Sustainable distribution: opportunities to improve vehicle loading

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Summary
This article surveys opportunities to improve the utilization of road vehicles, including their potential economic and environmental benefits. Road transport’s impacts on the environment can be reduced through increasing the share of freight moved in environmentally less damaging ways, increasing vehicle load factors, improving energy efficiency, and decreasing emissions per unit of energy consumed. An increase in vehicle load factors (the ratio of the weight of the goods carried to the maximum weight that could be carried) can help slow the growth of freight traffic.

Résumé
L’article passe en revue les solutions possibles pour une meilleure utilisation des véhicules automobiles, notamment sous l’angle des avantages économiques et écologiques potentiels. Pour diminuer les impacts des transports routiers sur l’environnement, on pourrait notamment augmenter la part de marchandises acheminées par des moyens de transport moins préjudiciables à l’environnement, accroître le coefficient de remplissage des véhicules, améliorer le rendement énergétique et réduire les émissions par unité d’énergie consommée. Une augmentation du coefficient de remplissage des véhicules (rapport entre le poids de marchandise transporté et le poids maximum transportable) permettrait, par exemple, de freiner la croissance du trafic de marchandises.

Resumen
Este artículo examina la posibilidad de mejorar el uso del transporte motorizado, así como su potencial de dividendos económicos y ambientales. El impacto ecológico del transporte por carretera puede reducirse, aumentando el porcentaje de carga que se desplaza por otros medios menos contaminantes, incrementando el factor de carga de los camiones, mejorando su consumo energético y reduciendo las emisiones por unidad de energía consumida. El aumento del factor de carga (la relación entre carga máxima y carga efectivamente transportada) podría ralentizar el crecimiento del transporte por carretera.

Production and distribution systems are becoming increasingly transport-intensive. In the EU, for example, the volume of freight moved, measured in tonne-km, has been growing faster than GDP and industrial output (Figure 1). Many transport planners and policymakers had hoped that trends in GDP and freight traffic growth, which have been closely correlated for decades, would naturally “decouple”, with the latter gradually tapering. People might then enjoy the benefits of economic growth without suffering the adverse environmental effects of expanding road traffic. In practice, decoupling has occurred but in the opposite direction, exacerbating the associated environmental problems.

To limit future growth in freight tonne-km, it would be necessary to restrain or reverse the processes that have contributed to accelerating freight traffic growth (e.g. sourcing of products from further afield; subcontracting of intermediate stages in the production process to outside specialists; centralization of production, warehousing and terminal capacity). However, these processes are intrinsic to economic development and the growth of international trade. They are also likely to be relatively insensitive to increases in freight transport cost. Prospects for suppressing growth in demand for freight transport do not look promising, particularly in the short term. It would nevertheless be possible to reduce environmental impacts by 1) increasing the share of freight moved in less environmentally damaging ways; 2) increasing vehicle load factors; 3) improving freight transport operations’ energy efficiency; and 4) reducing emissions per unit of energy consumed in freight transport.

Governments in many industrialized countries have traditionally seen option 1, the “modal shift” option, as the most effective method of reducing freight transport externalities. This generally entails transferring freight from road to rail and water-borne modes, and offers the additional benefit of easing traffic congestion. The EU is promoting intermodal (or “combined”) transport as the main means of achieving sustainability in the freight transport sector.

While modal shifts would usually be environmentally beneficial, their net contribution to energy and emission savings might be relatively modest. In countries where road is the dominant freight transport mode, increasing truck loading could yield greater environmental benefits. Initiatives to increase fuel efficiency in the road freight sector (e.g. though improvements in vehicle design and maintenance, fuel type and driver behaviour) have usually not considered the importance of vehicle loading.

Figure 2 compares projected reductions in CO2 emissions in the UK from increasing truck loading by 10%; reducing empty running of road vehicles; and doubling rail freight traffic. It is arguable that road-based measures would be more achievable than doubling of rail freight traffic.

Measuring vehicle fleet utilization
Different indices can be used to measure the utilization of vehicle fleets, each giving a different impression of transport efficiency.

Tonne-kilometres per vehicle per year
The tonne-km index generally presents the trucking industry in a positive light. It is essentially a productivity indicator, measuring the average amount of work done annually by trucks. In the UK, for instance, it increased 130% between 1970 and 1996, mainly as a result of firms taking advantage of increases in maximum truck weight and running their vehicles for more hours per day. This trend impacts on the environment in several ways:

- Raising vehicle productivity reduces the real cost of transport. As transport gets cheaper, companies tend to use more of it, often internalizing transport cost savings in more centralized production and distribution systems.

Against this environmental disbenefit can be set three benefits:

- Trucks that are used more intensively wear out more quickly, shortening replacement cycles and accelerating the adoption of cleaner vehicle technology.
- An increasing proportion of deliveries are made during the evening and night, when traffic levels are low and vehicles can attain more fuel-efficient speeds. (Working at night can, of course, aggravate the problem of noise.)
- Increases in vehicle weight and size limits permit greater consolidation of loads, and hence a reduction in traffic levels. This is discussed in greater detail below.

Vehicle load factors
This is generally expressed as the ratio of the actual weight of goods carried to the maximum weight.
that could have been carried on a laden trip. When this ratio is plotted through time, a much less rosy picture emerges. In the UK, for example, average load factors declined from 63% in 1990 to 60% in 1999.

It is often argued that replenishing supplies on a just-in-time (JIT) basis is depressing vehicle load factors. This seems plausible, since JIT usually means delivering goods more frequently in smaller quantities. If there were a pronounced effect on the road freight system, however, one would expect to see average payload weights diminish. An analysis of official transport statistics for the UK, the Netherlands and Sweden in the period 1980-95 revealed the opposite. Average payload weight actually increased respectively by 8%, 38% and 30% (Table 1).

While JIT has unquestionably reduced average consignment weight in some sectors, this has been more than offset by consolidation of loads in others. The overall increase in average payload weight has been exceeded by the growth in vehicle carrying capacity, causing the average load factor to decline. In the absence of JIT pressures, there would probably have been a higher degree of load consolidation and possibly an increase in average load factors.

The load factor is only a partial measure of vehicle utilization. As an exclusively weight-based measure, it takes no account of the use of vehicle space or deck area, or the proportion of vehicle-kilometres run empty.

Space utilization

Many low-density products fill the available vehicle space or “cube out” long before the maximum permitted weight is reached. In sectors characterized by low-density products, weight-based load factors tend to underestimate the true level of utilization. Where there are tight limits on a product’s stacking height, loading is usually constrained much more by the available deck area than by cubic capacity. The deck area may be covered with pallets stacked to a height of 1.5 metres, leaving a metre or more of wasted space above them. Very little research has been done on space utilization of vehicles, and few attempts have been made to collect volumetric data on road freight flows. In a study in the Netherlands and Sweden, Samuelson and Tilanus (1997) asked a panel of industry experts to estimate the average utilization of trucks, with reference inter alia to a series of space-related indices. This study revealed that cube utilization was typically very low, at around 28%. On average, however, just over 80% of deck area was occupied and 70% of the available pallet positions were filled. It was mainly in the vertical dimension that space was wasted, with average load heights reaching only 47% of the maximum.

Empty running

The most obvious form of vehicle under-utilization is empty running. Typically, around one-third of vehicle-kilometres are run empty, although this proportion varies with length of haul, type of vehicle and industrial sector. Empty running generally occurs when operators are unable to find a return load. Unlike passengers, who usually return to their starting point, most freight travels in only one direction. In some countries, the proportion of truck-kilometres travelled empty has been declining. It fell from 33% in the UK in 1980 to 27% in 1999. This is reckoned to have saved UK industry around £1.1 billion, and to have reduced CO₂ emissions by around 1.3 million tonnes per year. An analysis of the possible reasons for this trend identified several contributory factors: longer truck journeys; an increase in the number of drops per trip; growth in the reverse flow of packaging material/handling equipment; and greater effort by shippers to obtain return loads.

It is difficult to predict how low the proportion of empty running will eventually fall. It will clearly never reach zero. A substantial proportion of “structural” empty running will remain, as a result of geographical imbalances in freight flows, vehicle incompatibility, scheduling constraints, the short length of many journeys, and risk aversion on the part of companies that are reluctant to jeopardize the reliability of outbound deliveries. But even a marginal reduction in empty running to say, 25% would yield significant environmental benefits.

Measures to improve vehicle loading

Increased return loading

There are numerous examples of companies introducing initiatives to increase backloading in recent years. For example, Britain’s largest supermarket chain, Tesco, has implemented “supplier collection” and “onward delivery” schemes. In the case of supplier collection, a returning shop delivery vehicle collects goods from a supplier’s factory and carries them to the retailer’s distribution centre. Onward delivery occurs when a supplier’s vehicle offloads goods at the retailer’s distribution centre and backloads with supplies destined for one of the retailer’s shops. They are delivered on the way back to the factory, usually with minimal deviation from the direct route. Tesco has estimated that over a five-year period these schemes cut vehicle-kilometres by around 4.8 million, expenditure on fuel by £750,000 and CO₂ emissions by 23,000 tonnes (Department of the Environment, Transport and the Regions, 1998).

Advances in IT and telecommunications are

In 1998, a survey of 35 fleets in the UK food sector, comprising roughly 2200 vehicles, found that on loaded trips an average 78% of the deck area and 66% of available height were utilized, corresponding to a mean cube utilization of 50% (McKinnon, 1999). A study of vehicle utilization at European level by consultants A.T. Kearney (1997) concluded that “There are 15% extra grocery trucks on European roads as a result of a failure to optimize available height.” They estimated that, in addition to cutting traffic levels and emissions, more efficient use of the cubic capacity of trucks carrying grocery products could save Euro 1.8 billion.

**Table 1**

<table>
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<th>Year</th>
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<th>Rigid Articulated Total</th>
<th>Small Large Total</th>
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<td>3.5 16.0 7.4</td>
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<td>3.7 16.1 8.4</td>
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<tr>
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<td>4.7 14.5 8.8</td>
<td>4.1 16.5 9.3</td>
<td>3.6 24.4 15.5</td>
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<td>1995</td>
<td>4.5 14.4 9.2</td>
<td>4.3 16.0 10.2</td>
<td>4.5 27.2 17.8</td>
</tr>
</tbody>
</table>

1. small = max. payload ≤ 5 tonnes; large = max. payload > 5 tonnes.

Source: Netherlands Economic Institute, et al., 1998
creating major new opportunities for backloading.
- Electronic monitoring of vehicle activity. In-cab recording devices, supplementing conventional tachographs, provide operators with a detailed breakdown of vehicle performance and activity. This facilitates analysis of vehicle utilization across the fleet and can help identify backloading opportunities;
- Vehicle tracking in-cab mobile data communication. This allows vehicle schedules and routes to be replanned in real time, while the vehicle is on the road. Operators can exploit backloading and load consolidation opportunities arising at short notice. Communication with the vehicle and information on its positioning give clients greater confidence in “return load” services.
- Development of on-line freight exchanges. These exchanges, such as NTE.com in the United States and Freight-traders.com in Europe, enable companies to trade vehicle capacity on-line and make it easier for carriers to achieve balanced loading of vehicles in all directions.

Raising limits on vehicle carrying capacity
Very few loads simultaneously reach vehicle weight and volume limits. Most fill out the vehicle space before the weight limit is reached, or vice versa. Increasing the weight limit, or physical dimensions, of the vehicle can therefore result in greater load consolidation.
- Maximum vehicle weight. Within the EU, trucks engaged in cross-border transport have a weight limit of 40 tonnes. For domestic road haulage within Member States, weight limits vary from 40 to 60 tonnes. The UK government recently commissioned a detailed study of the costs and benefits of increasing maximum truck weight from 41

Figure 2
Comparison of energy-saving scenarios in the UK’s freight transport sector, 1995

The new IRU Guide to Sustainable Development

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The International Road Transport Union (IRU), through its national associations in more than 60 countries, represents the entire road transport industry worldwide. It speaks for the operators of trucks, buses, coaches and taxis, from large transport fleets to driver owners. By working for the highest professional standards, the IRU aims at improving the safety record and environmental performance of road transport and ensuring the mobility of people and goods. In 1996, in response to Agenda 21, the road transport industry, under the leadership of the IRU, the IRU Charter for Sustainable Development, a commitment by the road transport industry to drive towards sustainable development.

Implementation follows commitment
With this year’s IRU Guide to Sustainable Development, the IRU continues its efforts to bridge from commitment to drive towards the goal of sustainable development, to factual implementation of sustainable development practices.

