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AND
INTERNATIONAL ENERGY AGENCY

# GOOD PRACTICE GREENHOUSE ABATEMENT POLICIES: TRANSPORT

INFORMATION PAPER

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## FOREWORD

This document was prepared by Gene McGlynn, Philippe Crist (OECD), Lew Fulton (IEA) and Mary Crass (ECMT) at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change and as part of the OECD Environment Directorate, IEA and ECMT programmes of work. However, the papers do not necessarily represent the views of the OECD, the IEA or the ECMT, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations", if appropriate.

## ACKNOWLEDGEMENTS

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All the papers and presentations from the transport roundtable are available at: http://www.oecd.org/env/cc/

To purchase the OECD Publication, *National Climate Policies and the Kyoto Protocol*, and other OECD publications, visit the OECD Online Bookshop at http://www.oecd.org/bookshop or send an email to sales@oecd.org.

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## Preface

Climate change is one of the major global environmental challenges facing policy makers today. Greenhouse gas emissions arise from nearly every facet of modern life. Radical reductions from current emission levels in OECD countries, through changes in both technology and behaviour, will be necessary to achieve the long-term goal of stabilising greenhouse gas concentrations. This publication examines issues affecting implementation of climate change abatement policies in the transport sector - one of the largest and fastest growing sources of emissions. It builds on previous and ongoing work of the OECD, IEA and ECMT, attempting to place transport sector policies within a broader climate policy framework.

The UN Framework Convention on Climate Change (UNFCCC) does not set out legally binding emission targets, but requires industrialised countries to adopt programmes and policies that aim to stabilise greenhouse gas emissions at the 1990 level in 2000. The Kyoto Protocol of the Convention establishes, for the first time, internationally agreed, quantified and comprehensive greenhouse gas targets for all industrialised countries. The Protocol calls on these countries, in aggregate, to reduce their emissions by around five per cent by 2008-2012 relative to 1990 levels.

Meeting the Kyoto targets could require OECD countries to reduce emissions in the 2008-2012 period to a level some 20 to 30 per cent below trend on average. The Protocol and the Convention provide cost-effective flexibility to mitigate emissions across the range of gases and sectors. Low cost opportunities to mitigate greenhouse gases exist in the forestry, agriculture and waste sectors, and some countries are exploiting these options. However, $CO_2$ emissions from fossil fuel combustion dominate greenhouse gas emission trends. Growth in the commercial, residential and transport sectors are likely to be the main drivers of future emission trends, along with the structure of energy supply. To be effective, domestic policy in the OECD will thus need do more to stimulate investment in cleaner technology and energy sources, encourage materials and energy efficiency, and changes in consumer behaviour.

While notable progress has been made in a few countries, policy action is partial and fragmented. New policies are necessary to achieve the Kyoto targets. Adaptive policy experimentation and learning from experience will be beneficial. OECD analysis suggests that gradual phasing in of action starting now will cost less than waiting for cheaper abatement technology to emerge in the future. More effective frameworks for action are needed now to help meet Kyoto targets cost-effectively, and to ensure success of future negotiations aiming to achieve the ultimate objective of the UN Framework Convention on Climate Change.

While there is no single formula for tackling climate change, and different countries require different policy mixes, studies to date point to a number of elements of a framework for “good practice”:

- Getting prices right is a key to cost-effective responses. Subsidy reform (especially for energy and agriculture) can have both economic and environmental benefits. For example, OECD case studies indicate that abolition of selected fossil fuel subsidies could reduce $CO_2$ emissions from the energy sector by one to eight per cent. Fiscal policies that ensure consistency between economic and greenhouse gas objectives, including eco-taxes, may be especially effective.

- Mitigation policies should use markets where possible. Domestic emission trading is a leading example of how environmental policies can operate in a market framework to achieve emissions reductions in a least cost manner. To be effective, such systems require good monitoring and effective enforcement as well as clear property rights to unambiguous emission limits. Several OECD countries are developing prototype systems and these may provide valuable experience for international emission trading as foreseen under the Protocol.

- A mix of other policies will be required. Lack of information, mixed incentives and other market failures mean that voluntary approaches, standards, green government purchasing, incentives and seed funding in R&D, for example, will still be required. Policies will also need to target consumer behaviour. "Soft" policies provide information, training and raise public awareness and may be key to long term innovation. Cost-effectiveness is a key criterion in the design and implementation of these measures.

- Closer monitoring and assessment of emissions and the impact of measures is also required. As we move to legally binding targets, it will be important that monitoring systems provide information that is transparent, accurate and reliable to support the Kyoto Protocol and its flexibility mechanisms.

- Good institutions will be necessary to meet the multi-faceted challenge of climate change. This requires early engagement of many ministries, different levels of government and other stakeholders to build consensus and to take action. A key is achieving multiple benefits simultaneously, for example, to curb fossil fuel and unsustainable land use, while at the same time improving the local environment.

- Finally, international co-operation is important. Countries are working to reduce emissions simultaneously, and can learn from each other. This requires regular contact between countries to share their experiences. International co-operation may also help give governments the resolve to reform subsidies and market distortions that lead to higher greenhouse gas emissions.

As part of its work supporting effective implementation of the UNFCCC, the OECD and IEA have conducted analyses of specific types and sectors of domestic policies. The Annex I Expert Group[1] has held a series of roundtables on domestic policies, which included background analysis by the OECD and IEA Secretariat, and presentations and discussion by national delegates of country experience. This publication contains three papers from the discussions on transport, covering a general overview of the sector, the role of technology and voluntary agreements, and freight transport. Examination of other important areas of domestic policy is part of the ongoing work of the OECD and IEA on this important topic.

1 The Annex I Expert Group is an ad hoc group of government officials from Environment, Energy and Foreign Affairs ministries from countries that are listed in Annex I to the UNFCCC, and those that have acceded to Annex I commitments. Annex I countries include most OECD member states and some countries from central and eastern Europe and the Commonwealth of Independent States that are undergoing the process of transition to a market economy.

# 1. Domestic climate policies and measures in the transportation sector - Roundtable summary[2]

On 18 February 2000, the Annex I Expert Group (AIXG) held a one-day roundtable, chaired by Andrej Krancj of Slovakia, on domestic climate policies and measures in the transportation sector. This roundtable was one of a series convened by the AIXG to share experiences in member countries with implementation of domestic policies to abate climate change. The roundtable covered recent developments at the national level, technology and social innovation, in passenger and freight transport.

A summary of the roundtable follows. This publication also includes the background papers prepared for each of the three sessions.

*Session 1: Transport and climate change: an overview of key issues*

Gene McGlynn (OECD) briefed the group on background information, indicating the rapid growth in transport sector emissions, apparent ineffectiveness of policies to date, comparisons with the stationary energy sector indicating the more significant challenges in transport sector abatement, and possible elements of a policy framework. John Dodgson (NERA, for ECMT) then presented a framework for quantification of the impacts of transport sector policies, indicating the importance of careful modelling of changes in the vintage and stock of motor vehicles, rates of technological progress, and relationships between different abatement measures. Maurice Girault (France) outlined some elements of proposed new greenhouse abatement actions of the French Government, indicating the apparent difficulty in reaching the Kyoto target in transport without significant economic cost, and the importance of actions at the European level. Martin Kroon (Netherlands) outlined actions the Dutch government was implementing, with a strong focus on enhancing driver awareness of the environmental consequences of driving behaviour and recognition that transport choice was affected by motivations other than transport alone. The discussion included a number of views on pricing, including the relative importance of the size of increases versus the predictability, importance of charges other than petrol taxes, demand elasticities of fuel prices versus elasticities of parking or other factors, and the importance of how petrol tax revenue is spent. There was also discussion of the size of potential no-regrets measures, the need to integrate environmental concerns in sectoral policies, and the importance of road quality. There was a general view that more attention to the specific concerns of EITs was needed.

*Session 2: Technological change in the transport sector*

Lew Fulton (IEA) presented the issues paper on voluntary agreements, indicating the ambition and innovation of the EC agreement and the availability of technologies to meet the target. He also pointed out potential difficulties with the agreement, including the need for governments to deliver on fuel quality outcomes and the need for complementary measures to ensure market demand for more efficient (and more expensive) vehicles. These could include fuel consumption-based fees (or "feebates", fees combined with rebates), and incentives for the adoption of advanced, "next generation" technology. Gunter Hoermandinger (EC) briefly discussed some of the implementation steps associated and indicated that the

2 This paper was written by Gene McGlynn, OECD.

EC is working with the auto industry and others to monitor the agreement and consider follow up steps. Frazer Goodwin (Transport and Environment) questioned the speed and efficacy of the EC VA, but indicated it did have potential if it were strengthened. In the discussion, questions were raised as to whether VAs provided adequate support for downsizing of the vehicle fleet, how transparency of VAs can be reached, how VAs could be enforced, whether VAs were preferred to regulation and whether limiting VAs to specific markets could lead to problems of competitiveness and global shifts in the nature of markets that would make VAs globally less effective.

*Session 3: Policy responses in freight transport*

Philippe Crist (OECD) briefed the group on the importance of freight transport, the rapid growth in freight volume and the likely inability of technology to outweigh the growth of freight volume and reduce emissions. He also indicated the potential emission reductions through logistics management, and the wide spread in emissions performance among different fleets, but the lack of policy frameworks to support such improvements. Shinji Nakagawa (Japan) identified approaches the Japanese government is taking to reduce freight emissions, including promoting more efficient use of large, efficient vehicles, and infrastructure to support inter-modal freight transport. Discussion included the difficulties of targeting small trucks, the potential importance of information technology in creating and managing transport demand, the low percentage of total costs accounted for by transport, and the need for careful data analysis to understand real differences in emissions intensity of modes.

# 2. Greenhouse abatement policies in the transport sector: an overview[3]

## 2.1 Background

The transport sector accounts for 20-25 per cent of Annex I GHG emissions[4]. From 1990 to 1996, transport sector GHG emissions grew by around ten per cent in the OECD, accounting for more than half the total growth in emissions. In most EIT countries, emissions from the transport sector account for less than ten per cent of total emissions, and fell from 1990 to 1996 due to economic restructuring and GDP declines. However, this was not universal, and recent trends indicate that emissions from this sector may now be increasing in many EIT countries. Road transport is the dominant source of emissions in both passenger and freight movement. Roughly speaking, passenger transport accounts for 60 to 70 per cent of emissions.

Emissions from road transport are a function of many factors, which can be classified as:

- **A**ctivity **-** the level of transport tasks undertaken
- **S**tructure **-** the split between different modal shares (road, rail, air, water)
- **I**ntensity **-** the efficiency with which energy is used to complete travel tasks
- **F**uel **-** the types of fuel used to power transport

These can be broken down further. Modal activity, in passenger or tonne-km, depends on vehicle activity, vehicle capacity, and actual capacity utilisation. Modal intensity in turn can be decomposed into vehicle intensity (fuel/km) and utilisation. Vehicle intensity depends on a vehicle's size and characteristics (like speed, weight, and power), and on actual driving conditions. All of these variables are subject to policies that provoke changes in technologies and changes in consumer or user habits and behaviour. Good policy analysis depends on understanding these variables ex ante, and detailed evaluation to follow their evolution over time.

## 2.2 Drivers and trends

### *Activity*

The level of transport activity relies on the underlying demand for mobility of people and goods, the nature of transport infrastructure and load factors. These are in turn driven by growth in wealth and trade, consumer tastes, lifestyles, urban development patterns and other factors. Historically, GDP growth and the expansion of the transport sector have been strongly correlated, while road transport has grown even faster.

3 This paper was written by Gene McGlynn, OECD.

4 Excluding land use change and forestry, and bunker fuels.

While patterns vary somewhat from country to country, general trends in the last 20 years or so in passenger transport include:

- Increasing levels of car ownership (which has impacts both on levels of travel and modal split)

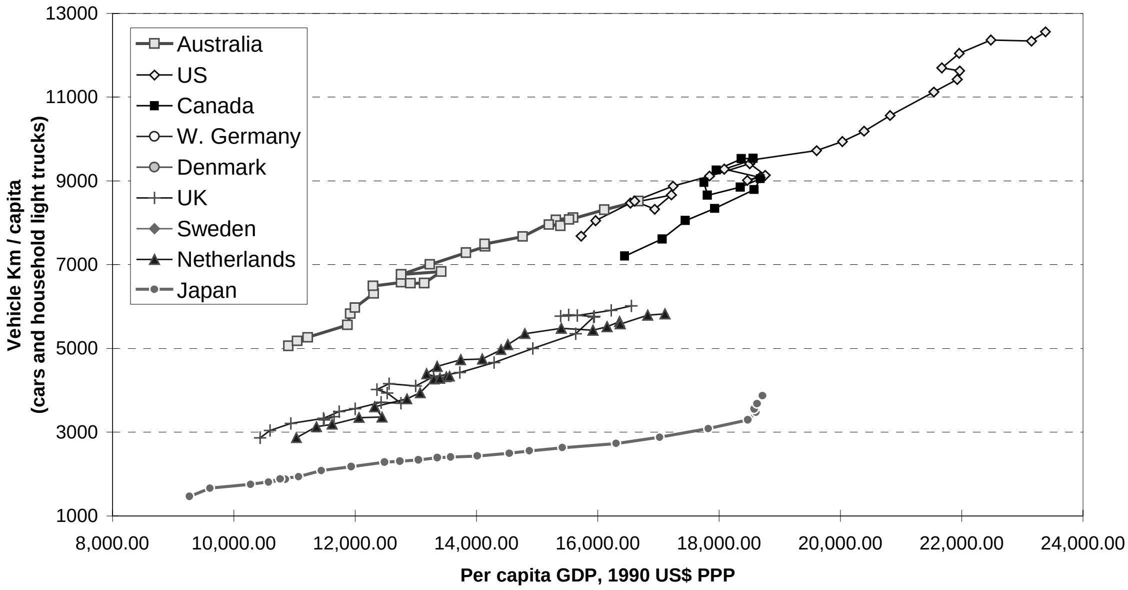
- In road transport, falling average load factors (persons per car) due to more (mostly single-person) commuting trips, smaller households and higher car penetration. By contrast, load factors for aviation are much higher as a percentage of capacity and have increased in recent years.

- Increasing average distance travelled per capita, due to changes in urban settlement, patterns of work, shopping and leisure, falling costs of motoring and growing road networks.

- Increasing road passenger-kilometres travelled per capita in the OECD, up by about one to two per cent per year. Meanwhile, growth in domestic and international passenger air traffic has been even more rapid, at five to seven per cent per year.

