Division 44
Environment and Infrastructure
Sector project "Transport Policy Advice"

Sustainable Transport:
A Sourcebook for Policy-makers in Developing Cities
Module 4f

EcoDriving

Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

commissioned by:

Federal Ministry
for Economic Cooperation
and Development

Overview of the Sourcebook

Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities

What is the Sourcebook?

This *Sourcebook* on Sustainable Urban Transport addresses the key areas of a sustainable transport policy framework for a developing city. The *Sourcebook* consists of more than 20 modules.

Who is it for?

The *Sourcebook* is intended for policy-makers in developing cities, and their advisors. This target audience is reflected in the content, which provides policy tools appropriate for application in a range of developing cities.

How is it supposed to be used?

The *Sourcebook* can be used in a number of ways. It should be kept in one location, and the different modules provided to officials involved in urban transport. The *Sourcebook* can be easily adapted to fit a formal short course training event, or can serve as a guide for developing a curriculum or other training program in the area of urban transport. GTZ is elaborating training packages for selected modules, being available since October 2004.

What are some of the key features?

The key features of the *Sourcebook* include:

- A practical orientation, focusing on best practices in planning and regulation and, where possible, successful experience in developing cities.
- Contributors are leading experts in their fields.
- An attractive and easy-to-read, color layout.
- Non-technical language (to the extent possible), with technical terms explained.
- Updates via the Internet.

How do I get a copy?

Please visit http://www.sutp.org or http://www.gtz.de/transport for details on how to order a copy. The *Sourcebook* is not sold for profit. Any charges imposed are only to cover the cost of printing and distribution. You may also order via transport@gtz.de.

Comments or feedback?

We would welcome any of your comments or suggestions, on any aspect of the *Sourcebook*, by e-mail to transport@gtz.de, or by surface mail to:

Manfred Breithaupt
GTZ, Division 44
P. O. Box 5180
D - 65726 Eschborn / Germany

Further modules and resources

Further modules are anticipated in the areas of *Financing Urban Transport*; *Benchmarking*; and *Car Free Development*. Additional resources are being developed, and an Urban Transport Photo CD-ROM is available.

Modules and contributors

Sourcebook Overview and Cross-cutting Issues of Urban Transport (GTZ)

Institutional and policy orientation

1a. *The Role of Transport in Urban Development Policy* (Enrique Peñalosa)
1b. *Urban Transport Institutions* (Richard Meakin)
1c. *Private Sector Participation in Transport Infrastructure Provision* (Christopher Zegras, MIT)
1d. *Economic Instruments* (Manfred Breithaupt, GTZ)
1e. *Raising Public Awareness about Sustainable Urban Transport* (Karl Fjellstrom, GTZ)

Land use planning and demand management

2a. *Land Use Planning and Urban Transport* (Rudolf Petersen, Wuppertal Institute)
2b. *Mobility Management* (Todd Litman, VTPI)

Transit, walking and cycling

3a. *Mass Transit Options* (Lloyd Wright, University College London; Karl Fjellstrom, GTZ)
3b. *Bus Rapid Transit* (Lloyd Wright, University College London)
3c. *Bus Regulation & Planning* (Richard Meakin)
3d. *Preserving and Expanding the Role of Non-motorised Transport* (Walter Hook, ITDP)

Vehicles and fuels

4a. *Cleaner Fuels and Vehicle Technologies* (Michael Walsh; Reinhard Kolke, Umweltbundesamt – UBA)
4b. *Inspection & Maintenance and Roadworthiness* (Reinhard Kolke, UBA)
4c. *Two- and Three-Wheelers* (Jitendra Shah, World Bank; N.V. Iyer, Bajaj Auto)
4d. *Natural Gas Vehicles* (MVV InnoTec)
4e. *Intelligent Transport Systems* (Phil Sayeg, TRA; Phil Charles, University of Queensland)
4f. *EcoDriving* (VTL; Manfred Breithaupt, Oliver Eberz, GTZ)

Environmental and health impacts

5a. *Air Quality Management* (Dietrich Schwela, World Health Organisation)
5b. *Urban Road Safety* (Jacqueline Lacroix, DVR; David Silcock, GRSP)
5c. *Noise and its Abatement* (Civic Exchange Hong Kong; GTZ; UBA)

Resources

6. *Resources for Policy-makers* (GTZ)

Module 4f

EcoDriving

About the authors

VTL is the largest specialised training institute in the Netherlands for the transport and logistics sector. It provides professional and vocational training for entrepreneurs, managers and employees in the sector for goods and passenger transport by land, water and air. For a large part of the vocational education programmes VTL also acts as collective employer.

Manfred Breithaupt received his Masters in Economics in 1975. After working as Transport Economist for a German consulting company in Europe, Africa and Asia he joined GTZ in 1981 and has since served as Senior Transport Advisor. His experience covers transport planning, transport sector policy and restructuring, mode specific technical assistance (including urban transport), and privatisation and commercialisation. He also works as an Assistant Professor for transport planning and policy.

Oliver Eberz studied Geography in Frankfurt and Roskilde/Denmark and is a specialist for urban transport, urban planning and international aviation geography. He joined GTZ as a freelance expert for Sustainable Urban Transport Development in 2002 and has also contributed to other work in the area of urban transport.

Written and compiled by:
VTL
Manfred Breithaupt (GTZ)
Oliver Eberz (GTZ)

Editor:
Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH
P. O. Box 5180
D - 65726 Eschborn, Germany
http://www.gtz.de

Division 44, Environment and Infrastructure
Sector Project "Transport Policy Advice"

Commissioned by
Bundesministerium für wirtschaftliche
Zusammenarbeit und Entwicklung (BMZ)
Friedrich-Ebert-Allee 40
D - 53113 Bonn, Germany
http://www.bmz.de

Manager:
Manfred Breithaupt

Editing:
Manfred Breithaupt, Oliver Eberz

Cover photo:
Jürgen Meissner, ÖkoMedia PR
Driver training in Querétaro, México, April 2005

Layout:
Klaus Neumann, SDS, G.C.

Eschborn, June 2005

1. Introduction

In cities in developing countries, public transport is often the only affordable way of transportation for the majority of people. Only a few cities in these countries operate a subway system, and public transport most often relies on buses. Even in Bangkok, for example, a city with meanwhile two railbound urban public transport systems (BTS and MRT), still over 90% of all public transport is handled by buses. These buses, often old and fuel-intensive, are a major contributor to the negative environmental impacts in the urban areas, and due to their age, operating costs (fuel consumption, maintenance) are high. A reduction of costs can be reached by various measures, among them an upgrade of the fleet to new and more fuel-efficient vehicles, and/or by a change of the driving style of the vehicles' drivers.

However, the reduction of fuel costs is not the only effect of an economical driving style. It also means

- a reduction of variable costs (fuel, repairs, maintenance, tyres),
- an increase of effectiveness (less down times due to repair work and maintenance),
- a decrease of negative environmental impacts,
- increased road safety,
- stress reduction for the driver and the passengers.