The IRU Guide draws on the experience accumulated by IRU Member Associations in Denmark, Germany, the Netherlands, Norway, Sweden and the UK in their national sustainable development programmes. The results of these initiatives are synthesized into six IRU modules: a practical aid for all national road transport associations and transport operators in implementing sustainable development practices. The ultimate objective of the new IRU Guide is to encourage as many road transport operators as possible to implement sustainable development practices.

Learning from the best – the six IRU modules
The IRU modules documented in the new Guide cover a wide range of activities:

Module 1: Signing the IRU Charter
The signing of the IRU Charter for Sustainable Development by individual transport operators presents the first step, and helps raise awareness and commitment among hauliers. This can go hand in hand with organizing seminars to inform transport operators about the IRU Charter and Agenda 21, or providing written information such as manuals, etc. furthering its implementation.

Module 2: Well Driven Campaign
In a Well Driven Campaign, participating operators commit themselves to improving road safety according to a certain code of good practice elaborated by the national road transport association. No third-party audit is required; participants are responsible for compliance with the campaign’s code of conduct, and their success or failure is monitored by and reported to the public.

Module 3: Environmental Management System (EMS)
This module addresses the implementation and possible certification of an Environmental Management System (EMS), which is the most comprehensive and thorough way to integrate sustainable development practices into a company’s every-day activities. Environmental Management Systems can use the ISO 14001 standard or one tailored for road transport, with additional criteria for transport operators but still compatible with ISO.

Module 4: Environmental Controlling
This module describes the development and application of environmental controlling tools and techniques, such as green accounting, that measure use of resources and the environmental impact of specific activities. Green accounting complements the existing financial controlling system, with which it should be integrated. Standard indicators allow benchmarking against other companies.

Module 5: Promotion of Best Industry Practices
This module covers the promotion of best industry practices, including industry awards for environmental excellence and industry reports on good practices. Through such reports, for example, road transport operators can learn from each other’s efforts or about the standards set by the pioneers of the industry. Reports may be drafted in cooperation with commercial or
to 44 tonnes (for six-axle vehicles). It recognized that the resulting consolidation of loads in heavier vehicles could benefit both the economy and the environment. Environmental groups argued that this measure, by reducing the unit cost of road haulage operations, would divert freight from cleaner modes, principally rail, and would likely inflate demand for road transport. Analysis of available data indicated that, on balance, “small but significant” economic and environmental benefits would be likely to accrue from a maximum weight increase to 44 tonnes, even allowing for displacement of freight from rail to road and the generation of some additional road freight movement. Mid-range savings of around 80,000 tonnes of CO₂ and 3700 tonnes of NOₓ annually could be achieved (Commission for Integrated Transport, 2000).

Vehicle size and design: It is generally acknowledged that the average density and “stackability” of freight are declining. Table 2 lists the major reasons for this decline, which is partly reflected in the increasing use of taller 9’6” containers in deep-sea container operations and of drawbar-trailer combinations in European road haulage. Truck dimensions are constrained by the geometry of road layouts, bridge heights and loading bays, and by the height of bridges and tunnels. Where the transport infrastructure permits an increase in vehicle height, the insertion of an extra deck could allow firms to make more effective use of vehicle space. In the UK, where most roads have five-metre height clearances, double-decking of articulated vehicles carrying low density products could cut haulage costs by around £340 million per year and CO₂ emissions by 0.5 million tonnes per year.

- Vehicles can also be redesigned in other ways to permit greater load consolidation. Compartmentalization of trucks has enabled grocery retailers and their contractors to combine the movement of products at different temperatures on a single journey. This form of “composite distribution” enabled the UK retailer Safeway to reduce the average number of vehicle trips required to deliver 1000 cases from five in 1985 to one in 1995.

Use more space-efficient handling systems and packaging
The efficiency with which a vehicle’s cubic capacity is used partly depends on the nature of the packaging and handling equipment. Companies must reconcile the desire to maximize vehicle fill with the need to protect products from damage in transit, and to minimize handling costs. The following examples illustrate the effects handling/packaging changes can have on the transport operation:
- Choice of loading method. A large mail order company managed to improve vehicle cubic utilization and cut vehicle-kilometres by 6% through loading parcels loose rather than in bags;
- Nature of the handling system. By using wooden pallets rather than roll cages, a grocery retailer can load 15-20% more cases onto a conventional trailer;
- Stacking height. One manufacturer of soaps and detergents calculated that by increasing pallet height from 1.7 to 2.1 metres, it could reduce its road freight demand by 1.6 million truck-kilometres per year. As the pallet slots in most warehouses offer only 1.7-1.8 metre clearance, however, such a change would require reconfiguration of racking systems;
- Modular loads. A French food manufacturer improved vehicle fill by 35-41% by packing orders into modules of varying heights (University of St. Gallen, 2000);

Benefits for the environment and transport operators
Although sustainable development has a wider meaning, the six IRU modules aim at achieving the following specific sustainable development objectives:
- to create awareness among transport companies of the objectives and benefits of sustainable development;
- to improve safety and reliability of transport;
- to improve resource efficiency, especially fuel consumption;
- to reduce emissions (primarily of CO₂, CO, HC, SO₂, NOₓ and particulates); and
- to reduce noise, especially at company sites and in inner cities.

Measures aimed at improving safety, environmental performance and fuel efficiency can at the same time improve operators’ profitability and quality of service. Lower fuel consumption means not only reduced CO₂ and other emissions, but also lower fuel costs. Improved safety means fewer accidents, more reliability and less vehicle downtime, as well as lower insurance costs. Improved waste water management can reduce a company’s water bill significantly.

Compilations of practical examples, available on the IRU web site, demonstrate how effectively IRU modules and national programmes can put the environment and the transport operator’s business needs in a win-win situation.

Road transport companies, which, for example, implemented IRU module 3 (Environmental Management System), reported after a successful implementation:

- a reduction of waste water and waste oil of between 40 and 95%;
- a reduction of several tens of thousands of litres of diesel fuel per year; and thus
- a substantial reduction of particulates and CO₂ emissions.

Incentives – the accelerator for implementation
A critical success factor for accelerating implementation will be effective incentive schemes, set up by governmental partners of the road transport industry, to further encourage use of the latest available technology and best industry practices. Transport operators who implement the IRU modules, and who make corresponding efforts and investments in new equipment and practices, should be recognized and rewarded accordingly. These incentives could include preferential taxation for environmentally friendly vehicles and cleaner fuels, or user advantages for those operators who have implemented sustainable development practices as set out in the IRU Guide.

Outlook – what’s next on the IRU agenda
The IRU will continue its engagement for achieving sustainable development. Promoting implementation of sustainable development practices and its monitoring has become a key priority for the IRU and its Member Associations.

In cooperation with its Member Associations, and national and international governmental and commercial partners, the IRU will encourage and, where necessary, coordinate implementation of further national programmes aimed at making a positive contribution to sustainable development, based on the IRU modules.

As a follow-up activity to its Guide, the IRU will elaborate a Report on Best Industry Practices, containing practical examples of industry forerunners worldwide, aimed at achieving sustainable development in the road transport industry. The description of these best industry practices will include quantification of the benefits for the environment achieved by each measure taken.

Load consolidation, and hence reduce truck traffic, can be improved by various methods. The nature of the order filling process can have a significant impact on the efficiency of the transportation. The growth of “palletization,” and increased use of unitized handling equipment, has enabled firms to improve the efficiency of handling operations. The adoption of the Nominated Day Delivery System (NDDS) can lead to a reduction in truck-kilometres by 10%. Abandoning the monthly payment cycle can also improve the efficiency of vehicle utilization, as companies invoice their customers at the end of each month, giving them an incentive to order at the start of the month and thereby obtain a longer payment cycle and moving to a system of “rolling credit.” This can reduce the amount of freight that can be carried on each square metre of vehicle deck area.

### Conclusions
For environmental reasons, it may become necessary in the longer term to restrain the underlying growth of freight movement. In the short to medium term, it should be possible to mitigate the effects of this growth by making better use of vehicle capacity. Increasing vehicle load factors effectively reduces the ratio of vehicle-kilometres to tonne-kilometres, moderating the growth of freight traffic on the ground.

### References


Civil aviation and the environment

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Summary
The ICAO Council’s Committee on Aviation Environmental Protection (CAEP) addresses the main environmental problems associated with civil aviation: aircraft noise, and emissions from aircraft engines. Reduction at source is the main focus of CAEP work on aircraft noise, but noise abatement and land-use planning also receive considerable attention. Work on emissions falls into three categories: technology and standards, operational measures, and market-based mechanisms. ICAO provides environment-related assistance to countries through technical cooperation and training programmes.

Résumé

Resumen
El Comité de Protección Ambiental en la Aviación CPMA del Consejo de la OACI se ocupa de los principales problemas ambientales que plantea la aviación civil: el ruido de los aviones y la emisión de sus motores. En cuanto al ruido, el trabajo del CPMA se orienta a la implantación de motores más silenciosos, pero también presta mucha atención a la insonorización del entorno y la planificación del territorio. Respecto a las emisiones, se trabaja en tres ámbitos: tecnología y baremos, medidas operativas y mecanismos de mercado. La OACI facilita ayuda a diversos países en temas medioambientales, mediante cooperación técnica y programas de formación.

The importance of noise and other environmental issues for the aviation industry has grown considerably since the late 1960s, when the International Civil Aviation Organization (ICAO) first became involved in environmental matters. The Organization’s current environmental activities are largely undertaken through its Committee on Aviation Environmental Protection (CAEP), which is composed of experts from States, major sectors of the aviation industry, and an environmental umbrella group.

The Committee deals with the main environmental problems associated with civil aviation, namely aircraft noise and the impact of aircraft engine emissions. The guiding principles underlying its work are technical feasibility, economic reasonableness, and environmental benefit. ICAO standards and recommended practices (SARPs) relating to environmental protection are contained in Annex 16 to the Convention on International Civil Aviation (the Chicago Convention, 1944), while ICAO policies in this area are contained in a resolution adopted by the 32nd ICAO Assembly in autumn 1998.1

ICAO also assists States through its technical cooperation programme, providing the necessary expertise to help address environment-related issues affecting aviation. In addition, the ICAO Trainair programme has begun to get involved in environmental protection matters. It recently developed a course on airport noise assessment to help instruct and train personnel in this field. (The ten-year-old Trainair programme was developed by ICAO to improve the effectiveness and cost efficiency of civil aviation training in developing countries.)

Aircraft noise
There are three main themes to CAEP’s work in the noise field: reduction at source, use of noise abatement operating measures, and land-use planning.

Reducing noise at source
Reducing noise at source has long been the primary focus of CAEP’s work. In the 1970s, ICAO established noise certification standards in Annex 16. The initial standards for jets (aircraft designed before 1977) were included in Chapter 2 of Annex 16. Subsequently, newer aircraft were required to meet the stricter standards contained in Chapter 3 of the Annex. CAEP is now exploring the scope for a new noise standard more stringent than that contained in Chapter 3.

Almost a decade ago, an extraordinary session of the ICAO Assembly adopted a comprehensive policy on noise issues, including specific revisions regarding operating restrictions on noisier aircraft. In considering proposals by some States to restrict the operations of aeroplanes that exceed Chapter 3 noise levels, the ICAO Assembly of 1990 succeeded in developing a compromise solution. States with noise-sensitive airports could impose restrictions on operations of noisier aircraft if they so wished, but only under certain conditions. The restrictions could only be introduced gradually, and problems faced by operators from developing countries had to be taken into account. The resolution also included a provision urging States not to impose any restrictions on Chapter 3 aircraft.

The adoption of the resolution, by consensus, was the culmination of four years of analysis and development by the ICAO Secretariat, the Council and the Assembly itself. The outcome was seen as a substantial achievement, considering the wide differences around the world in environmental pressures and in air carriers’ economic circumstances.

In recent years, governments have been turning their attention to the situation that will exist once operations of Chapter 2 aircraft at their airports are largely replaced by Chapter 3 aircraft. There are concerns that the rapid growth of air transport could increase noise levels once again. A consensus has yet to emerge in ICAO on how to address these concerns.

European governments have focused on preventing an increase in operations of aircraft which have been recertificated to Chapter 3 standards through re-engineing or hush-kitting. While this pertains to European airports only, it could impact on carriers based elsewhere and has raised questions within ICAO about consistency with the compromise solution of 1990, as well as the possible impact on ICAO’s worldwide noise standards. In April 1999, the EU Council adopted a regulation on this subject which became applicable on 4 May 2000. That regulation recently became the subject of a complaint filed by the United States with ICAO, under the Chicago Convention’s provisions for settling disputes (Article 84). The relevant procedures for dealing with such issues are now under way.

