ECODRIVING
Technical Report Summary

Ing. Miloš Veverka, PhD.
Ing. Daniel Lešinský, PhD.
Content
1 What is ecodriving? ........................................................................................................................................ 3
2 While you start the engine ............................................................................................................................. 3
  2.1 Is this car driving necessary? ................................................................................................................... 3
  2.2 Car-sharing ............................................................................................................................................... 3
  2.3 Carpooling ................................................................................................................................................ 3
  2.4 Plan your trip before driving ................................................................................................................... 3
3 Choose the right car ....................................................................................................................................... 4
4 Emissions control technologies – filters and catalysts ................................................................................... 4
  4.1 Technologies for gasoline vehicles – The 3-way catalyst ........................................................................ 5
  4.2 Technologies for diesel vehicles .............................................................................................................. 5
  4.3 Diesel particulate filter (DPF) .................................................................................................................. 5
5 Fuel type ......................................................................................................................................................... 6
6 Ecodriving tips while driving ........................................................................................................................... 6
7 Parking and departing tips .................................................................................................................................. 7
8 Smart use of air-conditioning .......................................................................................................................... 7
9 Train in ecodriving .......................................................................................................................................... 8
10 Abbreviations ................................................................................................................................................ 9
11 Sources ......................................................................................................................................................... 9

Contact
CEPTA - Centrum pre trvaloudržateľné alternatívy
Miloš Veverka milos.veverka@inter-net.sk
A. Nográdyho 39 +421 (0)904 417 202
960 01 Zvolen www.cepta.sk
Slovakia

Acknowledgement
Co-financed by the EU's LIFE financial instrument:

Associated campaign:
1 What is ecodriving?

Ecodriving is a driving style which reduces fuel consumption and thus the emissions. It is economical and also ecological.

15 – 25 % of fuel can be saved due to the application of ecodriving principles [1, 2, 3, 4]. This report informs about these principles and brings measures and tips how to minimize detrimental effect of vehicles to the environment.

2 While you start the engine

2.1 Is this car driving necessary?

Before you sit into your car consider alternative ways of transport. For short trips the alternatives could be faster and more practical than driving at rush hour:

- walking – effective for short trips (up to 1 km) and it is also healthy,
- biking – during rush hour, biking for shorter trips (up to 5 km) could be much faster than car driving and it is also healthy,
- public transport – particularly taking a tram or a train is good possibility how to avoid traffic jams and arrive in time. Travelling by public transport for long distances is favourable – you do not have to drive, but you can work on your laptop, read a book, watch countryside or just relax.

2.2 Car-sharing

Car-sharing means to have an available car, but not to own it. The car is owned by car-sharing company, which maintains it and ensures that it is available for car-sharers (members of the sharing system). If a car-sharer needs a car, he/she just books it and picks it up at the car-sharing site. After using he/she returns it at the site [5].

Car-sharing is cheaper than car owning, because costs (except for fuel costs) are shared by all users – e. g. insurance, maintenance etc. Moreover, there is wide range of car types available to car-sharing members – small or large passenger cars, vans, trailers. A member can choose what he just needs [5, 6].

There has been no car-sharing system in Slovakia yet. The closest system is working in Brno (Czech Republic) [7]. Car-sharing is widespread in Germany [8, 9].

2.3 Carpooling

Carpooling means sharing of car journeys so that more than one person travels in a car [10]. It is cheaper and environmentally more friendly than the case when everybody drives their own car. There is a web portal www.carpooling.org which offers to join the carpooling [11].

2.4 Plan your trip before driving

By good trip planning you can save time and fuel. Take into consideration:

- Avoid traffic jam. „Stop and crawl“ driving under hard traffic conditions in crowded roads consumes a lot of fuel and time. So it is better to time the trip to avoid traffic jam [12]. Sometimes driving by side roads can be faster than using congested highway.
- Do not get lost. When planning unfamiliar journeys try to reduce the risk of getting lost and check the traffic news before you leave [13].
- Combine short trips. Cold starts use more fuel so it pays out to combine errands such as small shopping or collecting the kids [13, 14]. On short trips the engine does not reach its optimum operating temperature, increasing wear and reducing durability [14].

