Treatise
training in environmental transport

Ecodriving

Smart, efficient driving techniques

INTRODUCTION

Road Transport

Road transport is a major and growing source of CO_2, the principal greenhouse gas responsible for climate change. It also produces emissions that damage human health, it creates noise and congestion and - in Europe alone - it leads to tens of thousands of deaths each year through road accidents.

Drivers can greatly reduce these impacts, however, by taking a few simple steps based around choosing cleaner vehicles, driving more efficiently and using alternatives to single-occupancy cars when practical. In most cases these measures will lead to financial savings as well as environmental benefits.

The Treatise Project

Treatise is an EC project operating from January 2005 to June 2007 that provides free training on sustainable transport subjects, primarily for energy and transport professionals. The project covers three areas:

- Cleaner Fuels & Vehicles: an explanation of the key vehicle fuels and technologies, including their advantages, disadvantages, availability and cost.
- Ecodriving: The techniques – and the theory behind them - that lead to more efficient driving.
- Mobility Management: practical advice on how to reduce dependence on single-occupancy car travel.

For more information about the Treatise project or to enquire about sustainable transport training in your area, visit www.treatise.eu.com

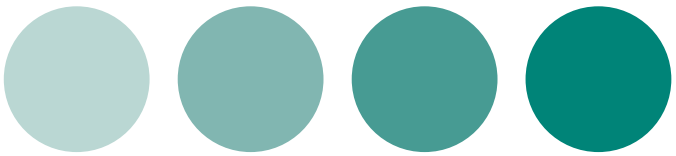
Treatise Publications

This publication is one of a series of three reference manuals produced by Treatise to cover each of the three subject areas listed above. The manuals, as well as an ecodriving simulator and other training aids can be downloaded for no charge from www.treatise.eu.com

This version by Energy Saving Trust, London (November 05) based on the original produced by SenterNovem, Utrecht for the EC Treatise project (September 2005).

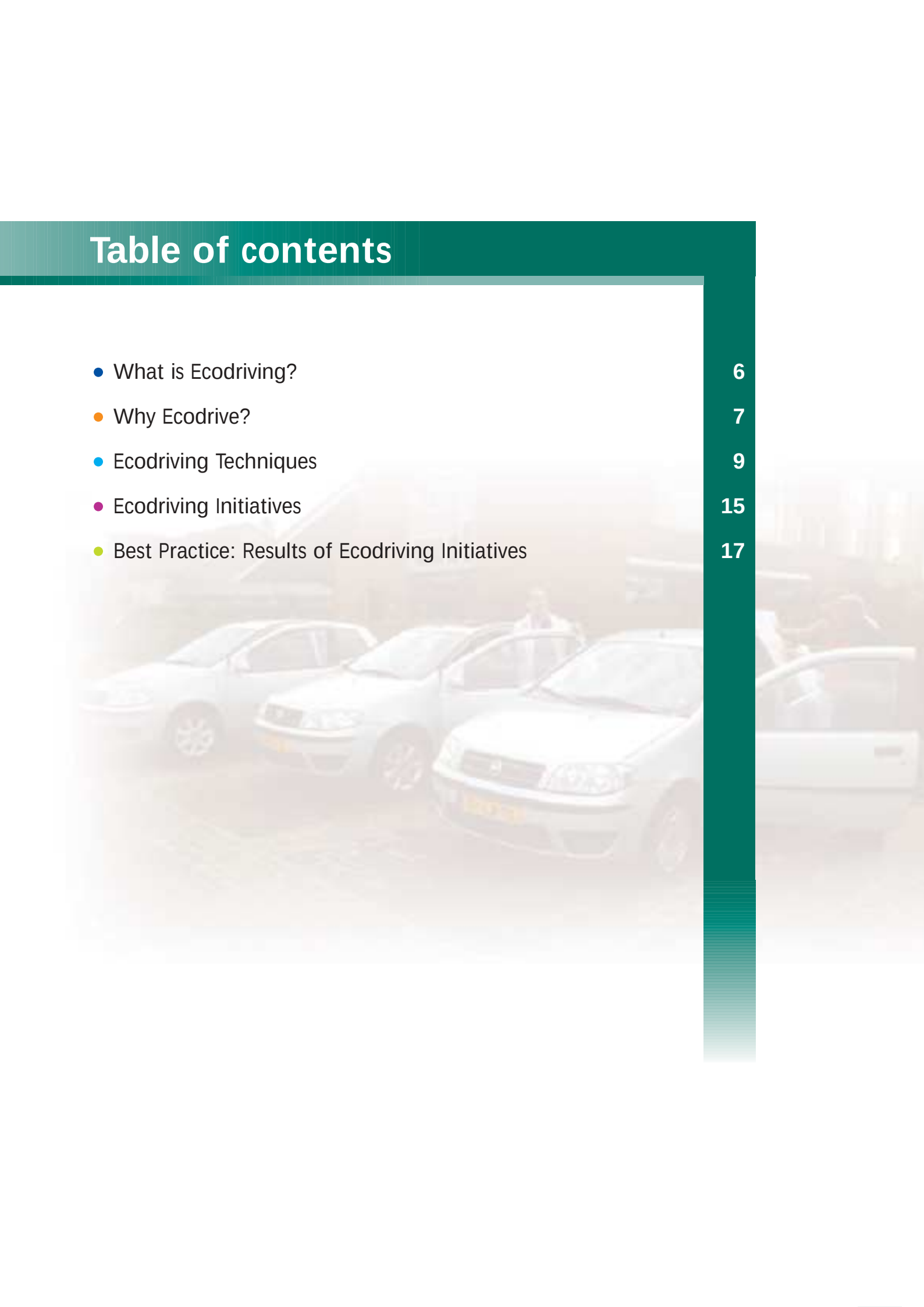
Supported by the
European Commission under the
Intelligent Energy - Europe programme

