COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels,
SEC (2008) 2207

COMMISSION STAFF WORKING PAPER

accompanying

COMMUNICATION FROM the COMMISSION TO the EUROPEAN PARLIAMENT, TO the COUNCIL, TO the ECONOMIC and SOCIAL COMMITTEE AND TO the COMMITTEE of THE REGIONS

Strategy for the internalisation of external costs

Technical annex to the strategy for the internalisation of external costs

COM (2008) 435
SEC(2008) 2208
SEC (2008) 2209

Unofficial translation: this document is made available for information purposes only.

COMMISSION STAFF WORKING PAPER

Technical annex to the strategy for the internalisation of external costs

1. INTRODUCTION

This technical annex aims to answer the legislator's request according to which the Commission should develop "a universal, transparent and comprehensible model" for the evaluation of external costs.

On 10 June 2008 at the latest, after having examined all the elements, in particular the costs relating to the environmental aspects, of noise, of congestion and of health, the Commission presents a universal, transparent and comprehensible model for the evaluation of all external costs, which has to serve as a base for the calculation of infrastructure expenses. This model is accompanied by an analysis of the impact of the internalisation of external costs for all the modes of transport and of a strategy for the gradual implementation of the model for all the modes of transport.

The report and the model are accompanied, if necessary, by proposals intended for the European Parliament and for the Council for a new revision of this directive (Directive 2006/38/EC).

A handbook [1]on the estimation of external costs was published in January 2008. It reviews the methods for estimating external costs and identifies best practices. The methodology proposed here is based on the conclusions of this Handbook.

2. WHICH MODEL FOR INTERNALISATION? PROPOSAL FOR A EUROPEAN COMMON FRAMEWORK

2.1. Principles of internalisation: marginal social cost pricing

Giving the right signals to transport users has to result in prices which do not lead to overexploitation of the resources, and which are not penalising for transport and, ultimately, for the economy. In economic literature, the equilibrium point is represented by **"pricing at the marginal social cost", which is thus proposed as a general principle for internalisation**.

The marginal cost approach must be consistent with the methods for infrastructure financing and can sometimes require more complex pricing systems (see box 1). Moreover, in certain cases, this approach will not necessarily be the most suitable (see box 3 on the costs related to noise).

[1] Handbook on the estimation of external costs in the transport sector. Available in http://ec.europa.eu/transport/costs/handbook/index_en.htm

Box 1: Pricing at marginal cost and infrastructure financing: the need for a coherent approach

When a Member State decides to charge at the same time for recovering the cost of the infrastructure and for the external costs, it is necessary to ensure consistency in the approach and avoid over pricing.

Regarding infrastructure charging, pricing at the average cost, which includes fixed and variable costs, (or pricing by more complex schemes) will be a suitable way of distributing the cost of the network between users and of recovering the infrastructure cost, insofar as there is a preference for avoiding recourse to general taxation. In such case, the pricing for the use of the infrastructure should concern only the recovery of construction and maintenance costs.

Regarding costs associated with externalities, charging should as far as possible follow the principle of marginal social cost pricing, since the production of the externalities is strongly dependent on the circumstances of use (period, location, characteristics of the vehicle).

In the case of congestion, there is a risk of duplication if the use of the infrastructure and the external congestion cost are charged at the same time. The need to develop an infrastructure is in fact strongly related to the number of its users. According to economic theory, in ideal circumstances, charging for congestion represents a suitable financing mechanism for the development of the network as congestion increase. But often infrastructure work is so expensive that the collection of resources related to congestion would be insufficient to ensure its funding. In such cases, a "mark-up", which takes into account the need to expand the infrastructure and its cost, should be added to the congestion charge to mitigate this shortage. Alternatively, one can apply charges related to past construction costs to finance future development costs of the infrastructure, as it is allowed by the "Eurovignette" Directive. In this case, in order to avoid any duplication, one should take account of the fact that the development costs can reflect the costs of the congestion to the same extent as congestion charges.

