The International Journal of
TRANSPORT & LOGISTICS
Medzinárodný časopis
DOPRAVA A LOGISTIKA

ISSN 1451-107X

Is ECO-tuning a real solution for fuel economy?

Nikolay Dragomirov Ph.D. [1]
[1] *Department of Business Logistics, University of National and World Economy (UNWE), 1700 Sofia, Students Town, Bulgaria, 00359 988819785, nikolay@balbg.com*

Abstract: *The effective usage of the resources is important, especially for the logistics system. A significant part of the costs is related to fuel types and their prices. That makes fuel consumption and use of alternative energy problems whose resolution can improve the functionality of the whole system. Finding a real working solution is vital for the organization.*
One of the alternatives for reducing fuel consumption is called Eco-tuning - that is, software modification of the vehicle's electronic control unit in order to give a variety of benefits without any upgrades of the mechanics. Depending on the type of the vehicle, its purpose and usage, it is possible to improve the fuel consumption by up to 9%,(depending on the driving style), increase the power output, improve dynamics, and reduce emissions.

Key words: *transport, logistics, fuel economy, ECO-tuning*

1 INTRODUCTION

Modern vehicles are more than a chassis with tires and engine. They are equipped with many computers that are responsible for controlling and optimizing all of the vehicle processes. Electronic control units (ECUs) are widely integrated and used for engine management, suspension control, braking assistance, navigation, emissions control etc. These technologies make it possible to get the best from the hardware. The ECU system adapts certain controllable parameters to satisfy driver needs as far as possible in a secure way.
The whole adjustment of the vehicle is carried out in the factory. That task is challenging, because different settings give varied results. In practice, automotive engine power performance involves a compromise between maximum engine torque, minimized fuel consumption and reduced emissions [1]. The manufacturer attempts to create the best configuration for a certain market and most of the vehicles have predetermined adjustments that are fixed and will not be changed during their operation. It is necessary to cover the specific customer's needs. Another reason for having different settings is the variety of the fuel quality in the different countries.
There is an opposite approach for configuration that is not fixed. Now there is a new technology used for ethanol engines. The ECU detects the content of the fuel mixture and

raises the maximum boost pressure. As a result, performance is increased by 20% and fuel economy is improved by between 3-7% [2]. All this is done only by dynamic modification of the ECU software parameters.

The total control of the processes in the transport systems gives vehicle manufacturers the opportunity to adjust the system parameters in the way they want. It is hard to believe but identically built engines can have a variety of power output versions, emissions and fuel consumption resulting only from different software settings of the engine ECU. Such examples can be found among most European car manufacturers. The same is true of one of the most popular diesel engines, the 1.3 Mjet [3]. The engine mechanics are the same but there is a variety of power outputs. This is possible because the ECU is like any other computer – an integrated system with hardware and software. The software is in the reprogrammable flash memory and determines the behavior of the ECU [4]. Setting different values for parameters such as ignition timing, fuel injection and turbo pressure will affect the power output and fuel economy. It has been proved that changing the settings significantly affects the fuel economy of a methanol engine under light loads [5]. These modifications are also possible for both diesel and petrol engines. When they are done for fuel economy they are called ECO-tuning [6] or ECO-remap. That activity is not something new, and positive results after experiments have been presented [7].

The best configuration for the specific vehicle/engine is set during manufacturing but it can be readjusted later. Changing the parameters is a revision of the ECU software and it is called a software update. This service can be performed using the right equipment to read/write to the ECU, provided one has the necessary knowledge for the modification/programming of the software. During this process it is possible to adjust the vehicle more precisely to meet one's expectations. The professional can re-adjust the system for more power, fuel economy, reducing emissions, adding or removing limiters etc. This is legal, and such activity is not restricted by law. The TUV-Nord [8] website says that this service in Europe should be made within these regulations:

- Exhaust gas measurement as per the regulations in EC directive 70/220/EEC.
- Vehicle noise measurement as per the regulations in EC directive 70/157/EEC.
- Engine performance measurement as per EC directive 80/1269/EEC.
- Maximum speed measurement as per ECE regulation no. 68.
- Possible checking of the braking effect and the tires at the increased maximum speed.