Produced in collaboration with the EC e-Atomium and Competence projects.



Notes

Table of contents



What is Ecodriving?

Introduction

A smart way of driving suited to today's engines

Ecodriving is a way of driving that reduces fuel consumption, greenhouse gas emissions and accident rates. Ecodriving is about driving in a style suited to modern engine technology: smart, smooth and safe driving techniques that lead to average fuel savings of 5-10%.

Ecodriving offers benefits for drivers of cars, vans, lorries and buses: cost savings and fewer accidents as well as reductions in emissions and noise levels. Several European countries have implemented successful ecodriving programmes.

In addition to promoting more fuel efficient driving techniques, other subjects usually included under the banner of ecodriving include fuel saving in-car devices; removing roof-racks and roof-boxes when not in use; using air conditioning sparingly and checking tyre pressures frequently.

Driver Training

Teaching novice drivers

Perhaps the most effective way of promoting ecodriving is to teach the techniques to learner drivers. However, this practice is only likely to become widespread if it is incorporated into the standard driving test.

It is also important to provide information for experienced drivers as most have been taught driving styles that fail to make the most of today's engine technology.

Provisional driver learning ecodriving techniques

Re-training experienced drivers

Re-training experienced drivers: On the road & using an ecodriving simulator

Why Ecodrive?