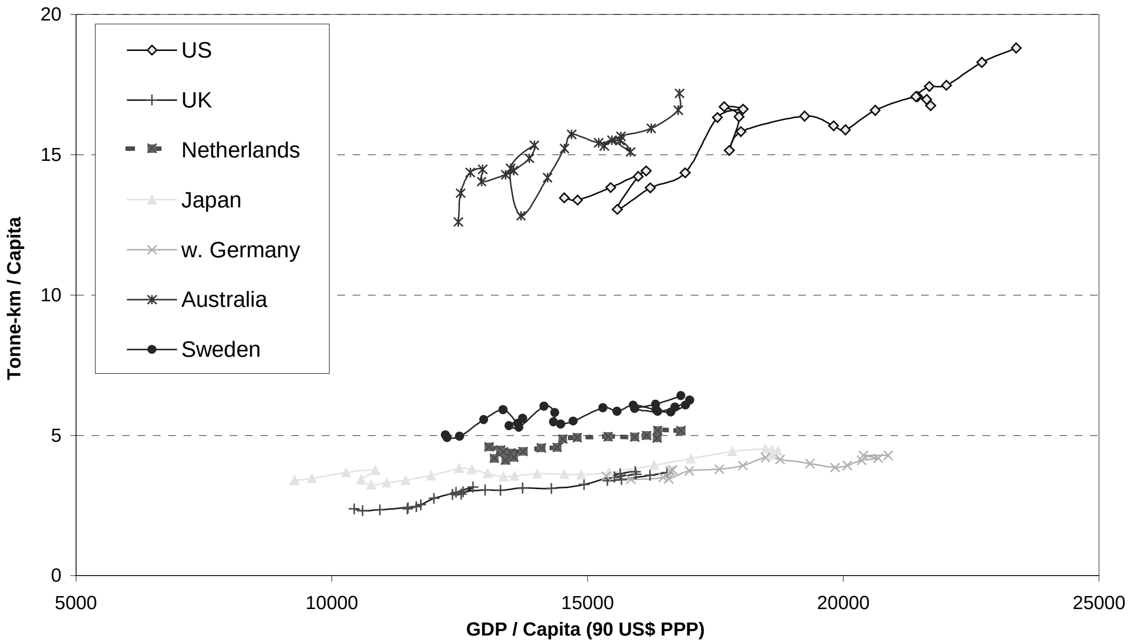
Figure 1 shows how car passenger travel, in passenger-km/capita, has grown with GDP/per capita.

Figure 1: **Car driving and per capita GDP 1970-1995**




Freight transport is closely linked to economic activity and to patterns of production, consumption and land use. It is influenced by expanding international trade, changes in company structures, changing consumer demands and increasing use of modern communication technologies. In general, domestic freight movements account for over 75 per cent of tonne-kilometres travelled and the bulk of these movements are comprised of relatively short trips. A particularly striking feature has been the growth of goods transport by road: nearly five per cent p.a. over the last 20 years, faster than GDP growth and even faster than car traffic. Figure 2 shows the growth in domestic tonne-km per capita vs. GDP per capita from freight in a number of IEA countries. In the European countries shown, trucking accounts for 50-70 per cent of total tonne-km, while in the large countries (the United States and Australia), rail and inland shipping accounts for 60-70 per cent of the much higher totals relative to GDP.

Figure 2: **Total freight volume and GDP**




### *Structure*

Modal shifts in the past have usually been in favour of more energy intensive modes. Road transport dominates in passenger and freight, while aviation exhibits the highest growth but is still small on an absolute scale. While the fuel intensity of passenger air transport (energy/passenger-km) has declined substantially over the last 20 years, it is still a highly energy-intensive mode, along with road. Aviation freight, while difficult to separate from passenger activity is considered by far the most energy intensive freight mode (three to five time the energy intensity of trucks). Rail remains far less energy intensive than either aviation or road, with the exception of some commuter systems that have low load factors. Trends in the different modes are:

– Road transport, both passenger and freight, has experienced tremendous growth over the past decades and is the dominant transportation mode with over 91 per cent of passenger travel and 75 per cent of goods transported. The flexibility of the ‘service’ available through individual vehicle use is the result of and results in particular urban structures and life styles (commuting, shopping, leisure and holidays). Patterns of urban development less focused on city centres can make it more difficult for public transit modes to compete with cars. An important rationale behind expanding car use has also been the significant proportion of GDP generated from automobile and related industries in manufacturing countries. In freight transport, trucking has won an increasing share of goods transport, at the expense of rail and inland waterways. Trucking has benefited most from the growth in small volume and high value manufacturing goods and trade relative to bulk material such as coal, minerals or agricultural products where rail and barge still play an important role. The expansion and improvement of road infrastructure, the technological improvements of vehicles (in power, speed and size) and a highly competitive environment have allowed trucks to offer expeditious, timely and door-to-door delivery of high value-added goods. Improved reliability and availability of road freight is both a cause and effect in the trend towards 'just-in-time' production and enables manufacturers to reduce warehousing facilities. Shifts in economic activity to suburban areas have led many firms to move to edge-of-town and out-of-town sites where they are no longer connected to existing rail and port terminals. The interplay between vehicle technology, the increases and flexibility of the service provided and infrastructure provision has fuelled growth of road transport relative to other modes.

- The share of rail transport, both passenger and freight, has been declining over the past decades in almost all OECD countries, except for rail freight in the United States. While passenger transport by rail has experienced an absolute growth over the past fifteen years, it accounts for only six per cent of passenger travel, and a much lower share in N. America. Trends in rail freight show maintenance of transport volume (tonne-km), but a diminishing share with respect to road freight.

- Water-bound transport has also experienced a declining market share, both for inland waterways and short-sea shipping, although these modes have been growing steadily in recent years. For maritime shipping, globalisation of production and expanding trade are driving its development. Like rail freight, maritime transport has seen market share eroded because of lower demands for bulk shipments of raw materials.

- Air transport's share of total passenger domestic travel is less than three per cent, except in some Nordic countries (six per cent) and in N. America and Australia (10-12 per cent). However, the international aviation industry has grown prodigiously over the past thirty years. Demand side drivers include economic growth, globalisation of commerce and industry, higher disposable incomes, and increased leisure time. On the supply side, falling airline tariffs due to enhanced competition, technical efficiency improvements and the relatively low cost of aviation fuel due to lack of taxes are also factors. While aviation still accounts for only a small proportion of total greenhouse emissions, the release of greenhouse gases at high altitude leads to greater global warming effect than equivalent ground level emissions, so this sector is of concern, especially due to its rapid growth.

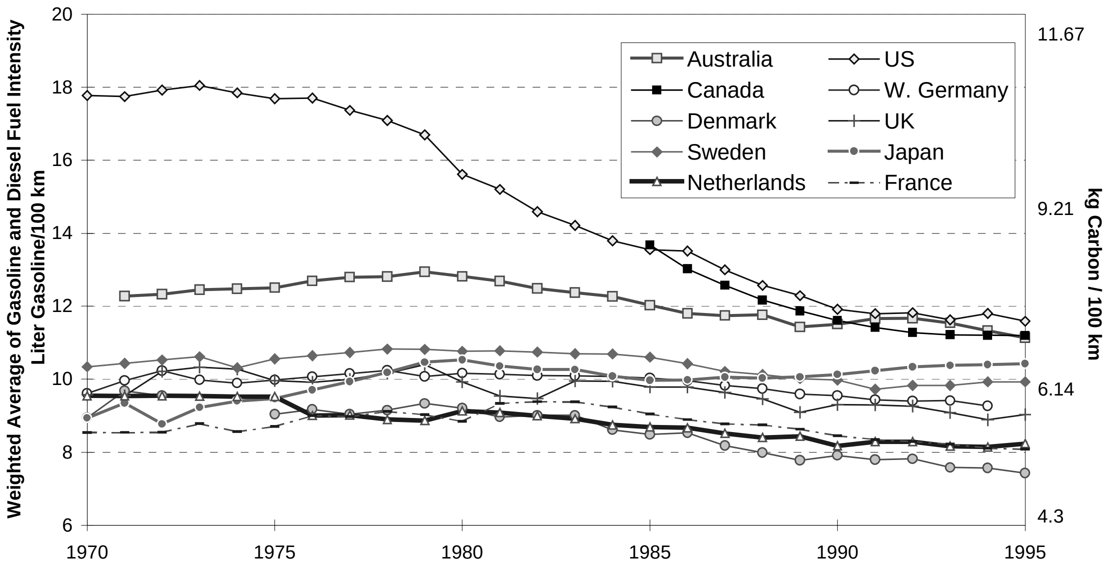
## *Intensity*

Fuel intensity is generally measured either as energy use per passenger-km or tonne-km of freight. While there have been significant and continuous improvements in automobile engine technology over the years, cars are becoming heavier (in part to accommodate more accessories such as air conditioning, electric windows, stereos, etc but also for safety reasons), more powerful, roomier and with larger engines. These increases in "hedonic" attributes have offset technical improvements, so that overall fuel intensity of vehicles has fallen only slowly, or even increased.[5] In recent years, especially in the United States, there has been rapid penetration of sport utility vehicles into the market. Together with passenger vans and pickup trucks, these now account for more than half of US passenger vehicle sales, and similar trends are

5 The exceptions to this were the United States and Canada, where vehicle fuel intensities improved dramatically from 1974 to 1990 due to combined effects of pricing, regulation and other policy and behavioural changes. However, as North American efficiency figures have approached those of other countries, there may be less scope for such dramatic improvements.

appearing in other OECD countries. In addition to these trends, the load factor of automobiles and other household vehicles has fallen steadily in virtually all countries, from over 2 people in the early 1970s to around 1.5 in the mid 1990s, which also limited the net decline in the energy intensity of passenger transport. Figure 3 shows the fuel intensities (and approximate carbon emissions/km) of the on-road fleets of a number of IEA countries.

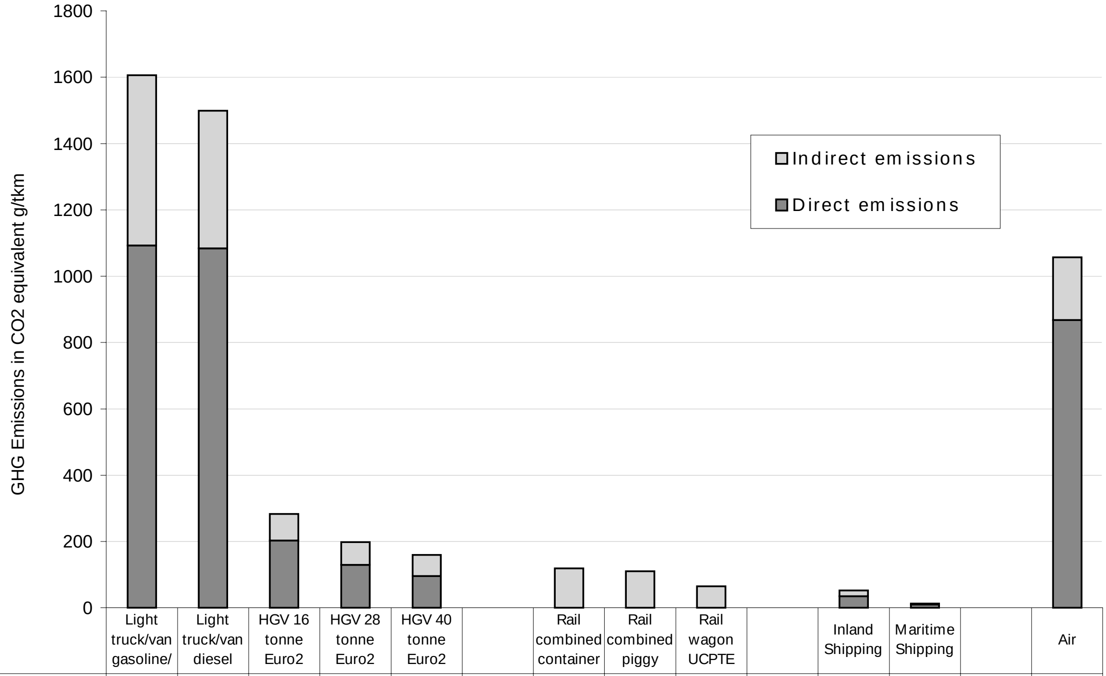
Figure 3: **On-road fuel intensity and carbon intensity of cars**




Energy intensity of freight traffic is a complex function of many factors. For road freight, these include mix of heavy and light trucks, traffic conditions, driving behaviour, load factors and levels of packaging, and the fuel efficiency of the vehicles themselves. In most OECD countries, there has been an increase in the share of smaller trucks, which have emissions intensities far higher than alternative modes (see Figure 4) for both technical and logistical reasons. While evidence is not complete, it appears that various factors have combined to leave the energy intensity of trucks relatively constant. However, the increasing share of road freight, has led to an increase in aggregate intensity of the freight sector. Figure 5 shows the energy intensity of trucking in a number of IEA countries over time. The wide spread reflects all of the aforementioned factors. Note intensities have fallen markedly in some IEA countries.

In passenger aviation, energy consumption per passenger-km has decreased rapidly compared to other modes due to high technological efficiency gains, stock renewal (and growth) and substantial increases in load factors.

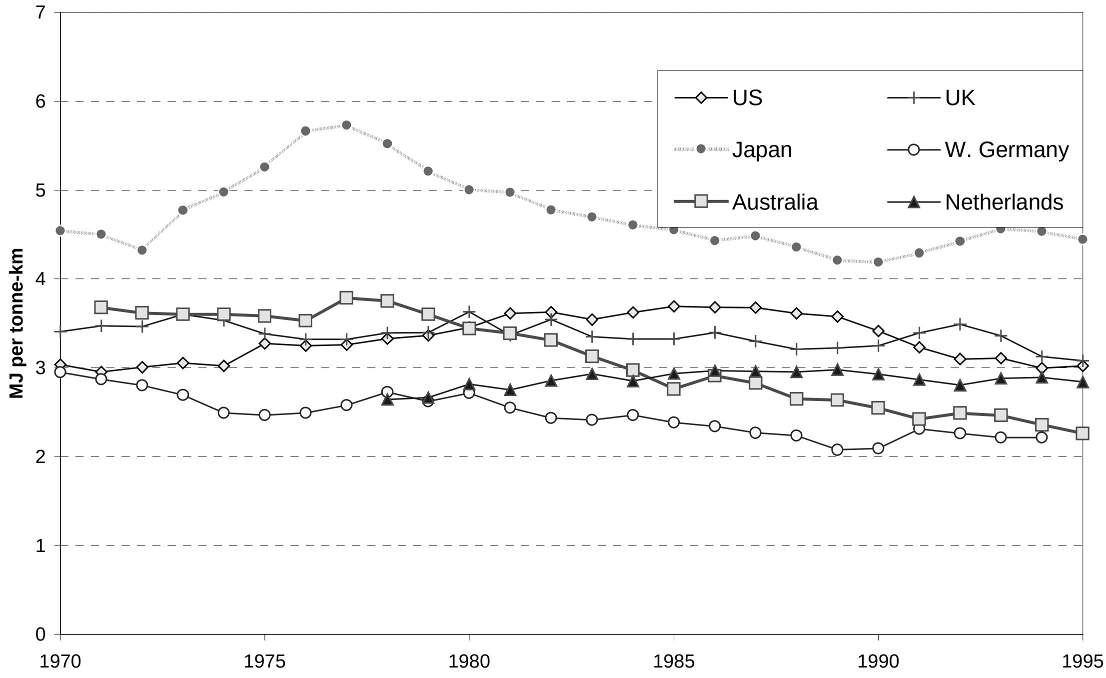
Figure 4: **Lifecycle GHG emissions for European freight transport modes**




| | Light truck/van gasoline/ | Light truck/van diesel | HGV 16 tonne Euro2 | HGV 28 tonne Euro2 | HGV 40 tonne Euro2 | | Rail combined container | Rail combined piggy | Rail wagon UCPTE | | Inland Shipping | Maritime Shipping | | Air |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indirect emissions | 513,367 | 414,9477 | 80,4059 | 67,85413 | 63,63896 | | 119,0136 | 110,4956 | 65,1665 | | 17,53645 | 2,973531 | | 189,1986 |
| Direct emissions | 1092,603 | 1083,939 | 202,9267 | 130,0351 | 96,07304 | | 0,003483 | 0 | 0 | | 35,13465 | 10,16909 | | 868 |

*Source:* INFRAS.

