ECO-DRIVING – POTENTIALS AND OPPORTUNITIES WITHIN GREEN LOGISTICS

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Abstract: *In the era of logistics companies' expansion and their endeavor to maximize profit, on one hand, and environmental protection efforts, on the other, there is also a growing need to solve simultaneously different problems by taking actions in both directions and achieving a best compromise solution. Nowadays, a discipline seeking for such a solution has got its name - „Green Logistics". In this paper, the authors deal with an approach to decrease the negative environmental impact of road vehicles and drivers, whose share in harmful gas emissions is prevailing. Eco-driving initiative is one of the programs that has evolved in the literature and practice as an efficient tool to attain green logistics objectives. The research focuses on potential eco-driving benefits and good practices of logistics companies that already implemented it. Through a survey realized in logistics companies, an analysis of managers' attitudes and preferences regarding eco-driving potentials based on previous experience and/or information is realized. Likewise, this survey will highlight the current condition in this field on our market and provide guidelines for potential future actions.*

Keywords*: logistics managers, survey, driving skills, road vehicles, environmental footprint*

INTRODUCTION

The expansion of logistics activities with the aim of satisfying growing users demand results in increased road transport volumes. Road transport is one of the unavoidable links in supply chains. Besides importantly influencing logistics costs, transport is a logistics activity with an equally high impact on the environment. This is the reason for being one of the main areas for development of green logistics practices. According to TRB & NRC (2014), green logistics refers to innovations in infrastructure, organizational initiatives, or traffic management that can result in more sustainable transport. It may also include increased driver training and other behavioral initiatives. These approaches can result in significant and cost-effective reductions in transport emissions and fuel consumption. Examples of such measures that could impact light- (LDV), medium- (MDV) and heavy-duty vehicles (HDV) are access control (including lane restrictions), urban traffic control measures, road pricing, smart traffic lights that provide more information to drivers on road conditions and traffic, ramp metering, and other fleet and fuel management approaches. The main idea of green logistics is not only to know the level of harmful emissions, but also to reduce emissions and energy consumption.

Thiell et al. (2011) outline that green logistics describes all attempts to measure and minimize the ecological impact of logistics activities. This includes all activities of the forward and reverse

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flows of products, information and services between the point of origin and the point of consumption. The aim is to create a sustainable company value using a balance of economic and environmental efficiency: the so-called eco-efficiency. Green logistics have its origin in the mid 1980's and was a concept to characterize logistics systems and approaches that use advanced technology and equipment to minimize environmental damage during operations.

This paper initially focuses on the eco-driving concept for influencing driver behavior and increase logistics and transport energy efficiency, while decreasing company's environmental footprint. Then, an insight into eco-driving in the field of HDV shows estimated and measured effects through worldwide experiences of logistics companies, as well as their future prospects. Subsequently, the present situation in the field of Eco-Driving Training (EDT) in Serbia and experience-based attitudes of logistics companies' obtained through an online fleet manager survey will be presented. Finally, important conclusions will be drawn including a set of short-term recommendations to overcome presently observed difficulties.

ECO-DRIVING CONCEPT AND TRAINING

Eco-driving, an environmentally friendly and cost-effective driving style, involves safe and responsible driving technique with minimum fuel consumption. It is a driving style adapted to contemporary vehicles and infrastructure technology including effective use of Advanced Driver Assistance Systems (ADAS), as well as available Intelligent Transport Systems (ITS).

As stated by Killian (2012), eco-driving evolved in the USA from the "hypermiling" originally applied in the Mobil Economy Run - an annual coast-to-coast road trip and demonstration taking place from 1936 to 1968, where the idea was to exceed a vehicle's fuel efficiency by modifying driving habits and adopting new techniques. Although not called by its current name, eco-driving was well present during World War II, the 1970's and 1980's oil crisis and later in times of worldwide fuel prices volatility. But as Barkenbus (2010) states eco-driving should be distinguished from hypermiling. While they share the same goal of reducing vehicle costs, they differ in terms of tactics. Hypermiling often involves downhill coasting (turning the ignition off) and drafting by getting as close to the vehicle in front as possible. Clearly hypermiling trades off safety for fuel economy, while with eco-driving there is no tradeoff. In Europe, eco-driving as an idea was initiated in Finland where two state-funded training programs were introduced in 1992: EcoDriving (for passenger car and van drivers) and KEY (for bus and truck drivers). Finland was followed by the Netherlands in 1995 and Germany in 1999. By mid-2000's United Kingdom, Austria, Italy, Poland, Spain, Greece and other European countries followed the path.

