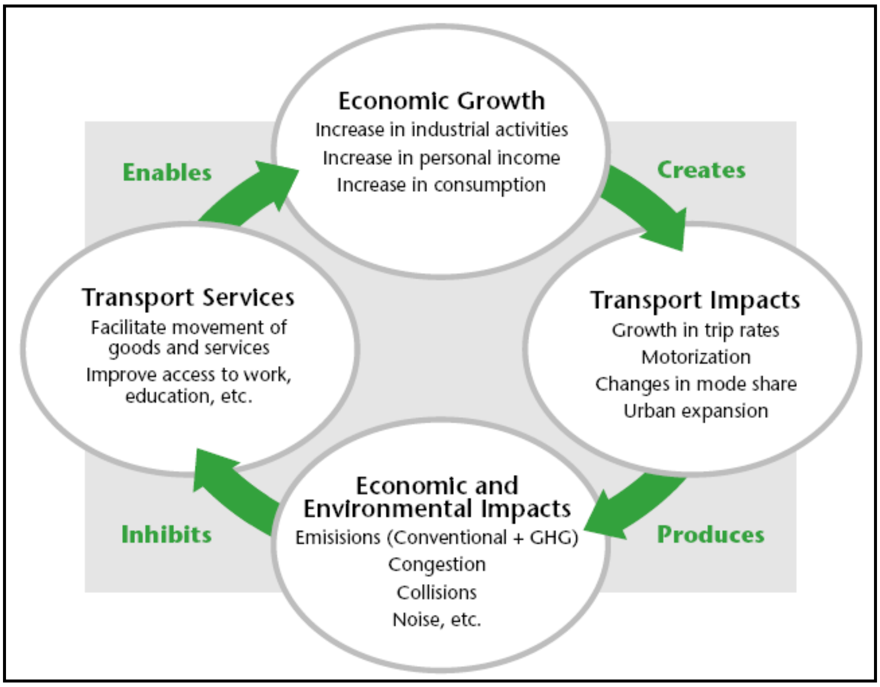

Figure 5: The challenges of making mobility sustainable

Source: Molina & Molina, 2002

For the United Kingdom (UK), the recently published Eddington Transport Study explored the long-term links between transport development and the UK's productivity, stability and growth in the context of sustainable development. The study concludes that major changes in transportation have been pivotal in the development of past phases of globalisation (Eddington, 2006). In the twentieth century, the falling cost of transportation for all modes of transportation, along with a falling cost of communication meant that goods and services could be traded faster and more cheaply (higher efficiency). For the UK, the falling cost of transportation over the last 40 years has boosted international trade in goods by 10 to 17.5% and raised GDP by 2.5 to 4.5% (Crafts and Leunig, 2005). A similar picture emerges for most other developed countries. The current phase of globalisation will mean for developed counties an increasing shift to services and high value manufacturing with the increasing importance of cities to enable the benefits of agglomeration economies to be achieved in these sectors. This will further increase volumes of passenger and freight both within countries and internationally.

Sustainable strategies

In order to recognize the role of transportation in productivity and growth as well as climate change, strategies must be identified that contribute to a sustainable future. The Stern Review demonstrated that there is a need to tackle a range of failures in the market which can be mitigated at a relatively low cost. First, the damage cost of GHG emissions has to be reflected in the price of goods (whether through taxes and charges, cap and trade schemes or regulation). Secondly, carbon pricing alone will not induce low carbon technology. Third, behavioural barriers will make abatement more costly if carbon pricing is relied on alone. A three-part approach is suggested which combines carbon pricing with an appropriate technology policy and the removal of other barriers. Figure 6 demonstrates the three-part approach and the interactions of factors and policies for a sustainable strategy. Figure 7 suggests a policy map for road transportation, taking into account the Stern Review's three-part approach.

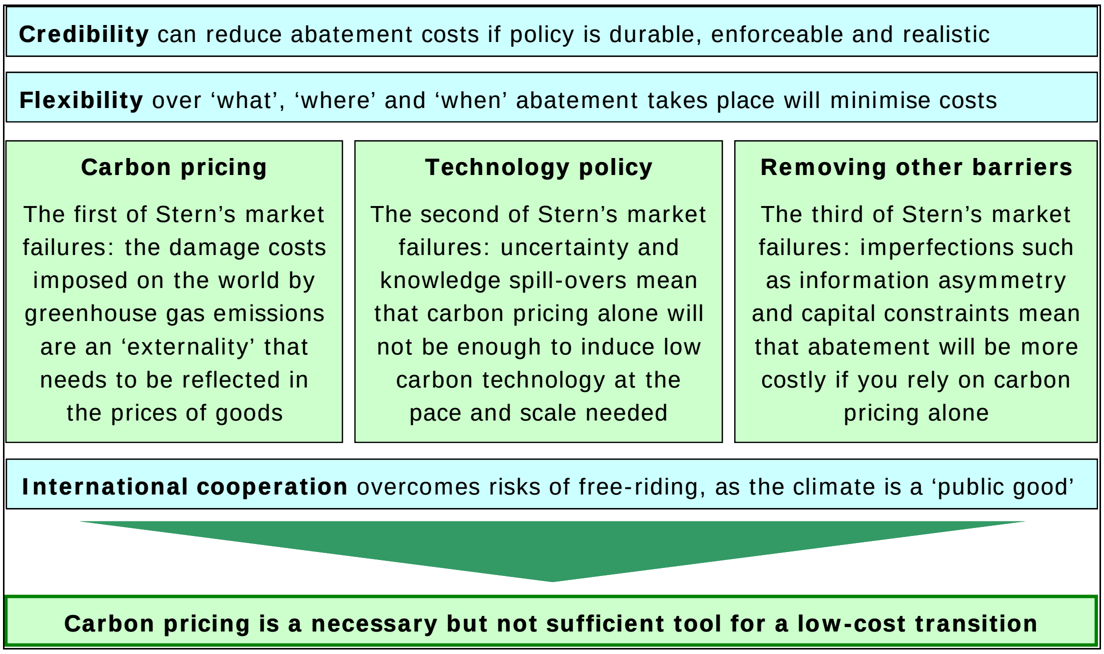

Figure 6: The Stern Review's three-part approach

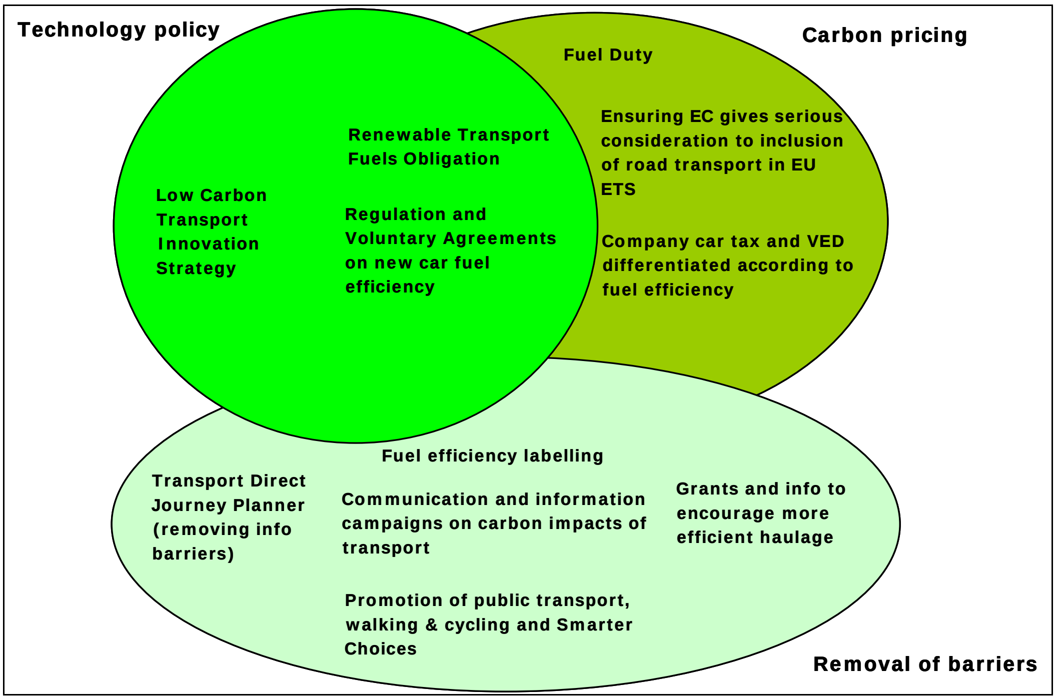

Figure 7: Policy map for road transportation

Analysis carried out for the UK (see Chapter 7 of "Meeting the Energy Challenge – A White Paper on Energy", available from http://www.dti.gov.uk/energy/whitepaper/page39534.html) shows that strategies based on the Stern Review's principles have the scope to yield positive cost-benefit returns and to provide material reductions in transportation emissions in the medium-term future.

2.2.2 Indicators

Compiled by Peder Jensen, European Environmental Agency (EEA), Aaron Scholz, Universität Karlsruhe (TH)

The TERM set of indicators tracks the integration of environmental aspects into transport policy. In addition to this, TERM provides an overview of relevant environmental problems in transportation on an annual basis.

One of the issues tracked is the development in freight transport, which grows slightly more quickly than the economy, and for which there is a gradual shift away from rail and towards road transportation. The story is almost the same for passenger transportation, although growth here is a bit slower than GDP growth. The modal split, on the other hand, is even more skewed in favour of road transportation, and the new EU member states are now quite similar to the older ones.

The result is a strong growth in the emission of greenhouse gases (26% between 1990 and 2004).