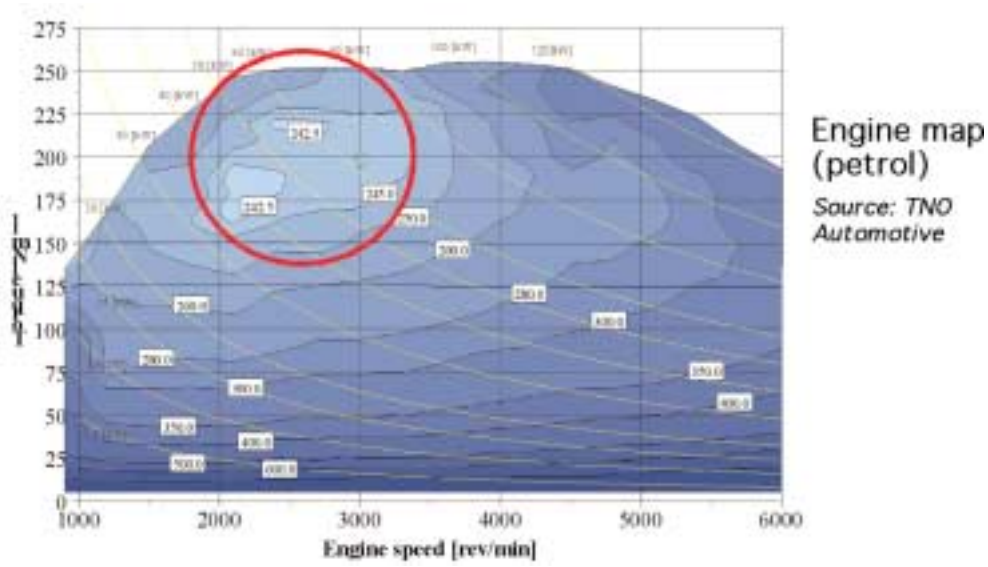
Technical Background

Technical developments over the last 15-20 years have led to great improvements in official emissions test results. These are the emissions measured over standardised test-cycles, which in Europe are stipulated by the EC.

Improvements in official mpg figures….

However, improvements in 'real-life' conditions have not been as marked, partly because few drivers know how to get the best out of their engines. By adopting ecodriving techniques it is possible to approach the optimal conditions on which the official fuel consumption and emissions results are based.

…rarely fully achieved in 'real life'



Petrol car engine 'map'

Engine map of a typical modern petrol car

One of the most important factors is that modern fuel injected engines (petrol and diesel) produce high torque even at low rpm. This can be seen in the diagram above, which shows the 'engine map' of a typical modern petrol car. Engine speed (revs per minute, or rpm) is shown on the X-axis and torque, which can be thought of as the amount of 'work' or 'effort' that an engine has to provide, is shown on the Y-axis. The different shades of blue indicate how efficiently the engine performs at different combinations of speed and load: the lighter the shade the more efficiently it is operating.

Red-circle shows most efficient engine speed/ load combinations

The red circled area is therefore an approximation to the most fuel-efficient part of the engine map. To operate efficiently an engine must be kept within this red circled area as much as possible, which is what ecodriving aims to achieve.

Why ecodrive?

Ecodriving brings environmental, financial & safety benefits

Environmental, Economical & Personal Benefits

Ecodriving has the potential for considerable fuel savings and consequently for reducing CO_2 emissions. The European Climate Change Programme (ECCP) calculated in 2001 that within Europe driver education and ecodriving programmes could lead to 50 Mton CO_2 avoidance by 2010. This would be the equivalent of 15 million cars' annual CO_2 emissions. Ecodriving promises a low-cost "no regret" option to help achieve Kyoto CO_2 targets and to improve air quality.

Rev counters can facilitate ecodriving

Ecodriving reduces:

- Fuel consumption
- CO_2 emissions
- Local 'air quality' pollutants
- Noise
- Vehicle repair and maintenance costs
- Driver (and passenger!?) stress
- Accident rates

The safer driving behaviour results from:

- An anticipatory driving style
- Reduced speeding
- A less stressful and aggressive driving style.
- Less overtaking

Ecodriving Techniques

This chapter gives an overview of the main ecodriving techniques and explains why they each contribute to greater efficiency. Remember that ecodriving techniques should never be employed in situations in which they might compromise safety.

1. Shift to a Higher Gear as Soon as Possible

A general rule for efficient acceleration is to change up to a higher gear at no more than 2500 rpm in a petrol car and at no more than 2000 rpm for a diesel. (Diesel engines reach their optimal efficiency at lower engine speeds.)

Shift up before 2,000-2,500 RPM

Shift up before 2000-2500rpm

The reason for keeping an engine's speed down is that some of an engine's power is lost to internal friction, which increases with engine speed. Driving at low engine speeds therefore limits the losses and reduces fuel consumption.

