

Analysis of the impact of ECO driving on fuel consumption and vehicle maintenance costs

Maida Eljazović¹, Ermin Muharemović², Adnan Tatarević³

¹ Nelt Ltd., Aerodromska bb, East Sarajevo 71123, B&H

² University of Sarajevo, Faculty of Traffic and Communications, Zmaja od Bosne br. 8, Sarajevo, B&H

³ Institute of Traffic and Communications, Zmaja od Bosne br. 7, Sarajevo, B&H

Abstract

The organization of the delivery of goods to end customers, especially in urban areas, is a challenge for companies nowadays. Originally due to the circumstances affecting the design of the logistics service and due to the high level of load on the transport infrastructure in urban areas. All this contributes to higher fuel consumption and faster wear and tear of delivery vehicles parts, which for companies represents a large investment in vehicle fleet maintenance. One of the approaches to overcome these challenges is the implementation of ecological driving. Eco driving is a driving style that contributes to reducing fuel consumption, extending the life of the vehicle and reducing environmental pollution. The paper investigates the impact of eco-driving on maintenance costs and fuel consumption of delivery vehicles in a company operating in BiH. The analysis refers to delivery in urban city areas and non-urban areas. The benefits and drawbacks of introducing eco driving in companies are analyzed. The paper provides an insight into the importance of ecological driving in the modern logistics environment and the potential benefits that can result from its adoption.

Keywords: analysis, eco driving, fuel consumption, delivery, costs

1 Introduction

Logistics companies or logistics departments within companies continuously strive to reduce costs and achieve more efficient operations. In order to improve their business, achieve quality and improve their position on the market, large investments in systems, employees or other values are often required. What poses a problem after implementing a system or training people is how to measure the effect of improvement or return on investment. In this paper, the system that monitors the driving of the train in capillary delivery through the so-called was analyzed and described. ECO drive driving evaluation and its impact on vehicle maintenance costs and fuel consumption. Also, an overview of the savings after driver training and the introduction of the ECO driving monitoring system is presented.

Ecological driving represents the adoption of driving behavior (or driving style) aimed at saving fuel and reducing harmful emissions [1].

Eco assessment is a methodological procedure developed in Brussels, which the Belgian government uses as an official tool for the formation of a policy of subsidizing transport companies. This procedure is based on the environmental assessment of the vehicle, taking into account the most important pollutants [2].

- The observed company had several goals for which it decided to introduce ECO drive. Some of the goals are:
- Achieving savings in fuel consumption;
- Vehicle preservation;
- Additional driver development;
- Green approach in performing logistics services;

Corresponding author: Maida Eljazović maida.eljazovic@fsk.unsa.ba)

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- Safe driving.

In order to further motivate drivers, the company has introduced compensation models in the form of rewards for drivers for the best ECO driving ratings.

According to recent research, the application of ECO driving can contribute to a reduction in fuel consumption from 10 to 25% [3]

2 Implementation of the system and method of monitoring ECO driving

ECO driving represents a driving culture that corresponds to modern engines, and enables the best use of the potential of advanced technologies in vehicles [4].

The implementation of the ECO driving system takes place through observation of the current situation, driver training and constant monitoring and evaluation of the driver's driving style. Investment protection is ensured by monitoring the entire fleet through a system of constant monitoring of driving style, reporting and ranking of drivers. Reports are automatic and individual for each driver or each vehicle.

- Implementation of the system implies:
- Upgrading the existing transport system or introducing a new one;
- Implementation of the ECO drive application;
- Modernization of "tracking" devices on vehicles;
- Calculation of the grade in values from 1 to 100;
- System maintenance.

3 Forming a driving assessment

Guided by the experience of companies that have implemented the Eco driving system, the driving rating is formed on the basis of 4 monitored parameters, which are expressed in percentages and serve for the overall rating of eco driving. The parameters monitored are:

- Smoothness- 32% (sudden decelerations and accelerations);
- Traffic monitoring - 31% (sudden braking);

- Engine management - 31% (speeds at which driving and transmission are performed);
- Idling – 6% (idle engine operation, i.e. the vehicle is switched on during longer stops).

Based on the scoring of all the mentioned parameters, a unique driving rating is obtained for each individual driver. The rating is recorded systemically and is available after the ride is completed in various reports (tabular, graphic, display on the map, etc.)

3.1 Smoothness

With the driving smoothness parameter, the quality of the overall driving is measured, in such a way that every acceleration is monitored, i.e. it is determined whether it was constant. Constant speed travel is monitored, has there been any speed dancing. The deceleration is also monitored, which must be continuous. Penalty points are awarded for sudden braking. Figure 1 shows a graphic representation of smoothness of driving.