If the EU is serious about its GHG reduction commitments, then transportation must be addressed as well. Our overall "allowance" will decrease over time (60-80% by 2050), but with increasing emissions caused by transportation, this entire quota will be used up by transportation from somewhere between 2030 and 2050 onward. (see Figure 8)

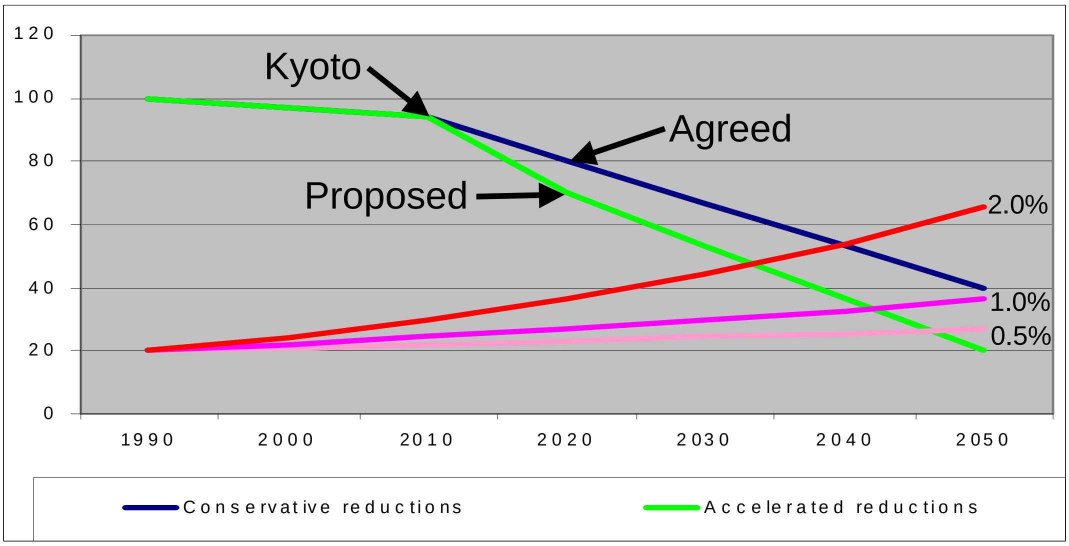

Figure 8: Transport emissions versus 'total emission allowance'

In spite of great technological progress, very little has actually happened in regard to the average vehicle in the fleet. Technology takes a long time to penetrate and development is slow. The voluntary commitment by the manufacturers is unlikely to be met and part of the problem is the fact that people tend to buy bigger cars. Smaller vehicles are indeed available, but are often difficult to sell. In the freight transport sector, development is even slower, in part because there was a higher degree of optimisation earlier (see Figure 9).

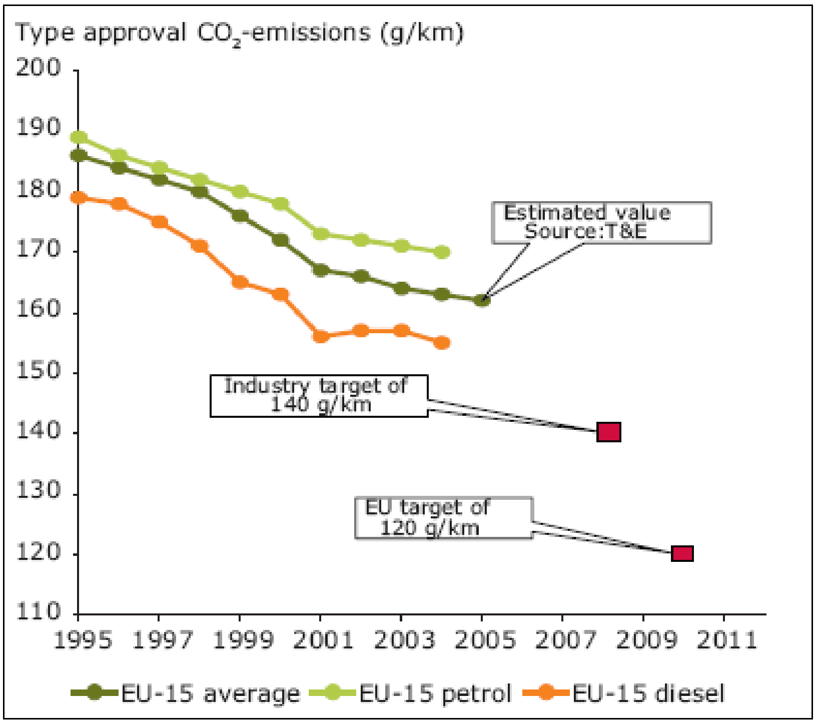

Figure 9: Efficiency improvements in passenger cars

One of the tools applied to reduce GHG emissions is the promotion of biofuels. But their use is only increasing slowly. In addition to this, the environmental benefits may be quite small.

Decreasing emissions is often pointed out as one of the prime examples of good regulation. However, we fail to see an improvement in urban air quality that corresponds to the decreasing emissions. It would appear that climate change is part of the explanation for the dilemma.

In addition to this, we note that some regulation merely shifts emissions around rather than actually reducing them. Sulphur emissions have only shifted from land to sea as a result of cleaner land transport fuel (see Figure 10).

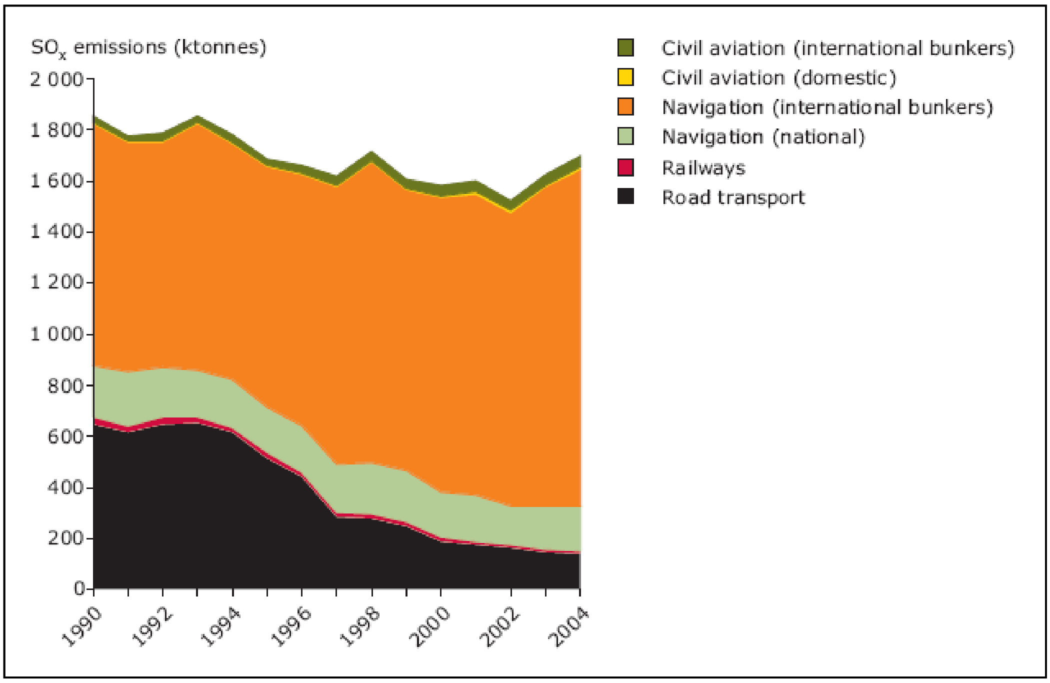

Figure 10: Shift of SO_X emissions from land to sea

Another area of indicators in TERM are economic indicators. The EEA is in the process of developing an indicator for transport subsidies based on a recent study. So far, there are a few reports of some results, but tracking the development via time series is not possible yet.

Even if we look at the most optimistic predictions, it is difficult to find a basis to believe that emissions will be reduced. It is clear that technology cannot solve the problem unless we see a quantum leap in performance. Serious questions are being raised concerning the sustainability of biofuel production in Europe and globally. Therefore, policy needs to include demand management tools as well as modal shift goals.

2.2.3 External costs in the transportation sector

Compiled by Markus Maibach, INFRAS Zurich

External costs are important information for use in policy-making

The estimation of external costs in the transportation sector has long been used to compare the whole cost of transportation for different modes and to prepare information for policy priorities, to extract unit costs for environmental damage to be used for the assessment of transport investments, and – last but not least – to prepare information for efficient pricing schemes in the transportation sector. The European Commission and many EU member states have prepared methodological input, modelling tools and quantitative results.

Especially Germany has recently been very active in preparing input on external cost information. The German Environmental Agency (UBA) has worked out a methodological principle for estimating environmental costs and a guideline on how to use unit values in socio-economic cost-benefit analysis. At the same time, the external cost of transportation in Germany has been updated by the 'Allianz pro Schiene'.

At the European level, DG TREN is working on a handbook on best practice methodologies and figures for the transportation sector as a basis for efficient pricing. The most important proposal is the continued development of the Eurovignette Directive, not only considering infrastructure, but also accident and environmental costs.

Values are already available

Thanks to increased efforts, there is – at the scientific level – a consensus on valuation approaches for external costs. Although external cost figures still have a certain range of uncertainty, there have been some breakthroughs worth noting:

- The valuation of air pollution costs is based on the ExternE model, which was developed by the IER in Stuttgart and improved upon in many EU research projects. Through this model, figures are available for the per tonne valuation of pollutants. The values differ by country and population density. In Germany, for example, the range is between 92,000 € (interurban transport) and 450,000 € (metropolitan areas).

- The valuation of the cost of climate change is a more tricky issue, since different possibilities and methodologies exist. The damage cost approach uses a global perspective and considers all sectors. There is no specific focus on transportation. The avoidance cost approach has to define clear goals and reduction strategies for different sectors. It is possible to have a specific look at the transportation sector. The most recent meta-analysis has shown that a reasonable average mid–term value for the valuation of climate change damages is 70 € per tonne of CO_2. However, the bandwidth is quite high - between 20 and 280 € per tonne of CO_2, depending on different assumptions concerning the dynamics and the consideration of specific risks. The following figure shows different types of uncertainty.