It is also important that the engine and its component (injectors, turbocharger, flywheel and etc.) are able to cope with the power increase. Our research interests are focused on modifications for achieving fuel economy. Collected information before the experiment gives the conclusion that the fuel consumption will be increased if the vehicle is under full load, but if a casual driving style is adopted, fuel economy of 10-15% can be achieved [9].

2 METHODOLOGY OF THE EXPERIMENT

2.1 Used vehicle

For the experiment we used a typical vehicle that can be classified as M1 (Vehicles for the carriage of passengers and comprising not more than eight seats in addition to the driver's seat) according the categorization of the European commission - Mobility and Transport [10]. The same model can be found as N1 (Vehicles for the carriage of goods and having a maximum mass not exceeding 3.5 tones). The examined vehicle was equipped with a turbo diesel engine with a 1,248 cc displacement and power output of 55kW with emissions standards Euro4. It also has a Euro5 version which has a diesel particulate filter (DPF). The

main reasons for making this selection were: 1) its popularity within logistics companies because it is of medium size; 2) low running costs, and 3) good fuel economy. Also, it is equipped with an ECU (MARELLI MJD6F3 MPC563) that supports ECO-tuning.
The vehicle in the research was driven to meet the company logistics needs. It was used for delivering small goods and to travel to sales/business meetings. The exact routing was unpredictable because of the nature of the business. The average distance traveled every month was about 4000 km, with a balance between urban and extra-urban traffic.

2.2 Driving conditions

Globally, there are many standards and procedures to examine the fuel consumption of the vehicle. Every one of them has its benefits and special conditions for application. We have common standards in Europe, USA and Japan. The usual test is made on a rolling road (a machine simulating driving conditions), with an exactly predefined load, acceleration, braking, max speed, ambient temperature and etc. The environment is totally regulated and cannot represent real driving conditions. These tests are made to evaluate the engine and to calculate average results. This is the main reason the car manufacturers give an additional explanation that the fuel consumption figures are in accordance with EC regulations and may not be representative of real-life driving. Fuel consumption is also influenced by a series of operating factors such as traffic, loaded weight, air conditioning usage, ambient temperature and so on. The most significant of these is the traffic conditions, which is indicated by the average speed [11]; a lower average speed is typical for heavy traffic, higher for the opposite.
According to regulation (ECE-R83) the vehicle test for CO_2 has two parts. The first one simulates urban traffic with four repeated procedures. The second one is the extra-urban situation, reaching a high speed of 120 km/h. The test is often called the *New European Driving Cycle (NEDC)*. Details of how the test is performed are presented in **Fig. 1.**