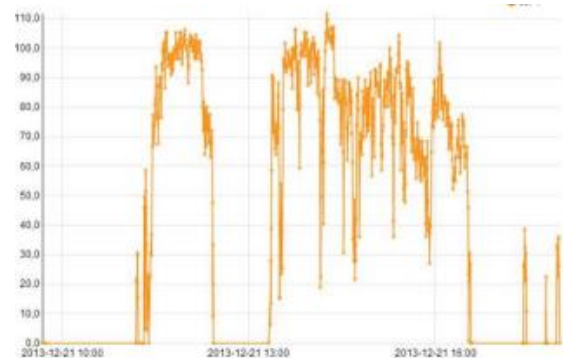


Fig. 1. Graphic representation of Smoothness driving

3.2 Traffic Monitoring

The percentage of the grade that includes traffic monitoring includes:

- concentration and anticipation of the driver
- whether the driver slowed down in time, and whether he braked with the engine or the brake,
- reached speed, how long it was at constant speed before deceleration
- standing, because standing too short is a mistake;

All listed parameters are normalized according to the achieved speed and/or average speed, and penalty points are awarded if the speed is exceeded. Figure 2 shows the speed tracking, the red circle indicates penalty points while the green circle indicates a positive rating.

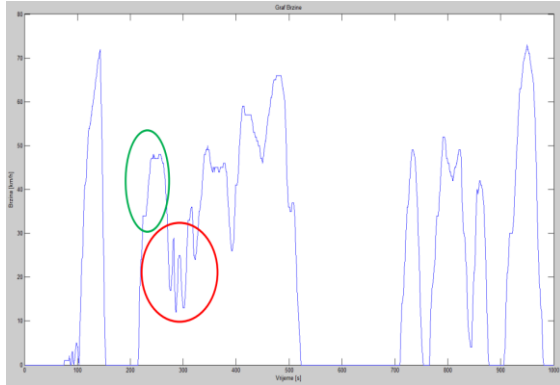


Fig. 2. Speed tracking

3.3 Engine management

Engine management implies an assessment of the quality of engine and gearbox use. During acceleration, the position of the gas pedal is monitored depending on the speed the vehicle is in. The number of revolutions is monitored (maximum during acceleration, minimum during deceleration and maximum during constant driving). Penalty points are recorded in case of exceeding the number of times, which is shown in picture number 3 and marked with a red circle.

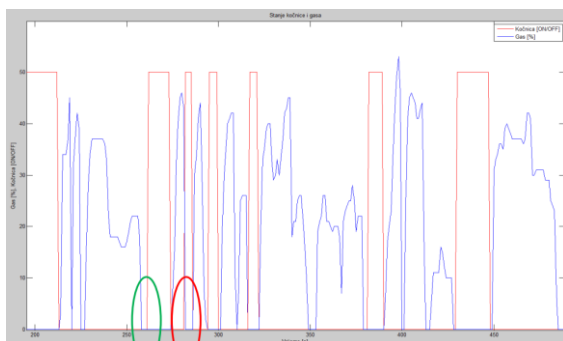


Fig.3. The relationship between brake and throttle use

3.4 Idling

With this parameter, the engine shutdown when standing still is evaluated. There is no need to turn off the engine if the stop is shorter than 30 seconds, because restarting it will use much more fuel. According to one of the studies conducted in the city of Delhi, the daily idle fuel consumption

is estimated at 9036 l, which is equivalent to an annual loss of about 4.5 million USD [5].

4 Data set

For the analysis used, it is necessary that the statistical data be processed in the STM-5 device and transferred to the server. The resulting driving rating follows the driving quality. As a rule, a better rating means lower consumption and less wear and tear on the vehicle. Since the system allows errors to be tracked separately, it gives the possibility to point out to the driver the location and moment when the error was made.

4.1 The effect of Eco driving on fuel consumption

Driving ratings of drivers before and after training were monitored and compared with fuel consumption and vehicle maintenance costs. Driving scores before training and before driver motivation were below 50, while after training scores ranged between 50 and 80.

An example of a system review of the driving assessment prior to driver training is shown in Table 1.

Table 1. Example of a system driving review before ECO drive training

Name	Kilometers	Grade	Adaptation to traffic	Engine management	Smoothness	Idling	Liters	CO2 %
x	53,3	43	20	75	27	96	8,41	19,93
x	56,8	38	39	59	9	90	15,35	36,37
x	286,0	46	32	71	29	89	55,89	132,40
x	312,3	46	33	77	21	96	43,45	102,95

Analyzed data and driving ratings were monitored daily for 60 delivery vehicles for one year.

Also in the following table No. 2, ratings are shown after driver training and the application of ECO driving with the percentage of parameters that influence the rating.

It is important to point out that the majority of drivers positively accepted the training and applied the new driving methods. Only a small number of drivers, about 5%, did not have an increased driving rating after the training. These 5% of drivers were mainly newly hired or drivers who intended to leave the company.

Table 2. Example of a system driving review before ECO drive training

Name	Kilometers	Grade	Adaptation to traffic	Engine management	Smoothness	Idling	Liters	CO2 %
x	617,4	60	67	75	33	98	72,44	171,61
x	394,0	61	61	75	42	91	78,12	185,07
x	660,1	59	64	76	32	98	132,43	313,75
x	17,5	60	39	84	51	100	2,28	5,40

Table 2. Example of a system overview of driving after ECO drive training

We monitored fuel consumption by type of vehicle and through analysis came to the conclusion that during the year consumption was reduced by 6% to 14%, depending on the type and model of the vehicle. As the Iveco Daly 70 is the most represented vehicle in the observed company, the total percentage of consumption in 2018 was 14% lower compared to the previous year. The consumption graph is shown below in Figure 3.