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already under way concerning a new noise standard more stringent than Chapter 3. CAEP is now exploring the issue of possible operating restrictions on Chapter 3 aircraft from a worldwide perspective. It has been requested to develop technical options for consideration by the Council in 2001.

CAEP will be making use of a new analytical tool, the Model for Assessing the Global Exposure to the Noise of Transport Aircraft (MAGENTA). The model will estimate the benefits of policy measures to reduce noise, in terms of changes in the number of people who would be exposed to a given level of noise. While information about the estimated benefits was sometimes available for a particular airport, until now there has been no reliable means of extrapolating this information to cover many airports. Using MAGENTA, it should be possible to estimate the benefits of different options on both a regional and worldwide basis.

Noise abatement operating measures
While CAEP’s primary focus has been on reducing noise at source through certification, or through restrictions on noisier aircraft, there is some scope for alleviating the impact on neighbouring communities through noise abatement operating measures. There are several methods of achieving noise abatement. Examples include preferential runways and routes, and noise abatement procedures for take-off or for approach and landing. The appropriateness of any of these measures depends on the physical lay-out of the airport and its surroundings, but in all cases priority must be given to safety considerations.

In 1995, CAEP recommended new take-off noise abatement procedures. These have since been given a thorough review by safety experts and are expected to be considered by CAEP at its next full meeting in January 2001.

Land-use planning
Land-use planning is one effective means to ensure that activities near airports are compatible with aviation. Its main goal is to minimize the size of the population affected by aircraft noise through introducing land-use zoning. Comparable land-use planning and control is also a vital instrument for ensuring that the gains achieved by reducing the noise of the latest generation of aircraft are not offset as a result of further residential development around airports.

ICAO guidance on land-use planning is contained in the Airport Planning Manual (Part 2C, Land-Use and Environmental Control). A revised edition of this manual (Document 9184) is being prepared by CAEP and is expected to be published shortly. The Manual, which provides guidance on using various tools for minimizing the impact of aircraft noise in the vicinity of airports, describes the practices adopted for land-use planning and control in several States.

Aircraft engine emissions
Aircraft engines burn fuel, producing emissions. The impact of these emissions gives rise to concerns at both ground level and the global level, where the principal concern is aviation’s contribution to climate change.

In the immediate vicinity of airports, concerns focus on the potential health and environmental effects of emissions such as nitrogen oxides (NOx) and particulates. Also at ground level, but more widely spread, there are concerns that aircraft engine emissions such as NOx may be contributing to acid rain.

In Aviation and the Global Atmosphere, a special report prepared by the Intergovernmental Panel on Climate Change (IPCC) at ICAO’s request and published in 1999, aircraft are said to contribute about 3.5% of the total radiative forcing by all human activities, a proportion predicted to grow in the future. Emissions from aircraft that affect climate change include carbon dioxide (CO2), water vapour, NOx, sulphur oxides (SOx), and soot. Deposition of the ozone layer does not appear to be an issue so far as emissions from the present subsonic fleet are concerned, but could become one if there were to be a significant fleet of supersonic aircraft.

Adoption of the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) in December 1997 has given increased momentum to CAEP’s work in the emissions field. In 1998, the ICAO Assembly adopted a resolution calling on CAEP to study policy options to limit or reduce greenhouse gas emissions from civil aviation. The Committee is required to consider the findings of the IPCC special report and the requirements of the Kyoto Protocol, and to report back to the next session of the ICAO Assembly in 2001.

CAEP’s work on emissions falls into three categories, namely technology and standards, operational measures, and market-based options.

Technology and standards
CAEP has been considering to what extent technology can help achieve reductions in emissions through improved engine or airframe design. The present ICAO standards for emissions certification of aircraft engines were originally intended to respond to concerns regarding air quality in the vicinity of airports. As a consequence, they establish limits for emissions of NOx, carbon monoxide (CO), unburned hydrocarbons (HC) and smoke, for a reference landing and take-off (LTO) cycle below 915 metres of altitude (3000 feet). These limits are expressed in terms of mass of emissions per unit of engine thrust.

While the standards are based on an aircraft’s LTO cycle, they also help limit emissions at altitude. Of particular relevance is the standard for NOx, a precursor for ozone. At ground level ozone takes part in smog chemistry, while at altitude it is a greenhouse gas. The standard for NOx was first adopted in 1981. It was made more stringent in 1993, when ICAO reduced the permitted levels by 20% for newly certificated engines, with a production cut-off on 31 December 1999. In April 1998, CAEP recommended a further tightening of about 16% on average for engines newly certificated from 31 December 2003, a measure adopted by the ICAO Council in February 1999.

CAEP is now carrying out assessments of technological advances, so that ICAO standards can be modified to specifically address greenhouse gas emissions. In particular, it is studying alternate emissions methodologies that will encompass all phases of flight (climb and cruise emissions as well as the LTO cycle). In addition to considering the types of emissions already covered by ICAO standards, the new methodologies will take into account the fuel efficiency and productivity of the whole aircraft, which would have a direct bearing on CO2 emissions. CAEP will also follow developments in the characterization and measurement of other emissions, such as particulates that could be relevant to contrail production and additional cirrus cloud formation. This is a very complex task, requiring close cooperation with industry and scientific experts, and recommendations for new methodologies are not expected to be completed until 2001. Definition of relevant standards, if appropriate, would follow.

Operational measures
CAEP is considering to what extent operational measures, such as more direct routings, might help reduce the amount of emissions produced. Work is currently focused on two key deliverables (by January 2001):

- Quantification of the environmental benefits possible with the adoption and implementation of ICAO’s satellite-based CNS/ATM (communications, navigation, surveillance/air traffic management) systems. This is a coordinated effort between the Federal Aviation Administration (United States) and the European Organization for Safety of Air Navigation (EUSOECON- TROL (29 European States). The study methodology, and an initial global assessment of the environmental benefits of CNS/ATM, have been completed. This initial study quantifies the emissions reductions to be achieved in the US and Europe, based on planned enhancements to the respective air traffic environments, and provides baseline assessments of the various ICAO regions on which to base future improvements. Next steps will be to work with ICAO’s regional planning groups to help them incorporate environmental considerations into their CNS/ATM implementation plans, and to provide an assessment of those benefits.

- A draft guidance material for States and the wider aviation community on operational opportunities to reduce aircraft engine emissions. The goal of the document is to offer practical information to reduce aircraft engine emissions through changes in operational procedures and practices. The document incorporates a wide variety of inputs from airlines, airports and air traffic service providers to provide an end-to-end look at practices now in use to reduce emissions. It has sections on technology, maintenance, non-revenue flying, weight reduction, load factor, flight planning, airports, take-off, climb, cruise, descent and landing, infrastructure, etc. The next step will be to finalize the document and make it publicly available as an ICAO Circular.
Market-based options
CAEP is also identifying and evaluating the potential role of market-based options, including emission-related levies (charges and taxes), emissions trading and voluntary programmes, as a means of limiting greenhouse gas emissions. As the IPCC Special Report has indicated, several different emissions from aircraft engines play a role in climate change. However, this tends to complicate the design and evaluation of market-based options. It has therefore been decided to focus on CO₂ emissions only at this stage, while leaving open the possibility of accommodating other emissions later if appropriate.

While CAEP has traditionally adopted technology-based standards for controlling emissions, market-based options also offer a potentially cost-effective approach to achieving environmental objectives. However, their use raises a number of important economic, legal and administrative issues that must be fully evaluated.

CAEP has identified and begun to define a range of specific market-based options, including:
- a fuel tax, with revenue going to national treasuries;
- revenue-neutral charge based on aircraft efficiency, with higher charges on less fuel-efficient aircraft offset by lower charges on more fuel-efficient ones;
- an en-route emissions charge, with revenues recycled to the aviation sector;
- an open emissions trading system, in which emissions from all aviation sources (domestic and international) are treated identically to other emissions, and trading may take place between the aviation sector and other sectors;
- a closed emissions trading system, in which international aviation emissions may only be traded within the aviation sector, with a fixed cap;
- voluntary programmes, as well as hybrid options drawing on elements from each of the three approaches under consideration (levies, trading and voluntary programmes);

CAEP has also developed an evaluation framework that will allow transparent comparison of the strengths and weaknesses of these options. The results of this technical evaluation will be subject to a policy review by the next full meeting of the Committee (CAEP/5) in January 2001, and consideration by the ICAO Assembly.

Future meetings
The present CAEP work plan in both the noise and emissions fields is aimed towards CAEP/5. Thereafter, CAEP’s recommendations will be reviewed by the Council of ICAO. Some aspects are also expected to be discussed at the 33rd ICAO Assembly in September/October 2001.

Notes
1. Resolution A32-8, the Consolidated statement of continuing ICAO policies and practices related to environmental protection, is accessible on the ICAO website (www.icao.int) under “Environmental Protection”.
2. Council Regulation (EC) No. 925/1999 of 29 April 1999 on the registration and operation within the Community of certain types of civil sub-sonic jet aeroplanes which have been modified and recertificated as meeting the standards of Volume I, Part II, Chapter 3 of Annex 16 to the Convention on International Civil Aviation, third edition (July 1993).
Le rail au service du développement durable : quel part du marché pour le fret ferroviaire en France ?
Luc Aliadère, Directeur de l’Environnement, SNCF, Direction déléguée Environnement
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Les tendances historiques
Le transport par chemin de fer a des qualités qui ne sont pas contestées, même par les lobbyistes de ses concurrents : il est économe en consommation d’espace, économiquement car moindre consommateur d’énergie, énergie qui est largement électrique, il est donc peu polluant et surtout très peu producteur de gaz à effet de serre.

| Source : External costs of transport, INRA/INFR, mars 2000 |
|-------------------|-----------------|
| EURO/1000/km/tkm  | Passagers       | Fret            |
| Route             | Rail            | Route          | Rail          |
| Accidents         | 35,1            | 0,9            | 11,5          | 0             |
| Bruit             | 5,7             | 3,9            | 6,7           | 3,5           |
| Pollution atmosphérique | 17,3 | 4,9            | 37,4          | 4             |
| Effet de serre    | 15,9            | 5,3            | 16,2          | 4,7           |
| Total             | 74,6            | 15             | 71,8          | 12,2          |

De fait, en ne considérant que les émissions de CO₂, le contenu moyen en gramme de carbone d’une tkm de fret ferroviaire est de 3 grammes ; celui d’une tkm de fret routier (en considérant un poids lourd moyen supérieur à 3,5 tonnes et une charge moyenne de 6 tonnes) est estimé à 33 grammes. Sur le territoire français, le transport de fret par train est donc en moyenne 10 fois moins producteur de CO₂ que le transport routier. On peut donc affirmer sans crainte qu’il est globalement respectueux de l’environnement.

Sur un terrain différent, davantage sociétal, le transport ferroviaire est très sûr. En effet, l’ensemble du système de sécurité des grands réseaux Européens est d’abord conçu pour le transport des personnes. Le transport des marchandises bénéficie de ce haut niveau puisque son exploitation est totalement intégrée dans celle des autres trains en cohabitant sur les mêmes lignes. Il en est de même du niveau de sécurité du transport des matières dangereuses qui, de ce fait, est très élevé. Sur le même registre social, les conditions de travail des personnels ferroviaires sont clairement définies et respectées, ce qui n’est pas nécessairement la règle pour tous les modes de transport.

Enfin, au plan économique, le fret ferroviaire sait être d’une grande efficacité et d’un coût raisonnable comparativement au transport par route. C’est d’autant plus vrai que les quantités à transporter sont importantes et que les lieux à desservir sont directement reliés aux réseaux ferroviaires grâce à des embranchements.

Souvent économiquement pertinent, pertinent également socialement et environnementalement, le mode ferroviaire peut à juste titre prétendre contribuer au développement durable.

Or, malgré ces atouts indéniables, le transport des marchandises par le rail est en déclin quasi permanent sur tous les réseaux d’Europe de l’Ouest, la France n’échappant pas à la tendance même si la part de marché du ferroviaire dans ce pays est encore comprise entre 20 et 25%. L’explication n’est pas très compliquée et éclaire sur les conditions d’un renouveau avec développement, en forte rupture de tendance.

L’analyse du déclin
La Société Nationale des Chemins de Fer Français (SNCF), tout comme les autres grandes entreprises ferroviaires, souffre de deux handicaps principaux : son insuffisante capacité à s’adapter et le niveau des prix du marché.