The driver of a vehicle is directly responsible for a more economical driving style. But he is not the only one in the chain of actors involved in transport to influence fuel consumption. Manufacturers, legislators, driving schools and vehicle holders – they all can influence the fuel consumption of vehicles in various ways.

This module mainly covers three topics:

- What does "driving defensively and economically" mean?
- What are the benefits of a more economical and defensive driving style?
- How can this driving style be achieved?

The first topic "driving defensively and economically" will cover the following subjects:

- cost savings to be achieved through driving economically (see also section 3.1),
- specific fuel consumption,
- external factors affecting fuel consumption, such as weather conditions, road conditions and traffic conditions,
- the vehicle and its fuel economy features,
- the driver's influence on fuel consumption,
- general hazards (driver behaviour, vehicle, load, weather),
- stress, and
- customer-oriented behaviour.

The second topic deals with the advantages of economical driving for the operator, the driver and the environment.

The third topic (how can this be achieved?) deals with different options to convey this driving style to drivers and operators of commercial vehicles.

The basic source of information for this module is the course reference guide "Het Nieuwe Rijden (A new approach to coach driving)" published by the "Stichting Vakopleiding Transport en Logistiek VTL" (The Netherlands Institute for Professional Training in Transport and Logistics).

Fig. 1
Mongolia: Responsibility and efficiency starts by learning beyond usual practice.
Photo: Anton Thomas, DaimlerChrysler, 2005

2. What is EcoDriving?

Economical and defensive driving not only depends on the habits of the driver (see section 2.3) but it is also dependent on various external factors such as weather conditions, road conditions, vehicle technology and traffic conditions. Most of these factors can normally not be influenced – but drivers can adjust their driving style accordingly. Therefore, it is important to be aware of these factors.

2.1 External factors

2.1.1 Traffic conditions

Traffic conditions obviously have a major influence on fuel consumption. In heavy traffic, e.g. during the rush hour, the driver has to accelerate, brake and change gear more often. This significantly increases fuel consumption. As a matter of fact, a single driver cannot change these circumstances but planners and decision-makers could change this situation, e.g. by introducing bus lanes, bus priority at traffic lights and other innovations. Examples are described in Module 4e: *Intelligent Transport Systems*.

Fuel consumption is in part determined by the degree of acceleration resistance. This occurs when the speed of a vehicle is raised. To put a vehicle into motion or to raise the speed requires energy while at a constant road speed the acceleration resistance is zero. The acceleration resistance is dependent upon the increase in speed and the total weight of the vehicle. A gentle acceleration and, above all, the avoidance of unnecessary acceleration and braking can save an enormous amount of fuel.

Anticipating traffic is a major factor reducing fuel consumption. But what is an anticipatory driving style? First of all, the driver should learn to predict what other participants in city traffic are about to do and how to react accordingly.

Anticipatory driving is safe driving but also economical driving.

Table 1 shows the relation between driving styles and fuel consumption:

The different driving styles assumed in this example are:

A: an aggressive driving behaviour: rapid acceleration, driving close to the vehicle in front and heavy braking

B: a normal driving behaviour

C: a gentle driving behaviour, with gentle acceleration, anticipation and minimal braking

The figures in Table 1 are averages of bus journeys along different routes:

- driving in urban traffic at an average speed of 30 km/h,
- driving on a secondary road at an average speed of 60 km/h,
- driving on a highway at an average speed of 90 km/h.

Unsurprisingly, fuel consumption is much higher when the driving style is more aggressive. In this case fuel consumption is 45% higher than the consumption of the "normal" driver. On the other hand, a more gentle style of driving can reduce fuel costs significantly, in the study the "gentle" driver saved 22% compared to the normal driver.

Table 1: Fuel consumption at different driving styles

	Light bus (8.8 tons)		Heavy bus (24.5 tons)	
Driving style	l/100 km	indexed	l/100 km	indexed
A: aggressive	37.8	143	101.5	145
B: normal	26.5	100	69.9	100
C: gentle	21.0	79	54.5	78

Source: VTL 2002

2.1.2 Road conditions

Two aspects of the road conditions influence fuel consumption: the surface and the inclination.

The road surface has an effect on the rolling resistance. Relevant surface conditions include:

- metalled or unmetalled road,
- dry or wet road surface,
- smooth or rough, uneven road surface,
- clean or dirty road surface (including snow).

High rolling resistance increases fuel consumption. As can be seen from the list above, rolling resistance is influenced by weather conditions, which is therefore determined by a combination of different factors. But it is also affected by other factors such as:

- the weight of a vehicle,

- tyre profile,
- tyre pressures,
- wheel positions.

2.1.2.1 Gradient resistance

It is self-evident that a vehicle driving up a hill requires more energy than a vehicle driving on a flat road. This results from the gradient resistance, which is dependent upon the percentage gradient and the total weight of the vehicle.

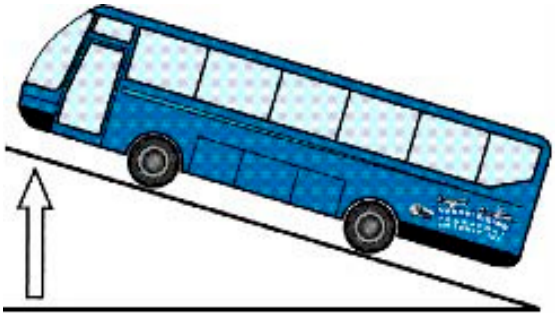


Fig. 2
Gradient resistance
Source: VTL 2002

Although it is not possible to influence the gradient resistance, drivers can take account of it. An economical driving style on a hill consists of:

- selection of the correct engine speed,
- correct shifting technique (change gear as little as possible when ascending), and
- use the increase in speed on a descent to mount the next rise.

2.1.3 Weather conditions

The influence of weather conditions on fuel consumption is mainly determined by three factors: air resistance, temperature and precipitation.

The main meteorological influence on fuel consumption is air resistance (see Figure 3). Air is not touchable or viewable but it is present – and how strong this factor is can be felt when you hold your arm out of a moving vehicle and try to push the arm forward, or when crosswinds hit a vehicle and push it aside. The vehicle has to "cross" the air barrier and to do so it needs energy and consumes fuel. Air resistance is dependent on the front shape of the vehicle, i.e. buses with the relatively large and flat front surface have a high air resistance. Air resistance increases raises in quadratic form, i.e. when the speed is doubled air resistance increases by the factor 4.

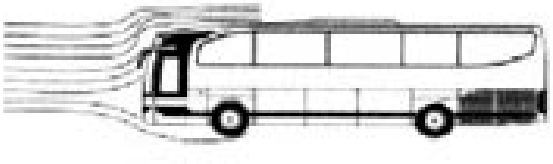


Fig. 3
Air resistance
Source: Evobus 2001

Other meteorological factors are temperature (higher temperatures may lead to a slightly lower fuel consumption unless air condition is used inside the bus) and the precipitation (wet and snowy surfaces increase the rolling resistance and lead to higher fuel consumption).