2.5 What to do before the trip:

- Clean junk from your trunk. Extra weight means extra fuel so if there's anything in the boot you don't need on the journey take it out [12, 13]. Driving with unnecessary things makes the vehicle heavier so the vehicle consumes more energy for maneuver. Do not fill your tank
completely. One litre of petrol weighs 0.73 - 0.78 kg [15], one litre of diesel weighs 0.80 – 0.85 kg [16]. Every 100 kg of extra weight consume 0.5 l of fuel per 100 km [17].

- **Remove unused roof racks and boxes**, if you do not need them. Such accessories increase aerodynamic drag what means higher fuel demands [12]. Roof box increases vehicle consumption up to 2 l per 100 km. [17].

- **Check tire inflation regularly**. Underinflated tires cause high rolling resistance what increases fuel consumption and wear of tires. By keeping of right pressure you can save 3 – 5 % of fuel [17, 18, 19].

- **Maintain your vehicle**, you save fuel, the air from exhaust and you also increase safety of driving. If the engine is not adjusted correctly fuel consumption is higher and it can also consume oil. Change oil, spark plugs (gasoline engines) and oil filter regularly. Air filter must be clean, check it. Fuel consumption influences also wheel alignment and worsening of breaking pads. If the vehicle is in good condition, you can save 4 - 10 % of fuel [2, 17]. Poorly tuned engine can emit pollutants equal to 20 vehicles [2].

- **In winter clean your vehicle off snow and ice**. Removing snow and ice from the vehicle not only increases safety on the road, but it is economical, too. Snow layer on bonnet increases aerodynamic drag and means also an extra load. 1 m$^2$ of 10 cm snow layer weights about 10 - 60 kg (depending on water content). Defrosting ice by using electric defrosters (rear window) is energy demanding. So fuel consumption of uncleaned vehicle is higher [12].

### 3 Choose the right car

By the choice of the right car we are able to influence future pollution of the environment. Since 2013 CEPTA has started evaluating cars at the Slovak market from the environmental impact viewpoint - the ECO-car competition. The results of the evaluation for the year 2013 were published on CEPTA webpage on 10.7.2013 [20].

This first year of the competition comes out from the methodology of partner organisation VCD (Verkehrsclub Deutschland), which has evaluated vehicles since 1989.

Three vehicle qualities were taken into consideration: fuel consumption, noisiness and emissions [21].

The aim of the competition is to introduce the dimension of environmental protection to the customers when deciding about the car model. Today it is possible to buy a car with CO$_2$ emissions up to 80 g/km, although the EU standard limits are to be 95 g/km since 2020.

Nowadays commonly used cars produce emissions over 160 g/km.

**Top 3 models of the ECO-car competition 2013:**

The best evaluated vehicle was Volkswagen eco up, small passenger car, powered by gas, with CO$_2$ production of 79 g/km (average consumption of 2,9 kg of CNG per 100 km), noisiness of 69 dB and performance of 50 kW/68 PS. At the Slovak market it can be bought from 12 050 €.

As the second best car, Lexus CT 200h was ranked – a compact hybrid model with CO$_2$ production of 87 g/km (average consumption of 3,7 l of petrol per 100 km), noisiness of 68 dB and performance of 100 kW/136 PS. This model costs 27 900 €.

The third best model was a family car Toyota Prius Hybrid with CO$_2$ production of 89 g/km (average consumption of 3,9 l of petrol per 100 km), noisiness of 69 dB and performance of 100 kW/136 PS. This model costs 22 900 € [22].

The list of top 10 environmentally-friendly cars, as well as family models and climate changes-friendly vehicles, which were ranked in the ECO-car competition 2013 can be found at [20]: http://www.cepta.sk/index.php/sk/clean-air-ciste-ovzdusie-projekty-736/514-eko-soferovanie.