La difficulté d’adaptation des chemins de fer est un sujet bien connu. Les économies nationales ont changé : les transports de matières premières et de Pondereux ont été supplantés par des besoins qui prennent une place de plus en plus intégrée et serrée au sein de chaînes de production ou de distribution dans l’esprit « juste à temps ». Or, le chemin de fer, moyen de transport très capitaliste aussi bien du point de vue des infrastructures que des matériels roulants, a besoin de temps pour adapter, d’une part son patrimoine, et d’autre part et plus généralement, sa production qui est largement imbriquée entre branches d’activité. Il appartient donc aux entreprises ferroviaires de réussir à mieux anticiper les besoins du marché pour être moins souvent en décalage, décalage qui s’apparente pour beaucoup à un cycle d’hystérésis.

La question du prix de marché est plus délicate, car elle relève beaucoup moins des seuls chemins de fer. Le transport routier est en effet devenu le mode dominant et c’est lui qui fixe les prix. Certes il est irremplaçable et le transport ferroviaire lui-même ne peut envisager de se passer de lui. Mais comme il ne fait payer à ses clients que la moitié environ de ce qu’il coûte à la collectivité, les conditions de concurrence sur le marché des transports conduisent à une situation préoccupante. Le résultat pour la SNCF est que celle-ci a beaucoup de mal à dégager des marges, qui sont pourtant les seules sources d’investissements indispensables à son développement. Mais plus généralement, il faut se demander comment infléchir une situation dans laquelle le prix du transport est si anormalement bas que la fonction “transport” sert de variable d’ajustement à bien des processus de production ou de distribution. Les transporteurs routiers et leurs partenaires servaient les premiers bénéficiaires d’une telle inflexion en permettant de mieux respecter l’environnement ou de faire progresser les conditions de travail des personnels.

Une vision ambitieuse de l’avenir
Si le “laisser-faire” de ces dernières décennies, à la fois si pratique et en apparence si efficace, a finalement hypertrophié un transport routier devenu difficilement maîtrisable, le rééquilibrage demandera du courage et de la volonté.

L’ensemble des acteurs doit d’abord voir loin et viser haut. Quelle que soit la dénomination d’un tel exercice (prospective, schéma directeur,…), il s’agit d’un renouveau à une échelle d’âge cicatricielle, décalé de 10 à 15 ans (environ) et indispensable.

De fait, si le mode ferroviaire peut acheminer des quantités de fret considérables, il doit pour cela disposer, sur ses axes majeurs, d’infrastructures qui lui soient quasiment dédiées. On y gagnerait là l’un des atouts majeurs de l’efficacité du TGV : pouvoir engager des convois aux caractéristiques quasiment identiques les uns derrière les autres à intervalles réguliers en optimisant le débit des lignes.

L’émergence d’un réseau Fret, sur lequel les convois devront pouvoir parcourir de grandes distances, est donc à préparer. Ce réseau contournera sys-
témérairement tous les nœuds ferroviaires situés en zones urbaines qui sont de plus en plus saturés par les dessertes grandes lignes (TGV) et régionales. Entre ces pôles, il s’appuiera largement sur des lignes existantes exploitées actuellement ou non, mais nécessitera parfois la construction de nouveaux tronçons aux caractéristiques adaptées.

Grâce à une telle ossature de quelques milliers de kilomètres bien connectée au réseau existant, et à condition qu’un effort comparable ait été fait dans les pays voisins, il est parfaitement envisageable de multiplier par dix (en tonnes km) le trafic Fret sur le territoire français.

Comment progresser fortement dans la durée ?

C’est sans doute là qu’est la difficulté majeure. En effet, chacun des acteurs doit faire évoluer durablement son organisation et ses performances et engager des financements non négligeables.


Les collectivités territoriales associées dès l’amont aux travaux prospectifs dans le cadre des contrats de plan qui lient l’Etat et les régions pour la période 2000-2006, participeront également aux études et à la réalisation de projets afin d’obtenir une cohérence entre les politiques nationales et locales de transport au sein des schémas de services. Elles devront, comme elle le font déjà très efficacement pour les projets de TGV ou de liaison rapide, jouer le rôle de relais entre les populations et les acteurs nationaux pour trouver les solutions les plus efficaces et les plus acceptables.

RFF devra étudier et engager les projets d’investissements permettant au transporteur de suivre le rythme de son développement.

La SNCF devra progresser encore dans la qualité de la production des services qu’elle offre à ses clients. C’est le sens de la création récente du Centre National des Opérations qui vise à améliorer ses fondamentaux : sécurité, vitesse, ponctualité. Elle développe également un suivi des circulations grâce au GPS pour informer en temps réel ses clients de la position de leurs acheminements. Des investissements substantiels ont par ailleurs été engagés avec le lancement de la première tranche d’un programme de commandes de 600 locomotives Fret. Il appartiendra à l’entreprise de dégager les moyens humains suffisants pour assurer la traction des trains de Fret sans conflit d’intérêt avec ses autres activités.

Enfin, les chargeurs et les industriels clients, présents et à venir, du transport ferroviaire devront accepter de poursuivre en l’amplifiant le partenariat actif qu’elles ont avec la SNCF. En effet, le mode ferroviaire, qui présente de forts avantages environnementaux, porte avec ces avantages d’une part une certaine inertie liée aux coûts d’investissement et aux procédés de mise en œuvre et supporte d’autre part des coûts totaux qui intègrent une large part des coûts externes qu’il engendre, contrairement aux transports routiers qui sont loin d’intégrer dans leurs coûts les effets externes qu’ils génèrent pour la collectivité.

Ces deux particularités imposent un partenariat loyal dans lequel chaque acteur assume ses responsabilités tout en œuvrant pour des objectifs partagés.

En conclusion : faut-il être optimiste ?

Le rédacteur de ces lignes n’engage que lui-même en répondant sans hésitation par l’affirmative. La nécessité de maîtriser le plus rapidement possible les émissions de gaz à effet de serre, qui conditionne la stabilisation du réchauffement de la planète, ainsi que la prise en considération par les citoyens de la qualité environnementale des produits et services qu’ils consomment, sont des éléments qui justifient le rééquilibrage évoqué et l’investissement public qu’il sous-tend. Quant à la SNCF, elle doit poursuivre l’amélioration de sa qualité au service de ses clients.
Sustainable mobility

The Mobility Account: a tool used by Deutsche Bahn AG and WWF-Deutschland

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On the occasion of the October 1999 UN Climate Conference in Bonn, the German environmental organisation WWF-Deutschland and the Deutsche Bahn (German railways) developed a study called Mobility Account for Passenger and Goods Transport – A comparative look at transport systems in Germany. The aim of this study is to compare the travel times, costs and environmental impacts of railways, cars, airplanes and inland water transport.

The Mobility Account is methodologically enhanced over earlier studies to increase its transparency and objectivity in comparing various means of transport. While earlier studies have mostly been based on average figures, the Mobility Account illustrates the environmental impacts of individual travel situations. Most common reasons for short- or long-haul trips (e.g. shopping, business, holidays) are selected and analyzed in order to allow a profound and comprehensive understanding, from an environmental point of view, of the weak and strong points of different transport modes. Using this knowledge, a software tool has been developed that helps the customer choose the best mode.

The fact that rail is comparatively environment-friendly is attributable to the advantages inherent in the wheel/rail concept: low steel-on-steel rolling friction: the track’s guidance function, which allows running long trains; and grouping of consignments, which helps ensure efficiency. However, customers rarely opt for rail travel solely on account of its environmental benefits. Their choice is influenced first and foremost by price, time and service. Environmental protection is an additional argument that may tilt the scales in favour of rail – if the service provided is an attractive and roughly comparable alternative to that of rival modes.

More important, drawing the attention of existing customers to rail’s environmental advantages may consolidate their decision. From the point of view of advertising psychology, this type of positive confirmation is one of the fundamental rules concerning customer loyalty. The automotive industry vaunts its three-litre car and the emission standards with which new vehicles now comply, which represent a decrease in exhaust emissions of up to >90% compared with the past. German airlines take out full-page advertisements to plug their fleet’s fuel consumption rate of 3.7 litres per 100 passenger-kilometres, also emphasizing that they are seeking to boost efficiency wherever possible. Railways cannot afford to rest on their laurels, relying on their historical image as an environmentally sound transport mode, as zero-emission vehicles and low-noise lorries are trumpeted as an alternative. They must learn to make their environmental advantages known to the outside world and firmly establish in public opinion their image as a resource-efficient transport mode.

Transport is considered one of the primary man-made causes of the greenhouse effect, probably the most acute environmental problem to be faced in coming decades. In the Federal Republic of Germany, transport’s share in energy-related emissions of the greenhouse gas carbon dioxide (CO₂) increased from 16% in 1990 to 20% in 1998. International air traffic emissions are not yet included in those statistics. Hence, transport accounts for a substantial and indeed growing proportion of German CO₂ emissions, more than, say, private households or manufacturing industry. Such developments seriously threaten attainment of the climate protection targets, agreed in Kyoto, that require Germany to cut production of greenhouse gases by 21% by 2008 taking 1990 as the reference year.

There is vast potential for reducing emissions from transport:

♦ Every tonne of transported goods transferred from road to rail in Germany reduces environmental pollution by 8.1 kg CO₂ per 100 km.³

♦ Every person switching from car to train reduces environmental pollution by 10.4 kg of CO₂ per 100 km.⁴

All in all, CO₂ emissions could rapidly be slashed by roughly 75% through switching from road and air to rail. Such potential, which can be realized through tapping into the rail system’s existing energy efficiency, underscores its social utility. This fact needs to be disseminated at regular intervals in political spheres, to bring home the need for an active railway policy.

The Mobility Account clearly demonstrates rail’s environmental advantages

For the reasons outlined above, it is crucial that rail maintain and amplify its competitive advantage in terms of energy efficiency. And it is at least as vital that methods be developed to publicize this competitive advantage beyond the rail sector in a proactive and convincing manner.

The Mobility Account, published in cooperation with the German branch of the World Wide Fund for Nature (WWF-Deutschland), is a step in the right direction. It is a precise decision-making aid for travellers attuned to environmental concerns. Moreover, it clearly demonstrates that rail is not only the most environmentally compatible transport mode, but in many cases also the most cost-effective and fastest. The fact that work on the actual substance of the report was steered by an independent German research body, the Institut für Energie- und Umweltforschung (IFEU) (Institute for Energy and Environment Research) in Heidelberg, lends this two-part publication the requisite credibility and weight.

Brochure explaining how transport modes are compared

The “Mobilitäts-Bilanz” (Mobility Account) brochure provides an overview of the environmental impacts of various transport modes using real-life examples of short- and long-haul trips for business, shopping and holidays. The criteria examined include energy consumption and emissions of air pollutants and climate gases, as well as expenditure and the time required for a given travel option.

By distinguishing between the different reasons for making a journey, it is possible to explain the relevant factors used to compare transport modes. Hence, when a car takes a family of four on holiday, use of capacity is four times greater than when a private car is driven by a single occupant on a business trip. Moreover, cars used for business trips tend to have more powerful engines. When the environmental impacts of two transport modes are compared, the conclusion drawn differs if the impact is calculated in terms of the number of people transported. The same is true for rail, where extensive use of capacity during rush hours means the environmental indicators are much more favourable than when measured for a late evening rail journey.

In the freight sector, rail is compared with road haulage and inland waterways. Once again, its environmental advantages stand out clearly.

The brochure makes a fundamental comparison between the various transport systems with respect to safety, comfort, noise, infrastructure and vehicle manufacture. It also outlines the commitment made by each of the Deutsche Bahn AG joint stock companies to improve even more on rail’s environmental record.

Example: “commuters”

One example illustrates the type of results produced and presented in the brochure.

If we consider a passenger who regularly commutes between Augsburg and Munich, the Mobility Account produces the results shown in Figure 1. Expenses are principally based on the full costs of a passenger car according to the declarations of the Allgemeine Deutsche Automobil Club ADAC (General German Automotive Club) published in its June 1999 car catalogue. The costs of the train journey are calculated based on the price of a second class annual ticket for this route and the respective public transport systems in Augsburg and Munich.

The journey takes about 80 minutes overall, of which 42 minutes on the CityExpress train and 20 minutes for changing transport mode and for tram use at each end (i.e. in Augsburg and Munich). It takes about 70 minutes by car.

The train’s high occupancy rate (70%) is one of the reasons our commuter
requires six times less energy to travel by rail than by road. This, by the way, presents a clear challenge to the railways to press ahead with respect to the occupancy rate, and not only for economic reasons. The train comes off even more favourably when CO₂ and other emissions are compared. This is due to use of electric energy for train operation being cleaner than benzene combustion in a modern passenger car with catalytic converter and lambda sound.

The train’s ecologically superior mobility chain helps the commuter save about 64 German marks (DM) on a return trip.