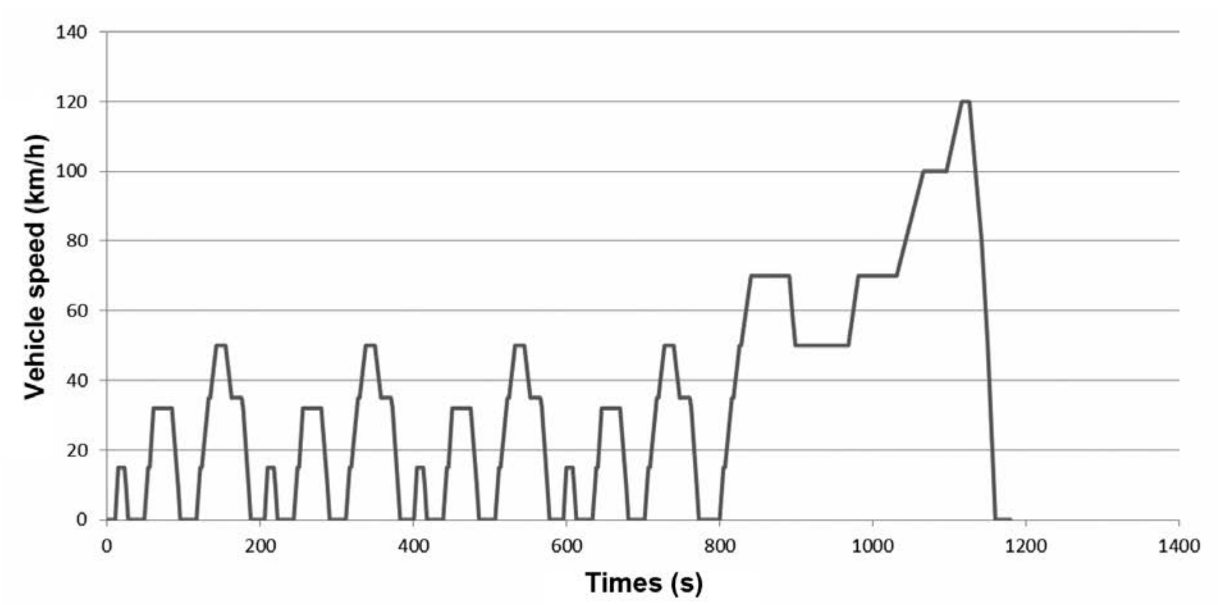

Fig. 1 *New European Driving Cycle (NEDC)*[12]

Another popular test according to ADAC Technik Zentrum is the *ADAC Highway Driving Cycle*, which shows good accuracy for European highway driving. Details in **Fig 2.**

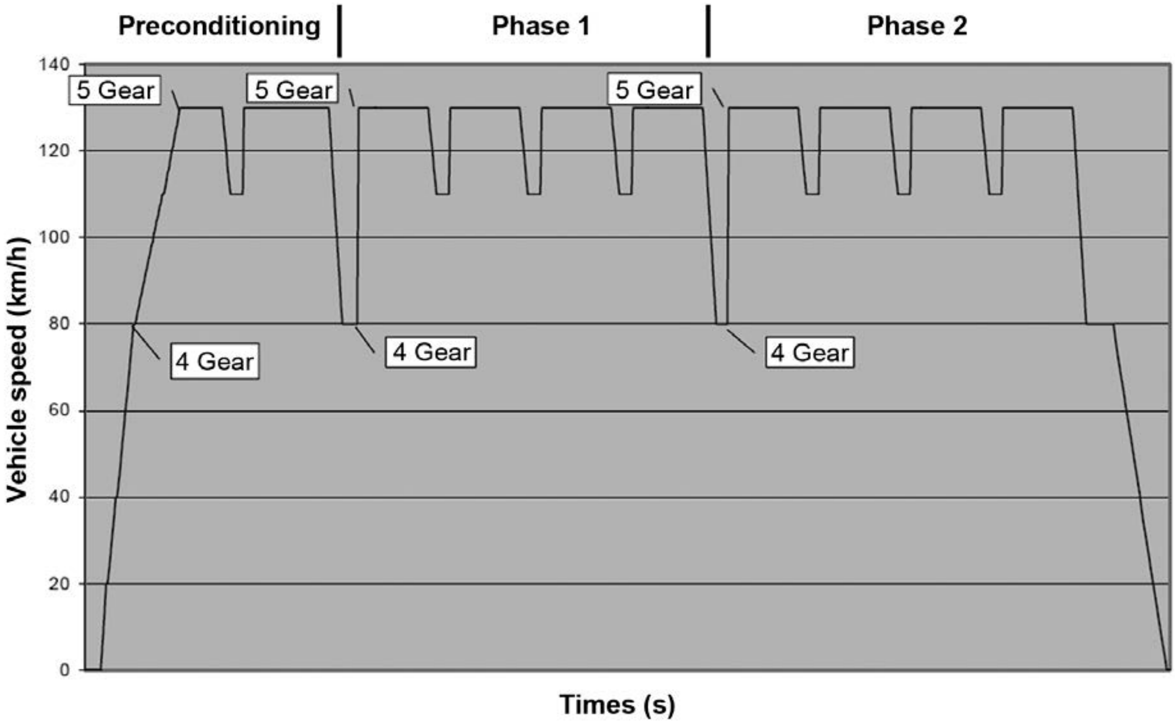

Fig. 2 *ADAC Highway Driving Cycle* [13]