### 4 Emissions control technologies – filters and catalysts

Emissions control technologies are frequently in use to reduce air pollution caused by vehicles and meet tightening air quality standards. The most common are catalysts and particle filters. These devices require the use of unleaded petrol or low-sulphur diesel [23].
4.1 Technologies for gasoline vehicles – The 3-way catalyst

For reduction of air pollution of gasoline vehicles, the use of 3-way catalyst is widespread. The catalyst turns emissions of CO, NO\textsubscript{x}, a HC into harmless products N\textsubscript{2}, H\textsubscript{2}O a CO\textsubscript{2} by additional catalytic burning at the catalysts (platinium, rhodium).

The 3-way catalyst requires unleaded petrol, because Pb is catalyst poisoning. Lifetime of the catalyst is also decreased when unburned petrol gets into the catalyst. It can happen while the engine is misfired, or while long starting or luggin of the vehicle to start without starter [24, 25]. Lifetime of the 3-way catalyst is about 80 – 160 thousand km [24, 25, 26].

4.2 Technologies for diesel vehicles

For reduction of air pollution of diesel vehicles, different technologies are used:

- **Diesel Oxidation Catalyst (DOC)** – reduces emissions of CO, HC and organic PM by catalitic burning. Efficiency of the catalyst is about 20 – 50 % for PM and 60 – 90 % for CO and HC. DOC is not able to reduce emissions of NO\textsubscript{x}. [27, 28]

- **Diesel particulate filter (DPF)** – see below

- **Selective catalytic reduction (SCR)** – reduces emissions of NO\textsubscript{x} by adding urea into the exhaust stream before it is get into the device. NO\textsubscript{x} is turned into N\textsubscript{2}. Efficiency of SCR is 75 – 90 %. [27, 29]

- **Exhaust gas recirculation (EGR)** – reduces emissions of NO\textsubscript{x} by partly recirculation of exhaust gas (5-10 %) into the engine. Thus NO\textsubscript{x} is decreased, but PM production is increased. The vehicle with EGR must be equipped with DPF for PM reducion. [29, 30]

4.3 Diesel particulate filter (DPF)

As PDF requires special principles, it must be kept to work correctly and we pay additional attention to it. Moreover, PM are very harmful for our health [31, 32] and also for the climate [33]. Diesel motors produce 200-times more PM than gasoline motors [34], so PM must be removed. For their removing DPFs are frequently used.

DPF filters PM through a system of number of small chambers – PM are trapped into the chambers, exhaust gas penetrate through porous (mostly ceramic) walls. When the filter is full it must regenerate – PM are catalytically burned to CO\textsubscript{2}. Regeneration can be passive - when exhaust gases are hot enough (350 – 500 °C), or active – additional fuel is required. [35, 36, 37]

Correct operation and maintenance of DPF:

- **Use low-sulphur diesel.** Content of sulphur should not exceed 15 mg/kg [38].

- **Clean DPF periodically.** DPF must be cleaned from noncombustible particles and ash periodically in professional cleaning services. The cleaning is required every 6 to 12 months – depending on the vehicle use. The filter should be cleaned if regeneration process is done too often or onboard control signalises it. [36]

- **Do not use diesel vehicle for short trips only.** Short trips are not good for diesel vehicle, because diesel engine warms up much more slowly than gasoline engine. Cold diesel engine consumes more fuel and produces much more PM than the warmed one. DPF fills up quickly and it has no time to regenerate. Therefore if you plan to use your car for urban driving, buy gasoline rather than diesel. If you are an owner of diesel, sometimes drive your car for 5 – 10 minutes fluently at 2 000 – 3 000 RPM (e.g. driving on a highway) so the regeneration of DPF can be accomplished [34].

- **Keep the engine in good condition.** Well maintained engine saves DPF, too. Co-burning of oil in the engine damages DPF [36].

If DPF operation and maintenance is correct, DPF works during all vehicle lifetime [38].

Retrofitting:

Older diesel vehicles can be retrofitted by DPF or other technologies (DOC, EGR) to meet stricter european emission standards enabling entrance to Low Emission Zones and also for better air quality in urban areas. E.g. older vehicles which do not meet emission norm EURO 4 must not enter into Low Emission Zone in Berlin [39].
5 Fuel type

Fuel type also influences economy and environmental impact of your car. By retrofitting of gasoline vehicle to LPG, you can save approximately 40 – 50 % of fuel costs. Other advantages are cleaner emissions, decreasing of emitted CO₂ and prolongation of the interval, when exchange of oil and oil filter is needed [40, 41, 42].