**A software programme for drawing up individual environmental impact assessments**

In conjunction with the brochure, a software programme, “Reisen und Umwelt in Deutschland 1999” (Travel and Environment in Germany 1999) is available for planning individual passenger trips. It enables users to generate their own environmental impact assessments for over 1600 connections throughout Germany using their home computers. In this way they can find out, for example, exactly how many litres of petrol (gasoline) they could save on their next trip and how many kilograms of climate-threatening CO₂ would not be pumped into the atmosphere if they opted for the train. Inspiration can be drawn from the rich store of pre-recorded travel examples.

**Mobility Accounts for freight transport need more work**

PR efforts to date have tended to focus on passenger traffic, with the aim of helping a broad public choose the best transport mode.

When it comes to freight traffic, the target group is completely different, with and highly specific expectations. An impact assessment instrument would be useful to help manufacturing industry and business evaluate and optimize their logistics precepts from an environmental perspective. As globalization gathers force, bringing with it growing cross-border trade flows, transport and its environmental impacts are becoming increasingly important factors in corporate environmental assessments. In some manufacturing sectors, transport contributes more than 25% of companies’ total energy consumption and up to 80% of emissions of relevant pollutants.

A uniform assessment tool could help standardize the often patchy and outdated data used for freight traffic and prepare it for practical application, thereby redefining its use in transport assessments compiled during corporate environmental audits. This type of practical tool could be an invaluable aid to many companies in light of revision of the EU’s eco-audit regulation (EMAS II), which stipulates that transport must feature in corporate eco-audits.

The first steps in this direction are being taken by a project group comprising five national railways (SJ, Sweden; SBB/CFF, Switzerland; FS, Italy; SNCF, France; DB, Germany). However, producing a comprehensive, widely accepted ecologistics assessment tool that can be used worldwide will require substantial financial and staff resources, as well as sufficient involvement of all competitors in compiling the content. Such an endeavour cannot be accomplished by the railways alone. The logical solution would be to set up a European research project, endowed with the requisite EU funding.

**Notes**


**Figure 1**

<table>
<thead>
<tr>
<th>Air pollutants</th>
<th>g/person and trip</th>
<th>Car</th>
<th>Railway</th>
<th>(Shuttle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides (NOₓ)</td>
<td>2.9 (0.3)</td>
<td>88.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>2.8 (0.4)</td>
<td>18.3</td>
<td></td>
<td></td>
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<tr>
<td>Non-methane hydrocarbons</td>
<td>0.08 (0.01)</td>
<td>40.0</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
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<tr>
<th>Carbon dioxide (CO₂)</th>
<th>kg/person/trip</th>
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</thead>
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<tr>
<td>Car</td>
<td>31.5 (0.4)</td>
</tr>
<tr>
<td>Railway</td>
<td>13.4</td>
</tr>
<tr>
<td>(Shuttle)</td>
<td>1.9 (0.2)</td>
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</table>

<table>
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<tr>
<th>Primary energy conservation</th>
<th>litre of benzene/person/trip</th>
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<tr>
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<td>0.42 (0.4)</td>
</tr>
<tr>
<td>Railway</td>
<td>0.40</td>
</tr>
<tr>
<td>(Shuttle)</td>
<td>7.00</td>
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</table>

<table>
<thead>
<tr>
<th>Time hours (single trip)</th>
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<tbody>
<tr>
<td>Car</td>
</tr>
<tr>
<td>Railway</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Expenses DM/person/trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
</tr>
<tr>
<td>Railway</td>
</tr>
</tbody>
</table>

*Second class annual ticket

Source: IFEU, 1999
Sustainable mobility: a government perspective

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Summary
Addressing transportation’s environmental impacts requires a holistic approach. Such an approach considers all aspects of the transportation system, in order to stimulate integrated, mutually reinforcing actions aimed at changing behaviour, technology and infrastructure. A key role for government (illustrated by Canada’s national climate change process in the transport sector) is provision of a supportive framework.

Résumé
Aborder le problème de l’impact des transports sur l’environnement exige une approche holistique, qui prend en compte tous les aspects du réseau de transport, de manière à susciter des actions intégrées complémentaires et qui permettent de modifier les comportements, la technologie et les infrastructures. Comme l’a montré le processus engagé par le Canada dans le secteur des transports pour lutter contre le changement climatique, les gouvernements ont ici un rôle clé à jouer : mettre en place un cadre de nature à soutenir ces actions.

Resumen
Para afrontar el impacto medioambiental del transporte, es preciso un enfoque integral, que considere todos los aspectos del asunto, para estimular iniciativas coordinadas y sinérgicas, que permitan cambiar la conducta, la tecnología y la infraestructura. El gobierno debe desempeñar un papel clave, mediante la creación de una estructura de apoyo (como en el caso del proceso nacional de cambio climático en el sector del transporte, efectuado en Canadá).

In a country as vast as Canada, transportation has an impact on every aspect of life and business. People make billions of trips each year travelling for work, recreation, medical care and other diverse reasons. Transportation also plays a vital role in Canada’s position as a trading nation. North-south transportation links with the United States have grown increasingly important with the signing of the North American Free Trade Agreement (NAFTA). Canada and the United States exchange nearly C$ 1.5 billion every day in goods and services. Transportation is also fundamental to tourism. It accounted for 40% of the C$ 44 billion spent in 1997 in this industry in Canada.

Canada’s well developed transportation system represents a large investment in infrastructure, vehicles, equipment and the fuel distribution network. The planning and managing of this system is complex. Four levels of government – federal, provincial/territorial, regional and municipal – have jurisdiction and regulatory authority over different aspects of the system. Making changes to improve the transportation system’s sustainability requires cooperation and agreement among governments.

In recent years, the role of the federal transportation department has evolved significantly away from direct operation of transportation facilities and services. It now has a more "arm’s length" role as landlord, overseer, regulator and policy-maker. This change in the nature of its responsibilities has important implications for how the department carries out its mandate, and how it approaches sustainable transportation.

Current trends are for continued growth in passenger and freight activity, particularly in the air and road transportation modes. Passenger transportation is dominated by private light duty vehicles (cars, vans and light trucks), which account for 87% of all passenger-kilometres travelled. Although energy efficiency is forecast to improve 0.7% annually until 2020, this progress is being overwhelmed by the increased use and number of vehicles. Figure 1 illustrates these trends for light duty vehicles in Canada.

Overall freight transport activity, as measured in tonne-kilometres, is forecast to increase by 60% between 1990 and 2020, with a 94% increase in trucking activity and 104% increase in air freight activity. These growth trends are shown by mode in Figure 2.

This growth will contribute to a variety of environmental pressures in Canada, ranging from air pollution, climate change, ozone depletion and acid rain, to land, water and groundwater contamination, depletion of non-renewable resources, disruption of habitat, and congestion and urban sprawl. In 1995, transportation was responsible for 52% of all nitrogen oxide (NOx) emissions, 40% of those of carbon monoxide (CO), 20% of those of volatile organic compounds (VOCs) and 5% of those of particulate matter. It is also the single largest source of greenhouse gas emissions in Canada – accounting for 25% of national emissions in 1997.

Climate change: a case study for sustainable mobility
The challenge of working towards sustainable mobility in Canada is well illustrated by climate change issue. Reducing Canada’s greenhouse gas emissions engages every aspect of the transportation system, and the way in which the individual components of the system interact with each other. Figure 3 illustrates the source of Canadian greenhouse gas emissions by mode. Emissions are directly proportionate to the level of transportation activity in each mode and the amount of fossil fuel consumed to support this activity. In many cases the solutions that can be found to reduce transportation greenhouse gas emissions also offer important benefits with respect to other transportation issues such as smog, congestion, noise, land use and urban sprawl.

There are four basic approaches to reducing transportation greenhouse gas emissions, each of which presents economic, technological, social and political challenges:

- limiting the growth of transport activity, potentially restricting mobility or the flow of goods in the economy;
- improving the overall efficiency of the transportation system by encouraging use of less energy-intensive modes, improving the interface between individual modes to reduce congestion, and encouraging multi-modal transportation;
- improving energy efficiency within each mode through the introduction of new technologies, operating practices and improved infrastructure; and
- reducing the carbon content of the transportation fuels used through new production technologies, changes in vehicles and engines, and new fuelling infrastructure.

Challenges facing decision-makers
Decision-makers face some significant challenges in assessing the options under each of these basic approaches. Transportation is a derived demand. Figure 4 shows how the demand for transportation has grown with the economy in Canada. Because the Canadian transportation sector is almost totally fossil fuel based, the sector’s greenhouse gas emissions increase with economic growth. By 2020, Canada’s economy is forecast to
be 70% larger than in 1995. Reducing greenhouse gas emissions from transportation will require us to break the traditional link between growth in demand for transportation and greenhouse gas emissions.

In assessing changes to the transportation system, it is important to consider potential impacts on the competitiveness of individual transportation modes, as well as impacts within the overall economy. Canada’s economy and transportation system are highly integrated within a North American framework. Its transportation options must take into account the United States’ response on climate change.

Commercializing and deploying new technologies takes time. Some equipment, such as airplanes, ships or rail cars, stays in service for many years, making rapid changes in the capital stock difficult without policy or market changes. Under current conditions and markets, it can take 20-30 years to turn over the current fleet of millions of vehicles. Changing urban infrastructure to favour less energy-intensive transportation will require long-term change.

Canada’s transportation system reflects the large area and relatively dispersed population of the country. Regional transportation systems have developed differently, depending on geography, climate, the regional economy, and the location of the population. Emission reduction strategies have to be flexible enough to accommodate regional differences and local circumstances.

Mobility is a key element of Canada’s standard of living. It is important to understand that various options will affect urban and rural communities differently. Choices with respect to land use, urban design, roads and public transportation have a profound effect on urban communities. In rural areas, distances to services are greater and there are fewer alternatives to the private automobile. Changes to transportation behaviour will only happen if the public is engaged, understands the issues, has high-quality alternatives to turn to, and can perceive a range of benefits in addition to reduced fuel use.

**The Transportation Climate Change Table**

In December 1997, the Prime Minister of Canada and the Premiers of the ten provinces initiated an innovative two-year national process to develop a climate change strategy that could respond to the recently negotiated Kyoto Protocol on climate change. Under this process, led by Ministers of Energy and Environment, a series of working groups (called “issue tables”) were set up to involve experts from across the country in analyzing options for reducing Canada’s greenhouse gas emissions.

As part of this process, the federal, provincial and territorial Ministers of Transportation jointly sponsored the Transportation Climate Change Table. This Table was co-chaired by one government official (Assistant Deputy Minister, Transport Canada) and one non-government official (Executive Director, Pollution Probe – a Canadian environmental group). The 25 members of the Table were drawn from every aspect of the transportation system: all freight modes (road, rail, marine, air), all passenger modes (bus, rail, road, air) conventional and alternative transportation fuels, vehicles and equipment manufacturing, shippers, consumers, federal, provincial and municipal governments, environmental and other non-governmental organizations.

The mandate of the Table was to identify and analyze a range of potential measures to reduce greenhouse gas emissions from transportation, including the impacts of measures, their associated costs and benefits, during the Kyoto period (2008-2010) and beyond to 2020. The Table was asked to build an incremental package of measures that would achieve progressively greater reductions in emissions within the transport sector until reaching, or if possible exceeding, a 6% reduction from 1990 levels (i.e. Canada’s national reduction target under the Kyoto Protocol). It is important to note that no sector was actually assigned a reduction target. The objective was to identify the most cost-effective options across all sectors of the economy.

The Table met every month or so for a period of 18 months. Table members began by producing a background paper to establish a common understanding of the transport sector, its emissions, and the broad options available to reduce these emissions. The Table then commissioned 24 analytical studies to identify and analyze specific measures in four categories: Road Vehicle Technology and Fuels, Freight Transportation (all modes) Passenger Transportation (urban and inter-city) and Road Infrastructure.

Through this analysis, the Table identified and studied roughly 120 potential measures. Using a number of criteria – including cost-effectiveness, ease of implementation, competitiveness impacts, confidence in the analysis and data, and potential for public acceptance – the Table ranked these measures into four categories (Figure 5). While it is not possible to convey all of the Table’s findings here, the following gives a sense of the type of measures which the Table found to be most promising and promising.

**Passenger transportation**

The Table identified a range strategies to reduce greenhouse gas emissions from passenger activity in urban centres. Measures such as tax-free transit benefits, telecommuting, car/pool sharing, and driver education could be combined to form an effective strategy for voluntary employee trip reduction programmes. Significant enhancements to urban transit service through improvements in pricing, service and infrastructure were seen as fundamental to reducing private vehicle use. The Table combined support for investments in transit, bicycle and pedestrian infrastructure with disincentives for car use through higher parking charges in the three largest Canadian cities.