Currently under development is the *Worldwide Harmonized Light Vehicles Test Procedures (WLTP)*. Its purpose is to harmonize the global standards on pollutants and CO_2 emissions. The procedure development is overseen by the *United Nations Economic Commission for Europe, Transport Committee*, and the draft report is already available [14]. Some main differences with NEDC could be mentioned [15] - the idling time of the WLTC is lowered and the whole test is 1800 sec, whereas it is 1180 sec for NEDC. The gearshift strategy of the WLTC is more “aggressive” than in the NEDC and there is more driving at higher engine RPM.

The logistics system is dynamic, especially for light vehicles. They have to meet company transport needs and that makes their driving cycle very unpredictable. It is common for the vehicles to be used for short distances with many cold starts, in heavy traffic with low average speed and fully loaded. The reality of logistics cannot be set in a framework or in a fixed examination model. This is why it is preferable for the experiment to be done in real driving conditions instead of controlled ones.

2.3 Collected data

The focus of the research is fuel economy, but this is not the only factor. When the experiment is conducted in a closed environment it is possible to collect a lot of quantity data. When it is real, it represents the actual logistics system and also some qualitative data can be found. During the experiment we measured these parameters:

- **Average fuel** economy for different styles of driving and driving cycles, measured by quantity of fuel used to travel 100 km at average speed.

- **Dynamics** and driver satisfaction. Because of the power increase, improved dynamics are expected.
- Maximum power and top speed measured on a track.
- Any technical problems appearing etc.

Different calculations were made:1) fuel consumption was worked out by noting the quantity of used fuel and traveled kilometers; 2) average speed was measured by dividing the trip distance by the time; 3) acceleration, power and speed were measured by additional equipment; 4) other data was collected by interviewing the drivers.

3 RESULTS

The experiment continued for approximately two months. The first measurements ware made with the standard settings. The vehicle was used in a typical manner - it traveled about 4500 km. After that, modification of the software was carried out by a company with a TUV-Nord and TUV-SUD certification. The remapped vehicle had increased power and torque as shown in **Table 1.**

Tab. 1 *Improved power output of the engine*

Standard	After the remap	Difference
Power 75 hp @ 3980 rpm	90 hp @ 4000 rpm	+ 15 hp
Torque145 Nm @ 1600	187 Nm @ 1640 rpm	+ 42 Nm

This upgrade was optimized to give a balanced improvement of performance and fuel economy of around 5-10%. It was noticed that the actual fuel economy depended on the driving style, road type, tire pressure and etc. The economy was a result of the increased torque, because when the engine is more powerful the car will accelerate faster and more easily, so the driver will continue to hold the reached speed. Of course, if the engine is on full throttle all the time there will be a significant increase in fuel consumption. This is also true for any stock vehicle [16], without any modifications.
After the modification a few trips were made to assess the vehicle's handling. Next, the new results were measured while the car was driven a little over 4000 km, and a survey of the drivers was conducted. The total and average fuel consumption before and after the modification are shown in **Table 2**. Calculated economy was about 7.2%, which was in the expected tolerance.

Tab. 2 *Average fuel consumption before and after the remap*

	Standard	After the remap
Total Distance	4 415 km	4 320 km
Total Fuel	252 l.	225 l.
Average Fuel Consumption	5.7 l/100 km	5.2 l/100 km

Based on a yearly distance traveled of 40 000 km the cumulative fuel saving would be about 200 liters of diesel, which is near the investment made in the remap. The change in the fuel consumption under different driving conditions was measured at different average speeds. For the inspected vehicle, data was collected for different driving styles with average speeds 15-20 km/h, 35-45 km/h and 75-85 km/h. Results for fuel economy after the remap are shown in **Fig. 3**