Disadvantages of LPG retrofitting are initial investment for retrofitting, reduction of luggage space because of LPG tank and ban of parking in closed spaces (garage, parking house etc.) [42]. Nowadays LPG retrofitting costs about 700 – 850 € in Slovakia. This initial investment will be payed back by fuel savings up to 2 years (if the car use is around 1 000 km per month). Diesel passenger cars can not be retrofitted to LPG in Slovakia. Technology is known, but this retrofitting is not authorised. To enable this process Slovak legislation must be changed.

6 Ecodriving tips while driving

To save fuel while driving, the following principles of ecodriving are important to be kept:

- **Set off just after starting the engine.** The engine is getting warm by driving more efficiently than idling. During the first 5 minutes, the idling cold engine in winter consumes 0,15 l of fuel [17].

- **Minimize idling.** Turn off the engine if you are going to be stopped for more than 30 seconds [17, 43]. Turning off the engine and starting again consumes less fuel than when the engine is idling. Fuel consumption while warm engine is idling is cca 0,5 – 1 l per hour [17].

- **Avoid aggressive driving, minimize braking and acceleration.** Driving style influences substantially the fuel consumption. It is very important to foresee the driving situation and in-time and right reactions. Drive fluently with traffic flow, without excessive braking and acceleration. Apply the rule: „Drive as if your brakes were damaged“. Every braking means an extra work of the engine during successive acceleration. Maximize using of vehicle inertia. Aggressive driving (braking and acceleration) increases fuel consumption by about 20 % [17]. Fuel consumption during “Start/Acceleration” makes up about 40% of the whole fuel consumption when driving in the city [44]. Smooth use of the accelerator, steering, transmission and brakes also decreases scrubbing of tires [17].

- **Use the engine as a brake.** Release the accelerator quickly - as soon as you see a red signal or a stop signal or also while driving downhill. If the accelerator is released when driving at a high speed, the fuel supply to the engine will be halted automatically. The vehicle is slowing down, because of braking force of the engine. There is no fuel consumption in this mode and you also save brake pads. When the engine speed is lowered, approximately as much fuel as will be necessary for idling will be supplied again [44].

- **Shift up early.** Use the highest possible gear. Do not drive at high RPM, put the car in higher gear at 2 000 RPM in a diesel car and 2 500 RPM in a petrol car [43, 45]. Driving at 50 km/h in 3rd gear consumes by 1 l per 100 km of fuel more than using 5th gear [17].

- **Drive at optimum speed and fluently.** Maintain safe distance between vehicles and avoid changing speed often [44]. Driving too fast but also too slow increases fuel consumption. The lowest consumption is at 50 – 70 km/h (depending on vehicle type) in the highest gear and low RPM [12, 17]. Aerodynamic drag increases exponentially with speed. Fuel efficiency can be improved by 10 to 30 % by driving at 80 km/h [44]. Driving at 115 km/h uses up to 9 % more fuel than at 95 km/h and up to 15% more than at 80 km/h. Cruising at 130 km/h can use up to 25 % more fuel than at 115 km/h [15]. Using the cruise control keeps the speed constant. It lowers fuel consumption, mainly on flat roads [12, 17].

- **Close the windows.** Opened windows increase aerodynamic drag – especially at high speed, so the vehicle consumes more fuel to keep the same speed [12, 17]. There is a rule: „Under 65 km/h open windows, over 65 km/h use air conditioning or ventilation.“ [2]. If you need to open a window, do not have more than 2 cm gap [17].

- **Driving in good weather is more economical** than driving while it rains or driving at snow or on ice [17]. Water, snow or slush on the road surface can dramatically increase rolling
resistance what leads to fuel consumption increase. In winter, if it is possible, wait for the snow plow [12].

- **Turn off electrical appliances**, if you do not need them. Every 100 watts of input power increase fuel consumption up to 0.1 l/100 km. Fan of ventilation system (not air conditioning) has input about 170 W, hi-fi booster can reach the input of 400 W! Turned-on fog lights can increase fuel consumption by about 0.2 l/100 km [17].