**Road infrastructure**

The Table focused on three key strategies for changing the way we build, maintain and use our roads and highways:

- enforcing existing highway speed limits, as vehicle fuel economy declines significantly above 90 kilometres per hour;
- using Intelligent Transportation Systems (ITS) applications for traffic signalization, traveller information and incident management, in order to achieve an overall improvement in traffic flow; and
R\text{Road vehicles and fuels}\n
The Table felt that the greatest potential for reducing greenhouse gas emissions from vehicles and fuels would come from working with industry and the United States to achieve a 25% targeted improvement in the fuel consumption of new cars and light trucks by 2010. The Table also saw promise in supporting expansion of ethanol production for blending in gasoline, and incentives for alternative fuels in niche markets in major urban centres and in fleets.

F\text{Freight transportation}\n
The Table identified a range of new truck technologies (e.g. advanced lubricants, speed control, load matching services, advanced tires) that hold promise for improving fuel efficiency within this mode. The Table also favoured an increase in the Capital Cost Allowance for rail equipment, voluntary codes of practice for the freight modes, and better truck driver training and operating practices. It examined options to shift freight transportation to less energy-intensive modes (rail and marine), but found that the specific options evaluated generated only small reductions at considerable cost. It was acknowledged that data in this area are weak, and the analysis is viewed as preliminary.

As part of its work, the Table also studied the use of market mechanisms such as parking charges, road pricing and fuel taxes to better reflect the full cost of different transportation services, and to encourage their most efficient use. In general, the Table felt there were significant design and analytical issues to be addressed for both urban road pricing and widespread urban parking charges, as well as considerable public resistance. These measures were therefore categorized as “Less Promising” in the Options Paper, even though their reduction potential was recognized.

Several fuel tax models were analyzed, but Table members did not reach a consensus on the use of these taxes as a measure to reduce greenhouse gas emissions. Figure 6 is a summary of issues raised by the Table. A key lesson learned from the fuel tax scenarios was that Canadians place a high value on current transportation behaviour. Fuel prices would have to more than double in Canada if fuel tax increases were to be used as a single, stand-alone tool to reach the Kyoto target in the transport sector.

The Table’s work represents a comprehensive but initial look at the costs and benefits of different options to reduce greenhouse gas emissions in the transport sector. Figure 7 summarizes the potential greenhouse gas reductions from the “most promising” and “promising” measures identified by the Table. The Table’s report was not intended to provide a prescription for implementation of the measures. It was recognized that many measures require more detailed analysis, design and consultation, including analysis by individual jurisdictions.

This message was reinforced during a series of eight workshops held across Canada to gather input from a broader range of stakeholders on the impacts and effectiveness of the measures in the Table’s Options Paper. The Table’s work was widely seen as a good first step, and a solid foundation for action. But there was a clear message that climate change measures must be assessed in the broader context of sustainable transportation and community development, and that there are areas that require further development.

C\text{Canada’s National Implementation Strategy on Climate Change: the transportation component}\n
The two-year national climate change process has produced Canada’s National Implementation Strategy on Climate Change, which was released in October 2000. As part of this strategy, Canada’s federal, provincial and territorial governments have agreed to develop a series of national business plans outlining concrete actions that they will take in all sectors of the economy to respond to climate change – individually, in partnership and collectively. These business plans will cover a three-year planning horizon and will be updated annually. The first national business plan for 2001-2003 was released by Ministers of Energy and the Environment in October.

The Government of Canada’s contribution to the first national business plan was announced on 6 October 2000 in Action Plan 2000 on Climate Change. This comprehensive package of measures includes a commitment to spend up to C$ 500 million over the next five years on new measures to reduce greenhouse gas emissions. This builds upon the C$ 625 million announced in the 2000 budget for climate-related initiatives.

Transportation is a substantial component of Action Plan 2000. It is based on four key transportation objectives:

- improving urban transportation;
- improving new vehicle efficiency;
- increasing the use of less greenhouse gas intensive fuels; and
- increasing the efficiency of our freight system.

The five new transportation programmes included in the Action Plan 2000 focus on initiatives that can produce cost-effective greenhouse gas reductions in 2010, offer clean air benefits for urban centres, have minimal competitiveness implications, have good public acceptance, support the take-up of new technologies, and improve the efficiency of the transportation system. The following is a brief description of these initiatives:

U\text{Urban transportation}\n
Building on the Transportation Table’s work, the federal government will work in partnership with provinces and municipalities to demonstrate the best urban transportation technologies and strategies to reduce greenhouse gas emissions. Four or five model “showcases” will be selected through a competitive process to demonstrate and evaluate a range of urban transportation options appropriate to local communities, including strategies to reduce use of cars and to shift passengers towards the less greenhouse-gas intensive travel alternatives. The results of the showcases will lay a foundation for the take-up of successful strategies in cities across Canada by 2010.

N\text{New vehicle fuel efficiency}\n
The government will work with the automobile industry and the United States to achieve new vehicle fuel efficiency targets by 2010. The objective will be to phase in a significant volun-
tary improvement in new vehicle fuel efficiency across Canada and the United States starting in 2004. This will be supported by increased new vehicle testing to confirm fuel consumption performance and remove potential safety barriers, and by a consumer education campaign to increase understanding of the importance of purchasing clean and efficient vehicles, as well as good driving habits and maintenance practices.

Fuels
The government will work with provinces and stakeholders to achieve a targeted increase in Canada's current ethanol production capacity of 750 million litres, which is triple our current capacity. This could enable as much as 25% of Canada's total gasoline supply to contain 10% ethanol (from biomass such as plant fibre, corn and other grains), a blend that can readily be used in all cars and that represents a lower greenhouse gas intensive fuel alternative.

Fuel cell vehicles
The government will establish a partnership with fuel cell suppliers, fuel providers, the automobile industry and interested provincial governments to encourage the acceptance and uptake of fuel cell vehicles in Canada. The partnership will work on a cost-shared basis to demonstrate and deploy hydrogen and other fueling infrastructure, and to address regulatory barriers to the increased use of fuel-cell vehicles.

Freight transportation
The government will develop partnerships and voluntary agreements within each freight mode to encourage the take-up of cost-effective practices and technologies that were identified by the Transportation Table. These five transportation measures were carefully developed to strike a balance between our technology, behavioural change and infrastructure needs. Although promising vehicle and fuel technologies exist, technology can only get us part of the way towards our goal. The emphasis on pilot projects and demonstration reflects the Transportation Table's conclusion that many measures in this sector need further assessment before launching into full-scale implementation. The measures clearly recognize that we need to build partnerships with the many diverse players that affect transportation: industry, municipalities, provinces, and (perhaps most importantly) the consumer.

What we learned from the Transportation Table process
The Transportation Table process provides some useful insights for decision-makers. Whereas previous climate change initiatives have focused on specific elements of transportation, this is the first time a holistic analysis has been undertaken to analyze the costs and benefits of options across the entire transportation system. Significant equity has been built up, in terms of both our knowledge and the engagement of government, industry and other stakeholders in climate change issues.

Much can be learned from the process itself about how to prioritize the many diverse players in the transportation system into the decision-making process. The process highlighted the importance of shared analytical work among transportation stakeholders — work that is planned, conducted and reviewed together. The 24 analytical studies conducted by the Table provided a critical opportunity to move towards a more shared understanding of complex, and often controversial, transportation issues.

The process also illustrated the importance of allowing sufficient time for new relationships to form across the transportation system, and for equity to be invested in the process. For the Table, this was achieved slowly over a two-year period. Although it has now formally disbanded, with its mandate complete, a solid foundation has been laid for implementing actions under the national business plan.

The Table's work greatly increased our base of knowledge concerning the costs and benefits of various opportunities to reduce transportation greenhouse gas emissions. It demonstrated that there are options that can help us achieve multiple transportation goals: climate change, smog reduction, congestion and efficiency. The Table also highlighted a number of areas where data on transportation is limited, and recommended the development of a national strategy to improve its quality. Further analysis was recommended to fill gaps in the Table's work, and much of this work has been undertaken or is underway.

Why do we need an integrated approach?
Perhaps the most important conclusion that can be drawn from the Table's work is that an integrated framework is needed to address climate change in the transport sector. There is no technology fix within the Kyoto timeframe. We need a mix of technology, behaviour change and infrastructure investment if we are serious about reducing emissions.

The measures identified by the Table have synergies, overlaps and cross-effects, which must be understood and incorporated within an effective reduction strategy. For example, the effectiveness of measures to reduce automobile commuter trips could be reduced if additional traffic were attracted back onto the roads by a reduction in congestion levels from efforts to improve traffic flow. Alternatively, strategies to reduce car use could be enhanced if they were combined with efforts to provide convenient alternatives, and with supportive infrastructure investments and land use planning.

Transportation is a complex system of infrastructure, vehicles, fuels, service providers and consumers. A successful greenhouse gas reduction strategy will require actions throughout the system, and the coordination of interactions between system components. The national climate change process described in this article is an illustration of how the government can provide a supportive framework through which the necessary partnerships and coordinated actions can be developed.

References
Transportation and Climate Change: Options for Action, Options Paper of the Transportation Climate Change Table, November 1999.
Sustainable mobility: perspectives from the transport sector in East and Southern Africa

Peter P. Zhou, EECG Consultants Pty Ltd, Energy Environment, Computer and Geophysical Applications, PO BOX 402339, Gaborone, Botswana (pzhou@global.bw)

Summary
A number of initiatives that could bring about improvements aimed at achieving sustainable mobility in East and Southern Africa have been studied. Energy efficiency could clearly be improved, and greenhouse gas emissions reduced, in these countries. Funding the measures needed remains a problem in view of the region’s lack of financial resources.

Résumé
L’article passe en revue plusieurs initiatives visant à façonner des pratiques de mobilité durables en Afrique orientale et australe. S’il est indéniable que l’on peut améliorer le rendement énergétique et réduire les émissions de gaz à effet de serre dans ces pays, financer les mesures nécessaires reste un problème à cause du manque de ressources financières de la région.

Resumen
Este estudio examina varias iniciativas que podrían contribuir a lograr un transporte sostenible en el Este y el Sur de África, donde es posible aumentar la eficiencia energética y reducir la emisión de gases de efecto invernadero. La financiación de las medidas necesarias sigue siendo problemática, dada la escasez de recursos de la región.

The importance of the transport sector with respect to development cannot be overemphasized. In Africa, as in other parts of the world, transport is an engine of economic growth. It moves goods and passengers to national, regional and international markets. There is a trend for countries to form economic entities such as the Southern African Development Community (SADC), the East African Community (EAC) and the Economic Commission of West African States (ECOWAS). Transport can also be considered a means of regional integration, linking people and regional markets.

Transport is one of the fastest growing economic sectors, in terms of energy and infrastructure demand and proliferation of vehicle fleets. While transport’s energy share in East and Southern Africa (ESA) varies according to country (Figure 1), it averages 12% of national final energy consumption.

Petroleum products are the dominant fuels in all ESA countries. In seven countries, these products provide all the energy used in the transport sector, and in the rest they provide over 80% (Figure 2). Except in Angola and South Africa, all petroleum products are imported, depleting scarce foreign currency. Electricity and coal are used to a limited extent, particularly in the case of rail transport (Figure 3).

Providing adequate road and rail networks
Most roads are unpaved or poorly maintained. Maintenance of the existing infrastructure has been neglected, obviously due to lack of financial resources as well as to resource mismanagement. Revenue generated in the transport sector is not directed at maintaining infrastructure, but is often channelled to other sectors with immediate financial needs.

Railway lines exist only along specific confined routes, with little flexibility for delivery of goods and passengers. The region’s railway systems are poorly managed and tend to operate below capacity. In general, they operate with run-down equipment, are unsafe for both freight and passenger delivery, have long turn-around times, and operate at a loss owing to public mismanagement.

Adequate telecommunication facilities in ESA countries (there are generally fewer than two telephones per 100 people) imply greater reliance on motorized transport systems for communication, particularly in urban areas. Frequent travel results in more demand for transport energy, more local and global emissions, and more fatalities.

Achieving high energy efficiency and low energy intensity in vehicles
African countries have low per capita incomes, and vehicles are generally over ten years old.1 These vehicles, which have high energy intensity due to poor maintenance and outdated design, continue to increase in number, as the ESA countries encourage the import of second-hand vehicles. The age of cars and light-duty vehicles (LDVs), which have the dominant modal shares in ESA countries (there are generally fewer than two telephones per 100 people) imply greater reliance on motorized transport systems for communication, particularly in urban areas. Frequent travel results in more demand for transport energy, more local and global emissions, and more fatalities.

