

CARBON DIOXIDE EMISSIONS AS AN INDICATOR OF REDUCTION OF NEGATIVE EXTERNALITIES RELATED TO ROAD MOTOR VEHICLE OPERATION

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Abstract

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This contribution deals with issues of carbon dioxide emissions generated by road motor vehicles in the Czech Republic and the European Union. We discuss the current need for the introduction of environmental features to the system of taxation of motor vehicles, aiming at the mitigation of harmful substances emitted into the atmosphere. The most harmful substance produced during the combustion of hydrocarbon fuels by motor vehicles is CO₂, whose emissions are subsequently used as an instrument for green tax reforms in the European Union member states. In this article we define the main EU legal standards regulating harmful substances emitted into the atmosphere as a result of road motor transport. We may cite for instance the Regulation (EC) No. 443/2009 setting CO₂ emission performance standards for new passenger cars. The aim of the European Union is to reduce average emission values of new passenger cars sold in the EU to 130 g CO₂/km by 2015 and to 95 g CO₂/km by 2020. Assessment of tax on motor vehicles according to CO₂ emissions shall help fulfil commitments from the Kyoto Protocol, aiming at the reduction of greenhouse gas emissions.

Keywords: CO₂ emissions, road vehicle, negative externality, European Union

INTRODUCTION

Road motor transport is undoubtedly an important factor affecting the life of each individual both in a positive and a negative way. The evident positive features of road motor transport can be seen, for example, in the transport of persons or goods, whereas the negative aspects include traffic accidents, emissions and noise caused by transport. The subject of this article is environmental aspects related to the road motor vehicle operation, in particular the production of CO₂ emissions as an indicator used for regulation in the European Union. Pollutants emitted by motor transport are generated mainly by fuel combustion, and the most significant harmful substances include carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), nitrous oxide (N₂O), sulphur dioxide (SO₂), ozone (O₃), volatile organic compounds

except methane (NM VOC), particulate matter (PM) and polycyclic aromatic hydrocarbons (PAH). According to Adamec, Marková, Jedlička (2007), other pollutants include e.g. aliphatic, aromatic and heterocyclic hydrocarbons, aldehydes, phenols, ketones, tar and also metals from the platinum group such as platinum (Pt), palladium (Pd) and rhodium (Rh).

Passenger as well as freight transport is attributed large proportion of carbon dioxide emissions due to the increasing performance of motor traffic, and thus the increasing fuel consumption. Therefore the introduction of environmental aspects considering CO₂ emissions in the taxation of vehicle operation has become ever more pressing. Tab. I shows data concerning carbon dioxide emissions from the respective types of transport in the Czech Republic with those selected components that use road motor vehicles,

I: Carbon dioxide emissions (CO₂) by mode of transport in the Czech Republic (thous. tonnes)

Items	2007	2008	2009	2010	2011
Total transport	19 542	19 572	19 099	18 113	17 930
Passenger car transport	10 521	10 531	10 329	9 632	9 451
Bus public passenger transport including urban transport	2 052	2 007	1 968	1 914	1 920
Road goods transport	5 551	5 523	5 418	5 264	5 281

Source: Ministry of Transport (2012)

and the aggregate figure for the entire transportation industry. It follows from the results shown in Tab. I that the biggest problem from the point of CO₂ emissions is represented by individual car transport, which produces 55.8% of all the CO₂ emissions (information for 2011).

MATERIALS AND METHODS

The main goal of this article is to provide a description and analysis of environmental aspects of operation and taxation of road motor vehicles, particularly CO₂ emissions as an indicator used for regulation and compliance with regulations and directives in the European Union. On the basis of the description and analysis results we shall discuss shifts in and achievement of the objectives set out in the EU legal regulations which aim at reducing CO₂ emissions and thus at meeting the commitments ensuing from the Kyoto Protocol.

In order to reach the goal, it is necessary to study a range of specialized sources, in particular EU legal standards covering the topic. All the sources used in this article are listed in the bibliography section below. This article is based on the analytic method as an approach using the decomposition of a whole into elementary units. The aim of the analysis is to identify the substantial and necessary properties of the elementary units of the whole, their nature and laws. The process consists in decomposition of the examined phenomenon into smaller parts in order to learn its nature. The contribution also uses description for mediating the characteristics of a certain phenomenon or process. Subsequently, the methods of deduction and synthesis are applied to formulate conclusions and recommendations.