Friction increases with engine speed

Note that the recommended rpm for gear changes is only a rule of thumb: the optimal engine speed varies between different vehicles and according to different traffic, load and weather conditions. Specific information on this point can be found in most vehicles' user manuals.

The efficiency of a car engine also increases when a high engine load is used. When accelerating, the most efficient way of driving is therefore to shift up early (at low engine speed) but to apply a relatively high load on the engine (i.e. putting your foot down relatively hard / driving with a relatively deep accelerator position).

Driving with a 'heavy right foot' can still be efficient

This is because for a modern petrol engine the position of the accelerator pedal is not directly related to fuel consumption. The accelerator pedal operates the throttle/butterfly valve and consequently only directly affects the flow of air to the engine. The quantity of fuel to be injected to the engine is then calculated by the engine management system based on various parameters including the position of the accelerator pedal, engine speed and air temperature.

Driving in a high gear automatically requires a high engine load to keep up with the flow of traffic.

Automatics

The advice to shift up early but apply a high load to the accelerator does not work for cars with automatic gearboxes. This is because a deep accelerator position is 'interpreted' by a car's engine management system as meaning that the driver wants to accelerate very quickly, which leads to shifting at higher rpm. Drivers of automatics should therefore accelerate gently whenever possible as this encourages the automatic gearbox to shift up at lower engine speeds.

The 'sports' mode of an automatic gearbox should be avoided as this also leads to shifting at higher engine speeds.

Ecodriving Techniques

2. Maintain a Steady Speed Using Highest Gear Possible

Driving at constant speeds requires relatively little power

Driving at a moderate, steady speed requires relatively little energy. For example, a typical car requires only around 5 kW (or 10% of its power) to drive at a steady 30 mph and 25kW (or 50% of its power) to drive at a steady 75mph.

An engine's full power is only used during hard acceleration or at very high speeds. When a vehicle brakes, energy is lost, ending up as heat in the brakes.

Driving steadily and avoiding unnecessary acceleration and braking therefore reduces fuel consumption. It also has a positive effect on exhaust emissions, traffic safety, traffic flow and passenger comfort.

3. Slow Down

90mph requires 25% more fuel than 70mph

The most efficient speed depends on the car in question but is typically around 55-60 mph. Above 65 or 70mph fuel consumption begins to increase very significantly with speed. For example, driving at 80mph instead of 70mph will typically add around 10-15% to fuel consumption and at 90mph a car is likely to use approximately 25% more fuel than at 70mph.

4. Anticipate Traffic Flow

Greater anticipation saves fuel & reduces accident rates

Read the road ahead as far as possible to anticipate situations before they arise. This is essential in order to be able to drive at a steady pace (as discussed in point 2) and avoid unnecessary braking and accelerating.

Whether approaching traffic lights or a roundabout, overtaking a cyclist or agricultural vehicle, or just driving on a busy highway, anticipating situations including other traffic's movements is not only important for safety but can also significantly reduce fuel consumption.

Anticipate as far ahead as possible

5. Decelerate Smoothly

A trailing throttle uses less fuel than coasting in neutral

When slowing or stopping, decelerate smoothly by releasing the accelerator as early as possible, leaving the car in gear.

Petrol and diesel cars manufactured from 1990 onwards are generally equipped with fuel injection systems that include an electronic function that cuts off engine fuel supply under engine braking conditions (accelerator released and a gear engaged). Under such conditions a car uses less fuel than it would if it were coasting in neutral. To take full advantage of this function a vehicle's accelerator should be released as early as possible, for example when approaching traffic lights. This also reduces wear and tear on the brakes, which in turn reduces maintenance costs.

Driving to maximise the use of engine braking not only has a positive effect on fuel consumption and emissions, but also on traffic safety, traffic flow and passenger comfort.

Additional Tips

a) Driving Uphill

Use a high gear uphill!