Substituting current petroleum products with low-emission fuels/energy sources (e.g. ethanol, CNG and hydroelectricity)
Fuel substitutes such as ethanol, compressed natural gas (CNG) and hydroelectricity can be made available in the region. Their use would reduce imports of imported petroleum products and limit environmental problems like air pollution and GHG emissions.

Ensuring practical application of the proposed measures
The right policies and necessary skills, institutional strengthening, legal frameworks and, more important, financial resources are also of paramount importance in ensuring successful application of proposed transport measures.

The East and Southern African countries are
The energy and climate change link

The potential to address these transport problems seems to depend on integrating transport plans with the current global effort to reduce greenhouse gases, since policies with a wider variety of social, economic and environmental objectives will also result in GHG reductions. GHG reduction strategies are likely to be more acceptable in ESA countries, and more successful, if integrated into broader transport, urban development and environmental policy strategies. Many kinds of sustainable mobility measures can result in GHG reductions: they range from technological (e.g. fuel substitution) to regulatory/policy-orientated (e.g. imposition of duties) to behavioural (e.g. education on driving practices). Several such measures identified as applicable in the transport sector in ESA countries are listed in Table 1.

Transport infrastructure

Providing or improving mass transit systems to replace large fleets of old cars and LDVs, and providing access to transport services and mobility in many EAS countries is envisaged that as part of the global effort to limit GHG emissions, ESA countries can obtain technological and financial resources to improve transport sector efficiency.

Table 1

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>Energy efficiency</th>
<th>Fuel substitution</th>
<th>Regulatory/policy measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass transit systems (e.g. rail for road freight)</td>
<td>Enhanced vehicle maintenance</td>
<td>Compressed natural gas (CNG) for gasoline/diesel</td>
<td>Vehicle inspections (maintenance and pollution)</td>
</tr>
<tr>
<td>Non-motorized transport</td>
<td>Fuel use efficiency</td>
<td>Enhanced ethanol blending</td>
<td>Fuel pricing</td>
</tr>
<tr>
<td>Road paving and maintenance</td>
<td></td>
<td>Hydroelectricity for diesel</td>
<td></td>
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<tr>
<td>Enhanced communications measures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated transport and urban planning</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pipeline for petroleum transported by rail or road</td>
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</tr>
</tbody>
</table>

Sustainable mobility measures

Many kinds of sustainable mobility measures can result in GHG reductions; they range from technological (e.g. fuel substitution) to regulatory/policy-orientated (e.g. imposition of duties) to behavioural (e.g. education on driving practices). Several such measures identified as applicable in the transport sector in ESA countries are listed in Table 1.

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Table 2

<table>
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<tr>
<th>Measure</th>
<th>Location</th>
<th>Technical potential (cumulative GHG reduction potential, million tonnes of CO₂ equivalent)</th>
<th>Period</th>
<th>Economic potential (US$/tonne)</th>
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<tbody>
<tr>
<td>Mass transit system – road freight – rail</td>
<td>Regional Corridor – Mutare-Beira</td>
<td>0.67</td>
<td>2005-2050</td>
<td>8.38</td>
</tr>
<tr>
<td>Mass transit – road freight - rail</td>
<td>Botswana</td>
<td>2.31</td>
<td>1995-2030</td>
<td>-100</td>
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<tr>
<td>Non-motorized transport</td>
<td>Uganda</td>
<td>26.8¹</td>
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<td>6.10</td>
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<tr>
<td>Road paving</td>
<td>Botswana</td>
<td>6¹</td>
<td>1995-2015</td>
<td>-1251</td>
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<tr>
<td>Pipeline</td>
<td>Pretoria – Gaborone</td>
<td>2.6</td>
<td>2005-2050</td>
<td>63.41</td>
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<td>Fuel substitution – CNG</td>
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<td>2005-2050</td>
<td>1.37</td>
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<td>Fuel substitution – electric</td>
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<td>2005-2050</td>
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<tr>
<td>Fuel substitution – electric</td>
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<td>Regulatory – vehicle inspection</td>
<td>Botswana</td>
<td>-10.99</td>
<td>1995-2030</td>
<td>0.6 to 1.7</td>
</tr>
</tbody>
</table>

1. Estimated cumulative emission reductions from annual estimated or averaged potential GHG reductions.

Sources:
- Zhou, 1999
- Magezi, 1998
- ZEED, 1999
- CEED, 1999
- Zhou et al., 1998

The Second Assessment Report of the International Panel on Climate Change (IPCC) estimates that primary energy use could be reduced by 30-70% through switching from car to bus or rail. Both transboundary corridor and metropolitan mass transit systems would improve access to transport services, mobility and air quality, as well as reducing GHG emissions. Intra-urban, inter-urban and regional corridor routes could be considered for both freight and mass passenger transport.

An examination of regional transport corridor options for shifting road freight (dry cargo) to rail between Zimbabwe and Beira in Mozambique provided insights into the mitigation capacity of such options. Abatement of 15,000 tonnes of CO₂ equivalent per year (at US$ 8.6/tonne) was projected. The GHG reduction capacity increases if more regional corridors and expanded freight transport are considered.

A similar mass transit option considered in an in-country case study for Botswana revealed a potential for reducing 77,000 tonnes of CO₂ equivalent in 2005 and 161,000 tonnes in 2030 (at US$ 100 per tonne) through shifting 40% of cargo transported between the north and south of the country, which is currently the road freight share, to rail.

Mass transit could be considered for urban areas, shifting passengers from minibuses to coach type buses. Analysis of this option for Uganda showed a potential reduction of 64,000 tonnes of CO₂ equivalent per year (at US$ 2.65/tonne). Concerning mass transit systems, the benefits of reduced energy intensity increase with the load increase. In all these cases, the necessary policies currently debt-ridden. Most of them are no longer sufficiently credit-worthy to satisfy requirements for sustainable transport mobility. Perpetuating the conventional transport system, however, means continuing high bills for petroleum products (and associated debt), traffic congestion, accidents, and noise and air pollution. The ESA countries’ contribution to GHG emissions would also continue to increase unabated. Some countries are already failing to meet their transport fuel demand through lack of foreign currency. Zimbabwe is a case in point.

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<td>Pretoria – Gaborone</td>
<td>2.6</td>
<td>2005-2050</td>
<td>63.41</td>
</tr>
<tr>
<td>Fuel substitution – CNG</td>
<td>1% of RSA cars and LDVs</td>
<td>5.4</td>
<td>2005-2050</td>
<td>1.37</td>
</tr>
<tr>
<td>Fuel substitution – electric</td>
<td>Zimbabwe – Mozambique – Mutare-Beira</td>
<td>2.55</td>
<td>2005-2050</td>
<td>27.57</td>
</tr>
<tr>
<td>Fuel substitution – electric</td>
<td>Botswana - N-S rail - cargo</td>
<td>1.81</td>
<td>2005-2030</td>
<td>343</td>
</tr>
<tr>
<td>Regulatory – vehicle inspection</td>
<td>Botswana</td>
<td>-10.99</td>
<td>1995-2030</td>
<td>0.6 to 1.7</td>
</tr>
</tbody>
</table>

1. Estimated cumulative emission reductions from annual estimated or averaged potential GHG reductions.

Sources:
- Zhou et al., 1998
- Magezi, 1998
- CEED, 1999
- Zhou, 1999
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Unpaved and poorly maintained roads
Fuel consumption on unpaved roads (some very poorly maintained roads fall into this category) is about 1.5 times that on paved ones. Mobility is very limited on dirty roads and those with potholes, both of which are common in East and Southern Africa. Paving a 300 km section of road in Botswana was found to have the potential to reduce energy consumption, resulting in a GHG emission reduction of 300,000 tonnes of CO\textsubscript{2} equivalent annually (at a negative cost of US$ - 120/tonne).\textsuperscript{4} Other benefits include less need for imported spare parts, the demand for which increases when vehicles are used on bad roads.

Pipelines to replace future demand for rail and road transport
Another infrastructure measure is the use of pipelines to move petroleum products from ports to the interior. The costs of maintaining roads and rail, and of fuel for freight vehicles, could therefore be reduced. To limit dependency on imported oil products, pipeline compressors could run on electricity in those countries with local hydropower resources.

A number of countries already have or plan to build such pipelines, but the potential exists for even more to be added. When consideration was given to constructing a pipeline from Pretoria, South Africa, to Gaborone, Botswana, the potential GHG reduction was found to be 57,000 tonnes of CO\textsubscript{2} equivalent annually (at a cost of US$ 63 per tonne).\textsuperscript{3}

Energy efficiency measures

Increasing the share of fuel efficient vehicles
Increasing the share of diesel at the expense of petrol (gasoline) vehicles in Botswana was found to have the potential to reduce energy consumption equivalent to 15,237 tonnes of CO\textsubscript{2} emissions in 2005 and 41,000 tonnes in 2030 fiscally free. The measure operates on the premise that diesel vehicles have better fuel economy than those burning gasoline. Inducing the shift has been possible through increasing the tax on gasoline more than that on diesel. However, diesel would increase air pollution, and use of catalytic converters may also increase N\textsubscript{2}O emissions.

Fuel substitution measures

Substituting CNG for petrol/diesel in vehicles
A typical example of use of CNG to substitute for liquid fuels, with some added benefits, is found in South Africa, where 22% of the liquid fuel consumed is produced from coal at a plant operated by the South African petroleum company SASOL. SASOL saves South Africa billions of Rand a year in foreign currency, limiting the economic impacts of oil shocks. The technology for converting natural gas to liquid fuels already exists in South Africa. Converting 1% of cars and LDVs from gasoline to CNG was found to have the potential to reduce 120,000 tonnes of CO\textsubscript{2} equivalent annually between 2005 and 2050 (at US$ 1.37/tonne).\textsuperscript{3}

There have been significant natural gas discoveries in East and Southern Africa. Coal bed methane can also be used as fuel. Using these fuels would achieve sustainability of fuel supply, despite calculated constraints imposed by the oil-producing countries.
Enhancing ethanol blending

Another important fuel substitution option would be to introduce or increase ethanol blending with petrol where feedstock such as sugar cane can be produced and sustained. Some established plantations and infrastructure for ethanol production already exist in ESA countries. Zimbabwe, Malawi and Kenya have already used ethanol blend. There is momentum in Zambia and Uganda to follow suit. In a case study on introducing a 20% blend for gasoline vehicles in Zambia, the potential GHG emission reduction was estimated to be 72,000 of CO₂ equivalent in 2010 and 120,000 tonnes in 2030 (at a negative cost of US$-97/tonne).6

Ethanol is sometimes not cost-effective as a transport fuel when petrol is cheap on the international market. However, repeated oil shocks suggest that the region should maintain a level of self-sufficiency.

Electrifying rail systems using hydropower

Electrification of rail systems is seen as another measure to achieve sustainable transport mobility. Electricity is produced in this region – unlike petroleum products, which must be imported. Experience in the region is that electric trains can pull greater loads than those running on diesel, providing benefits in terms of economies of scale. The GHG reduction potential could be significant where the source of the electricity is hydropower.

For Botswana, it was estimated that the same freight shift from road to rail, and electrification of the rail system using imported hydropower, would yield an additional GHG reduction of 57,000 tonnes of CO₂ equivalent in 2030, but at a high cost of US$ 300/tonne. The option is more cost-effective if loads are large, suggesting that it could be considered a long-term measure when regional loads have increased. This measure would be more practical for those countries with abundant hydropower.

Regulatory measures

Vehicle inspections

Introducing inspection for both road-worthiness and emission levels would encourage motorists to service their vehicles regularly and thus maintain high fuel efficiency. Garage owners estimate that a 10% improvement in efficiency is possible. The potential GHG reduction estimated for vehicles in Botswana alone was found to be up to 500,000 tonnes of CO₂ equivalent in 2030 (at less than US$ 1/tonne reduced).

Technical and economic potential of these measures

Table 2 summarizes the technical and economic potential of selected transport measures that could be implemented in the ESA region. The technical potential of the measures considered above could translate into an average annual GHG reduction of 2.5 million tonnes of CO₂ equivalent, with over 75% implementable (at less than US$ 10/tonne of CO₂ equivalent reduced). When translated into petroleum fuels and into money terms, as much as US$ 500 million could be saved annually in a region strapped for foreign currency. More could be realized through increasing the scope and number of transport measures. Reduced pollution would also contribute significantly to the benefits.

Financing

Serious consideration needs to be given to how such transport measures could be implemented, in view of the lack of financial resources in these countries. The UNFCCC foresees a financial mechanism providing grant and concessional funds to recipient countries for projects and activities aimed at protecting the global environment, through the Global Environment Facility (GEF). The introduction of the GEF’s Operational Programme 11 for transport measures is a welcome development that could address a number of transport needs in developing countries. What is most critical about GHG emission reduction measures aimed at the transport sector is estimating with a reasonable degree of accuracy the energy savings to be achieved through various actions. It is difficult to quantify the global benefits resulting from many measures, although it is understood that GHG emission reductions will be achieved.

