Sustainable policy for reducing harmful exhaust emissions in central urban areas - a Serbian perspective

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ABSTRACT:

The "environmental" charging scheme to be applied on certain vehicle categories will allow them to access critical urban areas for a fee determined on their environmental features. The first phase of implementation consists in splitting the day into charging and non-charging periods. Firstly, an appropriate charging scheme is put into effect only to light goods vehicles (LGV), due to an earlier failure to obtain political approval for a passenger cars' charging scheme. LGVs' negative impact on traffic congestion is evident to citizens and therefore restrictions will obtain necessary political support. Environmental efficiency of vehicles is determined by analyses of specific emissions of harmful exhaust gases. Vehicles are then categorised upon this and the fees for each category are set. Once this measure proves its effectiveness in LGV traffic reduction, in a second step, the charging should be extended to "inefficient" passenger cars as well. The first phase objective is to reduce traffic in the area by different time-based charges applied to categories upon environmental efficiency, thus slightly alleviating congestions and harmful gaseous emissions. The second phase consists of expanding the charging period to the entire day with tariffs adapted to the level of congestion. In this phase the possibility of implementation of entry- or kilometre-based charging scheme will be assessed. This second phase would likely induce a reduction of entries, and better planning and more efficient LGVs load factor (cargo capacity utilisation) in order to reduce costs for transport operators. Accordingly, it should also cause citizens' awareness to grow toward environmentally responsible vehicle purchase.

1 INTRODUCTION

1.1 The problem outline

Larger cities in developing countries, like Serbia, are facing each day more important traffic congestions and therefore increased exhaust emissions to the levels from the 1990's. Today, they are still not at a similar level as the developed countries were in the beginnings of the 90's regarding transport related emissions and atmospheric pollution. Their conscience about the scope of the problem of transport's negative impact, especially air quality in densely populated urban areas, however is still not adequate to induce policymakers to consider the adoption and implementation of appropriate environmental actions (either favourable or restrictive), especially in view of limiting personal mobility. Serbia is maybe facing even bigger problems, since it was in a national (civil war generated) crisis throughout most of the 1990's, and just got on the way back from ends of year 2000. Individual mobility and car ownership rate are rapidly growing ever since. The major issue, besides car ownership rate, is that the newly-made-rich businessmen have literally "flooded" the streets especially in capital's city centre with SUVs and luxury cars, inefficient regarding energy consumption and atmospheric emissions.

Although Serbia follows attentively the OECD countries regarding environmental policies and actions, the implementation rate is not adequate because of the lack of dedicated funds, since on the market there are plenty of measures with questionable rate of return. As a result, researchers are required to find the most suitable and sustainable measures, especially "profitable" from the point of view of the state budget. Meanwhile, public acceptance is not an issue here: the government cares for people's opinion only in times of elections, in addition, people easily forget and keep track of positive and negative ratings rather shortly, which hence comes very handy for the politicians. Though, the actual problem is that some of the restrictive measures will affect directly the politicians and their personal budget and therefore will not be viable. The researcher's task is to demonstrate and practically convince decision-makers of the advantages of giving up comfort to some extent and to indicate the importance of adopting appropriate actions in this field as soon as possible.

Therefore, the authors have decided to initially "switch the focus" to the problem of light goods vehicles (LGV), which yet aggravate already congested city streets and sidewalks. Moreover, the majority of citizens recognize at present delivery vehicles as problematic especially in peak periods. This is why public opinion on this issue is almost unanimous in favour of certain restrictions to LGVs. As we cannot prevent them from entering the city, we have opted to assess the sustainability of two restrictive measures: environmental (access) charging and off-peak (night-time) deliveries. The results of the environmental charging scheme assessment should serve as an incentive for politicians and decision-makers to get acquainted with its advantages and learn not only from worldwide successful examples, but also experience it personally and ultimately implement such an initiative on passenger cars.

In the paper, we have first analysed the literature regarding sustainable measures and policies to limit the negative environmental impact from LGVs as well as emission-based charging policy references. Then, background situation in Serbia was presented, and especially in Belgrade, its capital, where the measures are to be gradually implemented and assessed. Subsequently the methodology and its implementation stages are presented. Afterwards, the expected results of the measures' are shown in view of LGVs, as well as passenger cars (especially SUVs) and their estimated effects. Finally, some lessons learned from the assessment process and research are highlighted, which will hopefully help researchers in other similar cities facing the same challenges, as well as contribute to a common knowledge database regarding national experiences.

1.2 Literature review

The delivery and collection of goods within urban and metropolitan areas, especially in the core areas of cities with old and established centres has a major impact on the local community in terms of economic power, quality of life, accessibility and attractiveness of a city. This means that an efficient and environmentally friendly urban transport system is essential for the economic health and the quality of life of cities (Russo and Comi, 2002). Metropolitan areas discovered important reasons to be more active and thorough in their treatment of goods transport (TRB, 2008). Among the many issues involving goods transport are:

a) congestion: being at critical levels in many metropolitan areas, with levels of vehicle-miles of travel increasing faster than new capacity can be provided; commercial vehicles volumes have been growing at a much faster rate than those for cars, and projections suggest that freight flows will double over the next 20 years;
b) environmental impact: the effect of heavy goods vehicles (HGV) and diesel powered LGVs on NO_x, fine particulate matter (PM-2.5), and greenhouse gas emissions;
c) safety: mixing HGV with smaller passenger vehicles on congested highways increases the risks of accidents and fatalities for occupants of the smaller vehicle;
d) noise: HGVs significantly increase noise levels in the vicinity of urban highways; and
e) economic sustainability: goods transport access and efficiency are tied to current and future business location decisions and investment. Regional economic health also relies on efficient and reliable access to manufacturers, suppliers, ports, terminals, warehouses, and customers - both inside and outside the region.

Therefore, recently the environmental impact of urban freight has begun to interest both academics and practitioners. This new interest has happened simultaneously with a growing recognition of the importance of urban freight transport systems for cities' life both in economic and social terms (Zanni and Bristow, 2008). Freight transport is an important user of the limited and constrained urban space as a large range of different types of goods are not only transported to, from and across the city streets but also packed, stored, loaded and unloaded in these locations (Dablanc, 2007). In Germany according to Russo and Comi (2002) the population and activity high density on restraints areas has brought up earlier than in other European countries, the attention on environmental protection and quality of life. Currently, particular attention, justified by traffic congestion, is paid to city centres. The concept of City logistics has been put forward. It is a question of implementing a co-operative mode of grouping and collecting goods according to their type, quantity, time and location. Several city logistics projects have been tested in Germany.

A comprehensive definition states that a sustainable urban freight transport system should fulfil the following objectives (Behrends et al., 2008):

a) to ensure the accessibility offered the transport system to all categories of freight transport;
b) to reduce the air pollution, greenhouse gas emissions, waste and noise to levels without negative impacts on the health of the citizens or nature;
c) to improve the resource and energy efficiency and cost effectiveness of the transportation of goods, taking into account the external costs; and
d) to contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding accidents, minimising the use of land, without compromising the mobility of citizens.