The most efficient way to drive up a hill is to use the highest gear possible with a deep accelerator position. Drivers often feel that driving 'with their foot on the floor' at such low rpm must be wrong, but in fact modern cars are built so that they can be driven at full load at engine speeds as low as approximately 1200 rpm.

b) Switching Off

Switch off when idling

Switch off the engine at short stops, for example at a railway crossing, when stuck in traffic or while waiting for someone. Do not press the accelerator when re-starting the engine.

The fuel consumption of a modern car engine when idling is about 0.5 litres per hour, depending on engine type. Therefore switching off the engine in appropriate situations can soon lead to significant fuel savings.

The general guidance is to switch off if you think you'll be stationary for more than a minute or two. However, remember that techniques to increase efficiency should never prevail over safety concerns.

Avoid idling

Ecodriving Techniques

c) Starting the Engine

Do not depress the accelerator when starting up

When starting a modern fuel injected engine (all cars manufactured from the early 1990s), the accelerator pedal should not be pressed. The electronic engine management system decides the amount of fuel required according to many different parameters and pressing the accelerator will only 'confuse' the system. This will make it harder to start the car and will increase both fuel consumption and exhaust emissions.

d) Negotiating Bends

Drive round bends in a high gear, when safe & practical

The correct way to drive around a bend depends on many factors including the speed of approach, the weather conditions, the nature of the bend and the condition of the road.

The most efficient technique, however, is to reduce speed as much as necessary by releasing the accelerator and using the brake before the bend not by dropping down into a lower gear. This is really a variation of the first principle explained in this section: that the most efficient way to drive is to use the highest gear possible.

Furthermore, with sufficient anticipation it is often possible to enter bends at an appropriate speed without using the brake at all.

e) Avoid Carrying Unnecessary Weight

Remove unnecessary weight

Vehicle weight has a major effect on fuel consumption and this includes the weight of the load as well as that of the vehicle itself. For a medium size car weighing 1500kg, an additional 100kg load increases fuel consumption by about 7%.

At a practical level this might mean not leaving a set of golf clubs permanently in the boot or not carrying an unnecessarily large and heavy tool kit.

f) Aerodynamics

Remove roof-racks & close windows

Car designers go to great lengths to make their vehicles as aerodynamic as possible as this reduces fuel consumption and increases vehicle speed for a given engine power. Even minor details such as the shape of door handles are carefully designed to be aerodynamic as they make a significant difference at high speeds.

Even aerodynamic roof boxes significantly increase fuel consumption

It comes as no surprise, therefore, that accessories such as roof-racks and bike carriers are disastrous for aerodynamics: At 75mph a roof-rack will typically add around 20% to a car's fuel consumption. The effects of roof boxes and bike carriers are even greater.

Ecodriving Techniques

Open windows also add significantly to a vehicle's 'drag'. In fact, the effects of open windows are so marked that at speeds above 50-60 mph it is generally more efficient to keep the windows closed even if this necessitates using air conditioning. [See below for effects of air-conditioning].

g) Tyre Pressures

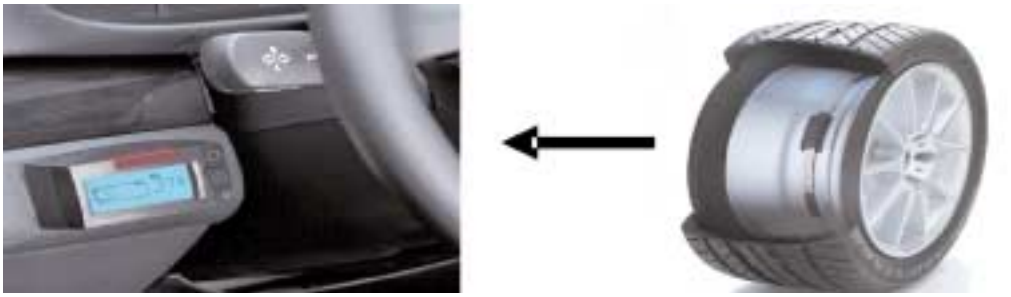
Under-inflated tyres add to fuel consumption

Most people know that under-inflated tyres are dangerous as they affect a vehicle's handling and are more likely to burst, but not everyone realises that under-inflated tyres also add to fuel consumption. In fact, a tyre under-inflated by 25% (e.g. 24 PSI instead of 32 PSI) will typically increase rolling resistance by 10% and fuel consumption by 2%.