The source data for this contribution were taken from the European Environment Agency and regulations applicable in the European Union. In the case of the Czech Republic, mainly Transport Yearbooks were used as the source information.

RESULTS AND DISCUSSION

Most of the European countries apply regular road tax on passenger motor vehicles, whose base is formed by the engine cubic capacity, number of axles, total weight and also carbon dioxide emission values. It is the CO₂ emissions that play the ever increasing role in the collection of the regular tax on motor vehicle operation. Some of the European countries base the assessment of road tax only on the level of CO₂ emissions;

others combine this feature with other criteria. There are ten countries altogether that take into account the CO₂ emissions in the collection of road tax on passenger cars. The list of member states and systems of application of an environmental aspect (CO₂ emissions) in the mechanism of road tax determination is shown in Tab. II.

II: Member states with road tax based on CO₂ emissions

Country	Road tax – passenger cars
FINLAND	CO ₂ emissions/weight x days
IRELAND	CO ₂ emissions/cylinder capacity
CYPRUS	Cylinder capacity, CO ₂ emissions
LUXEMBOURG	CO ₂ emissions
THE NETHERLANDS	CO ₂ emissions, weight
GERMANY	CO ₂ emissions
PORTUGAL	Cylinder capacity, CO ₂ emissions
GREECE	CO ₂ emissions
SWEDEN	CO ₂ emissions/weight
UNITED KINGDOM	CO ₂ emissions/cylinder capacity

Source: Andrlík (2012)

It follows from the basic overview in Tab. II that the mentioned member states apply the value of CO₂ emissions generated by individual passenger cars as one of the components for the determination of road tax. CO₂ emission level, which is easily measurable in each new car and thus serves as a suitable tool for greening the road motor transport, has been chosen as a unit of pollutants emitted to the atmosphere, which subsequently assumes the role of a “green” feature of the road tax in all the EU member states.

The analysis of the systems of taxation of trucks in the European Union member states has identified that all member states impose road taxes on trucks, typically using the combination of weight and number of axles or suspension of axles. However, the environmental aspect in trucks forms a marginal issue or is not addressed at all. The environmental aspect is only incorporated in the system of road tax for trucks in Bulgaria, Germany, Hungary, Netherlands, Sweden, Slovenia and Slovakia; this concerns either the determination of the tax base or a discount from the taxes assessed.

In the Czech Republic, the tax base for passenger cars is based on the engine cubic capacity, in the case of axles on the sum of maximum permitted

weights per axle in tons and the number of axles, and in the other vehicles the maximum permitted weight expressed in tons and the number of axles. Although the Czech Republic does not consider CO₂ emissions in Act No. 16/1993 Coll., on Road Tax as amended (hereinafter referred to as "ART"), this legal regulation contains several measures motivating operators to decommission old vehicles and to purchase more environmental friendly ones. These measures are reduction, or as the case may be, increase of the annual rate of the road tax, dependent on the date of the first registration of the vehicle and exemption from tax for vehicles using alternative fuel or drive. The reduction of the basic tax rate is based on a 36-month cycle, where after the first 36 months the basic tax rate is reduced by 48%, after another 36 months by 40%, and for the next 36 months the reduction amounts to 25%. This provision of ART can be considered a certain form of motivation for road tax payers to regularly renew their fleet and thus to acquire vehicles that are more environmentally friendly. Another provision that may be seen as an applicable environmental aspect is the relief on road tax defined in Section 12 ART in connection with combined transport. The aim of the tax relief is to motivate taxpayers to mitigate negative impacts on the environment caused by the growing volume of road freight transport. The relief for trucks depends on the number of travels made by one vehicle in the course of the tax period, if it meets the conditions strictly prescribed by the law.

Apart from the regular road tax, certain EU countries impose registration tax on motor vehicles, which can also contribute to the mitigation of CO₂ emissions. Registration tax has been introduced in 19 EU member states, of which 12 countries base the tax on CO₂ emissions. Registration tax, as defined in theory, is not collected in the Czech Republic, where a similar role is played by fees.