In view of increasing sustainability, between 1990 and 2006 the greenhouse gas emissions decreased by 7.7% in the EU-27 (EEA, 2008). The largest absolute emission reductions took place in Germany, United Kingdom and in most EU-12 Member States, while the largest absolute increases were observed in southern EU-15 Member States (Spain, Portugal, Greece and Italy). At the same time the share of CO_2 emissions generated by transport is gradually increasing in all regions of the world from 22% in 1990 to 24% in 2003 (ECMT, 2007), being even higher in developed OECD countries, with as much as 30% in 2003. Within the transport sector, private and commercial road transport has accounted for the great majority of CO_2 emissions in most countries, from what two thirds are split to passenger transport while one third to freight. Though freight transport operations in cities represent only 10% to 18% of vehicles, they account for 40% of air pollution and noise emissions (European Commission, 2006). Meanwhile, some of the CO_2 emissions abatement measures already adopted in the transport sector are expensive per tonne of CO_2 abated, costing upwards from 100 € per tonne. Among fuel economy measures covering a range of approaches including engine modification, drive train modification and lowering the weight of vehicles and fuel efficiency can be stimulated by three distinct types of measures: technical adaptations in vehicle design, behavioural changes in driving (more fuel efficient driving) and behavioural changes in purchasing vehicles (switching to smaller or lighter or more fuel efficient vehicles) (ECMT, 2007). The switch to lighter vehicles wouldn't be so tough if the average weight of LGVs and passenger cars didn't importantly grow in the meantime due to ever more "compulsory" safety equipment and passenger comfort elements. It is though very interesting and rather confusing that pre-Euro I goods vehicles have lower emissions than more recent models largely due to their smaller size, lower weight and the absence of air pollution reduction technologies that can work against energy efficiency. From Euro I there are some small improvements in CO2 emission factors (Zanni and Bristow, 2008).

In order to decrease the transport related CO_2 emissions in operation, it is indispensable to minimise the transport work accomplished i.e. goods vehicle gross weight. An appropriate operational measure could be to reduce total tonne-kilometres either by increasing LGV's load factor - adapting vehicles to transport tasks by decreasing their tare weight or consolidating shipments to maximise cargo capacity utilisation, or by optimising (minimising) transport routes length. Weight related emission indicators could be analysed either directly or derived, for example, per vehicle nominal load capacity (kg CO_2 per tonnes of cargo capacity), per vehicle cargo capacity utilisation (kg CO_2 per tonnes of transported goods), per total laden weight (kg CO_2 per tonnes of gross weight) or per specific energy consumption unit (kg CO_2 per vehicle). Besides, emission indicators could be expressed also over vehicle power and weight. In this respect, Kageson (2005) showed that weight and power rating of new passenger cars increased significantly during the 1980s and 1990s. Not only those buying large cars, but also customers of small and medium-size cars were increasingly offered a variety of engine sizes and power ratings. In a study realised for ECMT (1995) it was found that average power ratings rose by more than 9 kW between 1980 and 1990 in France, Germany, Sweden and the United Kingdom. This is very much the case of all goods vehicles appearing in the urban environment.

So, Markworth et al. (2004) highlight that most European cities and urban centres face the same problems with freight distribution: increasing urban congestion; increasing pollution and deterioration of the urban environment; increasing number of HGVs and LGVs, longer travel times and higher costs of goods delivery per trip; insufficient service quality for both the different actors of the logistics chain and for the consumers. However, analysis of distribution by LGV and HGV's environmental aspects in city centres is a relatively recent concept. Basically, everybody wants lively and accessible city centres where we can all move around safely and where trade and culture are flourishing. This requires delivery of goods on a daily basis. So far, the distribution of goods has not always been in accordance with our wishes regarding the urban environment. Sustainable city logistics solutions could be one of the solutions to the problems in the city centres. So in Copenhagen (Markworth et al., 2004) in order to meet the overall objective and thereby reduce heavy goods traffic and improve the environmental situation, the City has set up criteria to regulate the freight delivery:

a) better use of the vehicles capacity;
b) no stopping; and
c) establishing of loading and unloading zones.

To uphold these criteria the City of Copenhagen introduced an experimental certification system for freight delivery vehicles (over 2,500 kg) consisting in three types of certificates (green, yellow and red) and high fines (68 €) for infractions implemented since February 2002. The green certificate (44 €), valid for the entire two-year trial period, was accorded to vehicles utilising at least 60% of the vehicle's cargo carrying capacity and whose engine is younger than 8 years, giving them exclusive rights to use 20 special loading zones. For all other goods vehicles, not meeting the previous requirements, there is a yellow certificate (44 €), valid for 6 months, as well as the red one (7 €), valid for one day (Markworth et al., 2004).

But higher charges and taxation are not the only answer, because according to CBTF (2002) transport costs directly impact us all - from the taxes we incur to maintain the transport infrastructure - to the cost of goods and services we purchase - to the cost of commuting to work and other daily endeavours - to the cost of recreational activities. Time is money, so the more time spent on the road, the more costs we incur. The more costs incurred on transport, the less we have to spend on consumer goods, services and recreational activities. Businesses locate where expenses are minimised so that competitiveness and profitability, as well as worker productivity, are maintained.

Even in highly developed and environmentally aware cities, as London and Stockholm, that introduced congestion charging, this measure failed to decrease the share of energy- and environmentally-inefficient vehicles accessing those sensitive densely populated areas. Inefficient vehicle's owners and fleet managers obliged to pay a fixed time-based fee (daily, monthly or annual) and not the mileage- or entry-based depending on vehicle category (weight), do not share common social interests and neither show willingness or motivation to increase their weight efficiency: load factor in case of goods or occupancy in case of passengers. The weight inefficiency in goods transport is essentially based on two noticed trends: generally low load factor and growing ratio of empty runs of everyday heavier goods vehicles. It is likely that only severe restrictions would influence their current behaviour. Nevertheless, the authors do not anticipate that even introduction of really drastic measures like banning the access for goods vehicles to sensitive urban areas will lead to expected effects, but would most likely increase number of infractions and yet relocate the problem creating new critical areas (Momčilović et al., 2010).

According to Fullerton et al. (2005) if a vehicle emissions tax were feasible, then drivers (or fleet managers) could buy a newer, cleaner car, buy a smaller (lighter) car with better fuel efficiency, fix their pollution control equipment, buy cleaner gas, or drive fewer kilometres. Moreover, an emissions tax would induce consumers with different incomes or characteristics to choose different combinations of these abatement methods, as required for economic efficiency. Still some among them may choose to pay the tax instead of changing their habits (Fullerton et al., 2005).