		Uncertainty in Valuation →		
Uncertainty in Predicting Climate Change ↓		**Market**	**Non Market**	**(Socially Contingent)**
	Projection (e,g, sea level Rise)	Coastal protection Loss of dryland Energy (heating/cooling)	Heat stress Loss of wetland	Regional costs Investment
	Bounded Risks (e.g. droughts, floods, storms)	Agriculture Water Variability (drought, flood, storms)	Ecosystem change Biodiversity Loss of life Secondary social effects	Comparative advantage & market structures
	System change & surprises (e.g. major events)	Above, plus Significant loss of land and resources Non- marginal effects	Higher order social effects Regional collapse Irreversible losses	Regional collapse

Figure 11: Uncertainties in valuation and climate change predictions

Source: Downing and Watkiss (2003)

- Most recent studies on the external costs of transportation (accident and environmental costs) show that the share of climate change costs is about 20 to 25%, and rising. Climate change costs might account for about half of the total environmental cost. At the same time, the cost of air pollution amounts to less than 20%, with a decreasing tendency thanks to technical improvement.

The costs of reducing environmental damage varies

The discussion of the contribution of transportation to climate change has become a major issue since transportation is a growing sector and uses a major part of fossil fuels. This is especially true if the development in Eastern Europe or (in a more global perspective) the development in countries like China or India is considered. Compared to air pollution, for instance, where technical measures like particle filters are available, there are no readily available effective major mitigation measures to reduce the consumption of fossil fuels in the transportation sector. Nevertheless, there are some painless measures such as fuel-efficient driving (based on driving behaviour) and optimal tyre pressure. The technical reduction potential of the specific fuel consumption of cars and the change of fuel type is more costly and limited as long there is no change in traffic behaviour itself. This shows that the abatement cost of transportation is higher than in other sectors as long the focus is only on technical potential and sufficiency is not considered. A reduction of leisure transport using passenger cars or a reduction of international tourist trips by plane, for example, would be very effective, but difficult to place a value on, since a change in individual behaviour is needed. Thus, the reduction of CO_2 emissions would appear to be more costly than in other sectors, such as energy production and the increase of energy efficiency in the building sector.

Another component of external costs with a rather high cost of reduction at the source is noise. The reduction of noise (especially for the road sector) is only economically viable and effective with the use of passive measures such as noise barriers and sound insulation windows combined with energy-efficient measures (e.g. controlled air conditioning in buildings).

Internalisation measures and the relevance of modal shift

The external cost of rail transportation is about 3 to 4 times lower than the cost of road transportation, and about 2.5 times lower than for air transportation. For the latter, the cost of climate change risks are most relevant, since air transportation has increased the cost of climate change due to its emissions in high altitudes. Therefore, the strategy of a modal shift towards rail seems to be a possible way of meeting the increasing demand for transportation. On closer inspection, however, it is important to distinguish between different transport segments: The strategy should focus on segments in which rail transport is competitive, e.g. in urban areas and in competitive (high-speed) corridors, e.g. alpine transit. At the same time, the electricity mix plays an important role: The environmental balance of rail transport will deteriorate if railway electricity is produced with non-renewable sources such as coal, oil or nuclear energy.

Therefore, the modal shift strategy may offset the environmental damage caused by the increase in transportation, but it is not able to reduce the massive burden of existing transportation significantly. The external cost approach provides information on an economic approach to overcoming this dilemma. It provides cost figures for evaluating those measures with the highest cost-effectiveness and corrects market-based price signals. From the viewpoint of CO_2 emissions, for example, a CO_2 tax for the transportation sector and specific financial incentives to increase the fuel efficiency of new cars (e.g. a bonus-malus system) are most feasible. Such measures not only provide incentives to consumers to change their behaviour, but also generate revenue which can be used to finance efficient measures. Since the cost-effectiveness of reducing CO_2 in the transportation sector is limited, it might be advisable to use part of the revenue from environmental surcharges to finance investments in alternative modes of transportation and Clean Development Mechanisms (CDM according to the Kyoto Protocol), i.e. projects which reduce CO_2 in sectors other than transportation. Such a strategy could be combined with national or EU-wide programmes to reduce CO_2 emissions within the transportation sector itself as a way of holding the transportation sector accountable for its emissions.

3 Taking Responsibility in the Transportation Sector

3.1 Global responsibility

Compiled by Lee Schipper, WRI Centre for Sustainable Transport and Carola Schulz, IWW, Universität Karlsruhe (TH)

3.1.1 Troubling global trends

Over the past half-century, energy consumption has steadily risen with rising economic growth. With fossil fuel as the dominant form of primary energy in much of the developed world (and the urban developing world), CO_2 emissions have risen as well, although not as rapidly as economic activity. These trends were interrupted by the oil crises of the 1970s and 1980s which widened the gap between the rate of economic growth and that of primary energy or carbon emissions. But since the 1990s, emissions have been rising along with economic activity in most countries. The global rise in CO_2 emissions from fuel is shown in Figure 12.

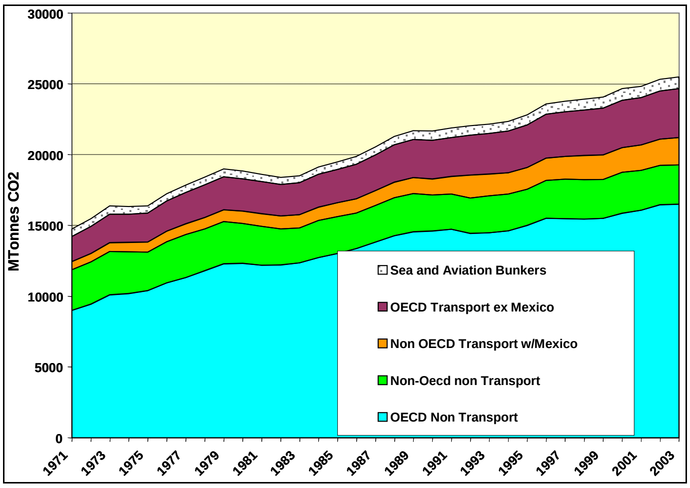

Figure 12: Global rise in CO_2 emissions from fuel

Source: IEA (2002)

OECD countries account for the vast majority of world CO_2 emissions from energy use, but non-OECD countries, particularly in Asia and the Middle East, are responsible for most of the growth. Between 1971 and 1997, the portion of global carbon emissions attributable to Asia grew from about 10 percent to 23 percent, while the share of the OECD declined from 66 percent to 54 percent, as shown in Figure 13. For most countries, the share of emissions arising from transportation has increased.

	1971	1990	1997	1971-1997 change	Annual growth rate 1990-1997
Africa	1.8	2.9	3.2	189	2.5
Asia excluding China	3.4	6.4	9.0	317	6.2
China	6.1	11.5	14.0	262	4.0
Former USSR	16.9	17.3	10.0	- 7	-6.5
Latin America excluding Mexico	2.7	3.1	3.9	124	4.6
Middle East	1.0	3.1	4.2	553	5.7
Non-OECD Europe	2.1	2.1	1.4	5	-5.1
OECD	66.1	53.5	54.2	29	1.3
WORLD	**100.0**	**100.0**	**100.0**	**57**	**1.1**

Figure 13: CO_2 Emissions by region

Figure 14 explores this relationship further, plotting CO_2 emissions from the transportation sector per person against per-capita GDP. The time frame for this unusual form of presentation is 1980 to 1997. Unlike emissions from the stationary use of fuel (industrial boilers, heating in private homes, to name some), emissions from transportation grew strongly during the observed period. Indeed, in most regions, emissions from transportation have risen more quickly since 1990 than those from all other energy-related sources combined, as shown in Figure 15, which means that the share of emissions from transportation is increasing.

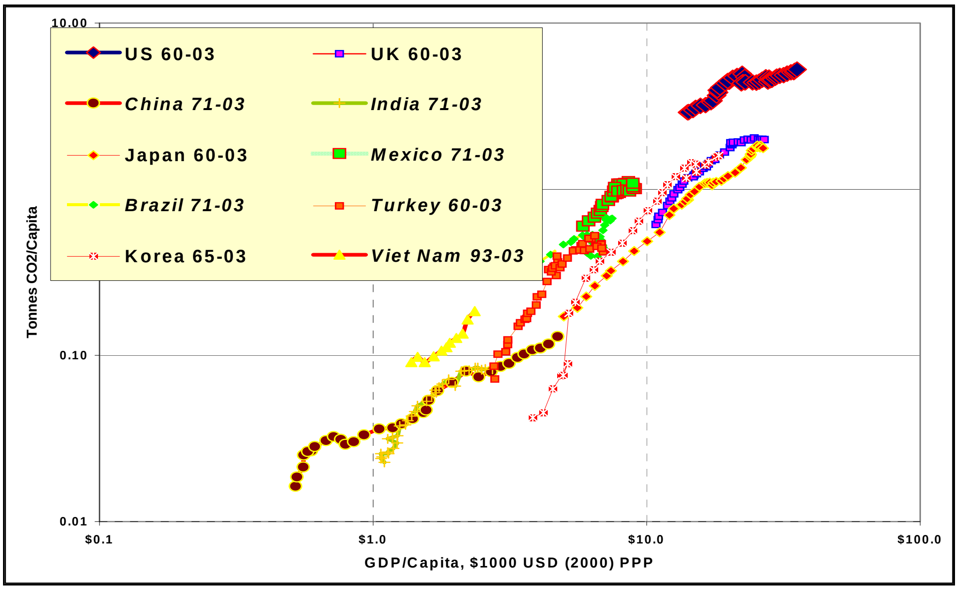

Figure 14: Global CO_2 emissions from transportation

Source: Schipper et al. (2000)