EDT has three goals to: 1) improve driving skills and use of latest technological solutions, 2) minimize fuel consumption and extend vehicle/components lifecycle, and 3) enhance safety. Thus, highly influential Barkenbus (2010) gave a general definition of eco-driving characteristics consisting in *"accelerating moderately, anticipating traffic flow and signals, thereby avoiding sudden starts and stops; maintaining an even driving pace (using cruise control on the highway where appropriate), driving at or safely below the speed limit; and eliminating excessive idling."* although referring to passenger car drivers, it is widely applicable.

In matter of MDV and HDV, according to ECOWILL (2013), there are several principles and techniques each driver should know to minimize (fuel) consumption **while driving**: 1) anticipate to avoid unnecessary acceleration or braking, 2) keep steady (lower) speed in highest gear at low RPM avoiding speed fluctuations, 3) apply engine brakes/retarders instead of braking, 4) shift up gears the earliest possible, including block shifting/skipping gears, 5) minimize idling, 6) use cruise control, 9) minimize use of air conditioners and electric equipment, and 10) avoid opening windows at high speeds; as well as **before driving**: 1) plan trip to avoid congestion, 2) monitor energy efficient tires' condition and inflation, e.g. by using tire pressure monitoring system (TPMS), 3) adjust aerodynamics devices (deflectors), 4) avoid overfilling the fuel tank, and 5) ensure proper and timely maintenance.

There are two approaches to EDT through: drivers' licensing or short training courses. In ECOWILL (2013) project, European eco-driving standard regarding eco-driving lessons directed at learner drivers and conducting short duration EDT for licensed drivers was compiled. Moreover, Croatia started an EU funded project for eco-driving curriculum conception for specialist secondary education with a schoolbook (Perotić et al., 2013) involving teachers and future specialist trainers. As stated in DfT (2010), SAFED and other short-duration EDT courses consist of two segments: theoretical lessons and practical (driving) exercises. Theory highlights basic principles, information and projected effects of economical and environmentally friendly driving, as well as all basic eco-driving tips. Practical exercises consist in driving the same route twice (i.e. rides): first prior to theoretical lessons, without trainer assistance and second after lessons, with trainer suggestions and interventions. After both rides fuel consumption, time taken and number of gear shifts are recorded, analyzed and further recommendations are drawn. Some EDT sessions rely on ADAS and on-board Fleet Management Systems (FMS).

Momčilović and Cvetković (2015) outline that the EDT should be supported by follow-up programs for driving skills correction and preservation of acquired knowledge and skills. It is shown that only months after training, the motivation for eco-driving decreases and drivers return to old driving habits and practices. It is therefore crucial for fleet managers to engage drivers into a sort of eco-contest and based on results reward those committed to eco-driving principles or to periodically repeat the training for the others.

ECO-DRIVING TRAINING POTENTIALS AND EXPERIENCES

Although some vehicle manufacturers promote and even ascertain higher fuel savings than 20% especially for HDV drivers, Barkenbus (2010) stresses that in normal driving practices, longer term fuel savings should be calculated at 5% without follow-up support beyond initial training and 10% with continuous feedback. Accordingly, ECOWILL (2013) revealed average fuel consumption on the day of short-duration training was reduced from 9.2% to 18.0%, with a weighted mean of 14.0% in all 13 countries. The long-term training effect for daily driving is estimated, based on experiences of other initiatives, to be around 7.5%. These results are consistent with values reported in the UK Freight Best Practice case studies. In numerous case studies, companies and drivers commonly reported an average fuel efficiency improvement of 5%, with actual results ranging from 1.9 to 17% improvement. According to HDV producers and their eco-driving trainers' attitudes, shown in Momčilović and Cvetković (2015), immediate EDT effects range from 5% to 15%, while only a few drivers may attain fuel savings higher than 20%. Moreover, DfT (2010) gives proof that EDT influences even the best HDV drivers in two UK logistics companies: largest milk delivery whose 2 best drivers participated EDT and although only one reached fuel saving (11%) and the other did not, both decreased gear changes by 19% and 42%; and a distribution company whose best driver improved fuel efficiency by 1.18%, gear changes by 4% and decreased number of faults by 66%. EDT implementation costs is expected to be recovered within half a year to one year. A three-day EDT conducted in Užice (RS) in 2011 with two of the best drivers on a 40 t truck and semi-trailer, described in Momčilović and Cvetković (2015), lead to immediate fuel savings of 2.7% and 4.4%. On the entire fleet of 80 trucks fuel savings were projected at 10%. Further analysis of operation data in 2013 revealed that same drivers degraded their driving style, due to lack of appropriate monitoring, regarding fuel consumption and idling compared to EDT results, but improved the use of cruise control.