Figure 5: **Energy intensity of trucking**



### Fuel

Petroleum fuels dominate motor vehicle transport almost entirely. Typically, petrol comprises 85 per cent or more of total transport fuel use, with most of the remainder being diesel. Diesel dominates the heavy truck segment. While there have been some attempts to introduce alternatives such as ethanol, natural gas and electricity into the mix, the combined share of these fuels in OECD countries is less than one per cent. International interest in these fuels suggest greater future potential for these fuels. A few countries have been more successful in substituting LPG and diesel for petrol, strongly supported by highly differentiated pricing. The greenhouse impacts of these petrol substitutions are limited as both LPG and diesel have significant emissions and lower fuel prices lead to some increases in travel volume.

Hybrid electric/petrol vehicles have recently been commercialised in Japan and the United States in small numbers. Due still high cost per vehicles they are not likely to command large shares in new vehicles sales in the next five to ten years but offer, once penetrating in larger numbers, a large potential for fuel savings.

### Summary of trends

The overall result of these trends has been rapid growth in emissions. Transport activity is growing quickly, while road and aviation transport wins increasingly larger modal shares. Technological efficiency improvements are largely balanced by increased demands for power and weight, or reduced load factors, and there is very limited penetration of low- or zero-emission fuels. Overall, increases in activity levels more than offset efficiency gains. While the levels of emissions and the rates of increase differ from country to country, and even some saturation may be evident, the general trend is that emissions keep rising with rising GDP.

Low and declining oil prices for the past 15 years or so have supported the growth of transport emissions. Until very recently, oil was at historically low levels in real terms. Constraints on market supply have recently pushed prices to levels not seen in a decade. Should these prices persist, a number of underlying trends may be altered toward lower intensity, as happened following the oil price shocks in the 1970s and 1980s.

### Box 1. **Transport in EIT countries**

EIT country targets under the Kyoto Protocol range from 92 to 100 per cent of base year levels; but large economic declines during transition have seen overall emission levels fall well below these levels[6]. Nevertheless, some of the more rapidly growing EIT countries may require further actions to keep emissions below target levels in the first commitment period. Trends in transport in EIT countries have been somewhat different than for OECD countries, although complete data are not always available. Since economic restructuring of these economies, the underlying transport drivers appear to be moving in similar directions, but from a different base.

In 1990, transport accounted for less than ten per cent of greenhouse gas emissions in most EIT countries, a much smaller share than for the OECD. In many EIT countries, more than 40 per cent of passenger-kilometres are on public transport, and rail's share is greater than in most OECD countries. However, following restructuring, the share of rail and buses has fallen dramatically. In Central and Eastern European EIT countries,[7] from 1989 to 1995, passenger-kilometres on rail fell by about one-half and on bus by about one-third. Meanwhile, volumes in passenger cars doubled. Increases in public transport fares, lower investment in infrastructure, as well as greater competition from passenger cars, accounted for these trends. Rates of car ownership are far lower than in OECD countries and are expected to continue to rise quickly. Additionally, rapid imports of used cars from Western Europe and expansion of production of western cars in Eastern Europe has boosted the size of fleets with larger cars.

In freight, overall volumes declined substantially from 1989, but began to stabilise and then increase from around 1993, especially with expanding trade links to Western Europe. Road has shown the most rapid recovery, with tonne-km returning to pre-reform levels by 1995, due to expanded roadways and fuel distribution networks. Rail is still the dominant mode for freight transport, accounting for 66 per cent of goods transport in 1994.

EIT countries have been recipients of considerable funding from international financial institutions for transport infrastructure. 46 per cent of European Investment Bank(EIB) transport funding in 1996 went to road projects, and another 12 per cent to air, while 53 per cent of European Bank for Reconstruction and Development (EBRD) transport funding from 1992-96 went to road. Rail projects accounted for 36 per cent and 26 per cent of funding, respectively. This preference in investment funding is expected to lead to relative declines in the capacity and quality of rail infrastructure relative to more environmentally-friendly modes. However, in some EITs, notably the Czech Republic and Poland, there has been considerably more focus on rail.

Policy-making in EIT countries faces special challenges. Institutional and data collection institutions are not always strong and environment does not always figure strongly in the political agenda. Macroeconmic imbalances and weak financial institutions, perceived economic and political risks have constrained affordable capital. In addition, foreign direct investment is focused in only a few countries. Environmental issues are rarely incorporated in company management structures. The position of many EIT countries at the crossroads between Eastern and Western Europe means that external forces will drive transport demand to a considerable degree.

Overall, EIT countries start from a positive basis for sustainable transport, with high reliance on rail-based and public transport. However, recent shifts in transport structure and increases in activity as economies grow, could lead to rapid increases in emissions in these countries. At the same time, market and policy frameworks require further development to manage these environmental challenges.

6 Bulgaria, Hungary, Poland, and Romania use years other than 1990 as base years for commitments.

7 Bulgaria, Czech Republic, Estonia, Hungary, HR, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia.

## 2.3 Policy-making in the transport sector

Quantitative assessment of the effectiveness of transport policy measures is difficult. However, most analysts would agree that there has been limited success (at best) among Annex 1 countries in controlling greenhouse emissions from the transport sector. While the rapid growth in underlying demand is clearly an important reason, there are number of other factors that complicate policy-making in this sector, including:

- Unlike in the stationary energy sector, transport emissions come from dispersed sources. There are no point-source emitters, so policies often work through indirect means.

- Alternative fuel options are somewhat limited in the transport sector, as most fuels do not provide major GHG reductions compared to gasoline. Those that do, such as ethanol, tend to be quite expensive. Most vehicles capable of running on zero-emission fuels, such as hydrogen fuel cells, are still at the prototype stage of development. Electric vehicles can be very low emission in countries with low GHG electricity generating capacity, but these vehicles are also relatively expensive. The lack of easy fuel-switching options limits the range of cost-effective policies.

- Transport patterns are closely linked with patterns of urban development, lifestyles, trade, and consumer demand. Many of the underlying factors of demand have long time frames for change and are politically sensitive.

- Transport is a highly emotive and political topic, and many policies to affect transport demand (especially through pricing) have encountered stiff and widespread opposition. For many people, cars are more than just transport. As all citizens are direct consumers of transport services, policy changes have a very wide base of stakeholders. This in part seems to explain why there appear to be many opportunities for cost-effective emissions abatement in this sector which are not implemented.

- Effective policies to address transport emissions will sometimes be outside the environment field altogether. For example, tax treatment of company cars (noting that in some countries more than half of new cars are company cars) and mortgages (which can have effects on the nature of housing demand and urban form) can be important to the success of policies.

Annex I countries have implemented a wide range of measures to address emissions from the transport sector. Effective policies would need to systematically address the main drivers for increases in emissions, and support underlying trends leading to lower emissions. Given the many factors supporting higher emission levels, there may be a need for a diverse, well-designed policy mix. In France, for example, a scenario to achieve Kyoto target levels in the transport sector includes large rises in fuel prices, reductions in public transport prices, changes to operations in road freight markets, driver training, enhanced traffic management and enforcement, supplementary measures to the EC Voluntary Agreement, support for alternative vehicles and improved transport and land use planning. Such packages can be difficult to assess, as there are many interrelationships and feedback loops. However, careful assessment of alternative policy approaches is necessary to determine an effective and efficient policy package. So, enhanced analytic capacity in assessing potential policies, as well as regular review of policies in place, are important to good practice.

Key elements in the design of a transport policy framework include:

- The road passenger transport sector tends to receive the bulk of policy attention in transport. An effective policy-mix will also explore options in other sectors. Freight transport, for example, accounts for 20-30 per cent of transport emissions, and there are abatement options through improved loading and logistics, technical improvements, driver training, alternative packaging and changes in order cycles to substantially reduce emissions at low or no cost. Aviation, while accounting for only a small proportion of total emissions, is expected to be the fastest growing sector for some time. Combined with the higher global warming impact of emissions at high altitude, this growth makes aviation an important area for policy attention. More widely, bunker fuels, though not included in quantitative commitments under the Kyoto Protocol, will require attention as part of a long-term, global response to climate change.

- Many countries' transport systems are integrally connected with other countries. This is especially true of areas such as the European Alpine regions and Central European EITs. In these situations, there is a need for international co-operation to fully address transport emissions. Furthermore, as fuel and automobile markets are global in nature, there can be constraints on what countries can do acting alone. And international aviation and marine transport may require international solutions. So, while domestic action is central to addressing emissions from transport, international Cupertino can also be an important element of an effective policy response.

- Non-greenhouse considerations, especially air pollution concerns in urban areas, have been the main drivers for environmental policy in the transport sector. While some technologies that may increase fuel economy could increase some kinds of local pollution (e.g., particulates from diesel), other technologies and strategies that emphasise traffic management and modal shifts to ameliorate both air pollution and congestion could restrain GHG emissions as well. Studies of the non-greenhouse benefits of greenhouse reduction policies have shown that these could range as high as USD 200 per tonne of $CO_2$ abated, largely because of improvements in air quality. Integrated policy design to maximise the range of environmental and social benefits is a challenge for policy-making, but is supportive of enhanced greenhouse response.

In EIT countries, air quality can be a more obvious and significant concern. In this case, the need for effective greenhouse policy to take non-greenhouse effects into consideration is heightened. This is for reasons of good policy-making, as well as recognition of the likely environmental priorities of policy-makers.

- Fuel and other transport-related taxes comprise more than 90 per cent of all environmentally-related taxes in OECD countries, with fuels being one of the most heavily taxed expenditure items. Experience following the oil shocks of the 1970s and 1980s shows that significant price rises were successful in reducing some of the least efficient energy uses (especially in the United States), but whether they would be equally effective today is unclear, and the long term price elasticity of fuel demand appears low. There is a correlation between countries with low fuel prices and per capita automobile fuel emissions, although many other factors make an analysis of this relationship difficult.

Price differentials may have greater impacts in *fuel choice*, as it appears that low diesel fuel prices played an important role in stimulating shifts to diesel cars and have been a basis for promoting LPG use in some countries. Fuel and vehicle charges may also not be the most effective pricing method to address transport emissions, as charges on parking, or roads, or unused freight capacity may provide more direct and effective signals for change. Relative prices across modes also need consideration. Large increases in public transport fares have been an important reason for the increase in automobile modal share in EIT countries. However, in considering alternatives to fuel price increases, governments will need to consider comprehensiveness and efficiency as well as impact.

Significant changes in transport emission trends seem unlikely without changes to the structure and/or level of transport prices, since price changes are such a cost-effective and comprehensive signal to change behaviour. However, the precise nature of these changes requires careful consideration, including their interactions with other policy measures. The politics of transport price adjustments can make progress in this area difficult and slow, although using some portion of revenue raised directly for transport abatement can help acceptability.

– A number of countries have implemented market reforms in road, rail, air and shipping. This has involved privatisation, introduction of competition and removal of subsidies, though significant market distortions remain. Experience with market reform can have mixed results for greenhouse emissions. Airline deregulation in the United States appears to have led to greater efficiencies in operation but a large growth in overall passenger numbers, and so a net increase in emissions. Policy must pay attention to the role of different modes as competitors when deciding on the timing and nature of reform processes. For example, the slower pace of rail reform relative to road in Europe may have hindered the ability of the rail sector to flexibly respond to market needs and maintain share. Market mechanisms to reflect environmental costs will also be important with increasing reliance on market signals.

For EIT countries, market reform can be more complex and more fundamental. Moving away from heavily-subsidised public transport systems has been a factor in the shift toward car-based travel. Given the magnitude of market changes underway in these countries, it will be important to ensure that environmental considerations are fully integrated into discussions of the nature and pace of reform in different sectors, and the possible need for complementary measures.

– Recently, there have been a number of voluntary agreements with the auto industry, seeking to ensure that the fuel efficiency of new vehicles is significantly improved. The EC agreement is notable both in its ambition and in its extension from fuel efficiency to emissions efficiency, providing more incentive for greenhouse-efficient fuel-switching. Some countries are relying on such agreements as a central element of their greenhouse response actions in the transport sector, but their effectiveness is yet to be tested, and progress has been slow. Complementary measures to improve fuel inputs and support market demand for more fuel-efficient vehicles will likely be required.

Technological improvement in vehicles will be a key element of long-term strategies to reduce emissions. However, governments need to consider if voluntary agreements are the most rapid or effective way to achieve this goal. In either case, the impact on total emissions may be limited, as this technological improvement will not affect the underlying drivers of increasing overall transport demand, and may even exacerbate them if they reduce the effective cost of transport. The slow turnover of the car fleet means that the impact of technological change in the Kyoto time frame could be limited, unless it commences immediately or is accompanied by measures to increase the turnover rate. The long-term potential of technological change is very significant.

Voluntary agreements can also play a role in areas other than vehicle technology. These agreements can play a powerful role in making companies aware of environmental and economic implications of choices, so agreements in sectors such as freight operations or retail delivery operations could be beneficial in raising awareness and commitment. Voluntary agreements in EIT countries may also be effective in helping companies there incorporate environmental issues into decision-making.

- While technological improvement will be important over the long-term, it is unlikely that it can deliver levels of abatement consistent with achievement of Kyoto Protocol targets, even recognising that the transport sector may not be required to achieve the same level of abatement as other sectors. In a transition to a sustainable transport future, behavioural change is likely to account for a significant portion of change. Therefore, governments must not rely solely on technological change, and must prepare the way for substantive changes in transport use patterns as well.

- The importance of addressing urban development patterns has long been recognised. However, in countries such as the United States, Canada and Australia where development patterns are already highly dispersed, fringe urban settlement continues apace. In the already denser cities of Europe and Japan, the scope for increasing density may be limited. There may still be options for "locally dense" or "mixed use" settlement. Linking urban development to lower transport levels and different transport modes is a difficult, long term challenge for all government authority levels (municipal, regional, national), and demands effective policy integration across a range of issues and levels of government. As such approaches are complex and operate over long time frames, it will also be difficult to assess their performance, raising the need for assessment techniques of matching complexity.