As we will later discuss some sort of access charging schemes, we would like to refer some of the successful European examples. The cities of London and Stockholm, although introduced costly state-of-the-art technological solutions, have barely survived public opinion guillotine in view of such restrictions' implementation. For example in London, where Ken Livingstone was elected mayor of London on his manifesto mainly based on congestion charging, not more than 40% of the public favoured the policy shortly before introduction (TfL, 2004). Moreover, his Transport Manifesto for the elections of 2008 (Livingstone, 2008) cost him his post, because he urged for introduction of a CO_2 charge extremely harsh on luxury executive cars and SUVs with higher CO_2 emissions. This time-based CO_2 charge had set the emission's lower limit at 120 g/km for the following periods: 1 day, 5, 20 or 252 consecutive days. All private cars under the mentioned CO_2 emission limit of 120 g/km should be exempt from paying this charge. For all others, the price for one day was assumed to vary between 8 £ paid in advance for moderate CO_2 emission cars (121-225 g/km) to 25 £ for the highest CO_2 emission cars (over 225 g/km). Consequently, for 252 consecutive days the cost was designed to be 1696 £ for the moderate CO_2 emission category and 5300 £ for the highest emission cars (SUVs included). On the other hand, in Stockholm (Brundell-Freij and Jonsson, 2009) congestion charging scheme has been successfully implemented. A full-scale trial during the first seven months of 2006, in which charges and increased public transport supply was implemented temporarily, was (to the surprise of many) followed by a positive referendum result. Unfortunately, many other cities have experienced a substantial majority of negative attitudes: Schade and Schlag (2003) report that for three suggested forms of road pricing, the proportion of their respondents who regarded the policies to be unacceptable varied from 84% to 91%, a review of British studies (Jaensirisak et al, 2005) found a mean acceptability of 35%, and in three Norwegian cities in which charging was going to be introduced, the policy was negatively evaluated by 54% to 72% of respondents (Odeck and Bråthen, 2002).

Due to all previously stated, the authors' idea was a sort of blend of the aforementioned in order to obtain somehow better results: to initially impose goods vehicles an emission charge for accessing critical urban area based on its maximum laden weight, which represents a weight-based emission charging scheme, that could be later influenced by a mileage-based or a daily period factor (off-peak deliveries to prevent congestions). Nevertheless, Fullerton et al. (2009) highlight that we should be careful while designing green taxes, a direct tax on the quantity of emissions generated is ideal but often unfeasible because emissions cannot be directly measured at reasonable cost. Where close proxies for emissions exist that are measurable and already subject to market transactions, green taxes can be successful. Fuel combustion is directly related to carbon emissions, and so a fuel tax closely resembles a carbon tax, for example. Where such links do not exist, a combination of taxes may generate better targeted environmental incentives than any one isolated instrument.

Another peculiar but expected trend is that the share of the most inefficient passenger vehicles (regarding CO_2 emissions) as SUVs and vans is in constant growth in the last decade or so. This is a common situation in developed OECD countries some time, but lately and unfortunately the developing countries as Serbia are showing similar tendencies. In the Table 1, an example of annual growth rate of shares of SUVs and vans in total number of registered vehicles in Germany between 2003 and 2010 has been given as an illustration of the aforementioned situation.

Table 1 - Shares of SUVs and vans in the entire car fleet in Germany (2003-2010)

Year	SUVs	SUVs share (%)	Vans	Van share (%)	Total (SUVs + vans)	Total share (%)
2003	742,371	1.7%	1,452,848	3.3%	2,195,219	5.0%
2004	830,752	1.8%	1,931,043	4.3%	2,761,795	6.1%
2005	939,292	2.1%	2,288,446	5.0%	3,227,738	7.1%
2006	1,098,605	2.4%	2,652,776	5.8%	3,751,381	8.2%
2007	1,236,822	2.7%	3,043,973	6.5%	4,280,795	9.2%
2008	1,191,247	2.9%	3,118,137	7.6%	4,309,384	10.5%
2009	1,311,863	3.2%	3,300,027	8.0%	4,611,890	11.2%
2010	1,493,281	3.6%	3,533,800	8.5%	5,027,081	12.1%

Source: Kraftfahrt-Bundesamt (KBA)

1.3 General background

Republic of Serbia, one of the six former republics of FR Yugoslavia, with approximately 7.32 million inhabitants in 2009 copes with a steady decline since 1990's, while simultaneously the number of inhabitants of its capital, Belgrade faces a constant growth to today's rough 1.63 million inhabitants. In **Table 2** are shown the most important socio-economic indicators of the Republic of Serbia between 1999 and 2009.

Table 2 - Socio economic indicators of the Republic of Serbia (1999 - 2009)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inhabitants [10^3]	7,540	7,516	7,503	7,500	7,481	7,463	7,441	7,412	7,382	7,350	7,321
GDP total [M €]	17,522	25,539	12,821	16,028	17,306	19,026	20,306	23,305	28,785	33,418	28,883
GDP per capita [€]	2,324	3,398	1,709	2,137	2,313	2,549	2,729	3,144	3,900	4,547	3,945
Surface [km^2]						77,474					

Source: Statistical office of the Republic of Serbia

The total GDP value as well as the GDP per capita, which had a growing trend since 2001 until 2008, due to the economic crisis (now evidently only its first wave) started to decline and unfortunately are not showing signs of slowing down or recovering to its not so faraway past upward path. Anyhow the number of passenger vehicles (unlike all other categories) continue to grow (as shown on **Figure 1**), as well as the motorisation rate (shown on **Figure 2**).