- **Use the „corridor effect“**: Driving at a constant speed within a flow of traffic (in the same direction) is more efficient than going the same speed in isolation. The reason is that you have lower aerodynamic drag when driving behind a vehicle [12]. But be careful of keeping safe distance considering current speed you are driving and other circumstances on the road.

- **Close the sunroof at higher speeds**. If the vehicle is equipped by sunroof, close it at higher speeds. Sunroof increases aerodynamical drag of the vehicle what means extra fuel [12].

- **Driving in traffic jam** [12]. If you must drive under the "stop & crawl" traffic conditions, leave as much space ahead of you as possible. This allows you to drive fluently though slowly. Maximize using of vehicle inertia and coasting driving (in neutral). Minimize repeated braking and acceleration. There is a risk a vehicle get into the space you create ahead of you. Deal with it.

- **Minimize driving with trailer**. Trailer towing increases aerodynamic drag and rolling resistance as well. If it is possible, avoid driving with trailer. Carry loads in the vehicle using roof racks. Optimal is to stuff in loads into the vehicle (no aerodynamic drag increase). To gain more interior space, you can flatten or remove the seats in some vehicle types. If it is not possible, avoid to drive with trailer, minimize towing speed, check tire inflation (minimize rolling resistance) and adjust your drive technique to account for the extra momentum the trailer and its load will add [12].

### 7 Parking and departing tips

The way of parking and departing from parking place also influences the fuel consumption. You should keep the following principles:

- **Park in the shade in summer**, if it is possible. Inner vehicle space overheats quickly in the sun, temperature of dark interior surface increases dramatically. Parking in the shadow ensures pleasurable interior environment and helps to minimize use of air conditioning [12].

- **Parking in a slope – gravity assists**. If you are parking in the slope, try to park downhill when you will depart. If the engine is cold with less efficiency and higher fuel consumption, it is more efficient to leave the parking place downhill [12].

- **Park in the periphery**. Choosing a parking place in the "periphery" of a busy site will be more efficient than navigating the rows of traffic/pedestrians to get as close as possible to the building or destination [12].

- **Start up not until you are adjusted**. When you are going to leave the parking place, do not start the vehicle until you are settled in (e.g. seat, mirrors adjusted), fasten your seatbelt, passengers are settled in as well [12].

### 8 Smart use of air-conditioning

Air-conditioning (MAC – mobile air-conditioning) belongs to the most energy demanding devices in cars. Its use influences fuel consumption significantly. So by smart use of air-conditioning you can save a lot. We bring some tips which should be kept:

- **Park in the shade** (see also in „Parking and departing tips“). Cooling of overheated vehicle, parked at the sunshine place, is much more energy demanding than cooling the vehicle parked in the shade [12].

- **Ventilate well before driving in summer**. This reduces the interior temperature (mainly if car is parked at the sunshine place) and energy need for cooling will be lower [46]. Activating of air-conditioning in overheated car can increase fuel consumption by 2.5 – 4.2 l/100 km transitorily [47].
• **Turn off air-conditioning for the short trips.** Air-conditioning does not manage to cool down the car interior on a short trip, so when it is turned off, you are saving fuel [46].

• **Do not activate air-conditioning automatically**, but only when you really need it. Activating air-conditioning and cooling the car interior to 24 °C increase fuel consumption by as much as 14 %, even if ambient temperature is 25 °C (temperature difference is only 1 °C, air-conditioning load is light). When ambient temperature is 35 °C (not unusual in summer) and air-conditioning is set to 24 °C, activating the air-conditioning increases fuel consumption by 38 % [44].

• **Keep windows closed after starting your journey.** Set the fan to medium speed in the first minutes of driving, and turn on recirculation. This prevents warm fresh air constantly coming in from outside [46].

• **Do not set the temperature too low.** The difference between outside air and interior temperature should not exceed 6 °C [46]. Big temperature difference increases fuel consumption dramatically and there is a risk of diseases emergence (colds, inflammations etc.).

• **Set fan correctly.** Do not aim the cold air to flow directly on your body, because cold draught can induce colds or inflammations [46].