In this section we have seen that fuel consumption is influenced by a variety of external factors. These factors are determined by various resistances (air, rolling, gradient and acceleration resistance). The value of these resistances is determined by weather, road and traffic conditions. The technical specifications and the equipment of vehicles also have an effect on these resistances. These effects will be the subject of the next section.

2.2 The vehicle

2.2.1 Tyres

2.2.1.1 Tyre tread

The tread of a tyre has the following purposes:

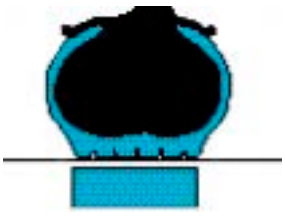
- to transfer forces between the vehicle and the road surface,
- to carry off water and contamination, and
- to cool the tyre.

Tyre conditions are often neglected and only little attention is paid to their maintenance. Legal requirements for minimum tread depths vary from country to country, however, a sufficient depth should not only be seen as a legal requirement but also as a factor that influences driving comfort, fuel consumption and – last but not least – traffic safety.

2.2.1.2 Tyre pressure

Tyre pressure is the most significant factor in tyre wear. With low tyre pressure (Figure 4, left

Figure 4: Tyre pressures



Pressure too low	Pressure too high	Correct pressure
• Tread is deformed • Temperature soars • Carcase may fail • Rapid and uneven wear • Poor ride stability	• Poor contact with road surface • Risk of damage • Springs and dampers are overloaded	• Driving, braking and lateral forces are optimally transferred to the road surface • Braking distance is at its shortest • Tyre durability is at the maximum

Source: VTL 2002

part), the carcass of the tyre collapses and the tyre shoulders wear rapidly. Deformation raises the temperature to such levels that the tread may be separated from the tyre. Low tyre pressure also has a negative effect on ride stability. Furthermore, when pressure is too low, tyres do not maintain optimal contact with the road which negatively affects rolling resistance.

If the tyre pressure is too high (Figure 4, middle part), only the middle part of the tyre wears and contact with the road is poor. This also leads to an overload of springs and dampers and thus affects driving comfort and safety.

Excessively low tyre pressures cause higher fuel consumption than do high pressures. When the pressure of all tyres of a vehicle is too low by 15-20% fuel consumption increases by 5-8%.

Besides tyre pressure and the depth of the tread, other factors influence the wear of the tyre as well:

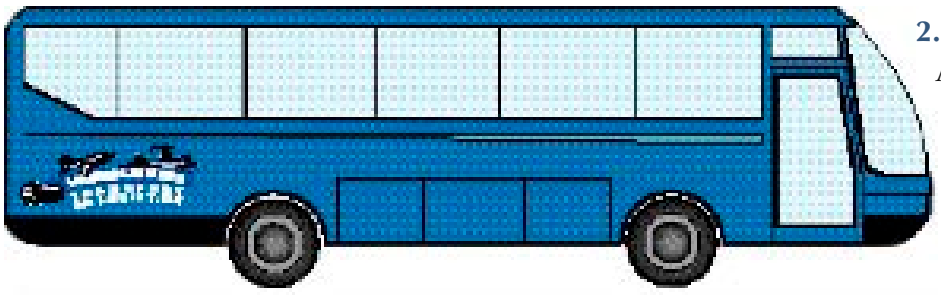
- an aggressive driving style, e.g. heavy braking and acceleration,
- overloading, and
- inaccurate wheel alignment.

2.2.2 The engine

The engine is the heart of a motorized vehicle. The diesel engine supplies power to drive the vehicle and all its accessories. The performance of the engine may be enhanced with the use of a turbo compressor and intercooling without increasing fuel consumption. Modern diesel engines are far cleaner than it was the case in the past, i.e. a modernization of the fleet with new buses will decrease average fuel consumption significantly and pay off in the long run.

Regular maintenance is important for all engines – both old and new ones – in order to ensure an economical operation. For example, correct injection timing and the changing of inlet air filters should be done according to the recommendations of the engine manufacturer as these recommendations result in the best compromise between performance, emissions and fuel consumption.

Fig. 5
Aerodynamic bus design



2.2.3 Aerodynamics

Air resistance has been introduced in section 2.1.3. A streamlined bus can thus be a contribution to reduced fuel consumption.

2.3 The driver

As we have seen, external factors can have a huge influence on fuel consumption. But all these measures can be worthless if the driver has an aggressive, fuel consuming driving style.

In the next sections we will elaborate on the different measures that a driver can carry out before and during the journey to reduce fuel consumption and to increase both the comfort and the safety of the passengers and himself.

2.3.1 Trip preparation

Before the commence of the trip, the driver should check his vehicle carefully. Even though most buses should be maintained by technicians on a regular base, the driver is also in charge of regular basic checks. A proper check will include the following:

- Fluids:
  - engine oil
  - coolant
  - screen wash
- Tyres:
  - check for rips and stones
  - tyre pressures
  - spare wheel
- Braking system
  - check pressure and pressure drop
  - bleed off condensation water
- Lighting and mirrors
  - check and clean as required

2.3.2 During the trip

Though pre-trip checks can already save a certain amount of fuel, the major part of fuel savings can be realised by a reasonable driving style.

2.3.2.1 Starting and moving off

When starting the engine for the first time of the day, the driver should allow the engine to run at a moderate speed until the correct oil pressure has built up. The cold (and therefore thick) oil must reach the various lubrication points in the engine before the driver can move off without causing damage.

Once the oil pressure has built up, the driver should move off gently. A cold engine wears faster than a warm engine – particularly at high engine speeds. This is due to the fact that pistons and cylinders are designed to fit best with a warm engine. When the engine is cold the metal has not yet expanded, the pistons and cylinders do not fit together so well and extra wear results. A VTL study showed that driving with a cold engine uses about 15% more fuel than with a warm engine. Table 2 presents results from tests at an average speed of 40 km/h.

Table 2: Fuel consumption when starting with a cold or a warm engine

	Light bus (8.8 tons)		Heavy bus (24.5 tons)	
	in l/100 km	indexed	in l/100 km	indexed
Cold	21.6	100	49.6	100
Warm	18.5	86	42.8	86

Source: VTL 2002

When the vehicle is stationary, the engine warms up only very slowly. A gentle driving style brings the engine to its operating temperature much more rapidly. Depending on the specific circumstances, a vehicle must be driven for about 30 km before its engine is properly warmed up. The driver should move off in the first gear with few gas or – when driving a newer model – without gas.

If the driver has to stop and wait for a longer time (e.g. at a railway crossing), it is wise to switch off the engine. This is not only better for the environment but it also saves fuel. A rule of thumb is to switch off the engine when the vehicle has to stand still for more than a minute. In more and more cities, the duration of the red phase at traffic lights is displayed on little monitors next to the traffic lights.