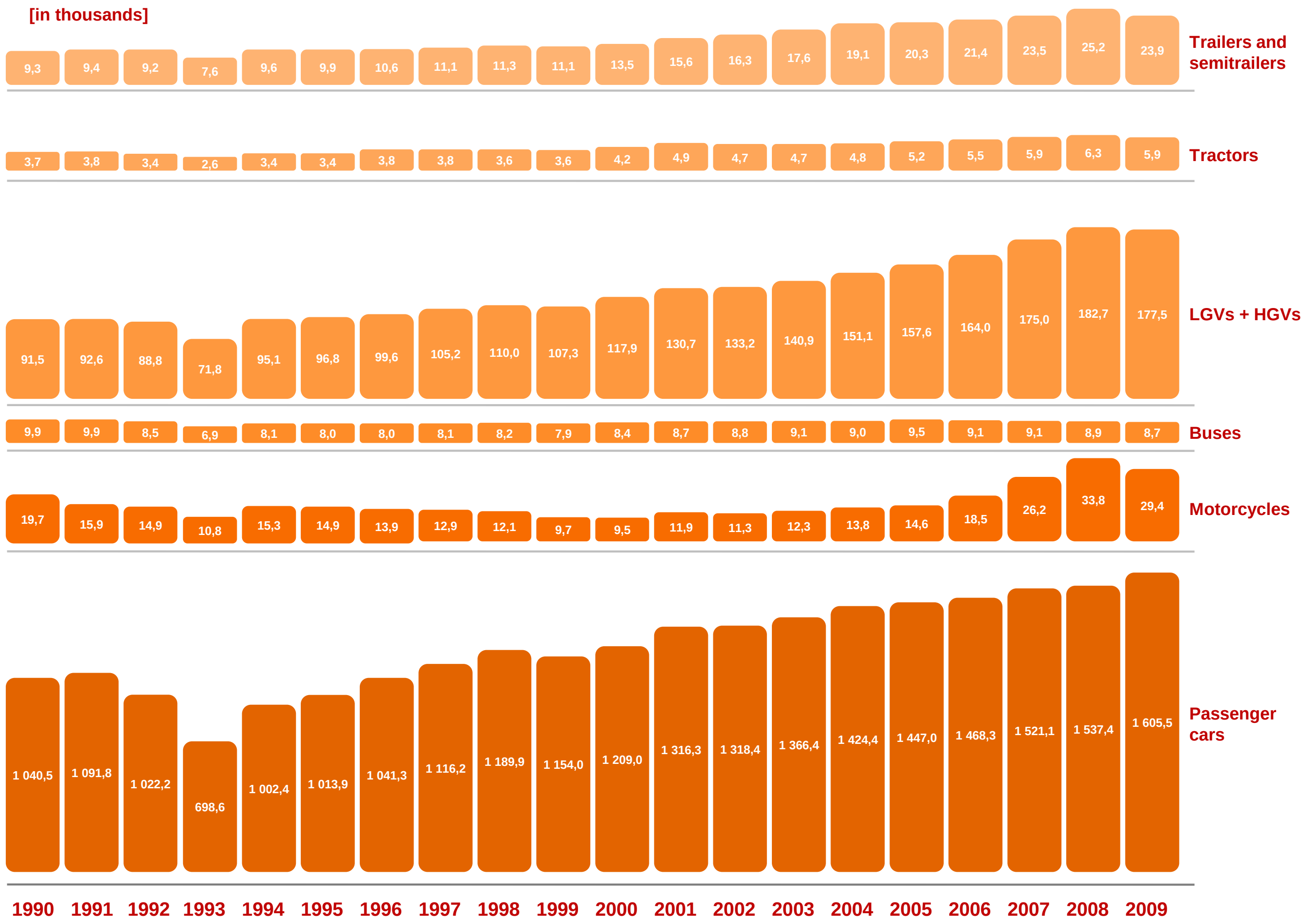

Figure 1 - Number of vehicles in the vehicle fleet of the Republic of Serbia (1990-2009)

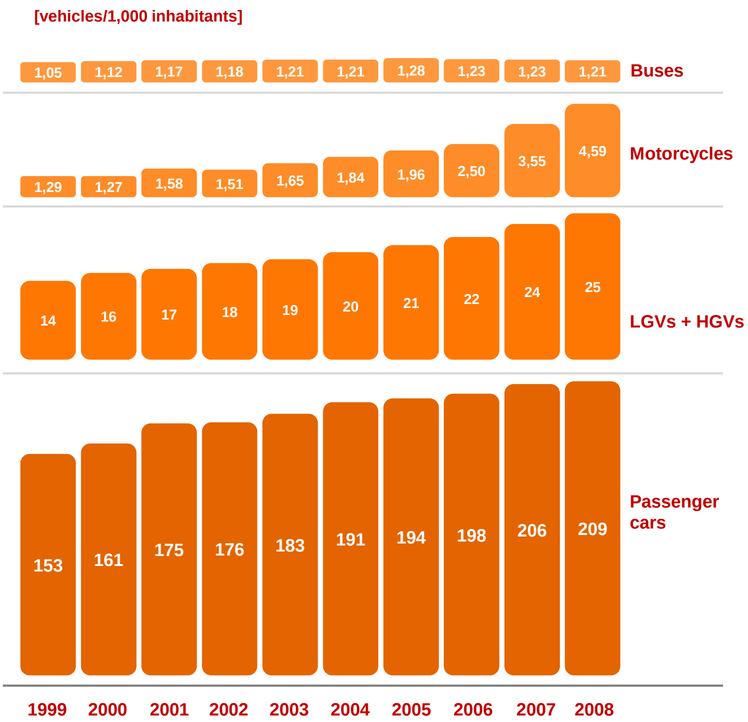

Figure 2 - Vehicle ownership rate in the Republic of Serbia (1999-2008)

Our case study site, the city of Belgrade, administratively comprises 11 urban municipalities, while its wider (metropolitan) area comprises another 6 suburban municipalities making 17 municipalities in total. The historic centre of the city, which will be the main study and implementation area, spreads over four different municipalities. In the last decade, Belgrade has benefited from important local and foreign investments in infrastructure planning and projects. Nevertheless the implementation rate is very low and evolving slowly. Even though decisions about investments are strongly centralised in the administrative and political centre (in default of serious decentralisation), Belgrade is still lacking of completed by-passes: inner and outer ring roads and rail links, only partially completed to date. One single bridge with single-track rail connection and two lanes per direction over river Danube is deteriorating, in the meantime we are building a colossal and expensive bridge over river Sava, where there are already 4 bridges operating. Heavy goods traffic including dangerous goods still must pass by the congested streets and urban highway adjacent to downtown historic landmarks, museums, lodgings and modern business buildings. Similar situation is with the rail.

Belgrade public transport (PT) system was well developed until the beginning of 1990's, with an integrated tariff system functioning since 1975. In 1998 the system finally collapsed and recurred to private bus operators and arrived to a sort of equilibrium by introducing a new integrated tariff system in 2002 (much too obsolete than the previous one), constantly in financial problems due to an inefficient fare collection and monitoring system. The gradually renewed vehicle fleets rely on outdated tramways, trolleybuses and buses, without an attractive heavy mode as an efficient alternative to passenger cars. There is though a sort of suburban rail called BeoVoz, which is not efficient due to the very long intervals between train passages. The entire network suffers from serious problems due to significant overlapping and no effective treatment yet, without important modifications since the end of the 1980's. Ever since, principal debate revolves around the choice of metro or light-rail transit system, without any completed projects at hand. The system equilibrium depends on diesel-powered buses, as a result PT network slowly collapses again due to severely congested streets. Even with dedicated bus lanes and tram's unconditional right-of-way, as they are not physically segregated from the general traffic, they are both irreparably slowed down by congested crossings and roundabouts.