Tyre pressures should therefore be checked frequently: at least once a month and according to the Highway Code, once a week. Tyres should be checked when cold. This means that if a car's been driven more than about 2 miles the operator should wait ten minutes before checking the tyres.

Correct tyre pressures improve fuel-efficiency and road safety

The required tyre pressures vary from car to car but will always be stated in a vehicle's manual and often also stated on a label close to the door post or fuel filler.



Tyre pressure monitoring system

Some new cars now come equipped with electronic sensors that continually monitor tyre pressures.

Ecodriving Techniques

h) Air Conditioning

Air-conditioning can add 25% to fuel consumption

Air conditioning (a/c) adds significantly to fuel consumption due to the additional mechanical and electrical demand that it imposes. Research published by ADEME in 2003 indicates that a/c working at full power can add around 25% to a vehicle's fuel consumption and that typical mixed use over a year adds around 5%.

Use air-conditioning sparingly

It is therefore recommended that drivers use a/c as sparingly as possible, as long as this does not necessitate opening a window at high speed – see 'aerodynamics' above. Some systems with 'climate control' will run their a/c compressors all the time on 'automatic' mode so should be set to 'economy' to avoid this.

i) Fuel Saving In-car Devices

Most cars are now fitted with rev (engine revolution) counters and many also have more advanced accessories with fuel-saving benefits such as cruise control and on-board computers.

A rev counter shows the speed of the engine, which can help ensure gear changes are made at an efficient speed.

Various in-car devices encourage ecodriving

Cruise control makes it easy for a driver to maintain a steady speed and hence to drive more efficiently. Cruise control also contributes to a more relaxed driving style and can help avoid unexpected speeding tickets.

Many modern cars are equipped with **on-board computers** that have a variety of functions including instantaneous fuel consumption and average fuel consumption for a journey.

When used in instantaneous fuel consumption mode, onboard computers provide immediate feedback on driving technique and can be a very effective tool to help drivers learn to drive more efficiently.

On-board computers give instantaneous feedback

Satellite navigation systems are an effective way to avoid getting lost on unfamiliar routes. This not only saves time and frustration but also brings the financial and environmental benefits associated with reduced mileage. Prices of "sat nav" systems are falling quickly, with basic models now available for around £200.

Onboard computer displaying instantaneous fuel consumption.

Some new cars are now being fitted with **'shift indicators'** which facilitate efficient driving by telling the driver the optimal time to change gear.

Ecodriving Initiatives

There are many ways of promoting ecodriving, including awareness raising activities, distribution of information and actual driver training.

Awareness raising activities can reach a wide audience, although the savings per person are unlikely to be as great as for initiatives that include hands-on training. Awareness raising & dissemination of Information can include:

Awareness raising activities can reach a wide audience

- Distributing ecodriving leaflets or manuals.
- Presentations to receptive groups e.g. employees, environmental organisations, schools.
- Organising ecodriving trials with a sample of the target audience and publishing the results (hopefully showing significant fuel savings!) to the wider target audience.
- Competitions, perhaps with ecodriving tuition as a prize. For national competitions vehicle manufacturers have even been know to donate cars as prizes.
- Encouraging companies and other organisations to specify on-board computers with instantaneous fuel consumption display for company vehicles.
- Ecodriving advertising: TV, press, internet, billboards etc.
- Providing driving schools with ecodriving information.

One-to-one **in-vehicle driving tuition** is the most effective way to teach an individual to ecodrive and in fact many companies and organisations already send their drivers on courses to teach them to drive more efficiently.

In-vehicle tuition results in the greatest savings per person trained

Amongst private individuals ecodriving lessons are virtually unheard of but perhaps this will change: research by the Energy Saving Trust in 2005 showed that 36% of drivers would consider paying £50 for a two-hour ecodriving lesson if this were to pay for itself in fuel savings within 8 months. (8 month payback time is realistic for a typical car and private driver).