A certain form of greening road motor transport is represented by the collection of administrative fees related to the registration of each road motor vehicle in the territory of the Czech Republic, and in particular, the collection of the so-called environmental fee at the moment of registration in case the vehicle does not comply with the relevant EURO emission standard. In this context, motor vehicles are imposed an administrative fee under Act No. 634/2004 Coll. on Administrative Fees, as amended by subsequent regulations, which under Item 26 sets out fees for the registration into the Central Register of Motor Vehicles. The administrative fee on the registration of a road motor vehicle with at least four wheels is determined by a lump sum of CZK 800.

The environmental fee is regulated by Act No. 185/2001 Coll., Waste Act, and amendments to certain other acts, as amended by subsequent regulations. This fee represents part of introduction of environmental features into the tax system of the Czech Republic. Under Section 37e Act

No. 185/2001 Coll., an applicant for the registration of a used vehicle of M1 and N1 categories into the register of vehicles is obliged to pay the fee for the support of collection, processing, use and disposal of scrap cars. The fee is paid on the first registration of a used vehicle of M1 and N1 categories in the Czech Republic. In case the vehicle has been registered in the Czech Republic, the fee is paid on the first re-registration. The amount of the fee is determined according to the compliance with maximum emission levels in accordance with legal regulations of the European Union as follows:

- CZK 3,000 in case of compliance with EURO 2;
- CZK 5,000 in case of compliance with EURO 1;
- CZK 10,000 in case of non-compliance with EURO 2 or EURO 1.

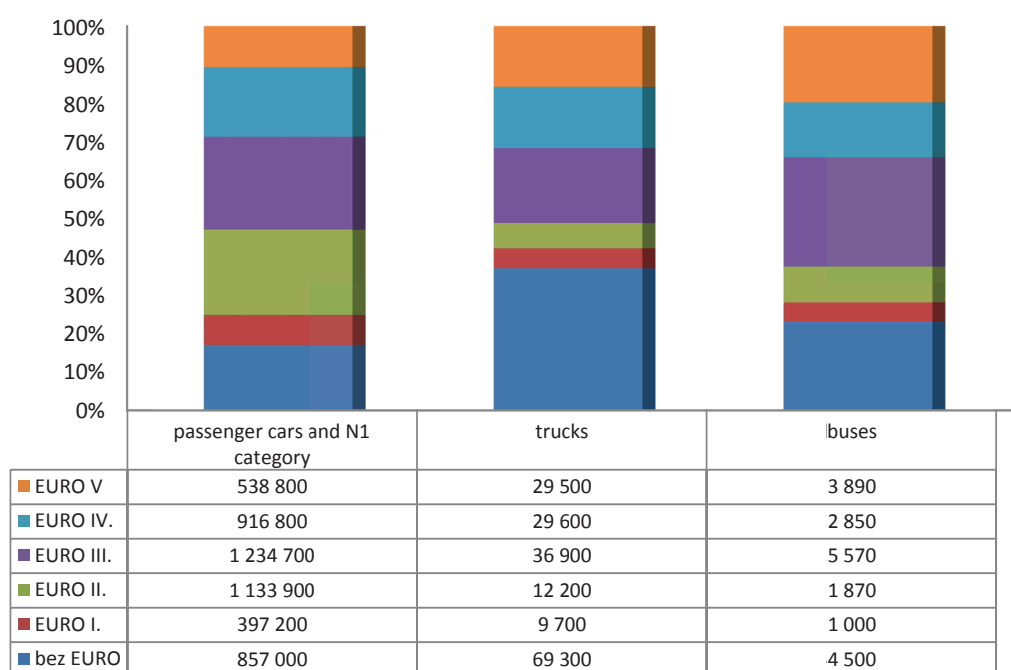
The fee is not paid for motor vehicles meeting at least the limits prescribed by EURO 3, for historical vehicles and those registered in the register of vehicles which have been issued a valid certificate of testing for historical value. The fees are part of revenue of the State Environmental Fund of the Czech Republic. However, the above measure is not an adequate tool for the support of renewal of private fleet, one of the reasons being that only the first registration is subject to fees. If a car meeting emission standards EURO 0, EURO 1 a EURO 2 is sold, another fee is not paid. It can be said that the main defect of this fee is that the owner of an old car is not sanctioned for its operation and motivated to acquire a new vehicle. For this reason, the introduction of road tax based on the objective to reduce average CO₂ emission levels of the fleet could be successful and could speed up the whole process of the fleet renewal in the Czech Republic. However, this measure supposes that road tax in the Czech Republic shall be levied on all road motor vehicles, and not only to those, as mentioned by Andrlík (2013b), that are used for business purposes or in direct connection therewith.