• **Turn off air-conditioning before the end of your journey.** Before you stop and end your journey, turn off air-conditioning to enable humidity to evaporate from the air-conditioning system [48]. You will also utilize accumulated coldness without any additional fuel consumption.

• **Regular maintenance is important.** No maintenance is necessary during the first 4 years. Subsequently, experts recommend having the air-conditioning system checked every 2 years to measure the loss of refrigerant. If the loss is not compensated for, the air-conditioning system must bear higher load and wears out more quickly. If you never switch the system on, the lifetime will also be reduced [46]. Cleaning and desinfection of air-conditioning system should by done yearly (filters replacement etc.) [47].

• **Ask for information.** When buying a car, ask about used refrigerant and the air-conditioning technology, as well as the additional fuel consumption to be expected [46].

### 9 Train in ecodriving

There are possibilities to train in ecodriving in some European countries, but not in Slovakia yet. There are also some initiatives and campaigns, which we would like to point out.

**Volkswagen Eco Driving Programme**

Volkswagen company offers within „Volkswagen Eco Driving Programme“ trainings for individuals and also for companies and fleet managers. After theoretical part you can test your ecodriving skills in practice. Special onboard device evaluates your driving style.


**Projest ECOWILL - ecodrive.org**

Webpage [www.ecodrive.org](http://www.ecodrive.org) deals with ecodriving [49]. It was created as a part of the international project ECOWILL (ECOdriving – Widespread Implementation for Learner Drivers and Licensed Drivers).

The main objectives of the project is to increase the awareness of ecodriving, to standardise and spread training courses on ecodriving and to certify trainers for providing training courses. The project also supports incorporation of ecodriving in the driving school curriculum. The project partners are several organisations from 13 European countries, but there is no organisation from Slovakia.

At the webpage there is a list of certified instructors of ecodriving trained within the project ECOWILL: [http://www.ecodrive.org/en/home/trainers/](http://www.ecodrive.org/en/home/trainers/) The closest instructors for Slovakia are in Austria and Hungary. There is no instructor in the Czech Republic.
Courses of Belgium company KDC
Belgium company Key Driving Competences NV (KDC) provides training courses geared to developing contemporary driving behaviour. The emphasis of the training courses lies mainly on the Ecological Impact (Eco-Proactive Driving Behaviour) and on Sustainable Safety (Proactive Driving Behaviour).

The courses are for the transport sector and also for companies and individuals - drivers who already have driving licenses in one of the following classes: B, C, CE and D. The courses are in Dutch and French. You can find more at [50]: http://www.keydriving.be/en/index.html

Driving Clean Campaign, TNT-UNEP toolkit
Delivering company TNT within Driving Clean Campaign started cooperation with UNEP in 2006 to develop TNT-UNEP toolkit.

This toolkit was finished in 2009. It helps you to develop a strategy for reducing the environmental impacts of your fleet. To develop your own fleet strategy you need to follow the instructions at the webpage [51]: http://www.unep.org/tnt-unep/toolkit/index.html.

This toolkit enables you to monitor environmental impact of your fleet and to take action for the improvement. Ecodriving is one part of the measures.

10 Abbreviations
CNG – Compressed Natural Gas
DOC – Diesel Oxidation Catalyst
DPF – Diesel Particulate Filter
EGR – Exhaust Gas Recirculation
LPG – Liquid Petroleum Gas LEZ - Low Emission Zone
MAC – mobile air-conditioning
PM – Particulate Matter
RPM – revolution per minute
UNEP – United Nations Environment Programme

11 Sources
[5] Čo je car sharing a ako funguje? (What is it car sharing and how does it works?) Available at (in SK): http://udvb.sk/?p=5159


[24] Wikipédie: Katalyzátor výfukových plynů (Wikipedia CZ: Catalyst). Available at (in CZ): http://cs.wikipedia.org/wiki/Katalyz%C3%A1tor_v%C3%BDfukov%C3%BDch_plyn%C5%AF


[40] CO₂ emission from various fuel types. Available at: http://www.travelmatters.org/calculator/transit/methodology#offsets


[49] International webpage on eco driving (Project ECOWILL). Available at: www.ecodrive.org