As for the future, Transport & Mobility Leuven (2017) states that HDV driving can be optimized by built-in systems, communication systems with other vehicles (V2V) and infrastructure (V2I) and by driver training to: 1) change their behavior and 2) optimally use ADAS and ITS systems. Among other options, logistics and supply chain organization and legislation can be optimized or fundamentally modified with the aim of minimizing fuel consumption. Measures include

improving vehicle load factors, routing, driving at fuel efficient speeds, or using more digital or collaborative transport and logistical solutions. So, EDT will be unavoidable in the future, too.

ANALYSIS OF PRESENT ECO-DRIVING PRACTICES IN SERBIA

An anonymous online survey named "Environmentally and cost efficient driving" was realized in March-April 2017, involving fleet managers from 57 logistics and freight transport companies. The aim of the survey was to collect fleet managers' attitudes and raise their awareness on environmental and financial effects of EDT. They were asked about their number of drivers, fleet size (per categories, i.e. LDV, MDV and HDV), the average annual mileage, dominant transport operations (urban delivery, national and international), and whether (and how, if yes) they currently monitor fuel consumption. Afterwards, they expressed their attitudes toward EDT considering fuel savings, safety and environmental effects, as well as negative impacts on delivery delays or additional driver burden. They had also to estimate immediate fuel savings and expected investment return period. Note that authors suggested to survey participants the aforementioned likely fuel saving percentages: 5% for superior drivers up to 20% for inferior ones. Participants shared if they previously trained their drivers (and reasons, if not) and their experiences with EDT results. The authors decided to illustrate survey results regarding EDT accomplishment by drivers and meeting company's expectations (Fig. 1), as well as the percentage of fuel expected to be saved by EDT (Fig. 2) for the entire survey sample.

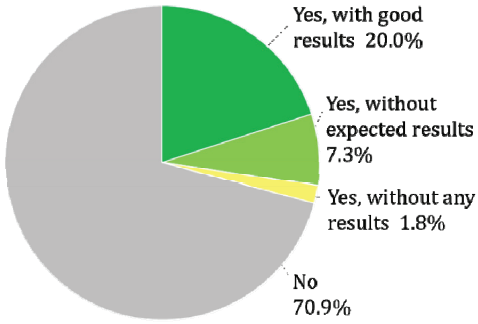

Figure 1. EDT accomplished

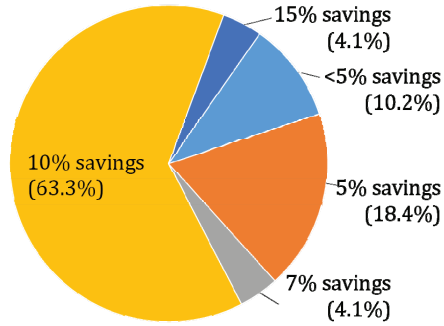

Figure 2. Expected fuel savings from EDT

It is obvious from Fig. 1 that the majority of companies did not train their drivers for eco-driving, but from those who did, the greater part were satisfied by the attained EDT results. Majority of managers consider fuel as the most important saving, but some state vehicle components (tires, brake pads, etc.) longer lifecycle, accident prevention and savings in maintenance and repairs. As reasons for not setting up EDT, they stressed backup drivers' shortage, lack of drivers' time for training, drivers' fluctuation, inexistence of reliable training centers, intolerance for longer return of investment period, and previous unawareness of existence and effects of such trainings, etc. The unawareness about EDT is logical since not many training institutions exist, neither the state has put enough stress on this issue. As for Fig. 2, the vast majority opted for 10% fuel savings, but almost ⅓ of respondents (32.7%) expect less than 10% savings: partly considering their drivers' quality, other part being more realistic in expecting important savings due to the present business conditions in Serbia.

For the remainder of the analysis, we have selected HDV as major fuel consuming vehicle category and important harmful and greenhouse gas (GHG) emitters, to display related survey results. The companies whose fleet managers' survey results and practices will be shown in Table 1 and analyzed in detail later are those where the total HDV fleet annual mileage was superior to 5 million kilometers. Let those companies be denoted by C1 – C7.