As mentioned in the introduction, in addition to carbon dioxide, road vehicles emit also carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter into the atmosphere. Emission limits for these pollutants which adversely affect health as well as the environment, are determined in European emission standards (EURO standards). EURO standards are used in the Czech Republic for the purpose of the environmental fee, as mentioned above. EURO standards are classified according to the vehicle type (car, truck, bus) and engine type (petrol, diesel) and determine the maximum amount of combustion products that may be generated by a vehicle. Application of EURO emission standards is the most frequently used method of considering the environmental aspect in the case of trucks. EURO emission standards set limits of exhaust emissions; higher EURO numbers imply stricter limits, requiring reduction of exhaust emissions. The standards restrict the volume

of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) and particulate matter (PM). The values are given in milligrams per kilometre. However, there are other substances generated by automobiles. Another example is the mentioned carbon dioxide and sulphur compounds (not regulated by the standard). Carbon dioxide (CO₂) is not monitored in trucks at all, and in registration books only values for the determination of the applicable EURO standard are stated (numbers of the relevant directives, which the vehicle meets). This is a major difference compared with passenger cars, where the CO₂ is the key quantity in determining the road tax base in ten member states of the European Union that have implemented the environmental reform in road taxes (see Tab. II). At the same time, by the introduction of new EURO standards the values for compliance become stricter.

At present, the strictest limits are set out in EURO 5, and EURO 6 should become effective since 2014. Fig. 1 presents the structure of the respective groups of fleet in the Czech Republic in combination with compliance with the relevant EURO standard.

It follows from Fig. 1 that in 2011, most vehicles in the categories of cars and N1 vehicles complied with EURO 3 emission standard (24.31% of the total number of registered vehicles). In the category of trucks, the most numerous are vehicles not complying with any EURO standard (37% of the total number of registered vehicles). In the category of buses, similarly to cars and N1 vehicles, the largest group is vehicles complying with EURO 3 (28.25% of the total number of registered vehicles). In order to enable the year-on-year comparison, Tab. III shows data on numbers of vehicles in the respective EURO emission groups in 2008 to 2010.



1: Composition of the fleet in CR according to EURO emission standards in 2011 in %
Source: CENIA (2012)

III: Numbers of registered vehicles in the respective emission groups in 2008 to 2010

Vehicle category	year	no EURO	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5
passenger cars including vans	2008	1 517 800	519 100	1 166 300	1 095 700	796 800	x
trucks	2008	101 100	14 700	24 600	51 400	23 400	x
buses	2008	8 080	1 870	3 120	5 630	2 260	x
passenger cars including vans	2009	1 075 200	488 400	1 166 100	1 151 400	842 000	179 200
trucks	2009	5 800	11 900	14 200	41 100	31 100	16 000
buses	2009	5 500	1 390	2 140	5 500	2 810	2 250
passenger cars including vans	2010	874 400	444 900	1 155 900	1 194 200	877 300	355 600
trucks	2010	5 430	10 800	13 300	39 100	30 900	21 600
buses	2010	4 100	980	2 000	5 420	2 820	3 000

Note: Data concerning EURO 5 are not mentioned in 2008, because the standard has been in effect since 2009.
Source: CENIA internal information

It clearly follows from data in Tab. III for years 2008, 2009 and 2010 that the structure of distribution in the respective emission groups in all the categories of monitored road vehicles underwent significant changes. EURO 5 was not in effect in 2008, and therefore no relevant data are entered. The highest proportion in 2008 represented vehicles not meeting any EURO standard (37% of the total number of registered vehicles). 2009 was the year of significant decrease in the numbers of registered trucks and cars not complying with any EURO emission standard, where the decrease in trucks was 94.26%. However, the largest group in 2009 was vehicles meeting EURO 3 and we can see a marked shift in comparison with 2008, caused by decommissioning of the above number of trucks and cars including vans. The numbers of registered vehicles in 2010 are similar as in 2009. In passenger vehicles and N1 category we identify the tendency of gradual decrease in the number of vehicles in lower EURO emission groups and a positive change consisting in a larger number of trucks meeting EURO 5 standard.