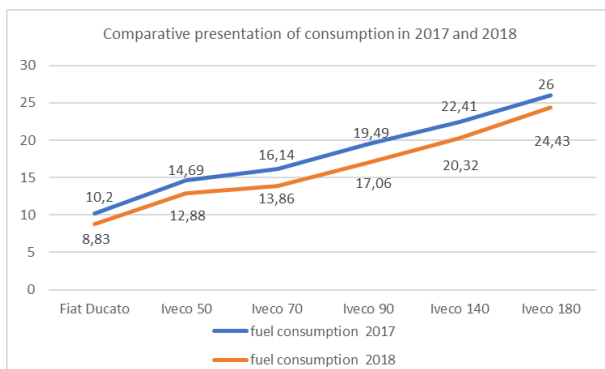


Fig. 4. Comparative presentation of consumption for delivery vehicles in 2017 and 2018

4.2 The impact of Eco driving on maintenance costs

Defective vehicles lead to an increase in company costs and can be one of the main causes of traffic accidents [6]. Previous studies have analyzed the impact of driving style on environmental sustainability and road safety. In this paper, we focused on the influence of driving style on vehicle wear and tear, that is, on the costs resulting from vehicle breakdowns.

By analyzing the collected data, we arrived at the amount of vehicle maintenance costs before the introduction of ECO driving according to the vehicle model shown in Figure 5.

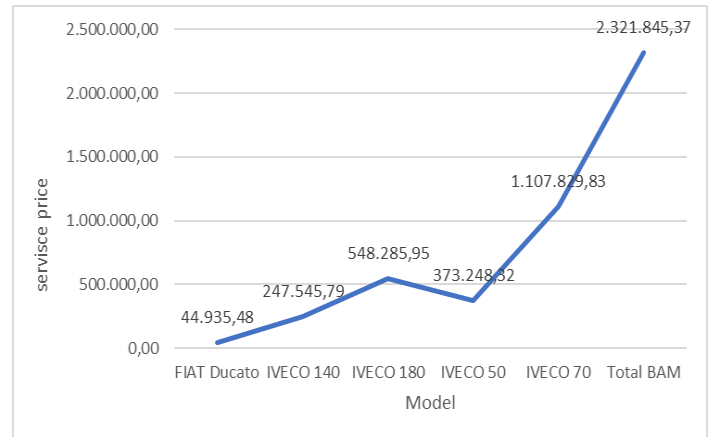


Figure 5. Graphic presentation of maintenance costs for delivery vehicles in 2017

Total expenses for 2017 year amounted to 2,321,845.37 BAM. Costs by vehicle model are shown in table number 3.

Table 3. Maintenance costs for delivery vehicles in 2017

Model	Service price
FIAT Ducato	44.935,48
IVECO 140	247.545,79
IVECO 180	548.285,95
IVECO 50	373.248,32
IVECO 70	1.107.829,83
Total BAM	2.321.845,37

Analysis of maintenance costs after training and application of ECO driving in 2018 is shown in table 4.

Table 4. Maintenance costs for delivery vehicles in 2018

Model	Service price
FIAT Ducato	43.142,66
IVECO 140	237.722,55
IVECO 180	526.967,88
IVECO 50	354.421,85
IVECO 70	1.043.987,39
Total BAM	2.206.242,33

From the analysis, it can be concluded that the costs of vehicle maintenance and servicing were reduced by 5% in 2018. It is important to note that the analysis included only parts of the vehicle that ECO driving could have had an impact on. Regular services and vehicle breakdowns not related to ECO driving are excluded.

Vehicle parts had the greatest influence in the analyzed services and the percentage of reduction in breakdowns:

- Brake calipers
- Brake shoe
- Brake linings
- Brake pads
- Brake disc
- Clutch

It is an interesting fact that the only increased need for servicing was the handbrake on the vehicles. A detailed analysis of the driver's driving behavior led to the conclusion that some drivers used the handbrake while driving to avoid braking with the pedal, thus obtaining a high driving score.

5 Conclusion

The results after using the ECO drive system and analyzing the data monitored on an annual basis show that 95% of drivers have shown remarkable improvements in driving efficiency. Feedback about their previous driving behavior had a special impact on drivers. We also came to the conclusion that in addition to road geometry, traffic, weather conditions, vehicle specifications and vehicle condition, driver's habits, i.e. driving style, have a great influence on fuel consumption. Frequent notes and presentations about driving style resulted in better ratings. Fuel consumption was reduced by 13% while maintenance costs were reduced by 5%. The only drawback within the ECO driving project was the increased cost of maintaining the hand brakes, but the total maintenance costs remained significantly lower.

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