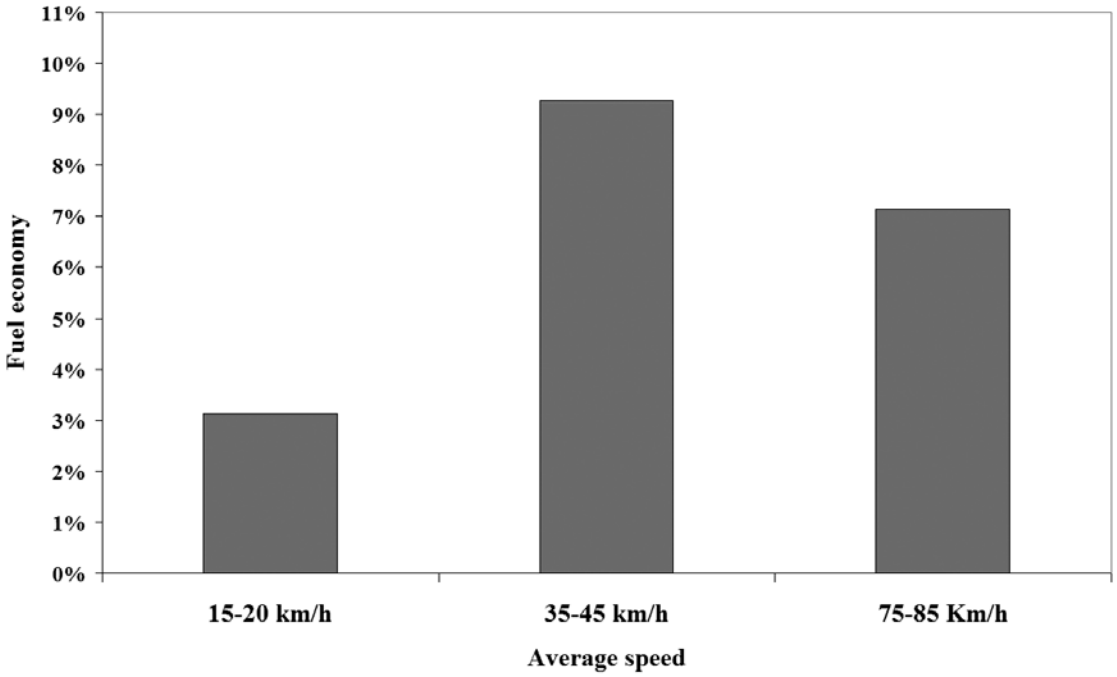

Fig. 3 *Fuel economy achieved at different average speeds*

The fuel economy was between 3% and 9% depending on the driving cycle. The smallest saving was achieved when the vehicle was in heavy city traffic. Better results were measured during extra-urban driving (mostly motorway), and the greatest fuel economy was when the average speed was 35-45 km/h. (combination of urban and extra-urban driving).

Another positive effect from the remap was found, namely in the car's performance. After the software change the car was different, the engine became more dynamic and elastic. The main benefits of this could be classified as follows:
- The turbo gap slightly disappeared.
- There was not a great difference between on and off air-conditioning.
- Better performance and drivability.
- Safer overtaking.

The top speed of the vehicle also improved. The maximum achieved top speed of 185 km/h was measured on a track. During the tested period we did not find any unexpected technical problems with the vehicle – engine, transmission, braking etc. Scheduled technical maintenance was carried out.

4 CONCLUSIONS

Fuel cost is an actual and current problem and businesses are expected to look for real solutions to reduce it. One possible way is Eco-tuning, which is a legal activity that is offered by certified companies. It is a fast and low budget solution, which can be implemented without any mechanical modification to the vehicle. The results of the research can be evaluated as follows:
- The engine software in the ECU can be optimized in a way to suit the vehicle's application needs.

- Eco-tuning shows real potential for fuel saving for the most common vehicles. Actual fuel consumption depends on the driving style but it is possible to achieve improvements of between 3% and 9%. The investment payback period depends on the type of ECU, the cost of the remap, fuel consumption and the traveled distance. In some cases there is a short payback period; in others there is not. This means that Eco-tuning has to be done after serious research into the compatibility and the fuel saving potential of the selected vehicle. Not every vehicle is suitable for that upgrade.
- Eco-tuning also upgrades the vehicle performance. There is better acceleration and safer overtaking. The tuning is safe for the engine and does not lead to any technical problems with the vehicle if it is done correctly.