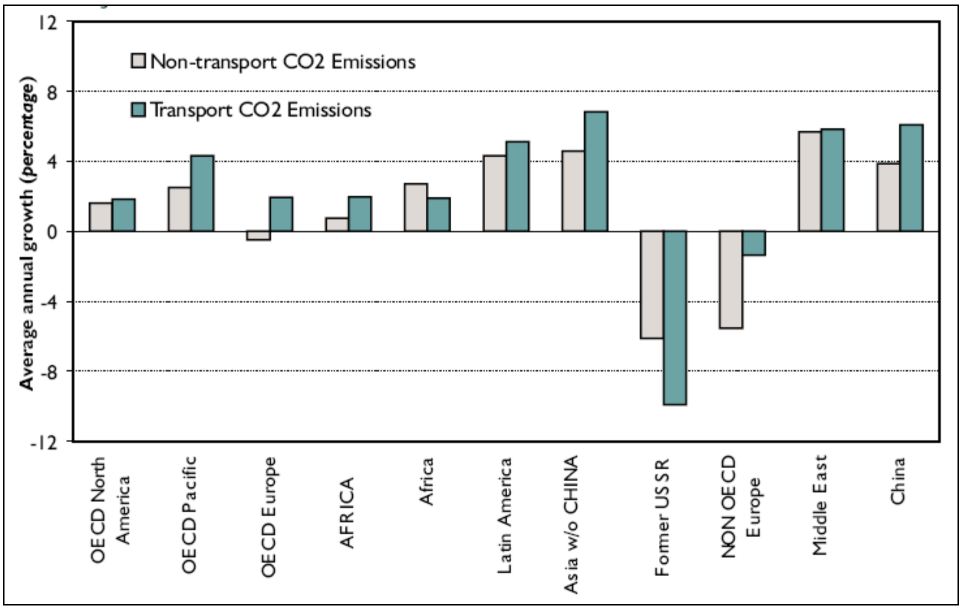

Figure 15: Rise in emissions from the transportation sector and the rest of the economy, 1990 - 97

The ASIF approach

Bank decision-makers need a method of countering the trends in transport-related emissions in countries or regions where projects are being considered. Schipper et al. (2000) propose the use of the ASIF method, which is shown in Figure 16. They differentiate between the focus on developed and developing countries and take various factors into account: total travel or freight activity (A), modal share (S), the mode's energy intensity (I) and fuel choice (F). With this tool, one can observe various effects of policies - intended and unintended.

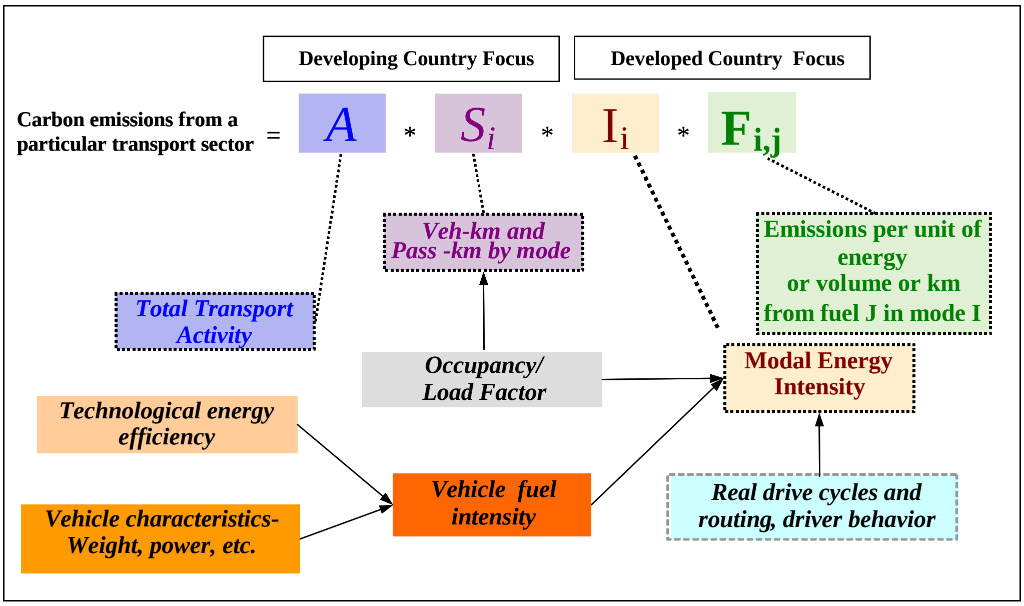

Figure 16: The ASIF method

3.1.2 Developed Countries – Reduction

Technology and Downsizing

Increase in motorisation is gradually slowing. Whereas the US still has more cars than drivers, a decline can be observed in the European Union and in Japan. Car use is also not growing as quickly as before.

However, technology, size and power of cars are increasing. About 20 years of technology have been dedicated to power and weight. The new paradigm should be smaller and slower vehicles. Lighter materials, lower drag, CVT, cold cylinders and gasoline or clean diesel hybrids could be used. A volume agreement has brought some reductions in Europe and Japan. A little serious impact of low carbon fuels can be observed.

Further approaches are:

- congestion tolls
- more compact settlements
- replacement of travel by internet use
- Plug-in hybrids – most driving is for short local trips
- Fuel cells? High costs, feedstock, material challenges
- City cars vs. long distance cars?

Alternative fuels or fools?

Our addiction to ethanol threatens to bankrupt us. Low-carbon fuels do not exist today, but could arrive at higher prices consistent with “more secure oil supplies”. Other options for liquid fuel would lead to higher costs and greater environmental damage, which would mean more CO_2 emissions.

Positive aspects of “biofuels” are:

- Low carbon footprint (Brazilian alcohol)
- Small-scale biodiesel

Negative aspects of biofuels are (particularly in the US):

- Subsidy-driven, energy-/carbon-intensive US corn ethanol

- Flex-fuel vehicle subsidies not based on performance
- The rush to specify chemical formulas, not low-carbon fuels

Some worrisome problems arise regarding low-carbon “biofuels”. Should agricultural land be used for food or biofuel? The possible damage to water and land must be considered as well as other hazards of carbon . Still, the temptation to turn carbon into biofuel exists.

Congestion Pricing

A possible solution to reducing traffic in large cities is congestion pricing, because other alternatives and voluntary approaches have failed in the past.

Travellers pay a toll for using roads at peak times. They are encouraged to shift to other times, routes and modes. Tolls are higher during rush hour and lower or non-existent during un-congested periods. Tolls can be based on a fixed schedule or can be dynamic. Furthermore, they can be specific to location, distance travelled or cordon.

Observed results are a proven reduction in car use, higher transit and faster speeds. For example, in Stockholm, the traffic volume decreased by 25 percent, which amounts to a removal of 100,000 vehicles during peak hours. Further positive effects were lower fuel use, CO_2 reduction and quieter streets.

Overall, one can say that it is more effective to regulate car use than to increase fuel taxes. A negative aspect of congestion pricing is the cost of implementation and the modes’ income transfer.

3.1.3 Developing Countries – Avoidance

The question for developing countries is: Follow the leader or advance to the rear?

Many developing countries follow the “OECD” mode. The technology and institutions have come from the West, but with 0-20 years delay. However, there is a possibility that China, Brazil and India may become the leaders soon. Their rapid urbanisation and motorisation worsen the growth of emissions. The problems are the same as in Europe or the US, but the consequences are worse. The air pollution is much worse than it has been in Europe and the US for the past 100 years. With travel mostly taking place outdoors, the lungs of the residents are tattered by pollution.

Some **facts** regarding the rising motorisation in the developing countries:

- Individual vehicles are taking over

- Two-wheelers are swarming all over Asia
- Roads get a disproportionate share of investments
- Environmentally more benign modes of transportation are forced off the roads
- Buses are stuck in traffic
- Low-cost rail is ignored for high-cost metro
- No sidewalks or bicycle paths
- Cities sprawling to accommodate cars
- Investments go into flyovers and motorways
- No effort is made to keep city centres dense but thriving

Some **options** for developing countries:

- Raising the share of low-impact modes
- Establishing bus rapid transit with real priority over other traffic, not just expensive metros
- Inter-modal facilities, particularly for pedestrians, bicycles and powered two-wheelers
- Development around and on top of stations (as seen in Taksim Square, Istanbul)
- Reducing the air pollution caused by motor vehicles
- Clean fossil fuels and engines (hybrids)
- Exhaust treatment with filters, maintenance of catalytic converters etc
- Smoother driving cycles
- Improving access with less vehicle travel
- Congestion tolls to preserve road space
- Better enforcement of parking regulations
- Careful planning of land use and expansion (e.g. Istanbul)

3.1.4 Conclusions

Clear international consensus and action on CO_2 is required:

- Introduce a carbon tax and other measures
- Strengthen fuel-efficiency standards
- Save carbon by saving oil, not by synthesizing it

A clear consensus on a new transport paradigm is needed:

- Cars are to be more efficient, as well as lighter, smaller and slower
- Urban transport systems should prioritise people over vehicles
- Clear decisions which are reinforced with taxes

A new path for developing countries is required:

- Focus on healthy cities and sustainable transportation
- Lead in low-oil, low-carbon technology
- Set good examples, don’t follow the US or Europe

3.2 Strategies in air transportation

Compiled by Prof. David Gillen, University of British Columbia and Aaron Scholz, Universität Karlsruhe (TH)

Global CO_2 emissions by mode of transportation show that air transportation has a total share of 12% of all transport-related emissions. Road transportation emits around 76%, rail 2% and water transportation 10% (Thompson, 2007). Taking responsibility in aviation and defining fair and efficient reduction strategies means analysing the following five key aspects:

- There appears to be a measurement problem in assessing the impact of transportation on the environment,
- The majority of work has ignored or assumed away the effects of modal substitution,
- The method of allocating permits has an important influence on the equilibrium outcomes for process, profit and output,
- The emergence of an emissions trading scheme will depend on market structure and the basis for competition and
- There are a number of sources for a solution but, overall, aviation sector management seems to have been downplayed.