Infrastructure provision is an important element determining future urban development patterns. Relative funding rates for road versus other transport modes may be one long-term indicator of likely future trends. In EIT countries, international financial institution funding patterns may support modal shifts towards road transport to the detriment of the environment. As well as negative environmental implications, this may have direct financial implications if it leads to fewer emission quotas being traded internationally. Making policies more coherent with environmental objectives could be advantageous.

- Policies to influence the *way* people travel (e.g. driver education, on-board instruments, public information campaigns) have been a part of many countries' emission reduction policies. The cost-effectiveness of such policies is hard to assess and policy makers should build in an assessment process when launching a policy. Approaches could include devices to help drivers monitor their driving performance to minimise environmental (and economic) costs. However, transport choices are not solely based on "rational" criteria but are a complex function of many psychological drivers. Therefore, measures based on assisting "rational" choice will have more impact in the context of broader approaches.

## 2.4 Conclusions

Greenhouse gas emissions from the transport sector have continued to grow rapidly, despite a range of government policies to address these. This may be due to the inherent difficulties in addressing diverse sources of emissions where there is a range of underlying drivers of emissions growth, or failure to fully integrate environmental considerations in related policy areas, or the political difficulties in addressing a sector where there are so many interested actors. Most likely, it is a combination of all of these. Given the inertia of the transport system, implementation of an effective policy framework is required soon, if transport is not to present a major obstacle to achievement of Kyoto targets, or require larger abatement in other sectors. A comprehensive policy mix that includes pricing, voluntary agreements, regulation, information and institutional reform, and which addresses both technological and behavioural change is likely to be required.

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# 3. Quantifying $CO_2$ abatement policies[8]

The principal objective of this study is to examine the quantification of transport sector measures against attainment of carbon dioxide ($CO_2$) emission reduction targets. Most countries have identified measures that could, in principle, stem growth in carbon emissions, but questions remain as to how to quantify the impact of these measures and, often equally important, how to assess the probability of success of specific measures. The study, [CEMT/CS(2000)8], seeks answers to these questions primarily by reviewing the attempts made by three countries, France, the Netherlands and the United Kingdom, to develop policies to control transport sector carbon emissions and to quantify their effects. This summary describes the main findings of the study while leaving to the longer paper the detailed description of the national policy approaches of the three countries.

## 3.1 Context

The transport sector is an important contributor to carbon emissions. In the European Union the share of transport $CO_2$ emissions increased from 19 per cent in 1985 to 26 per cent by 1995. In 1995 cars accounted for about 50 per cent of transport $CO_2$ emissions, and road freight for about 35 per cent. In Central and Eastern Europe, the transport sector accounts for less of the share of total emissions, roughly ten per cent, and decreased from 1990 to 1996 because of economic restructuring and declining GDP. Recent trends in a number of these countries, however, indicate that emissions from this sector may now be increasing, with road transport the primary source of emissions in both passenger and freight movement.

In the absence of intervention, carbon emissions from transport look set to rise further for two main reasons:

- Most transport is oil-based, and there are relatively limited opportunities to switch to non-oil-based fuels; and

- Transport, especially car, truck, and air transport, is growing in most, if not all, economies.

## 3.2 Main issues to be considered

There are a number of essential steps in developing and quantifying policy packages. Each must be adequately addressed if meaningful results are to be obtained. They include the necessity to:

1. measure existing carbon emissions from the transport sector;

2. determine the way in which these emissions are generated;

8 This paper was prepared by the European Conference of Ministers of Transport (ECMT) Secretariat, in collaboration with John Dodgson (NERA). This document was noted by Ministers at their Session in Prague on 30-31 May 2000 [CEMT/CM(2000)5/FINAL]. The full report will be made available on the ECMT website http://www.oecd.org/cem/.

3. forecast carbon emissions from the transport sector in a robust "Business as Usual" (BAU) case, in which present policies are continued in the absence of specific measures to limit carbon emissions;

4. identify specific policy options to limit carbon emissions below the levels they would reach in the BAU case;

5. quantify the impact of particular options both individually and when they are combined in specific packages of different options;

6. assess whether particular policies can be implemented, for practical – including politically feasible – reasons.

## 3.3 Identifying policy options

Once emissions levels are projected in the Business as Usual scenario, policy options can be identified. These can be grouped under a number of broad categories:

- Economic instruments (e.g. increases in fuel taxes, road pricing, feebates);

- Regulations and guidelines (e.g. speed limits, traffic management measures, land-use regulation and guidelines, fuel efficiency standards);

- Voluntary agreements and actions ( e.g. the 1995 joint declaration on the reduction of $CO_2$ emissions from new cars signed by ECMT and the automobile industry (represented by ACEA and OICA), and more recently, the voluntary agreement between the European automobile manufactures (ACEA) and the European Commission;

- Information and training initiatives (e.g. fuel-economy labelling of vehicles, driver training, use of econometers and other on-board instruments); and

- Support for research and development.

The full study describes how each of these types of policy options is used in the climate change policy plans of the Netherlands, United Kingdom and France. For the purposes of this summary, the importance of one policy in particular in all three countries – the voluntary agreement of the European Automobile Manufacturers (ACEA) and the European Commission – must be noted. All three countries, and indeed most likely a majority of other European Union countries as well, are relying on the reduction in $CO_2$ emissions from this measure to help them reach their national $CO_2$ abatement commitments under the Kyoto Protocol. The complete study identifies the complexities involved in quantifying the emissions reductions from this agreement in individual countries and highlights the importance of coherence in assigning emissions reductions due to improvements in fuel economy between BAU forecasts and emissions reduction scenarios. Countries relying on the agreement to reach their national emissions abatement targets will need to be increasingly aware of these complexities in the development of their national plans.

## 3.4 Developing policy packages

Quantification needs to consider not just the impact of individual actions, but also the impact of combinations, or packages, of measures. These policy packages are likely to be concentrated on the most important sources of carbon emissions from the transport sector, which in practice has meant road transport, but should not neglect other sources of transport carbon emissions.

The mix of policies varies between countries. For example, there appears to be relatively more emphasis on economic instruments in the United Kingdom and on regulatory policies in France. These differences may reflect general divergences in the emphasis on different policy instruments in different countries, in this case, a greater reliance on market mechanisms in the United Kingdom and a greater emphasis on planning measures in France. The policy package for the Netherlands includes a combination of fiscal measures and other non-vehicle related measures targeting traffic management, and on-board instruments to improve fuel economy. Policies to deal with carbon emissions from transport (and from other sectors) must fit within a range of government policies designed to achieve a variety of different policy objectives. As a consequence, it would seem appropriate that the emphasis on certain types of policy instruments in the transport sector will reflect national differences in the use of policy tools economy-wide.

Quantification of policy packages must avoid the danger of "double-counting" estimated impacts of individual policies that would, if combined, have overlapping effects. There is a danger of overstating the overall effects of these policies when combined in a package. This is proving to be a complicated issue in national estimations. For example, interactions mean that $CO_2$ emissions savings from the ACEA voluntary agreement with the European Commission can not simply be summed with the estimated impact of taxation measures taken in isolation.

Similarly, the importance of the agreement in national $CO_2$ abatement strategies would imply that countries may need to examine the tradeoffs between the voluntary agreement and policies such as safety regulations and those related to air quality. Changes in taxation relating to types of fuel may have an impact on the ability of industry to meet the requirements of the agreement, for example.

The study highlights the importance of the ACEA/EC agreement and of effective monitoring of the accord. However, it is also important that countries do not delay implementation of other measures. There are inevitably slippages in the implementation of policies, so a "wait and see" option has drawbacks. Consequently, countries may now want to consider accelerating the implementation of policies targeting other types of transport, and developing a specific package of policies to address carbon emissions from road freight, railways, and aviation.

In addition, "non-product" measures, including those addressing driver behaviour, vehicle maintenance, and traffic management have considerable potential for reducing $CO_2$ emissions relatively quickly and cheaply, though quantification of the impact of these measures remains difficult in some cases. This is particularly important because it is becoming clear that countries are finding it difficult to develop packages of measures in the transport sector that they feel convinced will deliver required savings in practice.

In terms of the actual construction of policy packages, there appears to be a complex iterative process in designing policy packages in each country. This reflects the need to identify options and to secure a consensus as to whether they should be included in the final package, a process that is not yet completed either in Britain or in France. The Netherlands undertook a multi-phase policy development process that involved policy-makers from different government branches. A set of policy options was first defined from which a more complete list of proposals was then made.

One of the most contentious issues is the political acceptability of economic instruments, especially road pricing, a policy that is often proposed, but not implemented in most countries. As delays occur in the process of implementing such policies, the contribution that such policies can make in meeting overall targets for the end of the decade is reduced. Moreover, if the policy is never actually implemented, a search will eventually need to be made for alternatives.

Finally, there are issues of political will to implement policies. Quantification may show that price increases, such as increases in fuel tax or implementation of road congestion charging, will reduce car travel and fuel use. However, these savings will not be realised if the policies are not actually implemented in full because of fears of the political consequences of their adoption.

## 3.5 Recommendations on quantification

The full study provides detailed descriptions of the quantification exercises undertaken in the Netherlands and the United Kingdom and general information on modelling in France. For the purposes of this summary, the principal recommendations on quantification based on the findings of the study are provided below.

First, there should be efforts to maintain as much transparency as possible in the explanation of how the impacts of different policy options have been quantified. A clear description of how the numerical estimates of potential carbon savings have been derived is essential, despite the inevitable uncertainties in the methods used, and the possible desire not to expose these uncertainties to public scrutiny. Public debate about estimates may, in fact, reveal weaknesses in the components of proposed measures, and consequently improve the make-up of policy packages that are ultimately adopted.

A second recommendation is the need to have a clear definition of the Business as Usual (BAU) scenario forecasts that show what would happen in the absence of a package of specific interventions. The data defining which measures belong to BAU and which to new policies are crucial.

As noted earlier, one of the most serious issues in terms of quantification identified in the study involves the possibility of "double-counting", where potential overall savings are over-estimated because of addition of estimated savings from individual policies whose impact is in fact interrelated.

As regards models available, there are a number of different approaches. In the Netherlands, the need to rapidly produce a policy plan was seen as a justified reason for using a variety of existing models to assess different components of the overall plan. Inevitably, modelling cannot “start from scratch” and must draw on existing experience. It is important, however, that if different models are used, they must be mutually consistent in their overall assumptions and elasticity values.

It is also important that the quantification methods adopted represent “best practice”. The international scientific community has an important role to play here in agreeing what best practice is. This may be a role that will be played by the present OECD/RTR-led study on the evaluation of measures to reduce greenhouse gases from the road transport sector, which is due to be finished by the end of 2000. However, there may be a need for a specific continuing panel of experts to review quantification methods available in all countries and make further recommendations regarding “best practice” modelling techniques.

The best way forward in terms of modelling is to develop disaggregate vehicle stock models, for all modes of transport and types of vehicle, which allow for changes in new vehicle consumption to be fed through into estimates of future vehicle use, fuel consumption and carbon emissions. Data from the Auto-Oil Programme could facilitate building such models in some countries.

In addition, whatever quantification measures are used, it is important that they allow for second round, or “rebound” effects, such as the impact of improved fuel efficiency or switches to lower priced fuels on reducing vehicle operating costs, which in turn increase demand for vehicle use.

In conclusion, while the number of countries examined in the study is no doubt too small to be representative of the quantification experience in all countries, the national modelling exercises undertaken in the three countries highlight some of the strengths and weaknesses involved in a select number of approaches. The experience of the examined countries, which are among the first to undertake comprehensive quantification exercises for their national climate change plans, illustrates the extent to which precise quantification of policy packages remains elusive. Refinement of quantification should continue to improve with further international collaboration to determine best practice in quantifying the impacts of different policies and policy packages. This will be essential to countries faced with the challenge of meeting their commitments to reduce greenhouse gases under the Kyoto Protocol.

# 4. Voluntary agreements as drivers of technological change in the transport (light-duty vehicle) sector[9]

## 4.1 Background

Light-duty vehicle fuel economy improvement (i.e., reductions in fuel intensity) could provide significant reductions in GHG emissions in Annex I countries by 2010, and much greater reductions in the 2020 time frame. High efficiency vehicles already on the market have a rated fuel intensity (in Litres per 100 km) on the order of 25 per cent lower than average vehicles of a similar size, and technologies are under development that could provide reductions of 50 per cent or more by 2010.

However, vehicle manufacturers have little incentive to build vehicles with low energy intensity, since a) the available technologies can also be used to configure vehicles for increased size, weight, and power at a given level of fuel intensity, and b) it is this latter approach that appears to sell cars – certainly in North America, but increasingly too in Europe and Japan.

Thus the central problem now facing manufacturers in promoting fuel economy is that it runs counter to the preferences of many consumers, and unilateral moves toward fuel economy improvement by individual manufacturers may well lead to reductions in market shares and profits. Voluntary agreements[10] represent a potential means to overcome these concerns by getting manufacturers to act in concert and, hopefully, introduce lower fuel intensity vehicles as a group. As a result, the market risk that would be associated with manufacturers acting individually can be reduced.

But a key question regarding voluntary agreements is whether manufacturers, even when acting in concert, can encourage consumers to "move" with them. That is, can they encourage consumers to purchase more fuel efficient vehicles simply by offering them? Or do they face a hopelessly uphill battle without the help of additional, reinforcing measures from government that encourage consumers to "move" in the same direction as producers – i.e. that stimulate a demand for more fuel efficient vehicles.

This section briefly reviews the potential benefits, and potential pitfalls, of voluntary agreements for GHG reduction through fuel economy improvement in vehicles – both in general and using the EU/ACEA agreement as a case study[11]. It suggests that while voluntary agreements can play an important role in achieving reductions in vehicle energy intensity, they may be insufficient for achieving long term fuel economy improvements, and may need to be reinforced by other supporting policies.

9 This paper was written by Lew Fulton, IEA.

10 "Voluntary Agreements" is a general term that also includes laws without penalties, such as is the case for the Japanese program discussed in this paper. Also see footnote 11.

11 Technically, the EU/ACEA "agreement" is actually a "commitment" on the part of the ACEA that has been "accepted" by the European Commission. Therefore, through the remainder of this document, the term "commitment" will be used to describe this particular program.

## 4.2 Existing voluntary agreements

Over the past 20 years, many IEA member countries have used voluntary agreements in some manner to encourage $CO_2$-reduction from transport. These programmes are reviewed in the IEA publication "Voluntary Actions for Energy – Related $CO_2$ Abatement" (1997). Several programmes have involved setting targets for improving fuel economy of new light-duty vehicles. These typically involve an agreement with the country's auto manufacturing association to attempt to achieve a certain target, typically measured in fuel consumption per distance terms for the fleet average of new vehicles, by a certain date. Table 1 summarises the major fuel economy-focused agreements and also lists several others focused on alternative fuels or other approaches to reducing $CO_2$ emissions from light-duty vehicles.