Table 1. Selected EDT survey respondents' data

	C1	C2	C3	C4	C5	C6	C7
Number of drivers	85	73	140	64	58	35	100
Total fleet size	81	62	134	54	60	64	100
LDV / MDV / HDV	0/3/78	0/2/60	5/0/129	9/0/45	4/0/56	9/5/50	6/2/92
Urban/National/Interna–tional operations [%]	2/8/90	1/1/98	0/0/100	5/10/85	5/10/85	10/30/60	10/10/80
HDV annual mileage [km]	135,000	121,200	105,000	115,000	100,000	100,000	125,000
Fuel monitoring method*	a/b/c/d	a/b/d	b	a/b/d	a/d	a	b/d
Expected fuel savings [%]	5	3	5	10	10	15	1
Drivers accomplished EDT?	yes	yes	yes	yes	yes	no	yes
EDT fulfilled expectations?	no	yes	yes	yes	yes		yes
EDT is necessary?	yes	yes	yes	yes	yes	yes	yes
EDT is affordable?	yes	yes	yes	no	yes	yes	yes
Investment return period (months)	3 - 6	3 - 6	≤3	≤3	12 - 24	3 - 6	≤3

* a - per vehicle monthly; b - per vehicle per refueling; c - per driver monthly; d - per journey

Regarding Table 1, from selected survey respondents all except C6 accomplished EDT and only C1 considers that it did not fulfilled the expectations. Although considering EDT necessary, C4 considers it not affordable, which seems conflicting with his/her statement about fulfilling expectations, but it is consistent with his/her unreasonably short period for investment return of less than 3 months (same as C3 and C7). Although C1, C2 and C6 are optimistic regarding investment return (3-6 months), only C6 has enthusiastic expectations for fuel savings (15%). From selected fleet managers only C5 is reasonable vis-à-vis investment return.

The respondents were asked about the following 7 attitudes toward EDT, i.e. if they considered it: 1) *fuel efficient driving* where 6 of them agreed, while only C6 partially agreed; 2) *safer driving* where C1 and C6 partially agreed, while the rest agreed; 4) *driving skill upgrade* where four of them agreed (C1, C2, C3 and C7), two partially agreed (C4 and C5), and only one (C6) disagreed; 5) *slower driving and potential delivery delays* where only C3 partially agreed and 6) *additional driver burden* where only C5 partially agreed, while all others disagreed. All 7 agreed about being 3) *a way to safeguard the environment* and not being 7) *unnecessary company expenditure*.

To be able to perform the what if analysis for the selected sample, we should first set some basic calculation assumptions. Let fuel consumption of a HDV (40 t truck and semi-trailer) be 28 l/100 km for all companies and let the diesel price in Serbia be 1.23 €. Total annual mileage of all companies' HDV's being 58.622 million km. For a 5% fuel saving it would then cut the fuel cost for 1.009 M€, while for 10% the saving would make 2.019 M€. If we apply their expected fuel saving rates (shown in Table 1) the total annual fuel cost savings for 7 selected companies for 510 HDV's would be 1.159 M€, which in average would amount to 2,271.97 € per vehicle.

CONCLUSIONS AND RECOMMENDATIONS

EDT is an important topic in developed countries having in mind the foreseen efforts to reach internationally agreed projected emission and energy consumption thresholds for road transport. An essential non-technological measure to attain its long-term sustainability is definitely the eco-driving initiative. This topic is still of high relevance in the European research community, continuously from 2006 onward, having drawn important financial resources mainly meant for cross country actions and wider awareness raising through EU-funded projects as: ECODRIVEN (2006-2008) 1.44 M€, RECODRIVE (2007-2010) 1.18 M€, ECOWILL (2010-2013) 2.90 M€ and ACTUATE (2012-2015) 1.01 M€. There is a strong political support worldwide to this practically soft and inexpensive measure. Serbian government recently

recognized the power of eco-driving in the third Energy Efficiency Action Plan as a measure to impact mileage intensive government employees and public bus drivers, with a vision to include eco-driving in the driving license requirement.

Among all survey respondents and potential benefiters from EDT, there is a positive feeling toward this measure and its influence, although not all respondents were aware of its potential short- and long-term effects. Besides awareness raising of fleet managers in logistics and road freight, another positive aspect of this survey is that 55.6% of respondents recognizes additional benefits beside fuel savings to invest in EDT. Some of those include: generally better trained drivers, safer driving, lower maintenance costs, longer vehicle lifecycle period, etc. The lower environmental impact still is not of great interest to fleet managers, of course, if it is not accompanied by profit or cost cutting related measure.

As for recommendations, eco-driving program should be considered for inclusion in specialist secondary schools curricula in transport and motor vehicle related education. Regarding EDT financing it is recommended that either state provide subsidies to relevant logistics and transport companies, either companies themselves dedicate funds for professional driver training, which having in mind mentioned potential cost savings should be easily refundable in one year at most. On one hand, drivers should commit to stay certain period in the company that financed their EDT e.g. at least one year to be exempted from repaying the training, while on the other hand companies should invest in their training anyway, because they should not ask themselves: what if I train them and they leave, but what if I don't and they stay?

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