3.2.1 Measurement Issues

Under the IPCC rules, the emissions associated with infrastructure are included in what is termed the 'process' provisions, meaning that emissions resulting from the construction of infrastructure are considered separately from the use of the infrastructure to generate passenger or freight kilometres of travel. However, it does not seem that the emissions resulting from the maintenance of infrastructure are considered anywhere; how much CO_2 is emitted to provide a flight or to provide a train-km of passenger or freight travel? For example, rail is considered to be relatively emission-friendly compared to other modes, yet rail maintenance (as well as highway maintenance) is energy- and hence emissions-intensive. The emissions associated with maintaining infrastructure needed to produce air, rail and road travel should be included in the transportation component but kept separate from the movement component since they are common across movements and have fixed and variable components.

The marginal damage cost of emissions should form the basis of setting prices for emissions. They would be a factor in the value of prices for tradable permits, although the permits market would be affected by many things. Literature has provided a huge range for marginal damage costs and recent work by Tol (2003) shows a meaningful range of 4.4 to 14.4 EUR per tonne of CO_2. Uncertainty as to the cost of damage may result in under- or over-reduction of emission reduction.

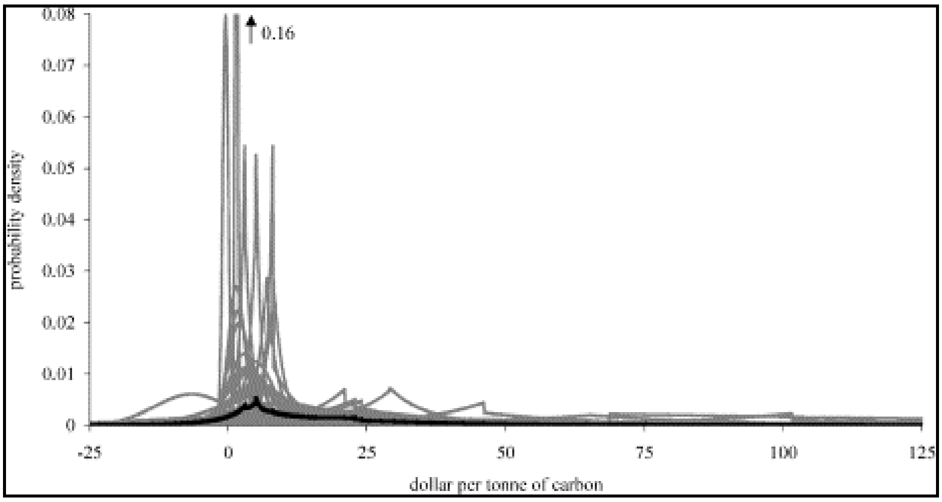

Figure 17: Probability Density Function of the Marginal Cost of Carbon Emissions

Source: Tol (2003)

3.2.2 Modal Substitution Effects

Most studies have focused almost entirely on direct effects in that they consider the inherent price elasticity of air travel demand and ignore or assume away the cross-elasticities. Air travel has many dimensions, and the impact of price changes will be very different across these many dimensions.

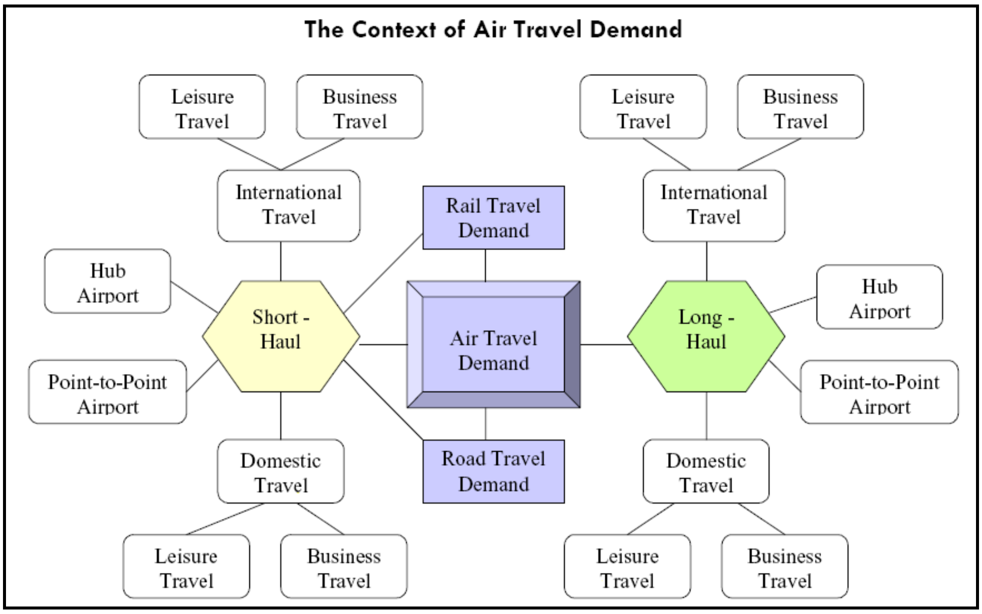

Figure 18: The Context of Air Travel Demand

Source: Gillen (2002)

There are several issues to be considered, including how relative fares change as permit costs are factored into the airfare. An increase in airfares will have a dampening effect on air travel. There will be several substitution possibilities; switch to another mode, switch to a LCC from a FSA, switch destinations or switch to other activities. In all cases, the substitute will also - generate emissions and, in some cases, may be more CO_2-intensive than aviation. For example, in Germany, rail and road are clear substitutes for domestic air travel, much more so than perhaps in Italy. Shifting passengers from air to road may not result in fewer emissions and certainly not in lower social costs.

3.2.3 Allocation of permits

The method of allocating permits has an important influence on the equilibrium outcomes for prices, profits and output. There are a few considerations to be made here. First, the allocation of permits can be performed using grandfathering, benchmarking or auctioning or some combination of these - such as grandfathering X% and auctioning off (1-X)%. Grandfathering is based on past pollution emitted – hardly a preferred method, since it rewards airlines for their past damaging actions. Choosing a base period to determine a ‘grandfathering allocation’ is data-intensive (requiring data on specific airlines and their fleet) and somewhat arbitrary. Grandfathering confers a sizable transfer to some carriers and establishes a barrier to new entrants if all permits are grandfathered.

Benchmarking also allocates permits for free, but does so on the basis of a carrier’s performance relative to some benchmark. Benchmarking can provide strong incentives for investments in emission-reducing technology. It can also be set up much like price-cap regulation, which induces firms to become more energy-efficient and emission-moderate. Benchmarking is less data-intensive than grandfathering and does not erect a barrier to entry.

Auctioning results in permits being allocated to incumbents and entrants on the same basis. It does result in a significant transfer from airlines to permit owners. However, these permits, once purchased, may increase or decrease in value, most likely increase. Therefore, it provides the right incentives for carriers to use the permits in the most efficient way possible. Revenue from auctioning should be earmarked for improvements in the aviation system such as ATC, and to provide incentives for upstream suppliers to develop energy and emission reduction.

However, the method of allocation to achieve economic efficiency must consider the downstream market structure. As Sartzetakis (2004) notes, competition in the emission permits market cannot assure efficiency when the product market is oligopolistic. He names the conditions under which an administrative mechanism (such as benchmarking) is superior to a tradable emission permits system. Price-taking behaviour in the permits market ensures the transfer of licenses to the less efficient abatement firms, which then become more aggressive in the product market, acquiring additional permits. As a result, the less efficient firms obtain a higher-than-welfare-maximizing share of emission permits. If the less efficient abatement firms are also less efficient in production (consider the LCC versus FSA cost structure), competitive trading of permits may result in lower output and lower general welfare.

3.2.4 Emergence of an emissions trading scheme

The emergence of an emissions trading scheme will depend on market structure and the basis of competition. Most studies assume a perfectly competitive market structure with marginal cost pricing. Oxera (2003) correctly points out that if airlines are operating out of congested airports, airfares will not increase, even with the addition of emission trading permits. The reason is, of course, that a congested airport essentially has a perfectly inelastic supply function and, under such circumstances, the ‘tax’ falls onto the producer (airline) in its entirety. Even under perfect competition, unless marginal costs are linear and constant, any increase in marginal costs will not increase airfares one to one, provided demand is less than perfectly inelastic. Under conditions of oligopoly (Cournot or Bertrand), the effect of a unit tax will depend on the conditions of entry, on product substitutability and on relative market shares. Prices may increase by less than they would in competitive markets or by more, since the price change has a direct and a strategic effect; these may work together or against one another. Therefore, the impact on emissions may be far less than previously thought, as fare increases from the added cost of tradable permits may be lower than previously calculated.