The issue of software remapping has not been examined very much in the scientific literature, although it has more than 20 years of practical history. There is a potential for further research to focus on Eco-tuning and its application to heavy vehicles, public transport, petrol, GPL, CNG, Bi-fuel engines etc. Another research area that could be defined is the impact of the ECU remap on the environment, especially the benefits from reduced emissions.

References

[1] Wong, P. K., Tam, L. M., & Li, K. (2012). Automotive engine power performance tuning under numerical and nominal data. *Control Engineering Practice*, 20(3), 300-314. Retrieved from http://dx.doi.org/10.1016/j.conengprac.2011.11.006

[2] West, B. H., Lopez, A. L., Theiss, T. J., Graves, R. L., Storey, J. M., & Lewis, S. A. (2007). Fuel Economy and Emissions of the Ethanol-Optimized Saab 9-5 Biopower. *SAE Technical Paper*. doi:10.4271/2007-01-3994

[3] Fiat group automobiles s.p.a (2013, March 22). *5 million 1.3 MultiJet engines produced*. Retrieved from http://www.fiat.com/news/5million

[4] Weimerskirch, A. (2009). Secure Software Flashing. *SAE International Journal of Passenger Cars - Electronic and Electrical Systems*, *2*(1), 83-86. doi:10.4271/2009-01-0272

[5] Gong, C., Huang, K., Jia, J., Su, Y., Gao, Q., & Liu, X. (2011). Improvement of fuel economy of a direct-injection spark-ignition methanol engine under light loads. *Fuel*. doi:10.1016/j.fuel.2010.10.032

[6] ADAC, *Chip-tuning and Eco-tuning*. Retrieved November 2013, from http://www.adac.de/infotestrat/technik-und-zubehoer/tuning/default.aspx

[7] Deutsche Welle (2013, October 16). Examine it!: Eco Tuning [Video file]. Retrieved from http://mediacenter.dw.de/english/video/item/1176477/Examine_it_Eco_Tuning/

[8] TUV-Nord. *Chip-tuning guide*. Retrieved November 2013, from http://www.tuv-nord.com/en/tuning-additions-changes/chip-tuning-2762.htm

[9] Dragomirov, N. Modern technologies for fuel economy for the vehicles used in the logistics. Actual problems of population and infrastructure protection, Conference 25-26 Oct. 2012

[10] European commission - Mobility and Transport (2013). Vehicle categories. Retrieved November from ec.europa.eu/transport/road_safety/vehicles/categories_en.htm#M

[11] Zhang, S., Wu, Y., Liu, H., Huang, R., Yang, L., Li, Z., Fu, L., & Hao, J. (2013). Real-world fuel consumption and CO2 emissions of urban public buses in Beijing. *Applied Energy, 113,* 1645–1655. Retrieved from http://dx.doi.org/10.1016/j.apenergy.2013.09.017

[12] Economic Commission for Europe of the United Nations (UN/ECE) Regulation No83 Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements [2006] OJ L375/223

[13] ADAC Technik Zentrum (2008). *EcoTest Testing and Assessment Protocol Release 2.0*. Retrieved from ADAC / FIA Foundation website: www.ecotest.eu

[14] Economic Commission for Europe of the United Nations (UN/ECE) (2013). *Report of the Working Party on Pollution and Energy (GRPE)* (66). Retrieved from http://www.unece.org/fileadmin/DAM/trans/doc/2013/wp29grpe/ECE-TRANS-WP29-GRPE-66e.pdf

[15] TNO (2012). *Development of a method for the measurement and monitoring of CO2 emissions for N1 multi-stage vehicles* (Final Report). Retrieved from http://ec.europa.eu/enterprise/sectors/automotive/files/projects/report-co2-emissions-multi-stage-vehicles_en.pdf

[16] Driving on a full throttle. (2014). *Auto Bild Bulgaria*, *379*(3), 28-35.