Fig. 6
Bogotá: Bus driver at TransMilenio bus.
Photo: Lloyd Wright 2002

Fig. 7
Bogotá: To drive consciously is a prerequisite for an economic driving.
Photo courtesy of TransMilenio 2002

2.3.2.2 Speed

To drive economically means to drive at a constant road speed as often as possible (although this is difficult to realize in urban traffic). A constant speed is not the same as the average speed. Driving an average speed of 40 km/h might consume much more fuel than a constant speed of 40 km/h as an average speed of 40 km/h with an aggressive driving style and a lot of acceleration and braking is far more fuel-consuming than a constant speed of 40 km/h. The difference in fuel consumption at an average speed and at a constant speed may amount up to 20% (VTL 2002).

Fig. 8
Argentina: After the theoretical driver training the acquired knowledge and skills are checked in the practice.
Photo: Julio Brizzi 2004

2.3.2.3 Anticipation

An anticipatory driving style involves matching the driving behaviour to the road and traffic conditions. Points to consider include:

- traffic in front of the own vehicle,
- traffic behind the own vehicle,
- oncoming traffic,
- traffic at intersections,
- overtaking, and
- reversing.

It also means, that the driver

- looks as far ahead as possible,
- drives with concentration,
- brakes deliberately,
- looks out for the vehicle in front,
- keeps an adequate distance,
- drives smoothly at a constant speed,
- adapts in good time to changing conditions,
- uses his knowledge of the route,
- takes account of road damage and of possible errors of other drivers.

2.3.2.4 Gear changing

To change the gear correctly is a fundamental part of an economical driving style. Changing up must be carried out in such a way that the engine can deal with the new gear. In practice, this means to allow the engine speed to pass through the green zone on the rev meter and then change. Conversely changing down should be done when the rpm needle reaches the bottom of the green zone.

Changing gears economically also means:

- it is not necessary to drive off in the lowest gear,
- changes to a higher gear should be carried out as soon as possible,
- it is sometimes possible to skip a gear.

2.3.2.5 Braking and coasting

The driver should avoid braking when it is possible to ease off the accelerator in good time and he should allow the coach to coast. Coasting

means releasing the accelerator pedal and using the engine as a brake, e.g. when approaching red lights or the end of a traffic jam.

When using the engine as a brake, the fuel supply is cut off. This saves fuel and prevents unnecessary wear to brakes and tyres. In section 2.3.2.2 have already been discussed the effects of frequent braking on fuel consumption.

2.3.3 Joining and leaving the traffic flow

In urban traffic, it is sometimes difficult to drive economically when joining and leaving the traffic flow. Often it may be necessary to accelerate stronger to join the traffic flow, e.g. when turning into a major road or merging with a "faster" lane. In this case road safety has priority.

2.4 Defensive driving

In the previous sections we have elaborated mainly on the technical measures to save fuel. These actions may lead to an economical style of driving (and a reduction of fuel consumption), but this does not necessarily lead to a more defensive style. Stated briefly, driving defensively can be described as: Predicting what others may do and reacting accordingly.

In order to adopt a defensive driving style, it is important that the driver knows his vehicle and that he takes into account his own situation, the capabilities and limitations of his bus, the road conditions and possible errors of others. A defensive driving style will not only avoid accidents, but it will also lead to a reduction in maintenance costs and fuel consumption, as well as to a more comfortable working environment for the driver and increased customer satisfaction.

The basic rule for a defensive driving style is to react accordingly. The "normal" working procedure of a vehicle driver is as follows: Observation ⇨ prediction ⇨ evaluation ⇨ decision ⇨ action.

Observation means: to look consciously and to process whatever information is necessary to solve the traffic problem

Prediction: what will the driver do and what will others do?

Evaluation: to estimate the effects of an action (pro and cons)

Decision: to decide the correct action (solution)

Action: the (re-)action the driver will execute.

Defensive driving begins by acting in accordance with these steps. But of course this does not mean that the driver should park his vehicle and take a time-out to thoroughly follow this procedure step by step. The idea is rather that the driver should simply be aware of these steps – but when he actually takes a decision this happens so quickly that with experienced drivers it may appear to be an automatic process. The foundation of defensive driving can be described with "think before you act".

2.4.1 The working procedure and defensive driving behaviour

The traffic speed requires the driver to (re-)act quickly and without lengthy consideration. This makes defensive driving so important. The driver has to be continually alert to risks, such as weather conditions, the behaviour of others, the capabilities and limitation of the bus, fatigue and so on. The driver has to be able to "foresee upcoming situations", for instance he should keep in mind that his range of vision behind or alongside his bus is limited, that cyclists may turn off without signalling, that children may suddenly run on the road or that motorcyclists sometimes travel too fast. Taking these factors continually into account can be expressed in a single word: anticipation (see section 2.3.2.3 and Figure 9).

Fig. 9
Jakarta: Stopping far from the curb makes embarking and disembarkung of the bus unecessary uncomfortable.
Photo: Karl Fjellstrom

The aim of defensive driving is to be one step ahead of the other road users, using the driver's road sense and experience to anticipate his driving behaviour and thereby avoiding hazardous situations.

But this anticipation makes certain demands on the driver:

- concentration,
- good observation,
- consideration, and
- constant alertness
  (which allows more time for taking decisions).

2.5 Common hazards

A driver of a vehicle can drive defensively and carefully, nevertheless there are common hazards occurring on the road.

2.5.1 Driver behaviour

The driver should take into consideration that not every driver is as educated and experienced as a commercial bus driver. A driver of a normal car, a bicycle, a motorbike or a pedestrian does not have the knowledge of the special features of a bus. The stopping distance of a 10 tonne bus is far longer than that of a car, the manoeuvrability is limited and the range of vision for the driver is restricted in certain directions.

2.5.2 Stress and emotions

External factors can be hazards (as seen in the previous section), but also stress and emotions can be hazardous for the driver. The pressure on the driver is considerable: passengers must be picked up and delivered on time, the traffic is busy and the driver bears a weight of responsibility for the passengers. For bus drivers, a lot of external factors can cause stress: crowded buses with unsatisfied passengers, heavy traffic which causes delays, heat, bad weather or personal problems. All these factors might lead the driver to rush, to drive faster than is safe, to overlook things, to become aggressive in his driving or to become impatient for other road users' errors.

It is thus important for vehicle owners and operators to allow the drivers enough time between the stops so that they do not have to rush and bring passengers, the vehicle and themselves into danger. A driver who is not under stress the whole shift drives smoother, more economically and defensively.

Emotions might also be a hazard for the driver. A happy, angry or sad mood may influence the driving style. It is important to teach the driver to keep these moods out of the everyday working procedure.

Fig. 10
Jakarta: New buses consume less fuel than older models.
Photo: Manfred Breithaupt

Box 1: Fleet Management Systems in Hamburg

(http://www.ressourcenschutz-hamburg.de)

In Hamburg, companies that save energy by using fleet management systems receive financial grants from the Senate. These fleet management systems consist of two parts:

- monitoring equipment, installed in the vehicles to measure fuel consumption, speed and acceleration; and
- driver training courses.

With the data gained from the monitoring equipment, the drivers are urged to change and optimize their driving style. The Hamburg Senate calculated a reduction in fuel consumption of 5-10%.

The financial grant can be up to 30% of the costs of the installation of the fleet management systems and the costs for the driver training courses.