3.2.5 Recommendations

Decreases in transportation costs and certainly in aviation costs have facilitated growing trade and economic growth. The relationships have been set out by Eddington:

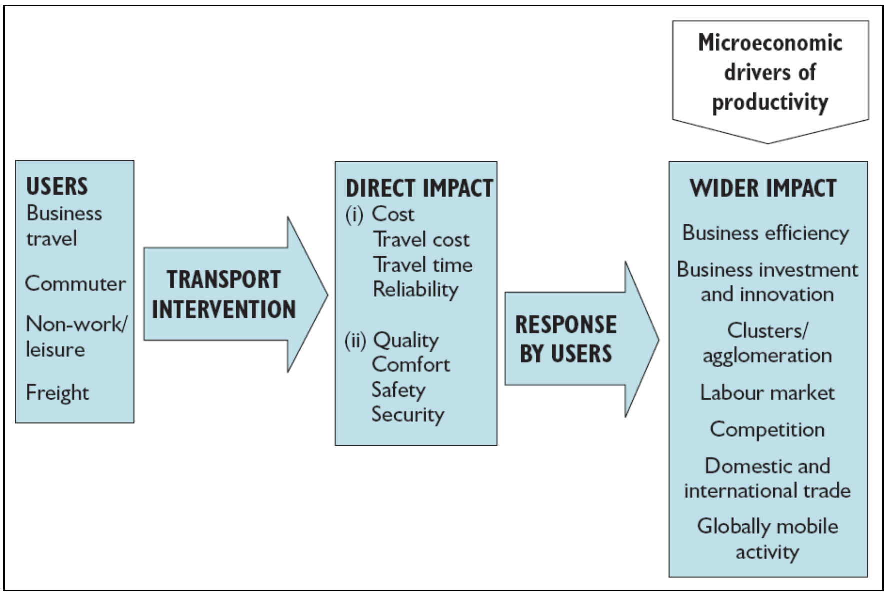

Figure 19: Link between transportation and economic performance

Source: Eddington Study (2006)

As a result, there have been real savings in resources all along the supply chain and positive agglomeration effects among firms horizontally as well as vertically. Research into gateways and corridors has concluded that aviation infrastructure has been important for economic growth, tourism and business location (estimates of a €750 million increase in UK output through aviation in 2000 – Source: Thompson 2007). Eddington has identified gateways and corridors as essential components in the future of real productivity gains and economic welfare.

However, such activity generates significant amount of CO_2 and other emissions, which may lead to irreversible changes in the climate. Despite aviation's current low contribution, they are growing and are expected to do so more quickly than other modes. Addressing the issue now will minimize the costs in the long run, since the marginal costs of inaction are non-linear. Transportation should pay its full social costs - all modes of transportation. Emission trading is one approach; one in which quantities are specified and prices are allowed to vary. This shifts the risk downstream. In the short term, aviation will most likely focus on carbon offsets, while in the long term, technology and shifts in behaviour will be needed to reduce emissions.

3.2.6 Conclusions

Taking responsibility in aviation implies that the total social cost of aviation is reflected in the prices which are paid by customers (this should apply to all modes of transportation - aviation should not be singled out). Secondly, the contribution which aviation makes to economic growth and economic welfare should be considered in assessing the costs and benefits of aviation. In particular, much of the debate seems to have ignored the value of aviation as measured to include traditional measures of economic welfare (including consumer surplus).

The way in which the demand for aviation services grows will have an important impact on the rise in emissions and on how effective trading schemes are at reducing emissions, especially if we observe growth in numbers of markets rather than market growth, it changes the importance of the possibilities of reducing emissions. Finally, an open trading system is important for minimizing the cost of achieving a desired level of emissions.

3.3 Strategies in road transportation

Compiled by Per Sandberg, WBCSD/Hydro and Aaron Scholz, IWW, Universität Karlsruhe (TH)

Strategies in road transportation are dependent on the challenge of making long-term mobility sustainable. Derived from the Brundtland definition of "Sustainable Development" (World Commission on Environment and Development - 1987), sustainable mobility has been defined as (WBCSD, 2004):

"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"

Mobility is almost universally acknowledged to be one of the most important prerequisites for achieving improved standards of living. Enhanced personal mobility increases access to essential markets as well as to services that make life more enjoyable. The vast increase in the number of automobiles and trucks over the last hundred years has been one of the most important manifestations of this desire for enhanced personal mobility and mobility of goods.

During the last decade, people have become aware that their enhanced mobility has come at a price. This price includes the financial outlay of mobility users to the providers of mobility systems and services which permit them to supply such systems and services. But it has gone beyond this. Enhanced mobility has tended to be associated with increased pollution, emission of greenhouse gases, congestion, risk of death and serious injury, noise and disruption of communities and ecosystems.

3.3.1 Indicator system for sustainable mobility

In order to compare the present and the future state of sustainable mobility and determine how effective various approaches might be in facilitating its improvement, a set of 12 indicators has been defined by the World Business Council for Sustainable Development to measure sustainable mobility, especially for road transportation.

Indicator Class	Indicator
Mobility users	Access to mobility
	User costs
	Travel time
	Reliability and comfort
	Safety
	Security
Society as a whole	Greenhouse gas emissions
	Impact on environment and public well-being
	Use of resources
	Impact on public revenue and expenditures
	Equity implications
Mobility providers	Prospective rate of return for private business

Table 2: Indicators for sustainable mobility

Source: WBCSD (2004)

The impact of mobility on climate change issues is included in the set of indicators by considering greenhouse gas emissions. Although carbon dioxide catches the headlines, other GHGs are also emitted by the transportation sector, such as refrigerants based on CFCs or HCFCs, unburned methane (depending on the fuels used), and nitrous oxide. Because various GHGs differ significantly in their impact on the atmosphere, it has been recommended to translate emissions into “carbon-dioxide equivalency” units, where the translation reflects the warming potential of each gas relative to carbon dioxide.

3.3.2 Future transportation forecasts

A number of important “drivers” for the development of personal transport activity show tendencies of increasing in the future. The most significant of these is the rise in the disposable income of households. Income growth impacts personal vehicle ownership, which leads to longer (and more frequent) trips being made. Higher personal income leads to a higher value being placed on time, which causes people to choose faster modes. Furthermore, income growth is an important driver of the economic process underlying freight transportation demand. Long-term economic projections to 2050 indicate that income will grow strongly, especially in certain countries of the developing world. This tendency is also reflected in predictions for the future of passenger (Figure 20) and freight transportation (increase by approx. 200% in tonne-kilometres per year between 2000 and 2050) with the attending impact on society, the economy and the environment.

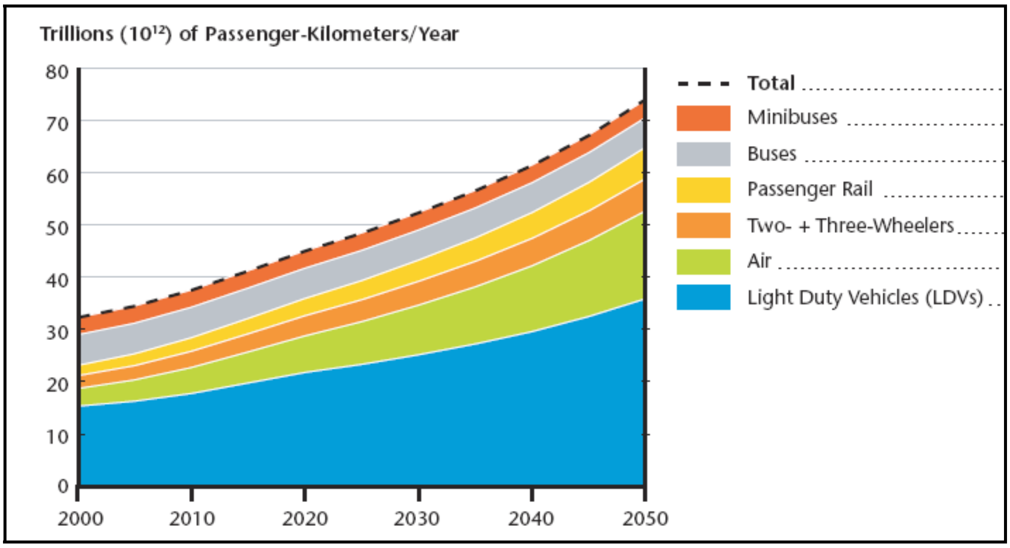

Figure 20: Personal transport activity by mode

Source: WBCSD (2004)

3.3.3 Outlook for sustainable mobility

When analysing the indicators for sustainable mobility, it appears that even today's system of mobility is not sustainable. Considering the predicted strong increase in transportation volume until 2050, it is very unlikely that mobility will become sustainable if present trends continue. Therefore, seven objectives have been defined to bring mobility onto a sustainable path (WBCSD, 2004):

- Reduce conventional emissions from transportation to levels where they do not constitute a significant public health concern anywhere in the world,
- Limit GHG emissions from transportation to sustainable levels,
- Reduce the number of transport-related deaths and injuries worldwide,
- Reduce transport-related noise,

- Mitigate traffic congestion,
- Narrow “mobility-opportunity divides” and
- Preserve and enhance mobility opportunities available to the general population.

Concerning GHG emissions, two specific time-periods can be outlined with different possibilities for action. Prior to 2030, the focus of reduction policies will be on improving the energy efficiency of transportation vehicles, on laying the technological foundation for the discontinuation of the use of fossil fuel and on planning the fuel infrastructure required for alternative fuels. After 2030, further changes will be related to the global “rollback” of fossil fuel technology and the application of the new technologies to other modes of transportation.

Six possible future technologies exist that appear to be at least capable of contributing to the stabilization of emissions until 2050 (dieselisation, hybridisation, advanced bio-fuels, fuel cells, carbon-neutral hydrogen, and vehicle-efficiency improvements not related to the engines (see Figure 21).