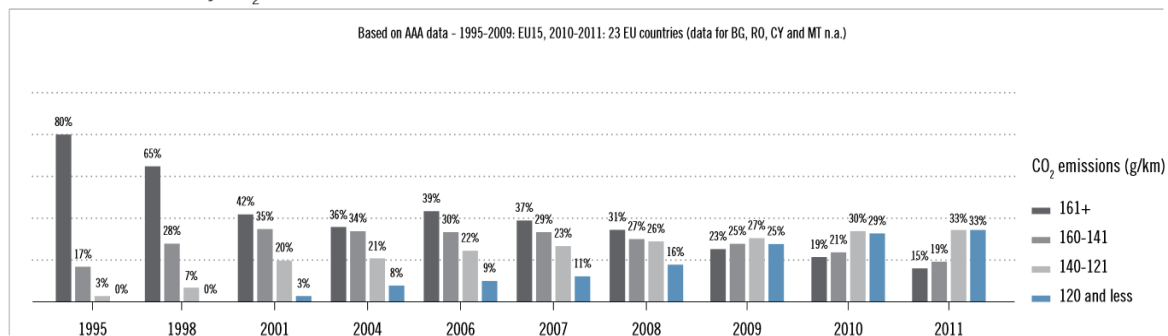
European integration requires cooperation of member states in the tax area, either in the form of coordination or even harmonization of tax systems. Whereas value added tax, excise and environmental taxes are harmonized on the level of the European Union, road tax has not been harmonized yet. Despite this fact, there are European directives regulating taxation of motor vehicles. The European Union also introduces various measures that should regulate CO₂ emissions produced by automobile industry.

According to the European Environment Agency (2013), carbon dioxide emissions from road transport increased by 21% from 1990 to 2011, and represent approximately one fifth of the total CO₂ emissions in the European Union (in 1990 to 2010 it was 23%). In order to meet goals set out in the Kyoto Protocol, the European Union has prepared a comprehensive strategy of reducing CO₂ emissions from new passenger cars and light commercial vehicles sold in the EU territory. Kyoto Protocol is linked to the United Nations Framework Convention on Climate Change, and was adopted in Kyoto in December 1997. The parties to the convention committed themselves in the Protocol to reducing greenhouse gas emissions at least by 5.2% in comparison with year 1990. Commitments of the parties concerning reduction of emissions are quantified, and manners of possible fulfilment are defined in the Protocol. The Czech Republic signed the Protocol on 23 November 1998 and ratified it on 15 November 2001. The Protocol requires reduction of emission of six greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). The signatory countries contribute by 63.7% to the total volume of emissions (Ministry of Environment, 2012).

Monitoring CO₂ emissions and fuel consumption at the moment of selling new passenger road motor vehicles was introduced by Directive 1999/94/EC of 13 December 1999. Concrete levels of CO₂ emission standards concerning new cars was introduced by Regulation No. 443/2009 of 23 April 2009, which set emission performance standards for new passenger cars as part of the Community's integrated approach to reducing CO₂ emissions from light-duty vehicles. Average CO₂ emissions from new passenger cars should be reduced to 130g CO₂/km by 2015. In 2020, average emissions from passenger cars sold in the European Union should not exceed 95g CO₂/km. The Regulation applies to vehicles of M1 category first registered in the European Union, which were not registered in a third country before such registration. Member states are responsible for collection of data concerning every new car registered in their territory and for reporting them to the Commission which is in charge of keeping the central registry of such data. Each manufacturer has average specific emission of CO₂ assigned, and if it exceeds the levels, it shall pay a fee.