In order to fight the congestion, Belgrade administration has introduced a street parking time-limitation scheme on November 21st 2003, with the charging period on weekdays from 7:00 to 21:00 and on Saturdays between 7:00 and 14:00. Initially, it was restrained to the city centre, which was subdivided into three zones according to their attractiveness imposing the following time-limitations: the most attractive (red) zone - maximum 1 hour, moderately attractive (yellow) zone - up to 2 hours, and the least attractive (green) zone a maximum of 3 consecutive hours parking. This time limitation concerns only consecutive hours, meaning that a break of 30 minutes is sufficient to restart another regular period. The parking problem has been relocated to the neighbouring streets and quarters without time limitations, which made it really difficult for their inhabitants ever since. Therefore the zones have spread across the city and another blue zone without time limit appeared paid per hour or per day. Besides, although the parking garages in the centre do not have time limitations and a majority hardly attain demand peaks of 60-70% of their capacity, the tariff inside is presently 2-3 times higher per hour than on the streets. Therefore, the majority remains empty most of the day although there is a growing parking demand.

In terms of light and heavy goods vehicles, a partial ban is in place already for a long period in Belgrade wider central area (designated by particular streets) during morning (7:00 - 9:00) and afternoon peak hours (14:00 - 18:00). Therefore, vehicles over 3.5 and up to 12 tonnes can circulate regularly, and stop or park against regulations upon written permission of the Secretariat for Transport, only in off-peak hours for reasons of commercial loading or unloading. HGVs over 12 tonnes are permitted to circulate only for construction sites' needs. Outside this designated central area they can circulate 24/7, but stop or park only in off-peak periods. LGVs and HGVs could be parked on the driveway during loading / unloading, but at most for 15 minutes. The exception to these rules is in streets with PT lines, where the ban of LGVs and HGVs' stopping and parking is broadened from 7:00 to 23:00. Meanwhile, from 23:00 to 7:00 they can park only during loading / unloading for a maximum of 15 minutes, if approved in written by the Secretariat for Transport. There are several streets in the city centre (10 streets), in centre of Zemun (2), in Banovo brdo (2) and two bridges linking the centre to Novi Beograd where between 7:00 and 23:00 is totally forbidden the presence of those vehicles (circulation, stopping or parking). This measure is not related to public utility fleets, emergency services, public enterprises for infrastructure maintenance and towing services, which must be adequately labelled and equipped with amber rotating light.

Although an off-peak delivery scheme already should have taken place (as presented above), the LGVs and even HGVs rarely obey those regulations and when spotted often are willing to pay the fine or even bribe the enforcement officers. The latter is importantly decreasing since year 2000, unfortunately still not negligible because of the economic crisis (and their moderately low wages) as well as for a long time neglected public service, left without reliable and severe supervision.

While a complete ban for LGVs is neither feasible nor recommended, as this would prevent commerce and retail shops' normal operation, a set of serious but feasible restrictive measures must be proposed and carefully implemented. A charging policy for LGVs and HGVs entering a "sensitive" yet enclosed urban area should be adopted. In a first period, for entering the area in a given time interval will be imposed a period based fixed charge (daily, monthly or annual), and later an entrance-based fee for each vehicle entry to the area during the charging interval. In the night-time, i.e. out of charging interval, there would be no charges, which should encourage transport operators to redistribute their plans and times of delivery, if feasible from the point of view of clients (as at the destination as well as at the origin, because of nightshifts, etc.) which will be analysed in detail in chapter 3.

Besides previously mentioned problems, Belgrade is experiencing almost critical situation in terms of traffic congestion and related emissions in central urban areas as consequence of numerous heavier, old, poorly maintained, and environmentally inefficient passenger vehicles, as well as a growing share of SUVs, vans and crossovers in the last decade. In the centre there is an obvious growth in the share of luxury cars (bigger and heavier) and SUVs especially in the last two decades. They show up and "proliferate" especially in the evening and night hours with the intention of visiting fancy cafes and mundane restaurants in the central area. The more expensive the car - the better! This is a question of prestige and social status, a kind of brand: they double park intentionally and on a regular basis and rarely obey traffic regulations. But the main issue remains: they are polluting much more than others. They "ride" alone in more than 2 tonnes of steel, or at most in couples - therefore they are extremely weight and environmentally inefficient.

2 TRAFFIC SURVEY

Traffic conditions and resulting CO_2 emissions in Belgrade will be illustrated by a traffic survey on the major corridors entering the survey area, accomplished in 2008 and described hereafter. The survey, assessing vehicle environmental efficiency, was realised in the historic city centre - area delimited by the circular tram line 2, marked on the following **Figure 3**.

Traffic situation and trends in Belgrade are regularly monitored and analysed by traffic counts, which take place biannually on the complete street network (including counts on external corridors of the wider urban area of 17 municipalities). At the level of Belgrade central area, a referential state had to be established before implementing any measure for vehicle weight and/or CO_2 emission abatement, as well as for energy efficiency enhancement of those vehicles allowed to circulate in the critical area.

Figure 3 - Belgrade central area and the major access corridors

Firstly, we have determined the diameter (D) of the central area (which is approximately 3.0 km). Secondly, we have determined the share of LGVs. In order to estimate their average numbers reported to the entire relevant day in Belgrade, the control traffic survey has been realised on all entry directions toward the central area on an average Tuesday (April 15, 2008). The survey was realised in three characteristic periods: morning peak hours - MPH (07:00 to 09:00), afternoon peak hours - APH (16:00 to 18:00), and night (off-peak) hours - NOPH (21:00 to 23:00). In traffic counts, we have split-up the data into the following vehicle categories: small cars, big cars, SUVs and vans, buses, LGVs and HGVs. The day that the survey was realised was rainy, which may have caused certain increase in the total number of vehicles on the streets. Nevertheless, the observed vehicle categories' shares did not vary significantly during different day periods compared to earlier comprehensive traffic counts. The results of this traffic survey are shown in Table 3 and on following figures 4, 5 and 6.

Table 3 - Belgrade traffic survey results in selected periods per access corridors, 2008

Access corridors	Small cars	Big cars	SUVs + vans	Buses	LGV	HGV	TOTAL	Access share (%)
Access 1	4,686	7,970	687	711	847	159	15,060	33.33%
Access 2	1,357	1,898	202	183	187	55	3,882	8.59%
Access 3	1,351	2,357	211	378	225	17	4,539	10.05%
Access 4	768	1,735	213	150	211	63	3,140	6.95%
Access 5	2,265	3,891	321	190	284	3	6,954	15.39%
Access 6	1,109	2,309	134	255	144	11	3,962	8.77%
Access 7	2,496	4,131	404	293	265	53	7,642	16.91%
TOTAL	**14,032**	**24,291**	**2,172**	**2,160**	**2,163**	**361**	**45,179**	**100.00%**

From the previous Table 3, the dominant access corridor is the number 1, carrying 1/3 of the traffic, which was expected because this corridor is the only link between the centre and municipalities of Novi Beograd (New Belgrade) and Zemun at the west. The two following corridors carry around 17% (access 7) and 15% (access 5) of traffic and both come from the southern Belgrade municipalities: the access 7 from southwest, and the access 5 from southeast. The Danube is a natural barrier to the development of the city towards the north, which is still today crossed by only one combined road-rail bridge (Pancevacki most) of insufficient capacity (rail: single track and road: two lanes per direction).