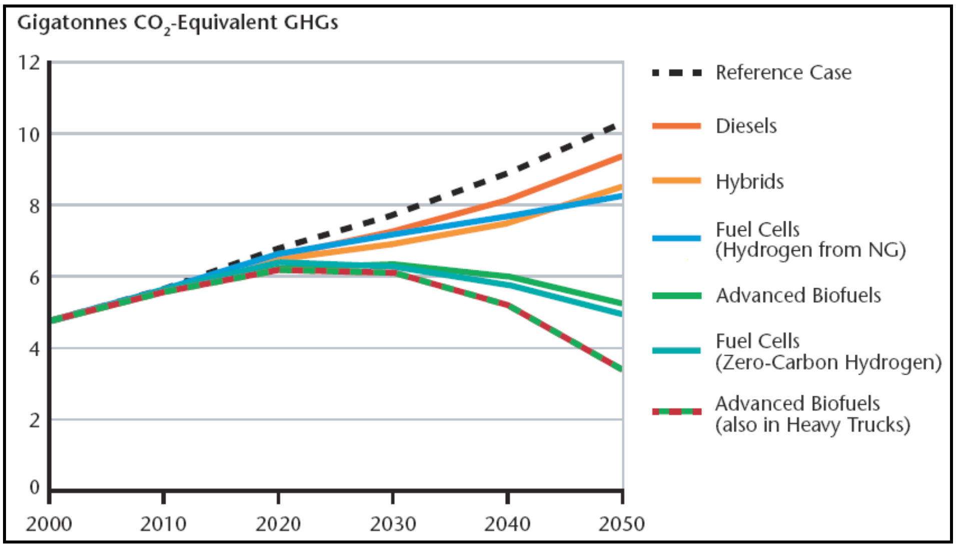

Figure 21: Hypothetical potential of individual technologies to lower CO_2 emissions of road transportation

Source: WBCSD (2004)

It must be emphasized that the individual technology examples are purely hypothetical and that the results for diesel and hybrid can do no more than slow the growth in road transportation emissions even if they were implemented world-wide. Only the use of carbon-neutral hydrogen in fuel cells and advanced biofuels would largely or totally offset the growth in CO_2 emissions produced by the growth in road travel during the 2000-2050 period. A substantial reduction in CO_2 emissions from road transportation requires the widespread adoption of several advanced fuel and vehicle technologies as well as exogenous factors (e.g. changes in behaviour).

3.3.4 Conclusions

Important progress in reducing greenhouse gas emissions can be made during the next two or three decades. No single technology can provide a stabilization, but combinations of new fuels, engines, and vehicles may reach the objective. The time lag between the widespread use of these technologies in the developed world and their use in the developing world will have an important impact on the trajectory of GHG emissions from road vehicles. It is important to begin considering how this lag can be reduced without making road transportation in the developing world unaffordable.

3.4 Strategies in rail transportation

Compiled by Dr. Edward Calthrop, European Investment Bank and Dr. Anselm Ott, Universität Karlsruhe (TH)

As Dr. Kopanezou from DGTREN pointed out in her contribution, the railway sector is a CO_2-emissions- saving alternative to road transportation, especially in the freight sector.

A support for rail freight is part of the current debate on reducing CO_2 emissions. Different studies confirm that the consumption of energy in the rail freight business is much more efficient than in the road sector.

In recent years, investments in the rail-freight sector have been strong. Great market potentials can be found in the ongoing boom of container shipping, which leads to an increase in harbour – hinterland transportation flows. Furthermore, there are big potentials in the markets for West-East transportation, e.g. between Germany and Poland.

But there are some risks as well: Despite the railway reforms in recent years in many European countries, there is a long way to go towards creating a commercial and market-oriented business. Therefore, it will take time to unlock the full potential. Furthermore, there have been failures to focus on key business objectives. The framework of the future will be uncertain as well, e.g. because of the unclear legal situation of 60-tonne trucks or pricing for road and rail.

The recent concerns about CO_2 make it more important – not less – to get rail investments 'right'. Basically, the decreasing cost of rail for long distances can help pinpoint new potentials (see Figure 22).

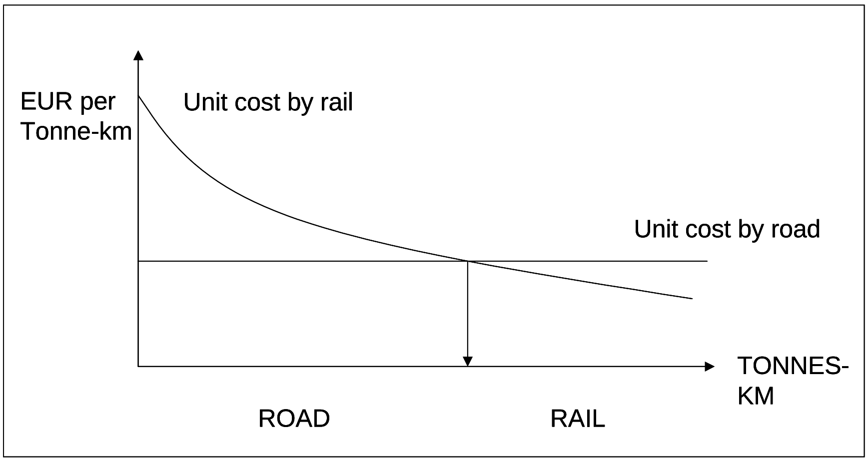

Figure 22: Decreasing cost for long distances

Over the last couple of years, railway reforms by the EU and (most of) the member states built the foundation for an economically successful future. Major steps have been:

- Open access for all railway companies to the national networks
- The definition, development and upgrading of the Trans-European networks (TEN)
- The technical and administrative solutions for creating an interoperable railway system

The new commercial freedom was used by the railway companies to develop new business models, e.g. trade lanes for certain industries (oil, paper, chemicals, etc.) or hub and spoke systems for the single-wagonload sector. In markets with high competition (Great Britain, Germany and Sweden), railways have been very successful and gained market shares from their competitors. In Germany, the modal share of rail freight climbed from 15.5 % in 1999 to 17.5 % in 2006. Today, railways in Germany have a hauling performance of more than 100 billion tkm.

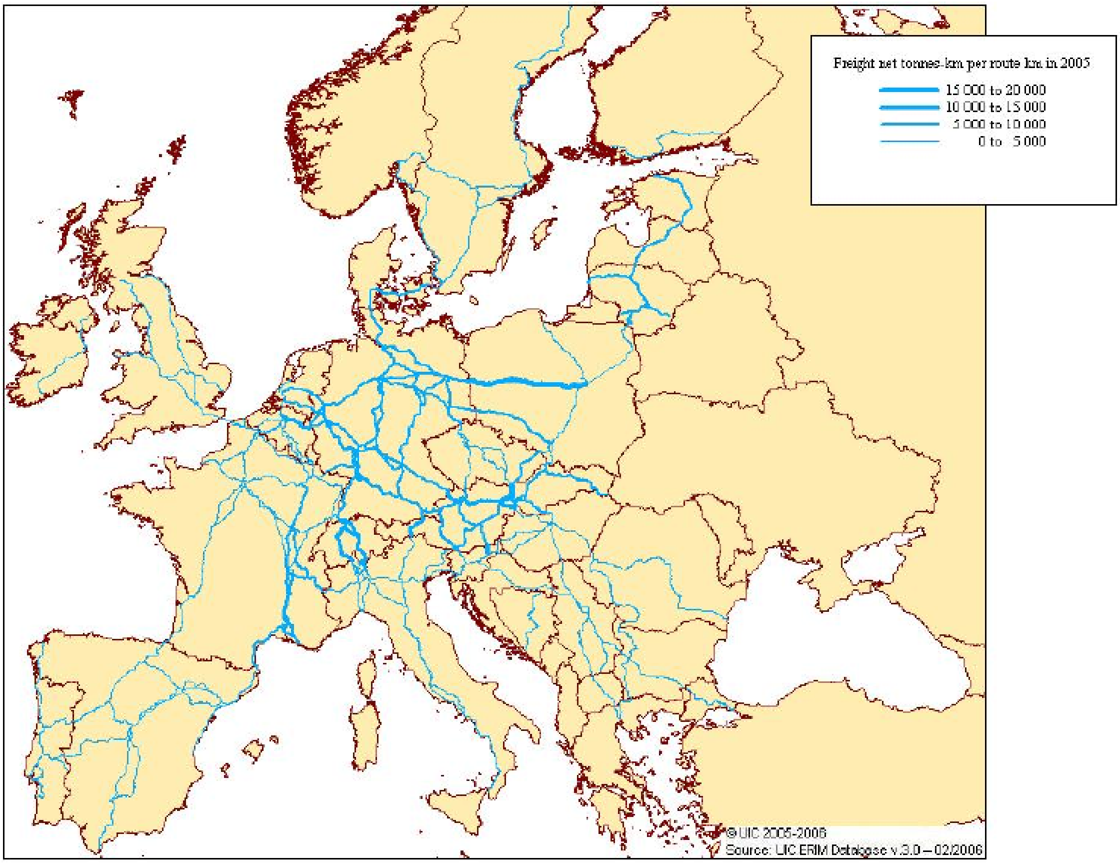

Figure 23: Major European rail freight corridors

Source: UIC, ERIM study (2005)

To promote growth in the railway freight sector, further improvements of the Trans-European Corridors are necessary. Investments in these corridors are important because more than 70 % of freight transport runs on six corridors. Especially in the east-west direction, improvements can be achieved by upgrading the lines for freight purposes. Organisational chances within the railway companies are also very important.

Lessons can be learned from the north-south corridor which is a link between the major North Sea ports in the Netherlands (and Germany) and the seaport of Genoa in Italy. Within this corridor, several very positive aspects can be identified:

- Fierce competition, strong growth (8% p.a.), falling prices (2-3% p.a.) and increasing reliability
- Concerted effort by infrastructure managers (IM) to manage corridors as a single entity (e.g. the rollout of ERTMS)
- Investments to relieve capacity constraints (Swiss tunnels; Betuwe line) – Germany and Italy to follow

When it comes to fostering the rail freight industry, especially regarding environmental topics, the following conclusions can be dawn:

- Rail freight has a large potential to reduce CO_2 emissions from transportation and trade.
- This makes it more (not less) important to secure value for money in rail investments.
- Investments must have:
    - A strong business rationale
    - A pragmatic, cost-effective approach to facilitating international demand (e.g. interoperability)
    - Nesting within broader reforms, including a coordinated approach to pricing of and investment in transport corridors
- Renewed efforts are required to ensure that new rail projects meet these criteria.