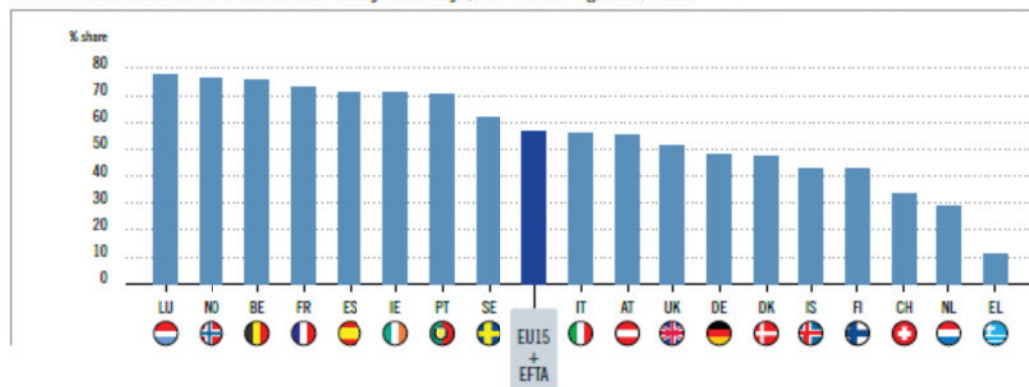
CO₂ emission standards for new light commercial vehicles were introduced by the Regulation No. 510/2011 of 11 May 2011, which set emission performance standards for new light commercial vehicles as part of the Community's integrated approach to reducing CO₂ emissions from light-duty vehicles. According to the Regulation, average CO₂ emissions from such vehicles should not exceed 175g CO₂/km and they should not exceed 147g CO₂/km by year 2020 (if feasibility of this target is confirmed). The Regulation applies to vehicles of N1 category, i.e. vehicles designed and produced for the transportation of load with the maximum weight of 3.5 metric tons. The weight of an empty vehicle shall not exceed 2,610 kg. Since 1 January 2012 and each subsequent calendar year, each member state shall record information relating to each new light commercial vehicle registered in its territory (manufacturer, type, specific CO₂ emissions, and weight).

The European Environment Agency has collected information on registration of new passenger cars ensuing from Regulation No. 443/2009 from member states for the third time. Information reported by member states on CO₂ emissions, vehicle weight and other characteristics were used for the evaluation of the new fleets in 2012 and of the progress leading to the fulfilment of the target set to 130g CO₂/km by 2015. According to preliminary results, in 2012 the average CO₂ emissions from new passenger cars were 132.2g CO₂/km, which is by 3.5g CO₂/km less than the year before. In 2011 the average CO₂ emissions from new passenger cars were 135.7g CO₂/km, which is by 4.6g CO₂/km less than the previous year. In 2010 the average CO₂ emissions from new passenger cars were 140.3g CO₂/km (European Environment Agency, 2013). Fig. 2 shows the development

New Cars in the EU by CO₂ Emissions | 1995-20112: New cars in the EU by CO₂ emissions in selected years

Source: ACEA (2012)

Diesel Penetration in the EU15+EFTA by Country (% of new cars registered) | 2011

3: Proportion of new cars with diesel engine in EU15 and EFTA in 2011¹

Source: ACEA (2012)

in the registration of new vehicles according to CO₂ emission bands defined in Fig. 2, along the timeline 1995–2011. We can clearly identify a marked shift and a growing number of registrations of vehicles whose CO₂ emissions are lower than 120 g CO₂/km, which has been caused by a growing demand for passenger cars with low emission levels and thus lower fuel consumption in recent years. It clearly follows from Fig. 2 that the proportion of new vehicles with CO₂ emissions below 120 g CO₂/km and the proportion of new vehicles with CO₂ emissions between 121 and 140 g/km have been increasing. On the other hand, the proportion of new vehicles with emission levels between 141 and 160 g CO₂/km and vehicles with CO₂ emissions above 161 g/km has dropped.

This positive development may be attributed to purchases of smaller and more fuel efficient cars and technological development, enabling reduction of fuel consumption by modernizing engines and other vehicle features. The number of diesel vehicles, whose average fuel consumption

and carbon dioxide emissions are lower, has been growing too. Diesel engine vehicles represented 54.9% of the fleet in the European Union in 2012 (55.3% in 2011). We can see in Fig. 3 that in 2011 the proportion of newly registered vehicles with compression ignition engine was almost 80% in Luxembourg, Norway and Belgium, and ca 70% in France, Spain, Ireland and Portugal.