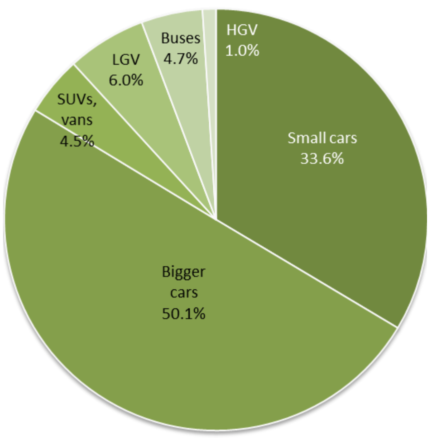

Figure 4 - Vehicle category shares in morning peak hours **MPH**, 2008

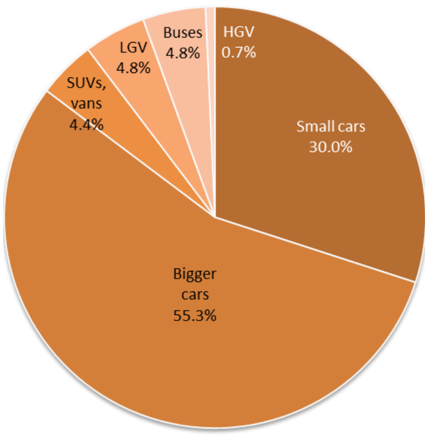

Figure 5 - Vehicle category shares in afternoon peak hours **APH**, 2008

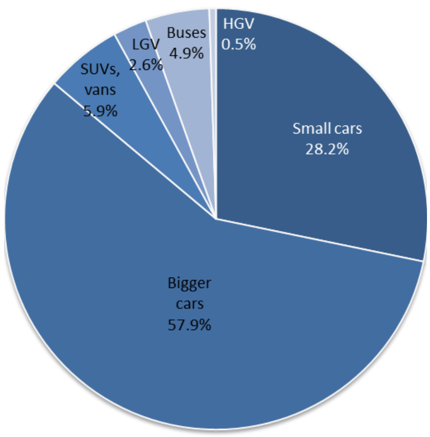

Figure 6 - Vehicle category shares in night off-peak hours **NOPH**, 2008

Now, the situation regarding the traffic flows and vehicle categories will be discussed. While bus share is almost uniform throughout the day (at approximately 4.8%), small cars' share decreases

from 33.6% to 28.2%. Big cars, SUVs and vans' share grows steadily during the day. Big cars increase roughly from 50% to 58%, while SUVs and vans' share grows from 4.5% to almost 6%. In total, those inefficient groups of vehicles are growing from 54.6% in the MPH, by 59.7% in the APH, to their maximum value of 63.8% in the NOPH.
Equally, the HGV's share (who shouldn't be there at all in morning and afternoon) is decreasing from 1% to 0.5% and at the same time LGV's share (as mentioned before) also decreases from 6% to 2.6%. So, the total commercial vehicles' (HGV+LGV) share is 7.0% in the morning peak, declining to 5.5% in the afternoon, and importantly decreasing to 3.1% during night hours, despite the fact that it should be exactly the opposite. Their presence should be minimal to zero during the peak-hours, while importantly growing in off-peak periods (like the evening and night hours).
The authors' observations of the situation regarding LGVs and HGVs in Belgrade central area were as expected due to the mentioned and observed traffic problems. Their peak in the MPH (over 6%) gradually decreases toward a minimum (around 2.5%) in the night hours, which is less than a half of its morning share. However, we must keep in mind that in absolute values situation (shown in **Table 4**) is even worse: the number of LGVs heading to the city centre was more than 4 times higher in the morning (higher peak period) than in the night hours (off-peak). Such unfavourable traffic situation reflects the absence of a consistent enforcement and penalisation of delivery vehicles making it a real issue in the city of Belgrade. Though, as mentioned before there is a slight problem with banning long distance and HGV traffic, because there still does not exist an alternative (by-pass road) allowing those vehicles to avoid Belgrade core and heavily congested urban highway section passing adjacent to the historic city centre.

Table 4 - Belgrade traffic survey results in central area, absolute figures by periods, 2008

Vehicle category	Morning Peak Hours (MPH)		Afternoon Peak Hours (APH)		Night Off-peak Hours (NOPH)	
Small cars	6,194	33.6%	4,922	30.0%	2,916	28.2%
Big cars	9,244	50.1%	9,070	55.3%	5,977	57.9%
SUVs + vans	838	4.5%	726	4.4%	608	5.9%
Buses	863	4.7%	792	4.8%	505	4.9%
LGVs	1,115	6.0%	782	4.8%	266	2.6%
HGVs	190	1.0%	118	0.7%	53	0.5%
TOTAL	**18,444**	**40.8%**	**16,410**	**36.3%**	**10,325**	**22.9%**

The chosen hourly intervals were compared to previous comprehensive traffic counts in Belgrade (2006) and their shares in the daily traffic have been then applied and adapted to the data from the survey from April 2008 (shown on Figure 7).

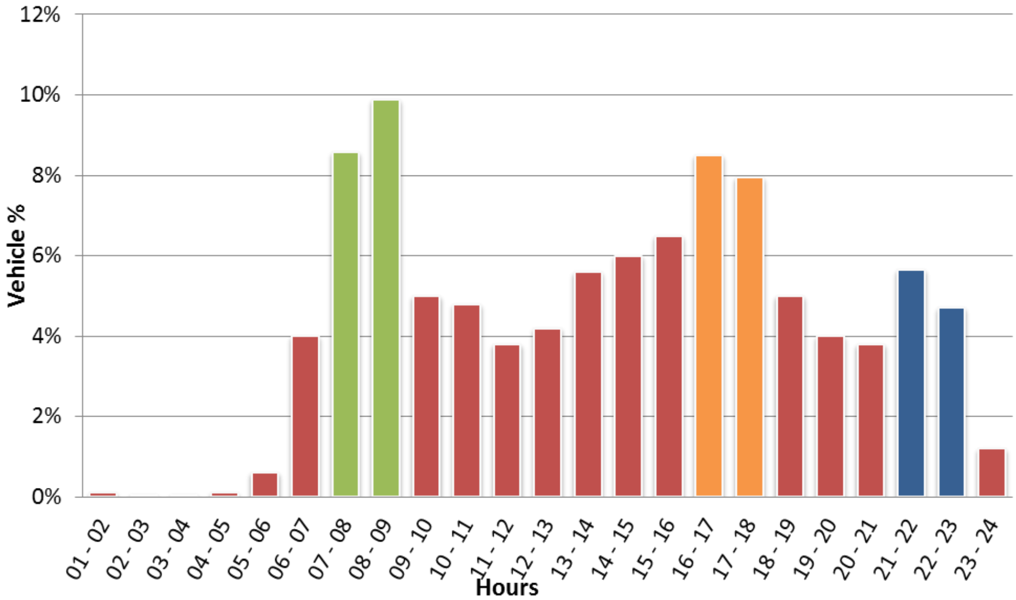

Figure 7 - Time intervals' shares MPH + APH + NOPH (pondered daily distribution), 2008

As a result from previous tables and graphs, it has been observed the distribution of hourly intervals on the entire day (00:00 - 24:00), as illustrated on the following Figure 8.