3.5 Strategies in shipping

Compiled by Prof. Hilde Meersman, Prof. Eddy Van de Voorde and Dr. Thierry Vanelslander, University of Antwerp, Department of Transport and Regional Economics

Traffic figures show that maritime volumes transported in 2005 were over 7,000 million tonnes, which is more than double the level of 1985. In terms of tonne-kms, sea transport had a share of 36% in 2004 as far as intra-European traffic is concerned, whereas it was responsible for an overwhelming 79% of global tonne-kms performed.

Further growth is likely to occur, as shown by the predicted increase in industrial activity worldwide and the stronger reliance on intercontinental trade for sourcing raw materials as well as finished products. The same conclusion can be derived from orders for new vessels, which are a good reflection of shipping companies' expectations for the future. In 2005, a total of 3,503 new vessels were on order, compared to a total available fleet of 15,019 vessels.

It is therefore fully justifiable and even necessary to keep an eye on the maritime sector's environmental performance when looking at effects that transportation may have on the deterioration of the world's climate.

3.5.1 Environmental performance of maritime transportation

In terms of energy consumption, maritime transportation in EEA-17 requires about 100 million tonnes of bunker oil a year. This puts sea transport at about the same volume of energy consumption as air transport. Road transportation consumes about six times as high a volume of energy.

Energy consumption automatically leads to different types of pollution. Airborne emissions are one of these. A distinction should be made between different types of air pollutant which have a different level of occurrence and a different impact in terms of harmfulness. A well-established air pollutant is CO_2. In relative terms, maritime transportation is the least harmful mode, as it has the lowest number of grams emitted per tonne-km by far. The same observation goes for CO emissions, as can be derived from Figure 24 for the total annual volumes emitted, and for NMVOC (Non-Methane Volatile Organic Compounds), although in the latter case, civil aviation does even better.

Figure 24 shows that maritime transportation has worse scores when it comes to NO_x and SO_2. For NOx, the total annual maritime emission level equals that of road transportation. In terms of SO_2 emissions, maritime transportation is by far the worst mode of all.

Water pollution is a second type of externality to which the maritime sector contributes. Water pollution can be caused either by accident or on purpose. It can be observed that with accidental pollution, mainly caused by ships crashing or grounding, the total amount of oil flooded into the sea has gone down since the beginning of the 90's. The growing importance of individual crashes is to be explained by the increase in average ship size: if serious accidents occur, damage, also to the environment, is usually higher.

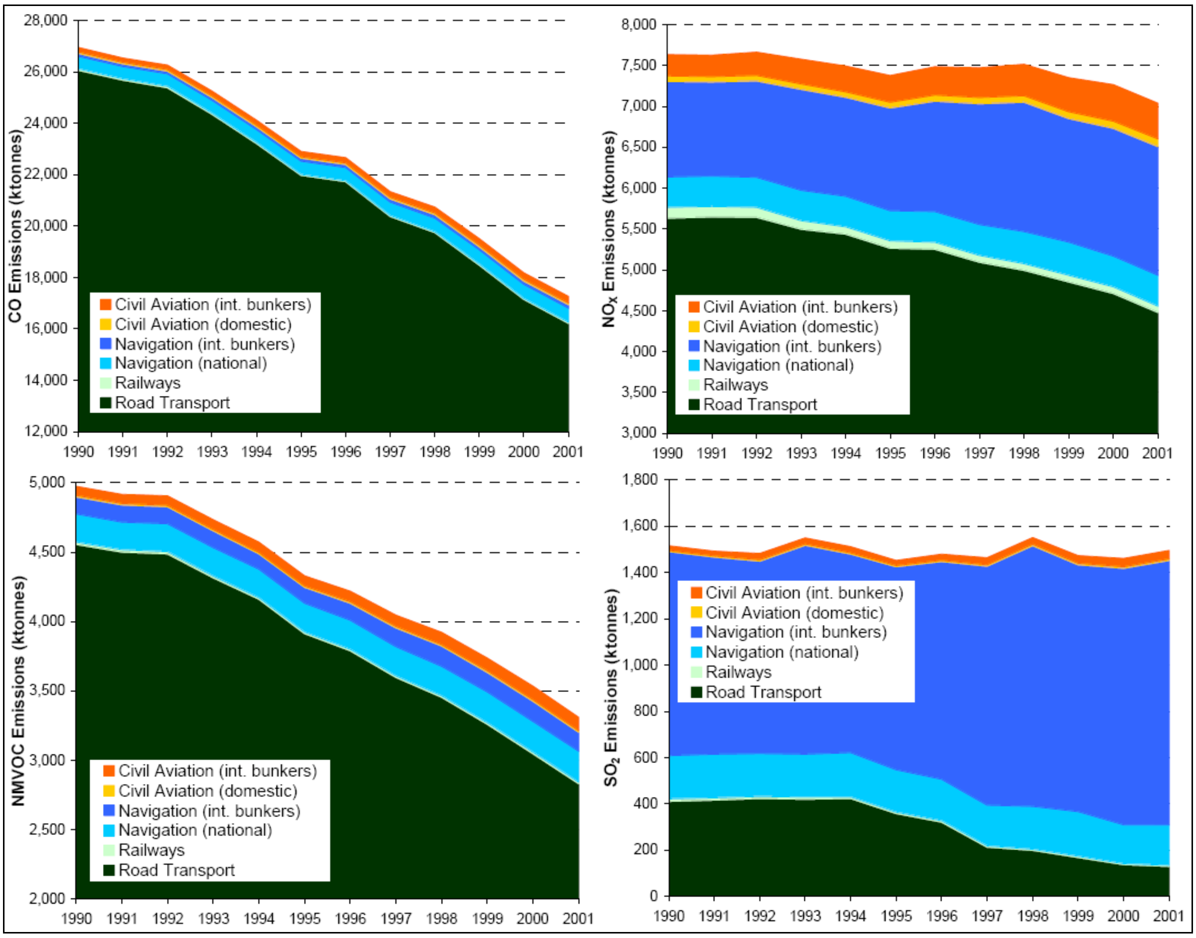

Figure 24: CO, NO_x, NMVOC and SO_2 emission levels for different modes of transportation

Source: EEA (2005)

Criminal acts are a second important source of water pollution: the discharge of cleaning and ballast water is a problem which has begun to attract attention in national and international maritime policies.

3.5.2 Scientific results and observations

In contrast to the relatively well-documented pollution levels, little research has been done in calculating the external cost that maritime pollution represents. The European research projects REALISE (www.realise-sss.org) and GRACE (www.grace.eu) are exceptions. Their most important findings are summarized here.

First of all, it can be observed that, for air pollution, unit costs that apply to other, better-researched transport modes, can also be used for maritime transportation. There too, however, a large variation of estimated costs can be observed, in a range from 50€/h up to nearly 3,900€/h. The large variations are explained by the specific types of fuel used, as well as by the sensitivity of the particular environment into which air pollutants are emitted.

A second observation relates to the cost of oil spills. Claims paid by shipping companies are a good proxy for assessing the external damage caused. In 2005, a total amount of 116,339,830€ in compensation funds was paid to various affected economic sectors, the most important of which are tourism and land owners (mostly governments) who had to clean beaches.

3.5.3 How does regulation tackle maritime environmental problems?

An important initiator in maritime regulation is the IMO. Their first initiative dates back to 1978, when a guideline on protected positions for segregated ballast tanks was communicated. In 1993, the introduction of double hulls for tankers was made compulsory, first for new orders larger than 5,000 TEU, later also for existing vessels up to 30 years old. In January 2007, a bill was passed bringing the final phasing-out of single-hull tankers forward from 2015 to 2010. It should be noted that IMO regulations are to be adopted by individual countries, and that some countries adopt rules that are much more stringent.

At the European level, the European Commission as well as the European Parliament have introduced a number of initiatives. In March 2003, a draft directive on pollution through ships was issued, the final version of which was published in October 2005. The directive imposed the deadline of April 2007 for adoption of the rule into national legislation. The main intention of the directive is to enforce the MARPOL regulations, but it goes further: accidental as well as intentional polluting is now subject to criminal prosecution in EU territorial waters as well as in international waters.

Jointly with legislation, a spy-in-the-sky system was introduced in April 2007 by EMSA (the European Maritime Safety Agency). The systems provides satellite images of European seas, and helps countries detect criminal acts.

As to air emissions, the EU has introduced a series of port- and maritime-related directives, among others ones on national emission ceilings for certain atmospheric pollutants, on reduction in the sulphur content of certain liquid fuels, on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations and one on substances that deplete the ozone layer which bans the marketing and use of ozone-depleting substances in the EU.

It is also interesting to note that some auto-regulation initiatives from within the sector have begun to turn up. The Port of Vancouver, for instance, recently introduced a system under which vessels are subject to differentiated port dues according to their pollution characteristics[1].

3.5.4 Strategic conclusions

It can be observed that maritime shipping is the largest mode in terms of tonnage and tonne-miles; this highlights the strategic importance of the sector when considering the environmental effects of transportation. Emission and pollution levels are well-documented, but research translating pollution volumes into damage costs is still lacking, mainly because of inspections which are hard to perform at sea and because of the stress that was put on accidents and oil spills. In terms of environmental impact, the sector has an acceptable image, except for emissions of SO_2 and water pollution either by accident or intentionally. That implies that there are opportunities for further improving the positive image of maritime shipping, and of this way of transportation in general.

[1] Normal tariff: 0.097 CADc/grt, vessels with Gold status: 0.057 CADc/grt (less pollution), vessels with Silver status: 0.067 CADc/grt, vessels with Bronze status: 0.077 CADc/grt.

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