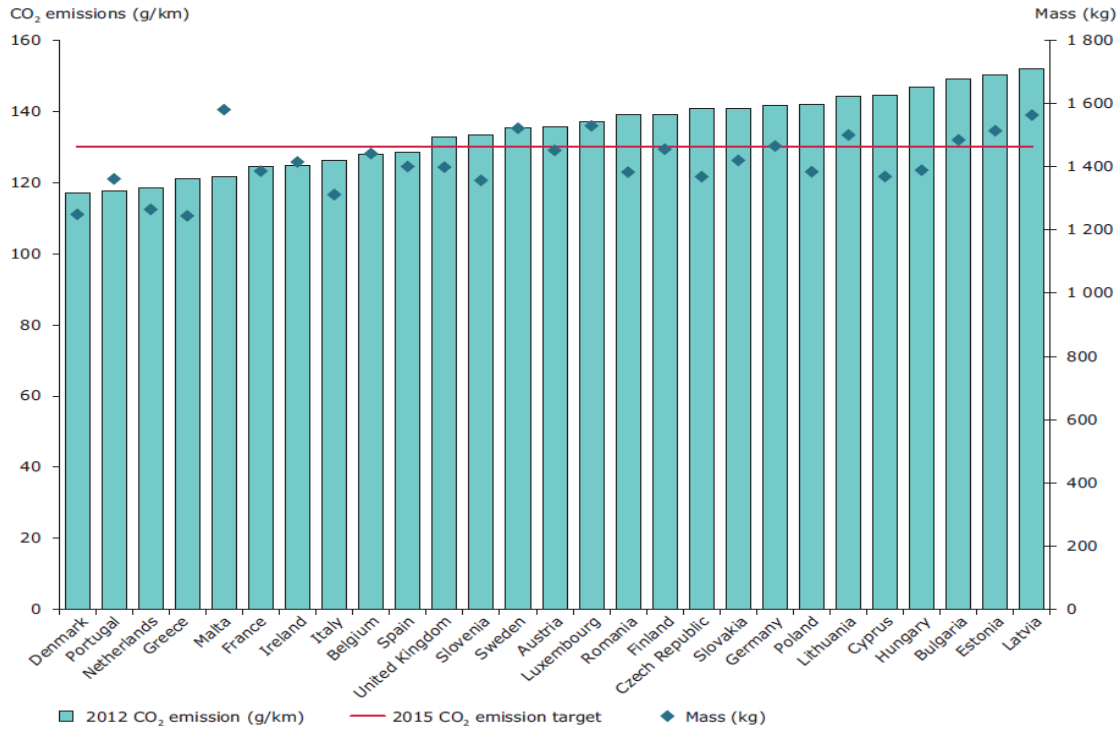
In the Czech Republic in 2011, the average CO₂ emissions from new passenger cars were 144.5 g CO₂/km, i.e. by 4.4 g CO₂/km less than in the previous year (148.9 g CO₂/km in 2010). The data for 2012 have not been verified yet, the value for new cars in the Czech Republic being 140.8 g CO₂/km, which would mean a decrease by 0.3 g CO₂/km in comparison with 2011. Generally, the average carbon dioxide emissions from new passenger cars in European countries have been decreasing. Fig. 4 shows average CO₂ emissions from new passenger cars and average weight of passenger cars in the European Union in 2012. Denmark, Portugal, the Netherlands, Greece, Malta, France,

¹ EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom. EFTA: Norway, Switzerland, Iceland.

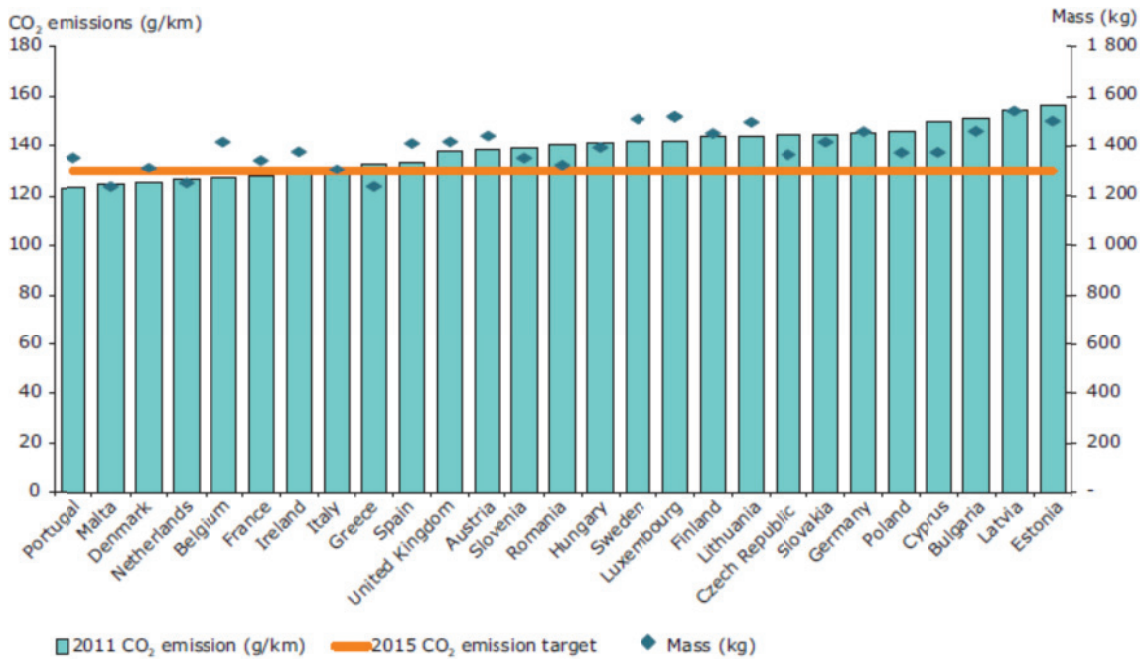
Ireland, Italy, Belgium and Spain have the lowest average emissions of newly registered passenger cars, which are below or on the edge of 130 g CO₂/km as determined by the Regulation No. 443/2009. On the contrary, the highest average CO₂ emissions from new passenger cars were recorded in Latvia