This section does not attempt to statistically analyse the impacts of individual programs on fuel economy, in part because it is difficult to measure the success or the impacts of these programs. This is in turn due to the difficulty in knowing what levels of fuel economy would have occurred without these agreements. Several programmes were developed in the late 1970's and 1980's, and were carried out at a time when fuel prices were rising, and concurrently with the US mandatory "CAFE" fuel economy program, which undoubtedly had impacts on the fuel economy of new vehicles all over the world, given the size of the US market. Since 1990, there has not been significant fuel economy improvement in most Annex I countries (seeFigure 6). It appears that any improvements in fuel economy in countries with agreements (or laws without penalties), such as Australia and Japan, have not pushed fuel intensity trends in these countries below the trends in other countries.

Could these programs have impacted fuel economy? The US agreement (its "Partnership for a New Generation of Vehicles") is different than the others since it focuses on long-term research and development and does not include a target for improving the average fuel efficiency of new vehicles. The Canadian agreement is designed to closely track the US corporate average fuel economy standards, and thus receives the benefit of being in the shadow of a very large market that (by law) meets nearly the same fuel efficiency targets. Thus the programs in Japan and Australia are probably the only ones that could have had a significant impact on the underlying fuel economy trend. However, in neither case does the trend in fuel economy improvement appear to depart significantly from the world-wide trend. Japan's program has recently been reinforced as a program with penal regulations and Australia's began in 1995 and it may be still too soon to tell if it will reach its 2000 goal.

Therefore, these individual country programs do not provide a particularly good indication whether voluntary fuel economy programs in general can be expected to produce improvements in a countries average new-vehicle fuel consumption level.

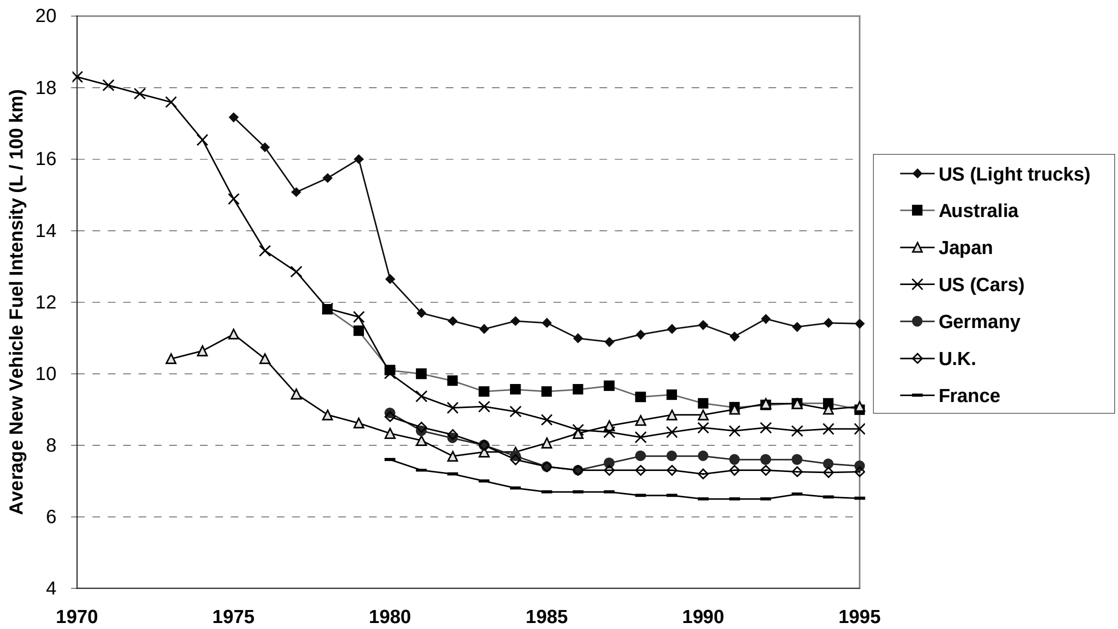
However, the recent voluntary commitment made by the Association of European Car Manufacturers (ACEA), and accepted by the European Commission, is different from the other agreements in several important respects, and makes an interesting case study in what could be called the "new generation" of voluntary agreement: larger, more ambitious, and with a more detailed and articulated structure than the others. It is described below, and a preliminary analysis of its prospects and potential pitfalls is provided.

Table 1: **Voluntary programmes for fuel intensity reductions for motor vehicles**

| Country | Type of Approach | Target and Time Period | Monitoring and Reporting |
|---|---|---|---|
| **1. Programmes focused on improving fuel economy of new light-duty vehicles** | | | |
| Australia | Agreement with auto manufacturers on fuel consumption and code of practice for reporting on fuel consumption; possible agreement for light commercial vehicles. | Fuel efficiency targets for cars light-duty trucks (8.2 litres/100 km) by 2000, including labelling of fuel efficiency (see note). | Information service and review of passenger motor vehicle plan by 1996. |
| Canada | Voluntary agreement with manufacturers and importers on Company Average Fuel Consumption (CAFC) requirements. | Fuel efficiency targets for cars (8.6 l/100 km) and light-duty trucks (11.5 l/100 km) by 1991 (starting year 1980). | Motor Vehicle Fuel Consumption Standards Programme; information to purchasers, including labelling. |
| Japan | This is a fuel economy law without penalties, based on achieving fuel consumption levels of the most efficient vehicles in each size class of new light-duty vehicles. | Fuel efficiency targets for the year 2000 for six light vehicles and light truck categories (base year 1990). | The law has recently been reinforced as a similar one with penal regulations for failure to meet target levels. |
| United States | Voluntary partnership programme for the development of a new generation of cars and alternative fuel vehicles. | Fuel economy improvements by a factor of three by 2005 as demonstrated by new vehicle prototypes in or before that year; nearer term improvements to specific technologies. | Annual report to Congress on progress and achievements in each year. Interim technology goals are also set and reviewed each year. |
| **2. Programmes focused on other approaches to $CO_2$ reduction in light-duty vehicles** | | | |
| Finland | Agreement between national and Helsinki municipalities on fuel saving. | | |
| France | Framework agreement with auto manufacturers and EDF to promote electric and natural gas vehicles. | Goal: 100,000 electric vehicles on the road by 2000, starting in 1995. | |
| Sweden | Joint government and industry demonstration programmes for alternative motor fuel use (ethanol from wood) in vehicle fleets. | Improvement of production and material use and combustion efficiency of engines. | |

*Note*: In Australia, the targets were part of an older agreement, while the labelling is part of a new regulation - which is not yet in place. It is unclear whether industry is still committed to meeting the existing targets. Negotiations on a new target for 2010 are underway.

Figure 6: **Evolution of average new vehicle fuel intensities, selected Annex I Countries**




*Source:* IEA Data. New Car (and light trucks in the US) test fuel consumption including gasoline and diesel vehicles.

## 4.3 Case Study: Summary of ACEA voluntary commitment

In October 1998, The European Commission accepted a voluntary commitment made by ACEA in which the automakers pledged to reduce average emissions of $CO_2$ from new cars to 140 grams per kilometre by 2008, from the 1995 level of about 186 g/km, about a 25 per cent reduction. If the current mix of fuels (primarily gasoline and diesel) were preserved, this $CO_2$ reduction translates into a fuel intensity reduction from about 7.6 to 5.7 L/100 km. Manufacturers have also committed to reviewing the potential for additional reductions by 2003, "with a view to moving further towards the Community's objective of 120 g $CO_2$/km by 2010".

The current ACEA commitment is different from the other voluntary agreements in several respects:

- It involves several countries. Since ACEA represents manufacturers across many countries, their commitment covers a large market for vehicles – about the size of the US market. By committing to improve fuel economy across such a large market the auto manufacturers are able to justify significant changes to their product plans, rather than just using marketing strategies to sell more efficient models that they already make.

- Auto manufacturers from many different countries are actively participating (although in other agreements importers have generally been included as well as domestic manufacturers). Including the Japanese manufacturers that have recently made a similar commitment for their cars sold in Europe, the vast majority of cars sold in Europe are made by companies that have made a similar commitment.

- The metric is a reduction in $CO_2$, not fuel intensity. This allows for the use of fuel switching to lower carbon fuels in addition to fuel economy improvements as means to meet the targets.

- The rate of improvement (25 per cent over 12 years or about two per cent per year) is more ambitious than most previous agreements, especially considering the long time frame it covers. It will require a sustained improvement program to be successful.

- The commitment includes several assumptions regarding market conditions that could be called "contingency factors" – conditions that, if not met, would presumably provide grounds for ACEA to back off the commitment, on the basis that the situation has made it too difficult to continue. Some of these contingency factors are dependent on EU or member country actions. Thus the commitment is not a "one-way" street, but may depend for its success on government actions as well as manufacturer actions (see below).

- The stakes are perhaps higher than they've ever been: $CO_2$ reductions from the commitment represent a significant proportion of the total overall $CO_2$ reductions from transport envisioned in the action plans of a number of European Annex I countries.

The "contingency factors" may prove to be quite important for the success of the commitment. There are four explicitly stated conditions that ACEA assumes will be present:

- **Availability of enabling fuel.** Mainly in order to meet emissions requirements with lean-burn technologies (including direct injection gasoline and diesel engines) ACEA assumes that there will be, by 2000, some availability, and by 2005, "full" availability throughout the EU, of fuels which satisfy the following characteristics:

➢ gasoline with a maximum sulphur content of 30 PPM and of a maximum aromatic content of 30 per cent;

➢ diesel with a maximum sulphur content of 30 PPM and a cetane number of minimum 58.

Strictly speaking, the EU fuel standard for 2005, with a maximum of 50 PPM sulphur, does not meet this condition, although it is close and it is not yet clear if this condition needs to be met strictly for ACEA to be able to fully utilise lean-burn engine technology.

- **Minimisation of "distortions of competition"** which might disfavour the European manufacturers due to their efforts to reduce $CO_2$ emissions, in particular the development of a similar commitment by non ACEA manufacturers for their European sales (which has occurred for the Japanese and Korean manufacturers) and efforts to achieve similar $CO_2$ reductions in other major markets around the world (which is not presently occurring in any identifiable way).

- **The "unhampered diffusion" of fuel-efficient technologies into the market.** This would presumably include availability of enabling fuel (first bullet above) and the absence of other policies that might restrict the marketability of new technologies.

- **Acceptance of Innovations**, meaning that the EU is prepared to accept and co-operate in the development and marketing of new technologies and new fuels that help ensure the success of the commitment.

Clearly, ACEA sees these four conditions as important for the success of the commitment. Therefore major problems in any of these areas could cause the commitment to fail. Therefore the recent decision on the part of the Japanese manufacturers association in Europe to make a similar commitment represents an important step in the EU's efforts to do their part in helping ensure success of the commitment.

### *Technologies available to meet the goals*

A key question in assessing whether the ACEA commitment can be successful is the availability of new technologies to allow the reduction in new vehicle fuel intensities needed to reach the target.

Due in part to research programs sponsored by IEA member governments, there are currently a significant number of new fuel economy technologies available to contribute to the goals of the EU voluntary program. These include technologies in the areas of weight reduction, aerodynamics, drivetrain improvements, accessory load reductions, and tires (see Box 2).

However, in the terms of its commitment, ACEA clearly puts a great deal of emphasis on new engine technologies, especially direct injection gasoline and diesel engines, as critical components of their strategy to achieve the targets. In laying out the condition that there must be "unhampered diffusion" of new $CO_2$-efficient technologies, the ACEA appears to be speaking directly to the issue of the emissions problems associated with direct injection. In order for vehicles with direct injection engines to meet EU emissions standards for NOx, it is expected that there must be cleaner fuels, in particular gasoline and diesel fuel with very low sulphur levels (in order to allow the use of advanced NOx catalysts). Whether the EU standard for 2005 of 50 PPM sulphur is sufficiently stringent to solve this problem is as yet unclear, as is the question of whether the commitment can be met without the use of these technologies. However, as shown in the box below, they certainly are not the only technologies available.

Direct injection gasoline and diesel engines are expected to provide anywhere from a ten to 30 per cent reduction in fuel consumption, depending in part on what they are being compared to. Clearly, these technologies alone could provide most of the improvement needed for manufacturers to meet their commitments, if they can get these technologies into a majority of new vehicles sold by 2008.

## Box 2. **Technologies and Techniques to Improve Fuel Economy**

Maximum fuel economy (or minimum fuel intensity) is achieved by minimising propulsion energy requirements and maximising the efficiency of the power train. Techniques to minimise propulsion energy requirements include reducing vehicle weight, streamlining the vehicle shape, minimising vehicle frontal area, and minimising rolling resistance of tyres.

Specific technologies to reduce engine requirements include:

- Aerodynamic improvements that involve increasingly streamlined bodies to reduce the drag coefficient. While not inherently expensive, at some point it becomes increasingly difficult to meet other consumer needs in terms of vehicle design and shape while continuing to reduce the drag coefficient.
- Weight reduction through materials substitution. This includes increased use of aluminium, plastics and lightweight composite materials as well as lighter steel components.
- Reduced engine friction through the use of advanced lubricants and synthetic oils.
- Reductions in tyre rolling resistance through the use of harder materials, advanced tread designs, and other techniques.

In addition to reducing the engine power level required by a vehicle, many engine drive-train efficiency improvements are possible. These include:

- Setting combustion speed as close as possible to emulate a constant volume combustion process and improve thermodynamic efficiency.
- Increasing the compression ratio or expansion ratio to improve thermodynamic efficiency.
- Using variable valve timing to minimise the throttling loss associated with part-load operation.
- Turning the engine off during periods of zero power demand (idle and deceleration).
- Reducing engine friction and parasitic losses.
- Recapturing and using exhaust heat energy.
- Transmission improvements such as 6-speed manual and 5-speed automatic. Other advances such as electronic transmissions and continuously variable transmissions are also coming into the market.

These techniques can be used to improve conventional engine drive- train systems. “New generation” engines such as gasoline direct injection, and hybrid-electric engine systems typically also take advantage of many of these techniques.

*Source:* IEA Policies and Measures Study, draft light-duty vehicle report, 2000.

## *Technology potential and cost*

The IEA is conducting an ongoing study of fuel economy technology potential in various IEA countries. The analysis completed thus far indicates that, in addition to new engine technologies, there is a considerable amount of new incremental technology available at relatively low cost. For example, our preliminary estimates for Germany are presented in Table 2.

Starting from a base level of fuel economy for automobiles in 1995 of 7.6 L/100 km, a 25 per cent improvement in this level would require a reduction of 1.9 L/100 km (to 5.7 L/100 km). However, if there are significant changes in the size-mix of vehicles sold, and/or the attributes of vehicles within each size class, such as engine size, power, and weight, some of the fuel economy improvements could be lost to reductions resulting from these changes. We estimate an upper bound on potential efficiency losses from changes in vehicle size, power and weight between 1995 and 2008 to be about 1.3 L/100 km. In order to compensate for these changes, manufacturers would need to reduce the fuel economy of the average vehicle by 3.2 L/100 km in order for the sales-weighted average to drop by the required 1.9 L/100 km[12].