The following table shows the possible amortization of the implementation of a fleet management system:

Fleet		Reduction of emissions	
40 vehicles "Ford Sprinter"		Fuel reduction 8%	12,400 l Diesel
Mileage	25,000 km/driver	Avoidance of CO_2	31,612 kg
Total mileage	1,000,000 km		
Total fuel consumption	155,000 l Diesel		

Costs/amortization		Grant	
Investment for 40 monitoring systems	40,000 €	30% of investment (incl. Training courses)	16,080 €
Investment for 80 training courses (2x40)	13,600 €		
Total investment	53,600 €		
Cost saving Diesel	12,152 €		
Amortization:	4.4 years	Amortization with grant:	3.1 years

2.6 Fleet management

It is obvious that the vehicle should be in the best technical condition for the daily use. It does not make sense to teach the driver to drive defensively and economically when the vehicle has technical insufficiencies and the savings reached by implementing the new driving style are overcompensated by an increased fuel consumption caused by an inadequately maintained vehicle. Proper fleet management will ensure that vehicles are in a good condition, as well as that the size of the buses is always adapted according to passenger demand.

2.7 Road users requiring special attention

In many cities, pedestrians build a huge group of traffic participants. Some groups need special attention:

- the disabled,
- children and young people,
- the elderly.

2.7.1 The disabled

We can distinguish many different types of disabilities: poor hearing, poor vision or blindness, difficulties in walking or a complete inability to walk. These disabilities are often not identifiable at a glance, which is problematical not only for other road users but also for the disabled themselves. They are aware of their limitations and conscious that other road users may not take account of them. Therefore, if the driver of a vehicle sees that someone has a disability, he should be patient and give them a chance to go on their way.

2.7.2 Children and young people

Children and young people, just like the disabled and the elderly, have problems with traffic, often caused by their lack or absence of road sense due to their age. For this group a defensive driver should always expect the unexpected, as these young people are far away from being able to do what is necessary in traffic. They

Fig. 11
Bangkok: Pedestrian and cyclist on a bus lane.
Photo: Karl Fjellstrom

cross the street without looking out for traffic, they play and they follow their friends without noticing the traffic.

2.7.3 The elderly

Elderly road users, either walking, cycling or driving, need special attention. Older people do still fully participate in traffic although they have certain restrictions such as:

- they may see less clearly,
- they sometimes walk less easily,
- they are more easily surprised,
- they are more vulnerably to serious injuries in accidents.

Although most older people are aware of the dangers in city traffic, it is necessary to pay special attention to their behaviour as they may act and react in unexpected ways.

In some big cities in developing countries, the bicycle is a popular mode of transportation. Not only in these countries many older people use the bike as this may be easier for them than walking. When older people mount a bike they need more time, and when they start their journey there may be a few wobbles. Therefore, it is important for drivers of motor vehicles to allow a little more room when older cyclists head off. Besides these problems, turning off on a bike can be more complicated for older people than it is for younger cyclists. Older cyclists may have difficulties to look around. So if they turn off the road they might indicate but then don't dare look around. They are afraid of falling und just press on regardless. The same thing can apply to indicating as some older people are afraid to cycle using one hand only, so they may not indicate at all.

Older people usually have a different concept of speed. In a car, they often drive slower than other motorists do. This holds true for urban as well as for rural areas and on motorways. It is important to be patient, however, and to pass them only when it is safe to do so. In addition, the driver should not drive close up behind them as chasing them with a huge bus only makes them more nervous.

3. Advantages of driving economically

3.1 Advantages for the business

"Driving economically can save a considerable amount of money, especially regarding fuel, tyres, repairs and maintenance."

Fuel: Fuel costs can be reduced considerably by an economical driving behaviour. Although the share of fuel costs differs considerably from country to country (fuel prices in developing countries can vary from 2 US-Cent to 90 US-Cent), an economical driving style in general can save a significant share of operating costs.

Tyres: Besides the expenses for fuel, the cost to replace tyres is another important factor of expenses. With an economical way of driving (which means first of all smoother acceleration and braking), tyres wear less rapidly and thus have to be replaced less often. This leads to significant cost reductions. If the vehicle is driven more economically, the lifetime of tyres can be extended from 60,000 km to more than 140,000 km.

Repairs and maintenance: Driving economically does not only reduce the costs for fuel and tyres but also affects the overall expenses for repair and maintenance. A defensive and economical driving style results in fewer repairs and leads to reduced maintenance costs and an extended lifetime of the vehicle.

Insurance: A more economical way of driving indirectly leads to the adoption of a safer style of driving, which will reduce the overall frequency of accidents. With the decreasing amount of accidents, insurance costs will fall in the long term and no-claims bonuses may rise considerably. This is another saving resulting from economical and defensive driving (although not in every country insurances offer no-claims bonuses).

3.2 Advantages for the environment

As we have seen by now, an economical and defensive style of driving leads to a reduction of operating costs for the owner of commercial (and private!) vehicles. But that is not the only positive effect: it also leads to a reduction of environmental pollution. Road transport is worldwide seen as a main source of negative environmental impacts, and environmental groups put increasing pressure on governments

Fig. 12
Jakarta: Poorly maintained bus with a breakedown, causing a traffic jam.
Photo: Manfred Breithaupt

Fig. 13
Surabaya: Bus causing heavy air pollution.
Photo: Karl Fjellstrom

to draw up and implement stricter legislation on exhaust emissions and noise.

3.3 Advantages for the driver

The benefits for the operator of a commercial vehicle and for the environment might not provide an incentive for the driver to drive economically (unless owner and driver are the same person). However, there are also direct benefits for the driver to adopt a more economical style of driving.

Fig. 14
Jakarta: Better working environment when new, well maintained buses are used.
Photo: Manfred Breithaupt

Box 2: Substances chiefly involved in air pollution

Hydrocarbons (HC)
HC appear in the exhaust gases as a result of incomplete combustion in the engine.

Carbon monoxide (CO)
CO is a toxic gas which displaces oxygen in the blood during respiration. Emissions are highest in low speeds and therefore in city traffic. CO is odourless and colourless and can hence not be directly perceived by humans.

Particulates
Particulates are extremely small particles. They consist largely of soot to which cancer-producing substances may be attached. Particulates may be deposited in lungs, airways and eyes.

Nitrous oxides (NO_x)
NO_x play an important role in the creation of summer smog. Nitrous oxide is converted in the atmosphere to nitric acid which is a significant component of acid rain.

Carbon Dioxide (CO_2)
CO_2 does have environmental effects not on the local but on the global level by contributing to the man-made greenhouse effect.

The financial benefits mentioned above (reduced costs for fuel, maintenance, repairs etc.) can indirectly result in better working conditions, higher salaries and a higher job security.

As driving economically automatically means driving more safely, this results in smoother and more relaxed working conditions. The driver will feel less exhausted and will be less prone to work-related stress. More incentives for the driver will be discussed in section 4.3.