with 151.9 g CO₂/km (European Environment Agency, 2013).

Fig. 4 is followed by Fig. 5 (with data for 2011) to enable comparison of the process of reduction of average CO₂ emissions in the EU member states. In both figures, the limit is depicted which should



4: Average CO₂ emissions and average weight of passenger cars in the EU countries in 2012
Source: European Environment Agency (2013)



5: Average CO₂ emissions and average weight of passenger cars in the EU countries in 2011
Source: European Environment Agency (2012)

be achieved by member states in 2015, according to Regulation No. 443/2009, i.e. 130 g CO₂/km. In 2011, 8 EU countries were below this limit, and in 2012

the number increased to 10, the Czech Republic unfortunately not being one of them.

CONCLUSION AND SUMMARY

This contribution defines harmful substances directly resulting from the operation of road motor vehicles. The basic indicator of environmental characteristics in trucks is compliance with the EURO emission standards. The analysis shows that the basic indicator of harmful emissions from passenger and commercial vehicles is CO₂. It is CO₂ emissions produced by the respective road motor vehicles that is subsequently used as an instrument for regulation by the European Union, leading to efforts for a cleaner environment. At the same time, carbon dioxide is used in connection with environmental tax reforms in the European Union member states. If the state policy aims at the mitigation of negative externalities ensuing from motor traffic (in the case of road taxes these are primarily CO₂ emissions), it should maximally encourage incentives for emission reduction both by the manufacturers and the consumers. As stated by Andrlík (2013a), considering environmental aspects in the process of road tax collection can contribute to a higher rate of fleet renewal in a particular country. Generally, newer vehicles produce a smaller volume of harmful substances. Reduction of CO₂ emissions is also one of the commitments ensuing from the Kyoto Protocol.

At present, 10 member states apply the volume of CO₂ emissions generated by a particular passenger car in the determination of the road tax base (see Tab. II). We can say that the general effort to reduce negative externalities related to road motor vehicle operation is reflected in the number of directives and regulations applicable in the European Union. From this point of view, the most important is Regulation No. 443/2009 concerning the reduction of CO₂ emissions in newly registered passenger motor vehicles. This Regulation establishes the short-term target of 130 g CO₂/km by 2015, but also the long-term target of 95 g CO₂/km by 2020. Furthermore, Regulation No. 510/2011 concerning the reduction of CO₂ emissions of newly registered light commercial vehicles aims to reduce the average CO₂ emissions to 175 g CO₂/km by 2017, and by 2020 the emissions should not exceed 147 g CO₂/km. The target of reducing CO₂ emissions in newly registered passenger cars was met by 10 member states in 2012, with the year-on-year increase by two countries.

The Czech Republic has not achieved this target; however, with the value of 140.8 g CO₂/km in 2012 and year-on-year changes it approaches the set value of 130 g CO₂/km. The analysis of the composition of the fleet in the Czech Republic according to the EURO emission standards and annual changes primarily consisting in the transition to higher EURO emission standard also speaks in favour of meeting the target set by the European Regulation.

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