The situation in developing countries such as those in East and Southern Africa is aggravated by poor transport data and lack of resources for monitoring such data. GEF OP 11 could be used to develop appropriate data for analyzing transport activities, as well as to stimulate the demand for such measures through demonstration projects. A lot can be learned, and management skills developed, through such GEF activities. There should be more emphasis in GEF financing on measures involving intricate data analysis with respect to achieved energy savings. The majority of measures in the infrastructure, energy efficiency and regulatory categories would be best addressed by this source of financing.

Furthermore, the Kyoto Protocol foresees flexible mechanisms such as the Clean Development Mechanism (CDM) and Joint Implementation (JI). Since these mechanisms require verifiable emission reductions, it would best to target measures for which GHG emission reductions could easily be calculated, as in the case of fuel substitution and infrastructure (e.g. pipeline) options. Projects could also involve corridor transport studies, where traffic monitoring is possible and modal shares can be estimated, allowing projections of demand for transport services and of GHG emissions avoided when improvements are made to corridor systems.

The developmental approach, whereby transport project activities are implemented as part of an integrated transport planning process, will yield potential GHG emission savings but probably not be good enough as CDM and JI projects.

In light of these financing mechanisms, transport measures should be aimed at providing efficient transport services and reducing GHG emissions, while the international community is expected to shoulder the greater portion of the financial investment burden.

In addition to current financing from multilateral lending agencies such as the World Bank Group (IBRD,
Sustainable mobility

the International Finance Corporation) and the African Development Bank, and from Official Development Assistance, a number of private sector financing options could be used to create transport infrastructure. These include “Build, Operate and Transfer” (BOT) and “Build, Operate, Own and Transfer” (BOOT) for new infrastructure, and “Finance, Rehabilitate, Operate and Maintain” (FROM) for rehabilitation of substandard transport infrastructure. Both local and international investors can inject their financial resources – local or foreign – and earn a return on their investment through the sale of services.

The various financing mechanisms need to be combined, maximizing the merits of each of them.

Institutional and legal framework
Transport measures that qualify as projects need to be marketed. Hence, institutions should be equipped to do business in this area. A legal framework is also required to ensure regulation of players, which will include the private sector, and to predetermine how the economy will benefit from such projects.

A concerted effort is required if ESA countries are to realize anticipated potential financial and technological benefits. This includes:

- establishment of information centres for financial sources, technologies, practices and management skills;
- a common agreed criteria for categorizing transport measures with respect to various financing mechanisms; and
- stressing direct involvement of regional expertise in the development of transport measures, to ensure the sustainability of technology absorption and the potential for upgrading such technologies in the future.

Deficiencies in both human resources and institutional capacity must be addressed, in order to make implementation of such transport measures possible.

East and Southern African countries should therefore have deliberate policies to strengthen their institutions, create a conducive legal framework for introducing these measures, develop the necessary human capacity, and institute relevant research and development.

Conclusions and recommendations

Conclusions

- Sustainable transport mobility can be realized in ESA countries by employing some simple and readily available technologies and practices already existing in the region. A good number of these measures are related to improvement of transport infrastructure and fuel substitution;
- Sustaining transport mobility would also require a measure of energy self-sufficiency to ensure security of supply in light of the behaviour of the international cartel constraining global supply. Use of regionally available energy fuels such as CNG, ethanol and hydro-based electricity could be developed;
- Since most of the measures presented in this paper can reduce greenhouse gas emissions, they can attract UNFCCC funding. These measures could also attract private sector financing when considered as service investments. Transport measures, in this regard, would limit debt accumulation and erosion of scarce foreign reserves/earnings;
- For all these measures to be implemented, domestic preparations for adopting and sustaining good practices are imperative.

Recommendations

- ESA countries should be in a position to appraise various related transport measures as preparation for developing projects. GEF OP 11 funds could be applied for this purpose;
- Domestic institutions also need to match appraised projects with various financing sources;
- Conducive policies should be put in place to encourage both UNFCCC and private sector investments in transport;
- Possibilities on how to create employment through implementation of transport measures. An example is to involve communities in provision and maintenance of low level infrastructure like pedestrian and cyclist paths;
- It is also important to explore regional cooperation with respect to tapping, storing and distributing regional energy resources such as CNG, ethanol and hydropower.

Notes

Strategies to achieve sustainable mobility involve promoting public transport, increasing the share of transport modes that do not consume fossil fuels, reducing trip length, and promoting clean fuel technology for motorized modes, including public transport. The majority of trips in large Indian cities are made by non-motorized or public transport. However, these cities have unacceptable air pollution levels and peak hour congestion, along with high fatalities in road traffic accidents. Furthermore, trip lengths tend to be short partly because a large number of people are forced to live close to their workplace in "unauthorized settlements".

Such transport patterns cannot be described as sustainable. They suggest that dependence on environment-friendly modes of travel exists in these cities since a large section of the population does not have any other option. In fact, the trend over the last 20 years shows that with increases in real incomes use of motorized private transport (cars and two-wheelers) also increases.

Even with subsidies, use of public transport remains cost-prohibitive for much of Delhi’s population. Assuming a minimum of four trips using public transportation per household per day, at Rs. 4 (US$ = Rs. 40) per trip the household would need to spend a minimum of Rs. 160 per month per person for 20 working days. In the case of low-income people living on the outskirts of the city, the cost per trip may be Rs. 8-10, depending on the number of transfers. On average, a household cannot spend more than 10% of its disposable income on transportation. This implies that monthly household income needs to be at least Rs. 3200 for the public transport system to be used at minimum rates. A 1994 survey found that the monthly income of approximately 28% of households in Delhi is under Rs. 2000. In outer areas, the presence of non-motorized vehicles (NMVs) and pedestrians on some important inter-city highways with comparatively long trip lengths demonstrates that many people use these modes not out of choice, but rather because they lack other options.

Since commuting to work is necessary for survival, people continue to use these modes despite a hostile physical environment, high risk, and inconvenience. Pedestrians and bicyclists are the most vulnerable group with respect to traffic fatalities. Figure 1 shows the proportion of trips made by different modes in Delhi and the distribution of fatalities. The risks are greatest for bicyclists and lowest for bus users, although there are no estimates concerning fatalities associated with access to cars or buses. Bus commuters are often killed or injured when entering or leaving the bus, or when they fall off a moving bus (there are no doors on Delhi’s public buses). If deaths associated with access to buses were included in the statistics, the number of bus commuters killed would be higher than is shown in Figure 1.

The risks associated with bus travel must deter private vehicle owners from using public transport. At present in Delhi, 62% of all motorized trips are made by bus. This share is likely to decrease as incomes increase. If it were maintained at present levels, the safety of commuters as bus users, bicyclists and pedestrians would need to be improved.

**Priorities for improving transport infrastructure**

Infrastructure policies do not adequately recognize the needs of public transport and NMVs. Investments in transport improvement plans continue to focus on projects that benefit car users at the cost of environment-friendly modes.

In 1997, the Government of India prepared a White Paper on pollution in Delhi. Subsequently an Environmental Pollution Control Authority (EPCA) was set up for the city. EPCA’s policy recommendations have been driven by environmental concerns aiming to achieve better speeds for motorized vehicles and less polluting fuels. These include the following:

- construction of expressways and grade-separated intersections;
- introduction of one-way streets, and of synchronized signals and area traffic control systems;
- construction of a metro rail transport system;
- phasing out of older buses and increasing the number of buses; and
- running the entire bus fleet on compressed natural gas (CNG).

Experiences from several cities suggest that construction of more high-capacity roads could have the unintended effect of reducing public transport and bicycle use, without increasing vehicle speeds or reducing congestion. Reductions in bus and bicycle use would result in higher pollution levels and possible increases in traffic congestion. No detailed studies have been carried out in order to understand the effect of these changes on road user behaviour in cities in low-income countries. It is possible that construction of high-capacity roads in these countries, at the expense of facilities for public transport and non-motorized traffic, may make things worse for everyone.

**Socio-economic burden on the urban poor**

The urban poor comprise almost 50-60% of the population in the cities of the South. In a recent survey in Delhi's slums, the residents noted that commuting to work is the most dangerous aspect of their work. Low-income households also spend a larger share of their income on transport, thus affecting other needs such as food, shelter and health. They are more vulnerable to events such as traffic accidents since they have no savings or any other social network. For this group, the economic and emotional costs of a traffic accident is enormous; there have been instances of families being forced to sell their meager assets, give up their temporary jobs, and take out loans that require a lifetime to repay.

**Avoided costs due to investments in bicycle/NMV friendly infrastructure**

Providing a separate bicycle/NMV track would make more space available for motorized modes, as well as making bicycling less hazardous. Our studies in Delhi show that on urban arterials the kerbside lane (3.5 metres) is used primarily by bicycles and other NMVs. Buses, which are unable to use this lane, are therefore forced to stop in the middle lane at bus stops. Motorized traffic does not use the kerbside lane even when bicycle/NMV densities are low. A segregated bicycle lane requires only 2.5 metres. Since most of Delhi's major arterials and those of many other Indian cities have a service road, the existing road is wide enough to accommodate a bicycle track without the need for additional right of way.

The 1998 Bicycle Master Plan for Delhi shows how existing roads could be redesigned in conformity with the given right of way to provide an exclusive lane for NMT modes (bicycles and three-wheeled rickshaws). Figures 2 and 3 show designs for arterial roads with integrated NVM lanes, along with dedicated lanes for buses, pedestrian paths and service roads. These designs benefit all road users.

[continued on page 48]
**Sustainable mobility**

**Increased capacity**
If a separate lane is constructed for bicycles, the kerbside lane becomes available to motorized traffic. This relatively small investment in bicycle lanes can increase the road space for motorized traffic by 50% on three-lane roads. Motorized vehicles benefit from improved road capacity and higher speeds. Capacity estimates for a typical arterial road in Delhi\(^4\) show improvements of 19-23%. If the corridor’s full capacity is utilized, with provision of a high-capacity bus lane in the kerbside lane, capacity improvements of 56-73% are possible (from a present carrying capacity of 23,000 passengers/hour to 45,000 passengers/hour).

**Improved speeds**
Buses and two-wheelers benefit from higher average speeds because the kerbside lane becomes available to them without interference from slow vehicles. On a typical arterial corridor in Delhi,\(^5\) overall time costs are estimated to be reduced by 48% due to a 50% improvement in bus speeds (from the present 15 km/hour to 30 km/hour) and a 30% improvement in the speeds of cars and two-wheelers.

**Reduced congestion**
Delhi and other Indian cities have invested in grade-separated junctions and fly-overs as one of their major congestion relief measures, at an average cost of Rs. 100-300 million for each intersection. However, detailed simulation of a major intersection in Delhi shows that replanning the junction to include separate NMV lanes and a bus priority lane could result in an 80% improvement over the present level of delays. The cost of this measure is 25 times less than that of the proposed grade-separated junction.\(^6\)

**Increased safety**
By creating segregated bicycle lanes and redesigning intersections, safety benefits estimated for a typical arterial in Delhi show a 46% reduction in accident costs through reducing accident injuries by 40% and fatalities by 50%.

**Reduced pollution and energy consumption**
Energy consumption and pollution are reduced since motorized vehicles drive more smoothly and faster. Estimations for the Delhi corridor show a 28% reduction in fuel consumption and a 29% reduction in health externalities related to air pollution.\(^7\)

**Induced bicycle trips**
There are approximately 1 million households in the middle- to high-income category. If the average number of trips per household is two per day, at least 10% of these trips, especially by schoolchildren and young adults, could be new bicycle trips for recreation and school journeys. This group would benefit from expanding their opportunities to participate in different activities. It is difficult to express this benefit in money terms, however.

**Vulnerable road users: the “critical element” in the city transport fabric**
Urban transport systems in cities in developing countries can become sustainable, providing mobility with minimal adverse environmental effects, only if there is safe and affordable transport for all sections of the population. Nearly 50% of these cities’ population needs to live near their place of employment. They also need inexpensive modes of travel in order to work to survive. If the planned transport system does not meet their travel needs, they are forced to live in sub-optimal conditions. They continue to live in places that were not planned for them. Consequently, land use and transport plans are violated and all transport modes operate under sub-optimal conditions.

The experience of the past decades of long-term integrated land use transport planning suggests that the existence of the informal sector and its travel needs must be recognized in preparing effective plans. This should encourage mixed land use patterns, and transport infrastructure especially designed for bicycles and other non-motorized modes.

**Notes**