Breaking fuel economy technology into four groups (lower cost incremental technologies, higher cost incremental technologies, and two specific engine types: gasoline direct injection and gasoline/electric hybrid), we estimate that there is the potential in Germany to achieve a 2.7 L/100 km reduction in the average vehicle by 2010, which is well better than the minimum requirement of 1.9 L/100 km but slightly less than the maximum estimated requirement of 3.2. Alternatively, if increased use were made of new-technology (turbo-direct injection) diesels (instead of gasoline direct injection and hybrids), the total reduction could be slightly better, but still does not quite reach 3.2.

Note that these numbers at best represent rough estimates, and that the data reflect the situation for only one European country, not the EU as whole. However, the estimates suggest that with the current sales mix of vehicle types and current vehicle attributes such as weight and horsepower, there is more than enough technology available to meet the $CO_2$ reduction commitment. Further, it can probably be met at a cost-per-vehicle under USD 2,000. Note that this cost estimate is before factoring in fuel cost savings, which at fuel savings of 2 litres per 100 km and a fuel price of USD 1 per litre could repay most of the increased initial cost of the vehicle after about 4-5 years of vehicle ownership[13].

However, meeting the terms of the commitment while chasing significant shifts in vehicle size, weight, and horsepower, as indicated in Case 2, could become much more difficult and expensive - or even infeasible - with currently available technology. Thus the role of consumers will be important, as will manufacturer efforts to encourage consumers to purchase the most fuel efficient vehicle models available.

12 Two other factors should also be noted. First, future requirements for emissions reduction and safety may require changes to vehicles that also offset some fuel economy improvements. Second, there may also be changes in vehicles that increase the gap between rated and actual in-use efficiency, such as increased market penetration of air conditioning. Such changes are not reflected in these estimates.

13 For example, a driver who drives 20,000 km in the first year of vehicle ownership, and drives five per cent fewer km per year each year thereafter, and who discounts future fuel savings by ten per cent per year, will save about USD 1,200 in present value of discounted fuel costs over the first 5 years of ownership, given a fuel savings of 2 litres per 100 km and a fuel price of USD 1 per litre.

Table 2: **Potential for fuel economy improvement by 2010, Germany (L/100 km)**

| | **Case 1**<br><br>**(current sales mix, HP, weight)** | **Case 2**<br><br>**(with changes in mix, HP, and weight)** |
|---|---|---|
| Base New Car Fuel Economy (1995, rated) | 7.6 | 7.6 |
| Potential L/100 km increase by 2010 due to sales mix shift, horse power and weight increase | 0.0 | 1.3 |
| Target: L/100 km 25% below (1995) | 5.7 | 5.7 |
| ***Needed reduction*** | ***1.9*** | ***3.2*** |
| | | |
| Potential L/100 km reduction from lower cost incremental technologies (< USD 750 per L/100 km) | 1.4 | 1.4 |
| Potential Benefit from higher cost incremental technologies (>USD 1,000 per L/100 km) | 0.2 | 0.2 |
| Potential Benefit from GDI Engines, assuming penetration of about 2/3 of gasoline vehicle market (about USD 700 per L/100 km) | 0.5 | 0.5 |
| Potential Benefit from Hybrids assuming penetration in about 1/3 of gasoline vehicle market (about USD 2500 per L/100 km) | 0.6 | 0.6 |
| ***Total reduction*** | ***2.7*** | ***2.7*** |
| | | |
| Benefit from TDI Diesels (instead of GDI and Hybrids – need to subtract out these to get new totals) | 1.2 | 1.2 |
| ***Total Reduction w/ Diesels instead of GDI and Hybrids*** | ***2.9*** | ***2.9*** |

*Source*: IEA estimates, Policy and Measures Study.

The cost estimates presented above have been developed as part of IEA's Policies and Measures project, which is on-going. It should be noted that these technology cost estimates reflect fully amortised costs in year 2000 dollars, but do not reflect any cost reductions in the future from experience and learning. However, IEA is conducting a related study of the potential for cost savings associated with new technology learning, and this effort may indicate that reductions in cost by 2010 of advanced technologies such as gasoline-electric hybrids can be expected. IEA is also planning to evaluate the fuel economy and cost potential of several other "new generation" technologies, particularly fuel cells, that may become available in the 2010 time frame and beyond. Cost estimates for fuel cells were not available in time for this paper.

### *Implications for the success of the ACEA commitment*

While any estimate that the ACEA voluntary commitment appears to be technically feasible is reassuring, it is far from a statement of certainty that the commitment will be fulfilled. As discussed above, there are a number of potential pitfalls that could derail the process. These include:

- Failure of any of the "conditions" laid out in the commitment to be met (some of which depend in part on EU action to be met).

- A withdrawal by one or more manufacturers who, for whatever reason, believe that the burden on them is unacceptable or that continued involvement will result in an unacceptable level of negative impact on their competitiveness or financial situation.

- An inability of manufacturers to offset increases in $CO_2$ emissions per km from trends such as consumer purchases of larger and more powerful vehicles[14].

### *Potential reinforcing measures*

The probability of success of the ACEA commitment, or any voluntary agreement for that matter, can be increased through reinforcing policies. Indeed, the EU programme on $CO_2$ reduction from cars includes three "pillars": voluntary commitments, consumer information and fiscal framework measurers[15]. The EC has already provided guidance to member countries on vehicle labelling programmes and is currently studying potential fiscal measures that could be used in support of the ACEA commitment. Fiscal measures are the focus of the following discussion of potential reinforcing measures.

First, it should be noted that the ACEA commitment already benefits from an important reinforcing measure – high fuel taxes in virtually every EU member country. These tax levels provide a strong incentive to the consumer to purchase fuel efficient vehicles. A vehicle owner travelling 15,000 kilometres per year can save USD 150 - USD 200 per year from a reduction of 1 Litre per 100 km in vehicle fuel consumption, which is a reduction that is within the range of variation for cars of a similar size available today.

However, since the level of fuel tax has not changed substantially in most EU countries in recent years (with certain exceptions, such as the United Kingdom), it is likely that most consumers are already at an "equilibrium" level of fuel economy with their current vehicles. If so, then they would not necessarily be willing to pay significantly above current levels for additional improvements in fuel economy. New, low cost technology will always be in demand, but this demand will be both for fuel economy improvement and for improvements in other attributes (e.g. acceleration, vehicle size), and as average incomes increase, the relative demand for the "hedonic" benefits such as acceleration are likely to rise relative to the cost savings provided by improved fuel economy. Further, the prospect of moving up the technology cost curve – to technologies costing significantly more than recently deployed technologies (e.g. hybrids) may be faced by even weaker demand for use in fuel economy improvement as the fuel savings are likely to be less than the increased vehicle costs. Therefore it may take additional reinforcing policies to encourage consumers to demand even better fuel economy than they currently have, i.e. to provide a demand-side component to a voluntary agreement or ACEA-style commitment.

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14 It should be noted that manufacturers have certainly contributed to this trend by offering many new models of large and powerful vehicles (especially in the minivan and sport-utility vehicle segments) in recent years.

15 European Commission, "Communication on a Community strategy to reduce $CO_2$ emissions from passenger cars and improve fuel economy", COM(95)689/Final.

There are a number of potential fiscally-oriented reinforcing policies that could be used to support fuel-economy-oriented voluntary agreements, that provide a greater demand-side stimulus for fuel economy improvements. An obvious one is increased fuel taxes. Two other, perhaps less-well known options are outlined below:

**Purchase fees/rebates based on fuel economy -** Often called "feebates", these are fees and/or rebates added to vehicle purchase price on the basis of fuel consumption or GHG emissions per kilometre. Such fees could provide a powerful signal to consumers to purchase higher fuel economy models from among available choices. By making a system of fees and rebates that are revenue neutral, countries can implement them without affecting the overall tax burden on vehicles. In countries with high existing levels of vehicle purchase taxes, the current taxes (usually *ad valorem*) could be transformed into fuel consumption based fees in a manner that maintains current revenues but sends a much stronger signal to purchase higher fuel economy vehicles than is sent by the current tax structure. As an example, for a vehicle driven 15,000 km per year, a vehicle purchase fee on the order of USD 200 per L/100 km could send as strong a signal to purchase a more fuel efficient vehicle as would an increase in fuel taxes on the order of USD 0.25 per litre[16]. In many Annex I countries, such a fuel consumption-based tax could be developed simply by transforming some of the current vehicle *ad valorem* tax, without adding an additional tax burden.

**Incentives for Adoption of Advanced Technologies –** new technologies, such as hybrid electric vehicles, could provide dramatic $CO_2$ reductions, but appear to be relatively expensive, at least in the near term. However, taking into account the societal benefits of the fuel savings, it may be justifiable for these technologies to receive a public subsidy to encourage manufacturers to adopt them and consumers to purchase them. A program to encourage rapid market introduction of advanced technologies will also speed the learning process and potentially lower the costs of production much more quickly than would occur otherwise, providing a payback for the initial investment. An advanced technology incentive could take the form of purchase price subsidies or rebates to consumers for the purchase of vehicles equipped with specific technologies, or for vehicles meeting a GHG emissions per kilometre threshold that is unlikely to be met without use of the targeted technologies. The governments of the United States and Japan have both recently proposed such measures.

There are a number of other potential supporting policies that could be employed as well. For example, measures could encourage a more rapid rate of stock turnover, using scrappage incentives or reducing the fees on new vehicles while increasing those on older vehicles. On-board diagnostic equipment may provide consumers with better signals on fuel-efficient driving habits. Another area for supporting measures is in increasing consumer awareness of their choices and the costs of different options, through training and labelling measures. The IEA will take a closer look at these types of measures in the next phase of the Policies and Measures study.

It should also be noted that any increase in fuel economy will reduce the marginal cost of travel, and thus there will likely be a "rebound" effect, i.e. an increase in travel, that results from the reduction in travel cost (although the size of such an effect is unclear). Additional supporting policies may be needed in order to offset such cost reductions and $CO_2$ emission increases associated with travel increases.

16 This example assumes a discount rate for fuel savings of ten per cent per year over seven years of vehicle ownership.

## 4.4 Conclusions

While previous voluntary agreements may have had some impact on improving vehicle fuel economy, most have been small in scope and not especially ambitious in terms of targets. While it is generally difficult to estimate the impacts of these programs, in some cases fuel economy levels have not departed significantly from an underlying trendline seen in other countries, suggesting that these agreements have not had a major impact.

The ACEA voluntary commitment represents an important step in the evolution of fuel economy voluntary agreements. It is quite different from previous voluntary agreements due, among other things, to the large size of the vehicle market it encompasses and the ambitious level of fuel economy improvement it targets.

Given the large size of the market covered by the ACEA commitment it may have a better chance to succeed than some previous small-market agreements, since manufacturers are more likely to recover the investment costs of vehicles designed specifically for this changing market. Furthermore, the ACEA commitment, if successful, could provide positive spillover effects to other regions. Many car models sold in Europe are also sold elsewhere in the world. Further, if North America were to adopt a similar program, the combined impact of the two programs could be large enough to encourage similar levels of energy intensity reductions in most of the world's other vehicle markets.

A key question is whether the ACEA commitment can be successful without additional policy support. While it already has considerable policy support – primarily in the form of relatively high fuel prices in European countries - it is unclear that this existing, and mostly static, fiscal incentive to consumers is sufficient to prevent a large-scale shift to larger, more powerful vehicles over the next seven years (similar to what happened in North America in the 1990s) that could offset the fuel savings from new technology and threaten the success of the program. There are a variety of fiscally-oriented policies that could be used to reinforce the agreement and encourage consumers to "move" in the same direction as manufacturers. These include fuel consumption based fees, or "feebates" and incentives for the adoption of advanced technologies.

In other regions, especially North America and Australia, it may be more difficult for manufacturers to make similar commitments, given the lower fuel prices in place in those regions. However (and somewhat ironically) it may take less of a supporting policy push to redirect consumers in such low-fuel-price areas, since a given absolute change in the marginal cost of travel represents a much larger percentage change than in Europe, and may therefore send a stronger signal to consumers.

The ACEA commitment recognises the need to transform market conditions to ensure higher demand for more fuel-efficient vehicles. The only question is whether additional measures will be needed beyond those already indicated in the commitment in order to ensure a successful outcome. One way or another, it appears likely the ACEA commitment will determine the view of other countries regarding whether voluntary agreements can really work – and whether automakers can successfully move markets without major interventions from governments.

# 5. Freight transport trends and their impacts on greenhouse gas emissions[17]

## 5.1 Context

While the transport sector as a whole continues to be a major focus of climate change policy discussions throughout Annex 1 countries, relatively little time is spent covering issues specific to freight, as opposed to passenger, transport. In order to counter this bias and to stimulate discussion, this section provides a broad overview of issues relating to freight transport from the perspective of climate change policies.

## 5.2 Freight transport activity and GHG emissions

Greenhouse gas emissions from the transport sector in general, and from freight transport in particular, are a function of travel activity, modal shares, energy intensity of each mode and specific fuel characteristics.

In 1980, the transport sector accounted for 22 per cent of all $CO_2$ emissions in OECD countries. By 1995, that ratio had increased to approximately 26 per cent of all $CO_2$ emissions and 22 per cent of all major greenhouse gas emissions ($CO_2$, $N_2O$ and $CH_4$). This trend has not changed significantly since then. Indeed, from 1990 to 1996, greenhouse gas emissions from transport in OECD countries have increased by ~ten per cent accounting for over half of the total growth in emissions. There exists, however, great variability in transport shares of overall $CO_2$ emissions throughout OECD countries ranging from less than ten per cent to as high as 30 per cent for many Nordic countries. Because of the much higher carbon intensity of Central and Eastern European and Economy in Transition country energy and industrial sectors, transport accounts for a much lower share of overall $CO_2$ emissions (approximately eight per cent). Of this, road transport accounts for a disproportionately large share of $CO_2$ emissions (77 per cent).

In general, freight activity accounts for 30-40 per cent of transport-related $CO_2$ emissions. Road-based freight transport ranging from light-duty commercial vans to heavy goods vehicles is responsible for the overwhelming bulk of $CO_2$ emissions from freight. However, $CO_2$ emissions from freight relative to GDP varies among OECD countries for a number of reasons relating to specific modal shares, modal intensities as well as total level of freight relative to GDP. Because of these factors, there is no universal ratio between freight activity and $CO_2$ emissions.