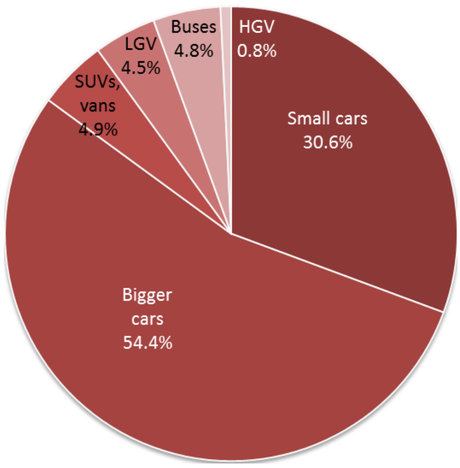

Figure 8 - Estimation of category shares on the entire day toward Belgrade's central zone, 2008

3 PROPOSED METHODOLOGY

Although, policy supports restraining the perimeter of goods vehicles' traffic within central urban areas because of their negative environmental impact, a total ban of their circulation is unfeasible. The proposed solution is to initially implement access restrictions and charging for LGVs and HGVs. In order to prevent even more bottlenecks, the payment will not take place at the access points to the central area, but in advance. All vehicle categories not having previously paid the specific emission charge (per entry, weight and CO_2 emission based) are banned from entering the charging zone and if anyway found within they will have to pay an appropriate fine.

The main charging criterion is a specific emission per vehicle. Similarly to exposed example by Markworth et al. (2005), there will be a labelling of vehicles allowing entrance to the restricted area. Proposed categorisation consists in four categories: one environmental category under the set limit - free of charge (green label) and three categories with progressive charge over the set limit: minor additional emission (yellow label), moderate (orange) and important additional emission (red label).

The criteria for determining tariffs are based on earlier researches conducted in respective central area regarding: traffic and emissions per adopted vehicle categories (applying the COPERT IV model).

Initially, another criterion for goods vehicles emission charging per entry during the congestion period is vehicle gross (laden) weight. As a second criterion, after certain implementation period, it should be introduced a charging during the entire day and therefore an additional period-based limit that would consist in variable charges for: congested (peak) and not congested (off-peak) periods. In the peak period each vehicle entry is charged more importantly as to make goods delivery cost inefficient to induce an incentive to fleet managers / logistics operators to switch their fleet operation to a more appropriate off-peak period. The off-peak period fee should reflect weight-based CO_2 emission externalities. Finally, the charges should be once again revised after a year of implementation, in order to reflect the implementation of yet another additional criterion: the mileage-based emission factor.

The assessment of vehicles' CO_2 emissions in the observed critical central urban area in the first implementation phase is based on the central urban area diameter (D), share of LGVs and HGVs entering the central urban area (N), average CO_2 emission values for all goods vehicles per kg of their laden weight (E_{CO_2}), and maximum gross (laden) weight in kg (W). After having established the central area diameter (D), the number of vehicle categories subject to environmental charges should be determined. Their specific share is determined by surveys (like previously realised traffic counts) on relevant corridors to central area. As stated previously, the day is divided into: peak (initially from 7:00 to 18:00 or 7:00 to 23:00 depending on streets determined by the Secretariat for Transport) and off-peak periods (from 18:00 or 23:00 to 7:00), although their precise starting and ending times should be fine-tuned according to local specifics. When the shares of LGVs and HGVs are obtained, the next step is to compare survey data with previous comprehensive traffic counts for same corridors and same periods. Based on our survey based on the average number of vehicles (N) of each category (i), we obtain the CO_2 emission from LGVs and HGVs for emission charging area on an average working day:

$$E_{CO2} = D \times \sum_i N_i \times W_i \times E_{CO2_i} \quad \text{.....................................(1)}$$

Following the implementation of the emission charging scheme, the number of LGVs and HGVs entering the critical area during the charging period is expected to decrease significantly. In the second phase, when the charging scheme would last the entire day, the authors expect that fleet managers will start improving the load factor, optimising routes and decreasing number of entries to the charged area. It is equally expected to influence efforts to integrate urban transport market to achieve better eco- and cost-efficiency with such imposed emission charging scheme. We should keep in mind that if receivers and carriers (Holguin-Veras and Polimeni, 2006) find that performing off-peak deliveries is not cost effective, then they will not undertake such an initiative. Therefore, a key objective is to find the break-even point for carriers and receivers, which is where performing off-peak deliveries would bring positive returns to profit.

In a subsequent implementation phase, as the public awareness grows regarding the environmental efficiency and related weight inefficiency of LGVs, private motorized modes will come up on the schedule. Nevertheless, car users from higher social or economic environment will never be willing to give up personal comfort, even if they dispose of a developed, accessible, comfortable, regular and punctual public transport, and even though they face everyday traffic and parking congestions. They are usually willing to pay any charge. Therefore we can always expect some energy and CO_2 inefficient cars accessing environmentally charged urban areas.

The passenger cars weight inefficiency is also based on similar trends: low vehicle occupancy and growing share of heavy passenger cars and SUVs. As SUVs are usually expensive, paying extra access, congestion, parking or similar charges to drive within the restricted but highly attractive area will not be a probable issue. In such cases, only severe restrictions would influence somehow their behaviour, however it is hardly expected that they will all switch to public transport or non-motorized modes. The authors consequently do not anticipate that such drastic measures will lead to optimistic results, but would probably increase the number of infractions. The concept is to restrict heavy private luxury cars and SUVs, weighting over an allowed initial limit of 1.7 tonnes, which encloses the majority of present big passenger cars. All those passenger vehicles over this weight limit should not be allowed to enter the city centre without having previously purchased the specific “weight charging” sticker. Initially, there will be only two categories: passenger cars within the limits (with yellow label) and those outside it (red label). Later on, after some period of test implementation, another decreased weight limit of around 1.3 tonnes should be introduced (to be further assessed). Subsequently, there will be three categories of cars: “efficient” under 1.3 tonnes (green sticker), “moderate” between 1.3 and 1.7 t (yellow sticker) and “overweight” over 1.7 tonnes (red sticker). The limits should be revised and assessed after some period lowering the lower gross weight limit to 1.0 tonne and upper limit to 1.5 tonnes. Nevertheless, the passage to 1 tonne limit should be preceded by an intensive media and marketing campaign aimed at the popularisation of smaller vehicle purchase as we suppose this is the way to efficiently decrease CO_2 emissions in urban areas.