Driving simulators, which may be static or mobile, can be very realistic and are also an effective way to teach ecodriving techniques. Simulators. Lessons on simulators are less expensive than in real vehicles and more people can be trained. Driving simulators also have the advantage of allowing for comparisons between different drivers faced with standardised situation.

Driving simulators can play a useful role

Ecodriving computer games, which may be loaded from a disc or player online, can serve as a good 'appetiser', especially for a younger target audience. Young people can thus find out about ecodriving even before they reach driving age. Games can also serve as an image building instrument and can be given away for the price of a disc. Ecodriving games have the big advantage that they are cheap so can be widely distributed to reach large numbers of drivers, both novice and licenced.

Computer games reach a younger audience

Ecodriving Initiatives

Project Partners

Seek trustworthy partners

Where possible it is a good idea to seek collaboration and build ecodriving partnerships with other organisations as people are generally more receptive to ecodrving messages from known and trusted sources. Furthermore, partner organisations are likely to have existing communication channels that may be used to deliver ecodriving messages.

Potential partners include

- Public transport companies;
- Driving schools
- Consumer organisations
- Environmental organisations
- Garages, tyre service companies and car dealers;
- Automobile clubs;
- Insurance companies;
- The media, whether local or national, motoring or general.

Best Practice:

Results of Ecodriving Initiatives

This chapter reports the results of a selection of successful European ecodriving initiatives.

Driving Standards Agency, UK

In 2004 the UK's Driving Standards Agency carried out ecodriving trials by comparing drivers' fuel consumption over a given course before and after they received 2 hours of ecodriving training. The trials demonstrated average fuel savings of 8.5%.

UK trial show 8.5% saving after 2-hour lessons

Car Panel Consumentenbond, the Netherlands

In 2002 a study was undertaken with the car panel of the Dutch Consumer Organisation, which consists of approximately 6,000 drivers, mostly private consumers.

Members were divided into ecodrivers and non-ecodrivers based on their own self-reported behaviour and the groups were compared against each other. Over the year-long duration of the study the ecodrivers consumed 7% less fuel per km than the non-ecodrivers.

Long-term savings of 7% among Dutch consumers

RACC (Real Catalonia Automobile Club), Spain

RACC (Real Catalonia Automobile Club) is one of the main automobile clubs in Spain, with more than a million members. RACC is also Spain's largest insurance brokerage. Trials conducted by RACC in October 2003 demonstrated average fuel savings of 13.4% when drivers adopted ecodriving techniques.

13.4% savings in Spain

Hamburger Wasserwerke, Germany

Towards the end of 2003, 91 delivery van drivers employed by Hamburger Wasserwerke (HW) received ecodriving training. Monitoring over the following 6 moths demonstrated that fuel consumption fell by an average of 5.8%, saving HW approximately 10,000 litres of fuel per year and accident rates fell by 40%.

5.8% fuel savings & 40% reduction in accident rates

Best Practice:

Results of Ecodriving Initiatives

Logistics Companies, the Netherlands

Savings of up to £950 per truck per year

In the Netherlands a consultancy analysed data collected from trucks operated by Dutch logistics (haulage) companies over the period 1995-2003.

The introduction of ecodriving measures was shown to reduce fuel consumption by an average of 2.1%: an impressive result for a sector in which there is already great emphasis on minimising fuel consumption. When combined with lower maintenance costs and accident rates, overall cost savings of more than £1 per 100 miles were achieved.

Indicator	Savings per indicator (%)	Cost savings (£ per 100 miles)
Fuel consumption	2.1	0.44
Maintenance	3.5	0.21
Accident damage	14.2	0.43
Total	-	1.08

Overall effects of the implementation of ecodriving activities in road transport (1995-2003)

For trucks operating within the Netherlands (averaging 50,000 miles per year) this resulted in savings of around £550 per year per vehicle and for trucks operating internationally cost savings of around £950 per year per vehicle were achieved.