### *Drivers and trends*

### *Overall activity*

Generally, freight transport is considered to be a derived demand that arises when the locations of resource extraction, production, consumption and final disposal are spatially separated. However, specific siting decisions for firms are rarely based primarily on projected levels of transport activity. Indeed, in many instances, transport levels and costs are secondary considerations that intervene only after an initial site has been selected. These different factors vary according to the type of firm, the nature of the site and national

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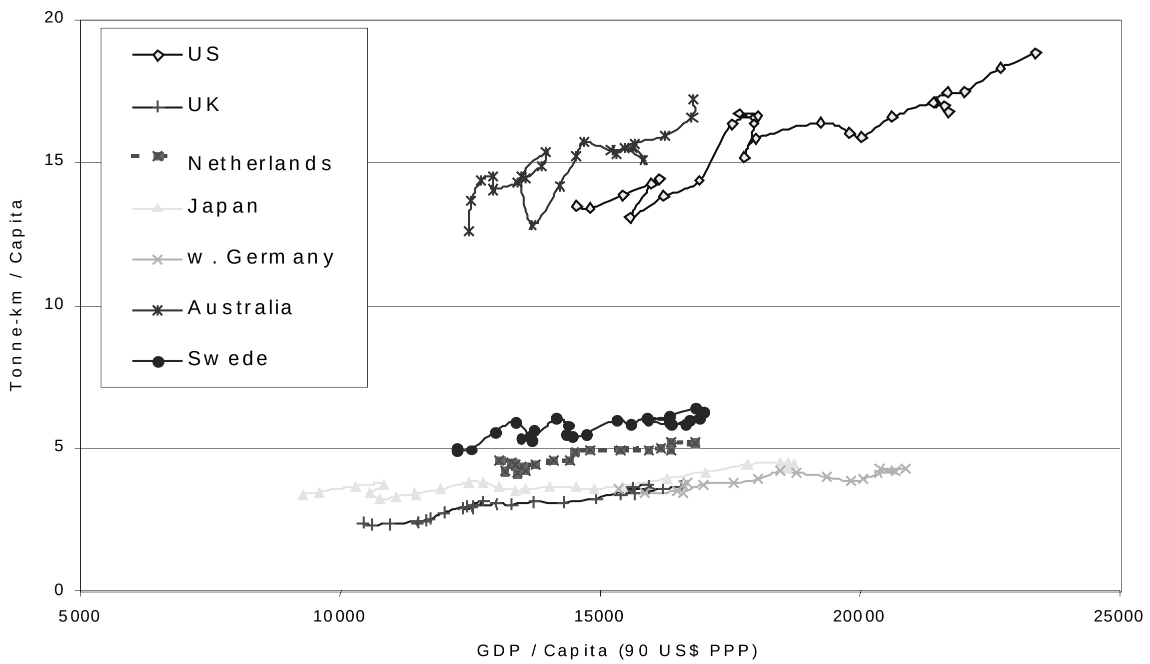
17 This paper was written by Philippe Crist, OECD.

and/or cultural preferences – for a same type of facility and activity sector, servicing a similar market, firms can make siting decisions that have very different impacts from the perspective of transport volume.

The transformation of raw materials into finished products usually involves a number of processes and transport links. As firms have sought to outsource non-core competencies, these links have tended to increase. Although this has usually brought about more transport activity, some firms have sought, on the contrary, to decrease transport volume by bringing subcontractors closer to – or even onto -- production sites. Another factor influencing overall levels of transport activity has been a trend in the economic rationalisation of firms' supply base. Generally, the costs of maintaining a diffuse supply base outweigh the costs of paying for increased transport from a fewer number of suppliers. This has led, in many cases, to longer transport distances (a growth of approximately 1.5-2 per cent per year in Europe), albeit at generally higher load factors. A trend in global sourcing and distribution of goods has further increased overall levels of freight activity.

Freight transport activity is usually measured in tonne-kilometres. The amount of tonne-kilometres travelled in any given country has historically been linked to economic activity as expressed by GDP. However, specific levels of freight activity for any given level of GDP vary among countries (see Figure 7 and Figure 8). Geography plays an important role in explaining these differences as large countries (Canada, the United States and Australia) tend to have high absolute levels of tonne-kilometres and relatively high shares of bulk rail and barge transport. Smaller, denser countries such as those of the EU and Japan tend to have lower levels of freight activity, shorter distances travelled and more reliance on road transport. Economic structure matters as well; countries that are large producers of raw materials have larger volumes of tonne-kilometres travelled both because of the bulk of the materials transported and the distances between their points of extraction to manufacturing and shipping points.

Figure 7: **Total freight volume and GDP**




*Source:* IEA.

Overall volumes of freight activity have been growing over the past 35 years outstripping growth in passenger transport and GDP. From 1990 to 1997 this growth has averaged 3.4 per cent per year for the OECD (5.4 per cent for road freight). Growth in freight transport is projected to continue in the foreseeable future with approximately a 50 per cent increase in tonne-kilometres by 2010. Trade liberalisation has helped to accelerate trends in freight transport growth by leading to more goods travelling longer distances. However, these international movements in goods have, and will continue to have, relatively little impact from a climate perspective as they will mostly concern rail and shipping.

In general, domestic freight movements account for over 75 per cent of tonne-kilometres travelled and the bulk of these movements are comprised of relatively short trips. In Europe, for example over 50 per cent of tonnes moved travel less than 50 kilometres and over 80 per cent of tonnes moved travel less than 150 kilometres. Trips by road transport tend to be shorter than trips by all other modes. Agricultural products, manufactured articles and cement account for the largest shares of tonne-kilometres travelled.

### *Mode Shares*

Trends in mode share have generally benefited road and, to a lesser extent, air freight to the detriment of other modes. Rail freight tonne kilometres have risen within the OECD, although rail has lost in mode share and, in Europe and Japan, has decreased in absolute volume. Inland shipping has also lost mode share to road although when coastal shipping is accounted for, short-distance shipping has risen in absolute terms. Air freight has displayed the fastest growth rates and will likely do so in the foreseeable future although in absolute terms it remains the smallest component of freight tonne-kilometres travelled.

Freight Transport in Central and Eastern European (CEE) and Economies in Transition (EIT) countries has followed a roughly similar trend. Since the region’s 1989 recession, absolute numbers of all freight tonne kilometres have fallen from what had been a relatively stable level. After 1993, roadways and the fuel distribution network were expanded helping road freight to recover more quickly than rail or inland shipping. Currently, while rail freight still dominates in absolute numbers of tonne kilometres, road freight has increased at a much higher rate.

**Road Transport:**

Much of the past growth in freight activity has accrued to road transport. Its rates of growth are second only to aviation and, in absolute terms, it is the most dominant freight transport mode within the OECD accounting for 44 per cent of all tonne-kilometres. This trend has been fuelled by a shift to smaller and higher value goods that require time-sensitive deliveries. A shift in distribution patterns, shorter production and market cycles, increased and more volatile consumption patterns have further contributed to the current dominance of trucking in the freight sector. Trucking also has benefited from extensive and relatively low cost infrastructure, technologically advanced vehicles and a competitive environment that has enabled a relatively low cost and highly responsive service. This service has allowed firms to move away from ports and rail terminals yet still benefit from high-quality freight transport that, in turn, has further fuelled road transport growth. Finally, firms’ internal logistics practices have also helped increase the volume of road freight transport as they have sought to reduce and rationalise warehousing and inventory stocking in favour of “just-in-time” product delivery cycles. Many of these factors have contributed to a relative decrease in average consignment size for high-value goods that, in turn, has contributed to the growth in the use of highly energy intensive small utility trucks and vans. In many OECD countries, growth in tonne-kilometres carried by small trucks and vans is projected to be greater than for other road freight modes.

The success of road freight transport has not come without problems, however. In many parts of the OECD, the road transport industry faces risks of longer travel times and limited growth opportunities due to road congestion. This has provided some impetus for the development of intermodal transport systems.

Many regional differences subsist as illustrated in Figure 8. The United States, along with Canada and Australia, have a relatively higher share of rail freight transport. Japan and Europe, on the other hand display a greater share of road freight transport. Apart from the geographical and economic factors mentioned earlier, these differences can be further explained by differences in these countries' respective regulatory environments. In the United States, deregulation of both road and rail freight started simultaneously in the early 1980's. This led to a period of heightened competition and increased flexibility on the part of both rail and road transport operators. In contrast, Europe embarked on road freight liberalisation in 1985 and has only recently (1998) commenced to seriously address the deregulation of its rail sector. To date, however, increased competition in the road sector has enabled the latter to better respond to market demands in contrast to the European rail sector. While it is not justified to conclude that rail may have retained or even increased market share had Europe deregulated both road and rail simultaneously, the missed opportunity has undoubtedly accelerated the modal shift from rail to road.

Road transport in CEE and EIT countries has recovered much more quickly from the region's economic recession in the early 1990's. Despite a drop in absolute levels, rail still accounts for the bulk of all goods transported in these regions (66 per cent in 1994). In contrast, since 1992-93 the road sector has grown in absolute terms and has gained modal share (from 29 per cent of tonne kilometres in 1990 to 32 per cent in 1994). This trend has since accelerated as these countries seek to develop and expand trading links with the European Union. Another factor underlying this growth has been the pattern of infrastructure investment by international lending institutions in these countries. Despite an early focus on rail, the bulk of infrastructure lending has benefited road infrastructure concentrating on certain key corridors (46 per cent of the European Investment Bank's and 53 per cent of the European Bank for Reconstruction and Development's lending for transport infrastructure went to the road sector, loans for rail infrastructure accounted for 36 per cent and 26 per cent respectively).

**Rail:**

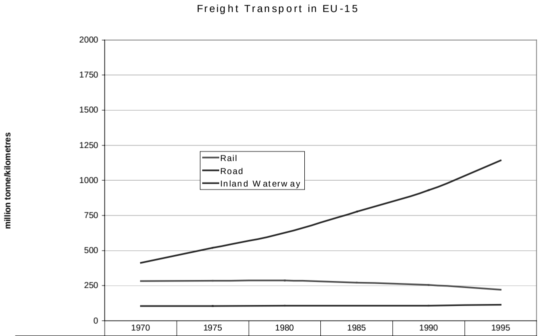
Rail accounts for 36 per cent of tonne-kilometres travelled within the OECD. It concerns mainly medium-to-low value manufactured and/or bulk goods transport. Despite an absolute rise in rail tonne-kilometres travelled, rail's share has remained stable or has decreased in all countries except the United States. Rail transport in Europe and Japan typically remains fairly unresponsive to rapidly changing market conditions and is characterised by relatively complex transport chains involving several handling operations.

Recent efforts to retain rail market share have focused on developing intermodal transport systems centred on rail or shipping. Such systems account for 7.5 per cent of all tonne-kilometres travelled in Europe with rail intermodal transport accounting for two per cent of tonne-kilometres. Intermodal rail has displayed high growth rates through 1996 (6.7 per cent for domestic European operations, 9.1 per cent for international operations) although there recent indications show these rates to be declining. One key to increasing intermodal rail transport will be the development of standardised intermodal transport containers that enable direct transhipment from rail to road vehicles without losing time in rail marshalling operations.

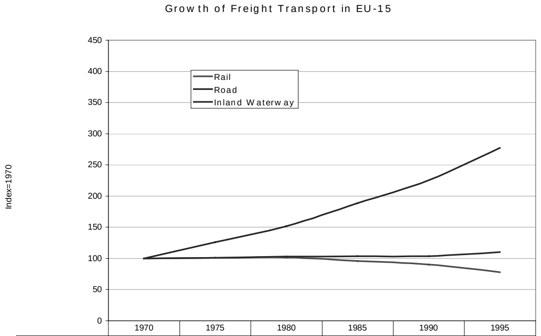
There are some indications that the deployment of new logistics information management systems will ease some of the frictions associated with intermodal freight transport chains. Door-to-door real-time tracking of consignments (a technology developed by express package services), coupled with competitive intermodal rail freight services shows promise for enabling rail to divert some high-value goods transport from trucking.

In 1993, rail in the CEE and EIT countries had continued to decrease in absolute terms and to lose modal share from its pre-1989 levels. This trend has partially reversed itself as absolute levels of rail tonne kilometres have increased from a low in 1993-94. Currently, rail accounts for more tonne kilometres than other modes although its modal share is rapidly being eroded by growth in road freight. Several factors contribute to this trend including the aforementioned trends in investment spending, the relatively low levels of rail freight in the European Union and quicker deregulation of the road as opposed to the rail sector. A final difficulty in retaining rail mode share remains that fact that rail infrastructure in these regions is largely oriented towards eastward movements (towards the former Soviet Union) while most new trade involves westward movements towards the European Union.

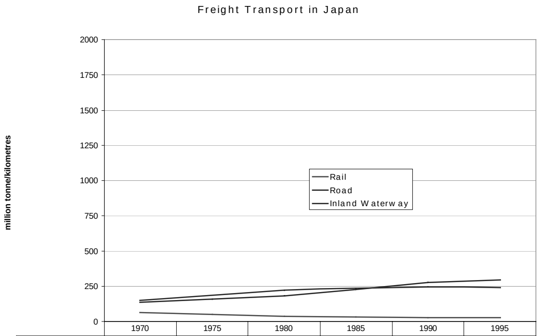
Figure 8: **Freight transport in European Union, Japan and United States**



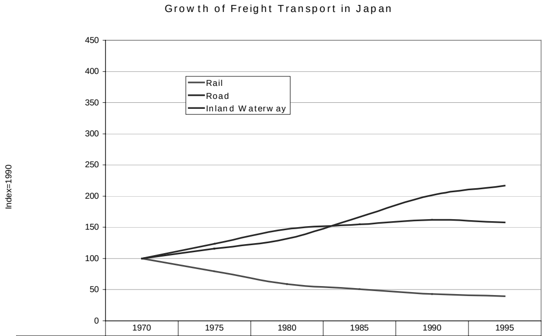

| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Rail | 282,8 | 285,1 | 287,3 | 271,4 | 255,5 | 220,6 |
| Road | 412,2 | 519,0 | 625,8 | 777,5 | 929,2 | 1142,7 |
| Inland Waterway | 104 | 105,2 | 107 | 107,4 | 108 | 114 |



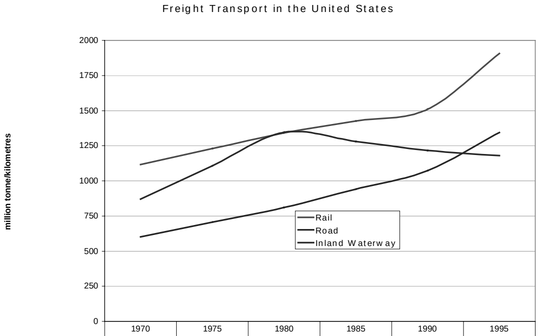

| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Rail | 100 | 101 | 102 | 96 | 90 | 78 |
| Road | 100 | 126 | 152 | 189 | 225 | 277 |
| Inland Waterway | 100 | 101 | 103 | 103 | 104 | 110 |



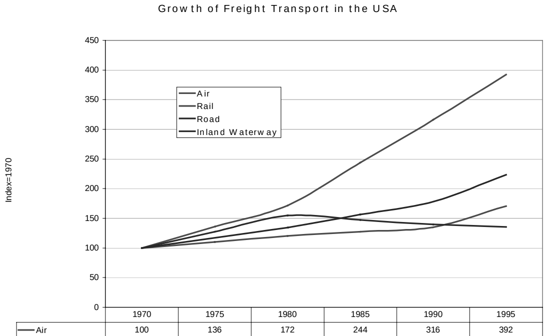

| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Rail | 63,4 | 50,4 | 37,4 | 32,3 | 27,2 | 25,1 |
| Road | 136 | 157,4 | 179 | 226,6 | 274 | 295 |
| Inland Waterway | 151 | 186,7 | 222 | 233,4 | 245 | 238 |




| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Rail | 100 | 80 | 59 | 51 | 43 | 40 |
| Road | 100 | 116 | 132 | 167 | 202 | 217 |
| Inland Waterway | 100 | 124 | 147 | 155 | 162 | 158 |




| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Rail | 1116,6 | 1229,1 | 1341,7 | 1425,6 | 1509,6 | 1906,3 |
| Road | 602 | 705,9 | 810 | 941,7 | 1073 | 1345 |
| Inland Waterway | 870 | 1108,1 | 1346 | 1281,4 | 1217 | 1179 |




| | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|---|
| Air | 100 | 136 | 172 | 244 | 316 | 392 |
| Rail | 100 | 110 | 120 | 128 | 135 | 171 |
| Road | 100 | 117 | 135 | 156 | 178 | 223 |
| Inland Waterway | 100 | 127 | 155 | 147 | 140 | 136 |

*Source:* OECD, ECMT, USDOT.