3.4 Advantages for the passengers

An economical style of driving contributes directly and indirectly to the satisfaction of passengers. A less aggressive driving style with gentle acceleration and braking leads to an increased comfort for the passengers and hence to a higher satisfaction with public transport (which in the long run will attract more customers).

Fig. 15
Bogotá: TransMilenio, a BRT system with new equipment and well trained drivers makes public transport attractive for passengers.
Photo: Klaus Banse

Fig. 16
Bogotá: Old buses and poorly equiped bus stops make boarding the bus dangerous and public transport unattractive.
Photo: Klaus Banse

4. How to achieve and sustain an economic and safe driving style

There is no doubt that economical driving leads to considerable energy savings, reduces operating costs for vehicles and leads to a reduction of greenhouse gas emissions. Experiences worldwide show that cost reductions of up to 25% can be achieved. On average, reductions of 10 to 20% are realistic. The higher the petrol prices, the higher the absolute cost savings that can be achieved (for example in Germany current prices are approximately 1,20 €/litre for gasoline and 1,05 €/litre for diesel). German automobile clubs calculated that for a medium-sized car with an average annual mileage savings in petrol of up to 500 € per year can be realised.

In view of this cost saving potential, an increasing number of courses on economical and save driving techniques for drivers of commercial vehicles are offered in Europe but also in the U.S., Canada, New Zealand, Australia, and increasingly in developing countries as well. These courses are predominantly targeted at bus and truck drivers but also at owners of private vehicles. Courses in Germany, for example, are offered by major car manufacturers, automobile clubs, driving schools, environmental organisations, but even by churches and NGOs. There are hundreds of different opportunities.

Regarding commercial vehicles, DaimlerChrysler, Volvo, Ford and other vehicle manufacturers are providing courses and offer related material.

Fig. 17
Latin America: Bus driver training publicity page on the Internet site of VRS
Source: VRS

bus driver
training

Acelerando con nuevos métodos

CBT, un programa de aprendizaje a base de nuevas tecnologías, ofrece métodos multimedia para la capacitación básica y avanzada de los conductores de autobús. El programa consiste de varios módulos: aspectos técnicos de conducir y el conducir de una manera económica. Los conductores que han tenido una formación bien fundada manejan de una manera más segura, protegen al medio ambiente y reducen los costos.

Reduciendo los costos

Se puede economizar en el consumo de la gasolina por un 10% o más mediante la formación CBT para conducir de una manera económica.

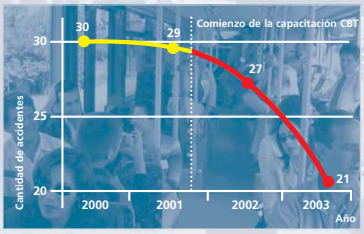
10 %

Mejorando el aire

Reduciendo las emisiones vehiculares por un 10% contribuye a la protección del clima y al mejoramiento de la calidad del aire en los centros urbanos.

10 %

Reduciendo los accidentes



La formación continua de conductores de autobús usando el programa CBT logró la reducción de los accidentes en una empresa de autobús en Alemania por un 33%.

33 %

www.busdriver-training.info

Box 3: Computer based training (Verband Region Stuttgart)

http://www.busdriver-training.info

The "Verband Region Stuttgart (VRS)" is a public authority representing the Greater Stuttgart area. It takes responsibility for the public transport, the regional planning and the economic development in the Stuttgart metropolitan area. In cooperation with the European Union, Verband Region Stuttgart aims at promoting the application of Computer Based Training (CBT) in the training of European and Latin American bus drivers on economical and environmentally-friendly driving (see Figure 17).

Training courses are based on Computer Based Training (CBT) which offers advantages such as:

- individualized learning with a high rate of success,
- easy implementation and better distribution of knowledge,
- environmentally friendly, and
- increased traffic safety.

The main objective of the project is to improve the qualification of bus drivers by providing newly developed training course material, advanced learning techniques and traditional didactic models. In particular, the focus is on safe, economical and environmentally-friendly driving.

It is important to raise awareness at all levels. This can be done via TV-spots, radio features, newspaper articles, flyers, articles in technical literature, signboards at motorways etc. It is also required that such undertakings receive the full commitment of the Government.

In Germany, for example, it is mandatory for driving schools to teach environmentally oriented and economical driving techniques since 1999. It is part of the driving test and a precondition for obtaining the driving-license. Approximately 1.3 million applicants join a driving school annually to receive a driving-license.

In Argentina, GTZ has executed a project on environmentally sustainable transport, including pilot courses on energy-saving driving techniques. The Argentinean Government has decided to include energy-saving driving techniques into the process of obtaining a driving license. This should go along with proper inspection and maintenance schemes and a strict regulatory framework to ensure periodic inspections. For details, please see Module 4b: *Inspection and Maintenance* of this sourcebook.

Energy-saving driving techniques are not yet broadly established in developing countries. There is a variety of reasons for this. In some countries, fuel prices are very low (below world market prices), so that potential savings are limited. Other reasons are unawareness of the importance and relevance of the subject, but also legal and institutional deficiencies exist.

International organisations acknowledge the importance of energy-saving driving techniques and stress the potential for microeconomic and macroeconomic savings, reductions of vehicle related local pollution and the reduction of CO_2 emissions. For example, the World Bank supports energy-saving driving in some of their programmes and also through the Clean Air Initiative for Latin American Cities and Asian Cities (CAI).

GTZ has worked in this area in Indonesia (Jakarta and Surabaya), Argentina (Buenos Aires and Mendoza), Chile (Santiago de Chile, see Box 4) and Costa Rica (San Jose). These GTZ projects proved that the participants of energy-saving driving courses achieved fuel savings of up to 20%. Details on these pilot projects are

Box 4: Results from a pilot project in Santiago de Chile (by Frank Dursbeck)

Eleven drivers of urban public transport buses have been trained during one week on EcoDriving. The training was based on a manual developed by GTZ in a corresponding project in Argentina.

The results were quite impressive. Fuel consumption decreased by between 8 and 32% with an average of nearly 20% (Figure 18). At the same time, braking could be reduced between 3 and more than 50% (Figure 19). The average reduction of braking is more than 25%.