4 EFFECTS AND THEIR ASSESSMENT

The proposed set of measures will directly influence goods transport economic efficiency by increasing costs of daily hours’ delivery. This will, for certain, encourage the optimisation of LGVs dispatching procedure and therefore strongly influence fleet management system in view of environmental issues. The new so-called “eco-efficient” LGV dispatching will decrease the number of LGV trips and entries to the access charging zone. This should also improve the logistics efficiency by increasing the LGV’s load factor, as well as causing time shift of goods delivery toward periods without charging or with importantly lower charges, within charged urban areas.

Before all, it is indispensable to assess what will be a realistic expected decrease in daily number of goods vehicles from targeted categories. A relevant “critical” decrease of goods vehicles’ share is estimated in order to determine optimal timing for the passage to the more rigorous emission-based access charging scheme involving complex criteria (as actual mileage in the critical zone). In the first phase of proposed measures implementation, there is a latent CO_2 emission reduction solely from relieving congestion and lower share of LGVs in traffic, but we do not anticipate some logistics efforts and increase in load factor, just shifting to free of charge off-peak deliveries. However, when the charging scheme expands to the entire day, the authors expect to lower the number of trips initially by 3-5% because of increased load factor. The subsequent steps would be introducing other city logistics measures as well as logistic centres that presently are not common in Serbia.

However, as discussed by Holguin-Veras and Polimeni (2006), the implementation of off-peak deliveries requires both: receivers willing to accept deliveries during the off-peak hours, and carriers willing to provide the service. Their project highlighted that receivers, by virtue of being the end customer, have a great deal of influence on what the carriers do. In this context, should a significant number of receivers decide to request off-peak deliveries, it is almost certain that the carriers would follow suit. This fact has important implications because - short of mandatory regulations forcing the private sector to do off-peak deliveries - it is clear that the long-term sustainability of off-peak delivery programs require policy incentives to mitigate the impacts on receivers, which are likely to face additional costs. On the other hand, carriers stand to benefit from the increased productivity associated with faster travel speeds during the off-peak hours, and are likely to participate in off-peak deliveries if a sufficient number of their customers request the service. (Holguin-Veras and Polimeni, 2006)

Regarding the results, only after the control surveys aimed at obtaining the average daily mileage of LGVs in the city centre, we will be able to precisely calculate the effects of such measures. We have though provisionally calculated the potential emission savings from registered LGVs operating on Belgrade metropolitan area. Those measures' implementation represents an important potential in CO_2 emissions savings. If we adopt, as an example, an average goods delivery trip length of just 3.5 km (which is actually lower than half of a more realistic figure of around 7-8 km, estimated today by fleet managers), we obtain potential emission savings of more than 4 tonnes of CO_2.

If we sustain that few of the smallest operators with just one or two fuel "inefficient" vehicles in the fleet but also some bigger transport operators to some extent, won't give up using their goods vehicles even in the most crowded periods, they will still consider buying new more efficient vehicles. Though if they are not willing to change the dispatching it will eventually make them become more cost inefficient therefore less competitive on the market than others. Since their CO_2 emission is expected to grow, the total potential CO_2 emission savings will be minor to previously stated figure. Additionally, if we succeed to report some of the HGVs to LGVs, we could improve our CO_2 emission savings. Those improvements are estimated as realistic for our specific environment (up to 5% change in behaviour). In contrary, there is a possibility to implement a more uncompromising national or local taxation policy in order to succeed in increasing the percentage of "greener" goods vehicles.

On the other hand, when it comes to passenger vehicles, if we adopt a realistic objective to decrease weight inefficient SUVs share to about 1%, then the decrease in the number of SUVs is 3.94% a day. With an average daily mileage in the central area approximated to 3.0 km, the potential CO_2 emission savings will be in total 3.54 tonnes. But as it was demonstrated that most of the "inefficient" vehicles' drivers are not willing to give up passenger cars, we have assessed that some of them will be reported to big car category and some others to small cars. Therefore, an increase of big cars is expected for approximately 3% and equally of small cars for about 1%. Likewise, their CO_2 emission will increase for 1.18 tonnes, the total potential CO_2 emission savings will be 1.20 tonnes. Additionally, if we succeed to report some big car users mainly to small cars for about 4% and a minor percentage (just 0.15%) to other more efficient modes (as PT or non-motorised), we account for CO_2 emission savings of 2.51 tonnes. Such improvements are estimated as realistic for Serbian environment.

Let's suppose the following average CO_2 emission indicators for:

a) small cars: 120 g/km,
b) big cars: 225 g/km and
c) SUVs: 300 g/km.

For such circumstances, from the average emission estimated at 193.4 g/km, just SUVs decrease for 4% will lower it to 188.9 g/km and big cars' decrease (for about 4%) will lessen it to 184.4 g/km, which at the city level does not represent considerable saving if automobile manufacturers do not make an extra effort to achieve more substantial weight and power savings in matter of urban vehicles. This measure has been already proved as efficient, so Kageson (2005) considers that reducing the specific CO_2 emissions of cars to 120 g/km could be achieved without a marginal loss of welfare by engine and car downsizing the abatement cost is low to moderate, even negative.

5 LESSONS LEARNED AND CONCLUSIONS

A complex emission charging scheme could directly influence mainly goods' transport efficiency, especially in metropolitan areas. But the prerequisite for off-peak delivery success is importantly sensitive to profit losses (where most of the measures crush in developing countries), public awareness and further favourable taxation environment for such a policy involving not only transport and logistics professionals, but also their users - receivers of transported goods that must become fully aware of all environmental threats and related economic effects. "Eco-efficient" vehicle dispatching, which results in higher LGV load factors, has the potential to decrease the number of LGV trips to charged congested urban areas. Higher (cost) efficiency and delivery time shift toward free of charge periods or to periods with importantly lower charges are certainly expected.

By a more aggressive marketing and media campaign, as well as more restrictive charging scheme and importantly favourable taxation for smaller and light urban cars, we could attain a substantial percentage of car users (SUV and big car included) to turn "green" i.e. to switch to eco-efficient cars (on alternative fuels), public transport and non-motorized modes. We could as well anticipate substantial improvements, but not a miracle, as this environment is reluctant to changes, charges, rising prices and still not fully aware of the ecological dangers waiting nearby on the way.

The objective of all measures is to influence public awareness of everyday people. The need for taking account of environmental criteria while purchasing new vehicles is maturing. The car buyer should bear in mind the wider picture, but still not forget to take care of his own needs - to be cost effective, which is still rather impossible with alternatively fuelled vehicles of today. Secondly, but not less important is to persuade manufacturers to initiate mass production of "light" passenger vehicles: without excessive power or weight. Incentives, restrictive institutional measures, but also tax exemptions seem very reasonable for "greening" manufacturers and will likely motivate those who still haven't thought about their own extremely powerful, "overweight" and therefore CO_2 emission irresponsible vehicles.

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