**Shipping:**

Inland shipping represents approximately 20 per cent of tonne-kilometres travelled within the OECD. This figure does not include and masks the importance of coastal shipping. Inland combined with coastal shipping accounts for 27 per cent of tonne-kilometres in the United States and 46 per cent in Europe. Even more so than rail, shipping generally concerns relatively low value bulk commodities travelling long distances although an increasing trend in the transport of containerised medium-value manufactured goods can be noted. The latter often form one link in intermodal transport chains. Expanding world trade is likely to boost activity in this sector although not by enough to prevent domestic and regional shipping operations to lose market share to road and, increasingly, air freight transport.

**Air:**

In absolute terms, air freight represents the smallest share of total tonne-kilometres and concerns the shipment of high-value goods over relatively long distances. Recent indications point to a trend towards shipping more medium-value goods by air as air travel costs have decreased. Intense competition, large improvements in carrying capacity per unit of fuel, and overall declining costs per tonne-kilometre (facilitated in part by the relatively low cost of aviation fuel) have all contributed to fast growth in this sector. These supply-side developments have been paralleled by trends on the demand-side for international sourcing of products and high-value manufactured components by companies operating on a regional or global scale. Rapid product innovation and development accompanied by short market cycles have also contributed to growth in air freight. From 1980 to 1990, air freight grew by an average of 5.6 per cent per year, it has since picked up and is projected to grow at 6.4 per cent per year through 2017 making it the fastest growing freight transportation sector. While $CO_2$ emissions from air freight are relatively small at present when compared to the road sector, air freight remains an important sector for policy action because of its projected growth and because non-$CO_2$ emissions from aircraft (ozone-forming $NO_x$, aerosols, $CH_4$ and water vapour), especially at high altitudes, have been calculated to have approximately 3 times the radiative forcing impact of aircraft $CO_2$ emissions alone.

## *Intensity*

Energy and carbon intensity for freight is a function of many factors including the mode share, the technical efficiency of each mode and capacity utilisation for each mode. Figure 4 provides an overview of representative lifecycle carbon intensities for European freight modes. The figures for road, shipping and air are roughly the same as for North America. North American rail, while still less energy intensive than other modes, produces more $CO_2$ per tonne kilometre as it is mostly reliant on diesel fuel rather than electric power.

These figures underline the very high $CO_2$ emissions from light-duty goods vehicles and the nearly non-existent direct $CO_2$ emissions from rail and intermodal operations. Air freight remains one of the most energy intensive modes for freight transport second only to light trucks in the European case. Calculating the specific energy intensity of air freight, however, remains problematic as a large majority (70-80 per cent) of air freight travels in the holds of scheduled commercial passenger flights. These figures also point to the relatively low carbon intensity of 40 tonne trucks which emit almost as little $CO_2$ as intermodal rail operations (a broader analysis of complete lifecycle impacts, however, underscores the non-climate impacts of the trucking sector including $NO_x$ and particulate emissions).

Improvements in the technical efficiency of different modes are likely to progress across the board with the greatest gains in the road and aviation sectors. Indeed technical improvements to trucks have lead to an increase in average fuel efficiency by 20-30 per cent over the past two decades (although energy intensity expressed in tonne-kilometres has remained essentially stable due to falling load factors and increased packaging? - it would be good to have an explanation of this). Likely technological developments will likely lead to smaller gains in the future along the lines of 2-5 per cent in the medium-term. Gains in aviation fuel efficiency have been even more spectacular and are slated to continue at a slightly higher rate than for road freight transport. Overall energy use and carbon emissions, however, are not likely to reduce or even stabilise as these efficiency gains are outstripped by increases in overall volume of freight tonne-kilometres.

As well as engine efficiency, there are many other options for reducing the greenhouse intensity of freight movement. In the road sector, these include increasing load factors and decreasing empty running, improved driver training (5-10 per cent fuel savings in the near- to medium-term) and overall improved logistics chain management (over ten per cent in the near- to medium-term rising to over 20 per cent when integrated into a comprehensive approach including fuel efficiency). An important issue in road freight (and to a lesser extent, air freight) remains the under-use of the weight capacity of vehicles. Most low-density high-value vehicle loads “square out”, that is cover the existing floor space of vehicles, before they reach the vehicle’s weight capacity. An even more pronounced phenomena is that road freight vehicles tend to poorly use vertical space. A lack of full utilisation of the cubic volume of trucks has been estimated to contribute as much as 15 per cent extra vehicle traffic in certain countries. In these instances, adding an additional deck in existing trucks can reduce vehicle kilometres by around 20 per cent.

Other measures such as increased return loading (where delivery vehicles also pick up consignments from suppliers), reverse logistics (ensuring that reverse flows of materials, including waste, utilise vehicles that previously returned empty), using more space-efficient packing, relaxing requirements for dedicated delivery and the adoption of more efficient order cycles (including nominated-day delivery services) all have the potential to lead to greater than 20 per cent reductions in vehicle kilometres travelled. Indeed, the wide range of existing practices among road freight operators results in great variability in their respective energy intensities. A recent survey of transport operators in the United Kingdom indicated that a 30 per cent savings in fuel use could be realised if the median performance of the two-thirds lower performing truck fleets where brought to up to the median performance level of the top third of truck fleets (see Figure 9).

## *Fuels*

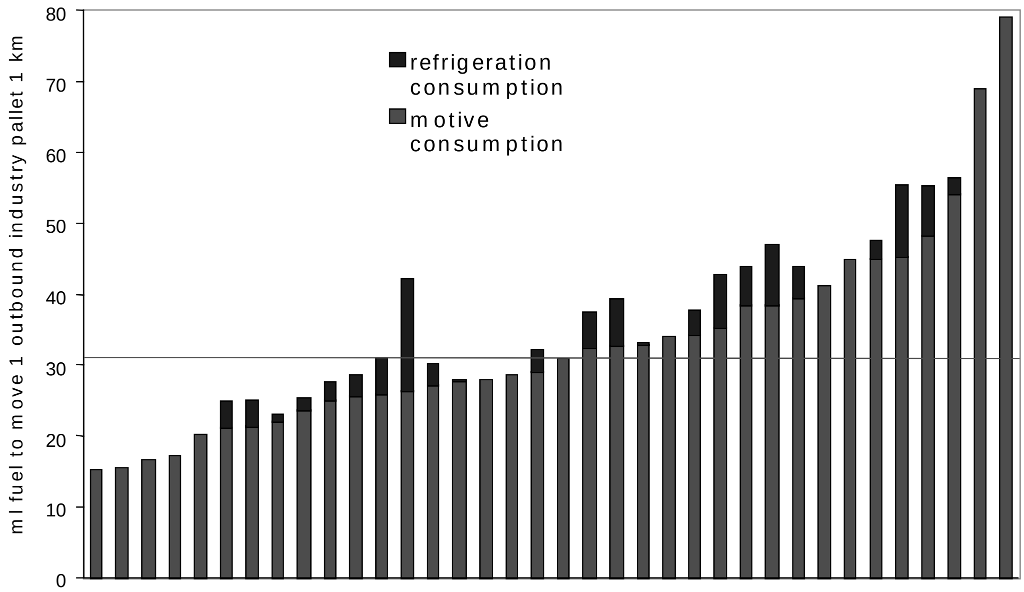
Petroleum-based fuels dominate the freight transport sector. Diesel fuel dominates the trucking sector and North American rail operations. Power from coal-based, hydrogen and nuclear electricity producing plants dominate the European rail sector. Kerosene fuel is exclusively used for air transport.

Generally, fuel prices have played a relatively smaller role in the evolution of freight energy use and $CO_2$ emissions than they have for passenger transport. Road transport costs represent a fairly small share of sales revenue --1.6 per cent for the average European company -- and direct fuel costs account for only 20-30 of the latter, making firms’ strategic decision-making processes relatively insensitive to variations in fuel prices. Policies targeting fuel costs will likely have a greater impact for long haul operations where fuel costs represent a relatively larger share of total operating costs.

Use of alternative fuels in the road freight sector remains relatively anecdotal although some initiatives in Europe have focused on introducing LPG and/or electric vehicles for light-duty goods deliveries in urban settings.

Market penetration of alternative fuel technologies, such as hybrid and fuel cell vehicles, is expected to occur rather slowly and it is not at all clear that these will deliver substantial overall life-cycle reductions in energy use and $CO_2$ emissions. Some potential exists for the use of methanol fuel cells in the rail and shipping sectors although these already have relatively low $CO_2$ emissions.

Figure 9: **Energy intensity of 36 UK trucking fleets**




Source: Professor Alan McKinnon, School of Management Logistics Research, Heriot Watt University

## 5.3 Policy Issues for reducing GHG emissions from Freight Transport

Achieving Kyoto and longer-term greenhouse objectives will require more effective policies, including in the freight sector. Recent work has indicated that as much as 60 per cent of the effort required to significantly reduce $CO_2$ emissions will have to come from non-engine technical measures. A number of specific policy issues are apparent from this brief examination:

- Fuel price changes may have limited impacts on modal choice or volumes, since they are a small part of total costs, except for long distance trucking which is already generally efficient. Pricing approaches targeted at modes and reflecting a range of environmental and social impacts, may be more successful.

- Patterns of urban development can lock in use of transport modes over long periods. Attention to freight implications of land use planning is important, especially where opportunities to encourage greenhouse-friendly intermodal transport exist.

- Considerable potential exists for companies to save costs and reduce emissions through better management of existing freight movements. Enhanced information and incentives for such changes may be beneficial. Alternatively (or in addition), given the diversity of freight operations, some form of voluntary agreement with major freight operators may help to improve performance.

- Air freight is of special concern given its rapid growth and high global warming intensity. But this mode is not well understood and difficult to analyse. Increasing attention to this sector will be an important element of long-term greenhouse response.

- Economic reform in the transport sector will have impacts on greenhouse emissions, making policy integration vital. The pace of reform in different transport sectors (e.g. road vs. rail) will be important.

Achieving the goal of stabilised $CO_2$ concentrations at twice their pre-industrial levels will require going far beyond technology-only measures.

Box 3. **GHG reductions through Supply Chain and Logistics Management: The Case of Otto Versand**

In 1993, the German mail-order retailer Otto Versand’s procurement of goods and materials caused more than 184,000 tonnes of $CO_2$ emissions. To lower these $CO_2$ emissions, Otto developed a four-pronged strategy. Beside testing and using alternative fuels to establish low or zero emission systems, the main aim has been to optimise the environmental and economic performance of the company’s supply chains. From 1993 to 1999, annual $CO_2$ emissions were reduced by some 40 per cent thanks to these measures.

One central element of Otto’s strategy involves shifting consignments from high-emission means of transport such as planes and trucks to lower-emission means of transport such as sea-going ships. In order to carry out this strategy, existing logistic chains had to be re-evaluated and new ones established. This means that new logistics chains have to be established as illustrated in the examples below:

- For the Turkish market, some five per cent of consignments were transferred from truck to ship. This led to a saving of 0.16 tonnes of $CO_2$ and DM 300.00 per tonne of merchandise. At the same time, handling was greatly simplified. In 2000 the share of sea going ship transportation should be increased to 20 per cent.

- For the Hong Kong market a total of eight per cent of pure air consignments were shifted to a combined sea-air transportation. As a result, $CO_2$ emissions were cut by 2.8 tonnes and costs by DM 1,800.00 per tonne of merchandise. In 2000 the share of sea-air transportation should be increased to 12 per cent.

The measures show that, even in times of "just in time" and "quick response" freight delivery trends, a reduction in emissions, handling effort and transport costs can be achieved by the establishment of new logistics chains and the use of low-energy and low-emission means of transport such as sea-going ships.

## 5.4 Decoupling economic activity from freight transport volume

More fundamentally, however, climate policy in the freight transport sector must address the strong linkage between economic activity and freight transport tonne-kilometres. This historical linkage has been confirmed by numerous studies although there is evidence that, in many countries, this linkage appears to be weakening. It has been suggested that this linkage is not necessarily a given but, rather, reflects structures, practices and habits that can be changed under the right conditions. A major question for policy-makers in OECD countries remains whether or not economic prosperity can be ensured with less over-all carbon intensity. Translated into the freight transport sector, the question becomes whether or not economic prosperity can be maintained with less overall energy use and $CO_2$ emissions from freight transport. Experiences from the energy sector indicate that such a decoupling is possible although maintaining and/or strengthening the process requires constant policy monitoring and adaptation. Factors working against such a decoupling include the dispersed nature of transport emissions and transport decision-makers, the relatively long time frames for changes in industrial production patterns and practices and slow stock turn-over rates associated with freight transport activity (both vehicles and production centres), and the number of external sectors and policy fields that impact freight transport activity and structure.

At the micro level, there are indications that $CO_2$ emissions from freight are more than they could be and that some firms and economic sectors stand to be able to compress these in sometimes spectacular ways without affecting their overall competitiveness and market standing. Some transport-intensive companies have been able to realise up to 35 per cent $CO_2$ reductions in a relatively short time by re-evaluating and re-adjusting their global logistics operations (see Box 1). Countries such as the Netherlands have recognised the opportunities for helping companies to avoid excess freight transport and are seeking to implement programmes to help identify and realise potential freight transport savings. At the aggregate level, however, it doesn't seem clear that facilitating wider diffusion of best practice and firm-level transport intensity improvements will necessarily translate into a significant or durable decoupling of freight activity and GDP. In this respect, tools that seek to place more direct limits on $CO_2$ emissions can prove to be helpful in bringing about beyond business-as-usual developments in freight transport.