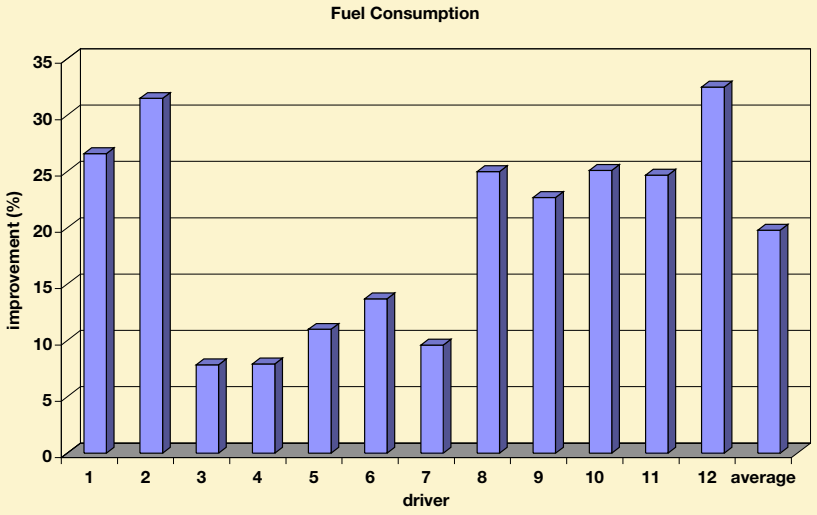


Figure 18: Decrease of fuel consumption

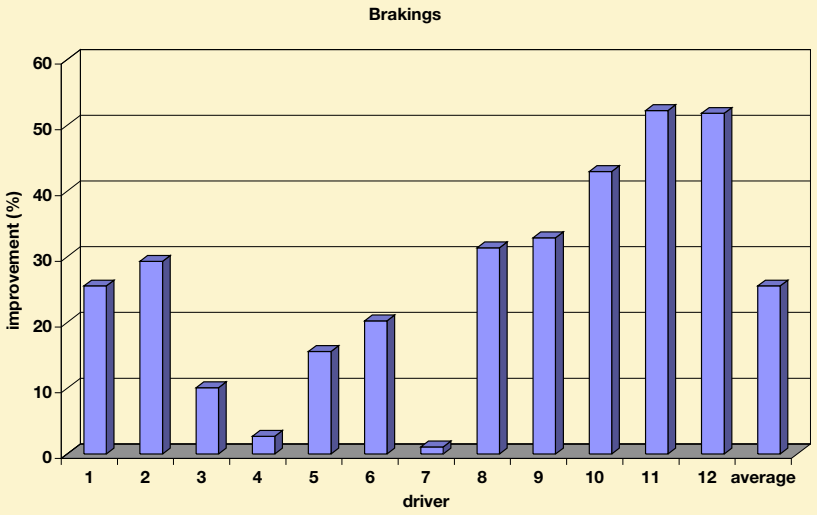


Figure 19: Reduction of braking

Besides these expected effects the improvement of environmentally important aspects like exhaust gas and noise emissions have been evaluated. Figure 20 clearly shows the reduction of RPM after the training program. As can be seen from the figure, the percentage of high RPM was reduced significantly with the effect of lower noise emissions.

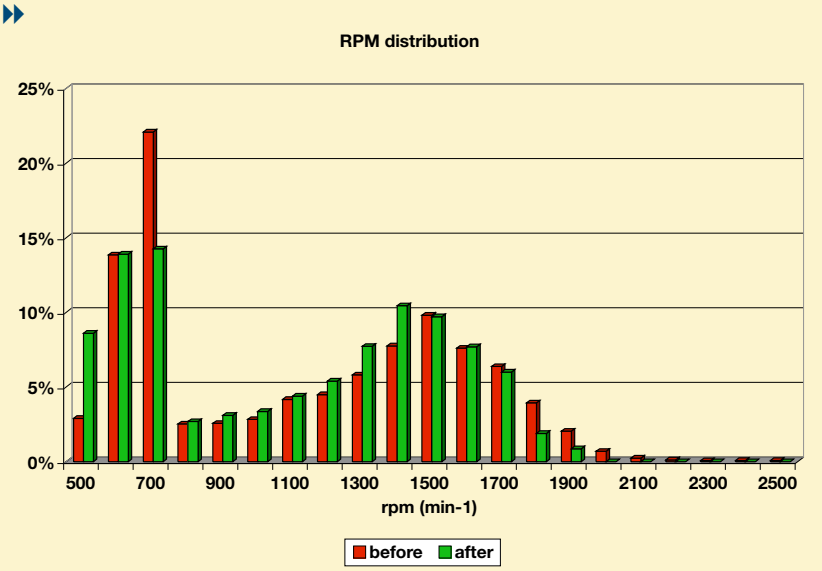


Figure 20: RPM distribution before and after training

The effect on exhaust gas emissions also was very impressive. For the Santiago bus fleet emission factors have been developed. Based on these data it was possible to calculate the difference in exhaust gas emissions as an effect of EcoDriving. The results are shown in Figure 21.

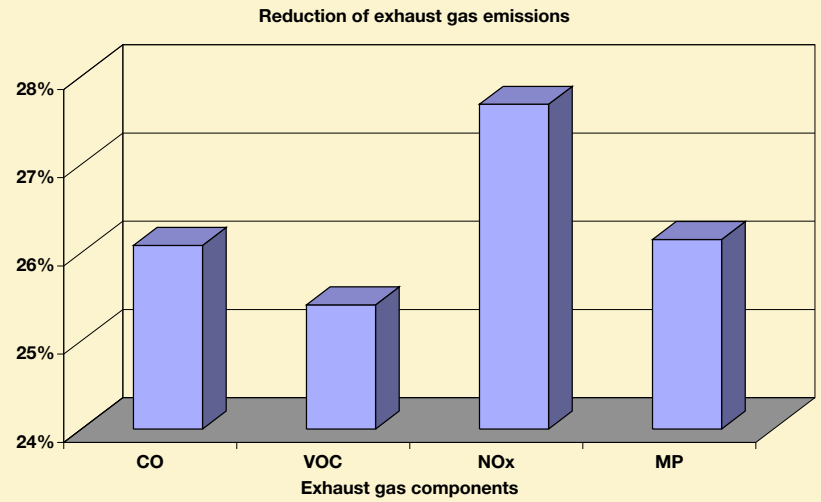


Figure 21: Reduction of exhaust gas emissions

These figures clearly show that by economical driving techniques alone significant improvements with respect to air pollution and noise emissions can be achieved – and all this does not involve any costs for authorities and the public. On the contrary this is a classical win-win-situation as the reduction of fuel consumption and the reduction of braking significantly decrease the operating costs of the vehicles. An example is given in the following table.

Bus operator with 30 buses

- annual mileage 105,600 km per bus
- 30 buses = 3.168.000 km for the fleet
- Actual fuel consumption: 2,409 km/l
- Total fuel consumption before training 1.315.068 litres
- Fuel consumption after training: 2,886 km/l
- Total fuel consumption with EcoDriving 1.097.713 litres
- Difference 217.354 l
- Total savings CLP 43.470.800 (equiv. 62,100 USD) without taking into account possible savings in maintenance and repair costs.

4.1 Results of selected GTZ-courses

GTZ has supported courses in Jakarta and Surabaya (Indonesia) for bus drivers of public municipal operators as well as for drivers of buses of private bus companies. A manual used for those courses in Indonesian language has been elaborated by the Swiss Development Aid and can be made available by GTZ. Energy savings were in the range of 7-15%.

In Buenos Aires, seven courses were held in 1999, with average fuel savings of 14.2% (see Table 3).

The courses also resulted a reduced use of brakes (-32.1%) and a reduction of gear changes (-22.9%). And as a surprise to many participants, the average speed increased by 7.3%.

GTZ also supported a private bus operator (with a fleet of 50 vehicles) in monitoring and supervising fuel consumption and operating costs over a period of one year.

In 2003 two urban bus lines in Mendoza/Argentina (Line 100 and Line 160) received technical support for the improvement of fuel efficiency and for the reduction of vehicle operating costs. Some main results of the project are summarized in Table 3. Again, average fuel savings were in the range of between 15 and 18% (see Table 4).

In Argentina, with high diesel prices, the savings resulting from the training courses and, more specifically, from the extended monitoring of fuel consumption (over a period of 6 to 12 months) were considerable. They outweighted

presented in section 4.1. GTZ has developed manuals in Spanish ("manual de conducción racional") in the context of the projects in Argentina and Chile. These can be obtained from the GTZ transport devision (transport@gtz.de).

Table 3: Result of GTZ-courses in Buenos Aires 1999

Course #	Round	Average speed [km/h]	%	Brakes	%	Gear changes	%	Fuel consumption [l/100km]	%
1	First	16.4		44		68		38.0	
	Last	18.7	14.0	35	-20.5	60	-12.4	32.0	-15.8
2	First	20.5		62		65		38.4	
	Last	19.6	-4.6	37	-40.7	55	-15.4	32.6	-15.1
3	First	18.8		27		63		38.5	
	Last	19.5	3.8	18	-31.6	49	-22.0	32.6	-15.1
4	First	19.2		31		61		37.7	
	Last	19.9	3.6	18	-40.0	39	-35.7	32.4	-14.0
5	First	17.9		33		56		38.1	
	Last	20.5	14.6	25	-25.0	43	-23.8	33.4	-12.3
6	First	19.0		31		55		38.0	
	Last	20.5	8.1	22	-29.0	43	-21.5	32.7	-14.1
7	First	18.1		33		58		37.3	
	Last	20.2	11.5	20	-37.8	42	-28.2	32.4	-12.9

by far the costs for consulting and training, even when the respective losses of production during the time the drivers were trained were included into the calculations. The results proved that this was a classical win-win-situation for the operators, the drivers, the passengers and the environment.

4.2 Results of other projects

In Japan, a study examined the effect of automatic “idling stop” devices in buses and other commercial vehicles. It showed significant fuel savings when vehicles were equipped with the system. The test run covered a distance of about 3,700 kilometres from Cape Soya in Hokkaido to Cape Sata in Kagoshima Prefecture. The use of “idling stop” devices also resulted in considerable reductions in carbon dioxide emissions. In cities, the saving was 13.4%. On intercity connections savings in fuel consumption were lower but even then a vehicle with the idling-prevention device used 3.4% less gasoline. Between cities, the time a vehicle spent at a halt was 7.9% of the running hours, compared with 25.9% within cities. However, impatient drivers do not like to turn off their engines at traffic light stops because they want to get off to a fast start when the lights change. With improved efficiency in starters and batteries, turning off the engine for a short time poses almost no problem. But even then many drivers find it a heavy psychological burden to deliberately turn off the engine by using the key. Toyota incorporated an "idling stop system" in the 1300-cc Vitz car it marketed in 2003. If the driver brakes with the gearshift in "drive," the engine automatically stops, and when the driver removes his foot from the brake pedal, the engine will restart. The car has a high-power battery so that the air conditioning will keep running while the engine is in "idling stop" mode. Toyota has also equipped other cars with the system. Similar systems have been employed in vehicles of other automakers, such as Volkswagen, Honda and Daihatsu. Idling cut-off devices have also been installed in trucks and buses produced by Hino Motors Ltd, Isuzu Motors Ltd and Nissan Diesel Motor Co.

Table 4: Result of GTZ technical support in Mendoza 2003

Bus Line	% Increase of energy efficiency	% Increase of the average speed	% Reduction of the particulate emission
100	15.1	2.4	27.3
160	18.0	4.2	35.7

In Switzerland, the results of the Eco-Drive@ courses where also quite impressive. Vehicle drivers who did not attend the courses had an average fuel consumption that was 11.7% higher than that of drivers who attended the courses. The average speed of the course participants was even slightly higher than the average speed of non-participants (48.21 km/h compared to 47.02 km/h).

4.3 Incentives for vehicle drivers to adopt a more economical and defensive driving style

It is one thing to educate vehicle drivers (who are not the owners) to adopt a more defensive and economical style of driving, but it is another question if they will actually apply this style in their day-to-day work.

The advantages for the driver have been described in section 3.3. But an employee who has developed a personal driving style over years or decades might not easily be convinced that changes really make his work life easier.

In some developing cities, especially in Asia, drivers sometimes rent vehicles from the owners for a fixed fee on a daily basis and operate it on their own account. In this case the driver benefits directly from fuel savings.

When this is not the case and drivers are employees of the bus company, companies may establish premium systems offering financial incentives to drivers whose fuel consumption is below average fuel standards (experience values of the bus companies). Premiums can also be provided to drivers who have not caused accidents for a certain period of time. To provide monetary incentives to drivers seems to be the most effective way to assure sustainability. Furthermore, it is also important to pay drivers a fixed salary instead of payments based on the number of passenger. The latter would lead to a "chase for passengers" and an economical and defensive driving style could not be implemented.

4.4 Some selected manuals for economic and defensive driving

A recommendable course reference guide, titled "Het Nieuwe Rijden – A new approach to coach driving"), is published by the "Stichting Vakopleiding Transport en Logistiek VTL (The Netherlands Institute for Professional Training in Transport and Logistics)" and is available from VTL.

The manual "EconoDrive", primarily published for private car users by the New Zealand "Energy Efficiency and Conservation Authority (EECA)" (http://www.eeca.govt.nz), a governmental organization, is recommendable as well.

EvoBus, a subsidiary of DaimlerChrysler, published excellent training material for urban buses. Unfortunately these are available in German only.

GTZ has elaborated a manual for its training courses in Argentina ("Manual de Conduccion Racional") and a slightly revised version for Chile ("El Estilo de la Conduccion Eficiente"). Those manuals are only available in Spanish.

The Spanish "Ministerio de Hacienda" has published a training manual for drivers of state-owned vehicles (e.g. police, military vehicles), entitled "Manual de Conducción Eficiente para Conductores del Parque Móvil del Estado". It is available in Spanish only.

In Portugal, the Energy Agency (Agência para a Energia – AGEEN) has published an EcoDriving manual in Portuguese language.

In Indonesia, SwissContact has produced training material in Indonesian language, while both SwissContact and GTZ have developed specific course programmes on energy-saving driving techniques

The U.S. Transportation Research Board (TRB) has published a research report on commercial truck and bus safety ("Training of Commercial Motor Vehicle Drivers"). Although it primarily deals with safety issues, it is worth reading.

Most of these manuals in various languages plus additional material and documents have been compiled on an Annex CD-Rom and will be available from http://www.sutp.org together with this module.

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Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

Dag-Hammarskjøld-Weg 1-5
P. O. Box 5180
D - 65726 Eschborn
Germany
Telefon +49-6196-79-1357
Telefax +49-6196-79-7194
Internet: http://www.gtz.de

commissioned by:

Federal Ministry
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