2.2. Method for the calculation of external costs and application within the framework of the internalisation

In order for prices to reflect external costs, it is necessary to know the value of these costs. Society suffers from pollution, noise or congestion, but these costs do not have a priori any market value. In recent years, numerous studies were carried out in the field and identified methodologies to give a value to these costs.

In 2006, the Commission launched a study aiming to review existing methodologies. The publication of this study in January 2008 in the form of a handbook[2] represents the first useful stage to know the state of the art on the matter.

The Handbook reviews various methodologies to evaluate and monetise the external costs generated by the activities of transport and identifies the "best practices" on the matter. The main external costs examined are air pollution, noise, climate change, congestion and road traffic accidents. The handbook gathers the key parameters for the application of these

2 Handbook on the estimation of external costs in the transport sector. Available in http://ec.europa.eu/transport/costs/handbook/index_en.htm

methods and provides indicative unit values by distance covered as a function of types of traffic situations. It makes it possible to give a common methodological framework and default values if these values are not available at national level.

The GRACE research project, mentioned in the impact analysis, developed software which makes it possible to obtain external cost estimates for all the modes. This tool, available at www.grace-eu.org, was not originally intended for the application of internalisation methodology, but provides a useful illustration of the quantitative stages to be set up and gives first approximation of the results. This software, which has still to be validated, is largely compatible with the methodology proposed in this annex and in the annex of the proposal for a Directive amending Directive 1999/62/CE. Its application should still be checked on a case by case basis and be adapted to the local circumstances by the user.

The sections below propose a common framework to calculate and internalise certain external costs: congestion in road transport, the costs related to air pollution, noise and climate change in all the modes of transport. Accidents are not treated explicitly in this document (see Box 2). Nevertheless, the handbook deals with these costs and constitutes a reference on the matter, for example for the calculation of the costs and of the benefits of the road safety measures.

Box 2: The internalisation of external costs and the treatment of the accidents

The impact assessment on the internalisation of external costs and the handbook show that external costs of accidents are primarily generated by road transport. The accidents constitute a high cost for society, in addition to the tragic consequences for those involved. Only a part of these costs are incurred by the vehicle drivers. The internalisation of the external costs of the accidents should be done by mechanisms capable of taking risk behaviour into account (speed, drink-driving) and to give the incentives to correct them. The insurance premiums, for example, via the bonus/malus system, already answer this requirement by taking the risk profile of the driver, although the level of premiums is correlated with the payments of the damages which, generally, do not cover all the costs. Although the consultation showed support for a repercussion of the costs on the insurance premiums, such an action should take into account the differences which exist between Member States and would require a more detailed examination, in particular on the questions of subsidiarity. At this stage the process is not sufficiently advanced to propose an initiative at European level.

Following the White Paper of 2001 which had fixed as an objective the halving of the number of victims of accidents, the Commission launched in 2003 a European action program for road safety. For example, very recently, on 19 March 2008, the Commission adopted a proposal for a Directive aiming to facilitate the cross-border application of legislation on road safety to the motorists who commit an offence in another Member State than that where their vehicle is registered. This system is intended to ensure the application of legislation, whatever the place of the infringement in the European Union and the Member State in which the vehicle was registered. Such a measure should encourage a reduction in risk taking behaviour abroad, which generates accidents.

Moreover, the results of the impact assessment on the internalisation of external costs also show that the internalisation of the environmental and congestion costs contributes to re-orientating the traffic towards safer modes and generates, consequently, a reduction in the number of accidents (between -0.7 and -1.2%)

2.3. Congestion costs in Europe

In Europe congestion is significant. The impact assessment showed that on average 29% of the European road network could suffer congestion between now and 2020 if nothing is done in the meantime.

2.3.1. What does one expect from congestion charges?

Road transport

The costs related to congestion are due to the limited capacity of the infrastructure in relation to transport demand and take the form of the time/delays imposed on other users of transport. Some can consider that these costs are already internalised since the waste of time is suffered by the transport user. However, the user imposes a waste of time on others, and it is this part which is considered external.

Imposing a congestion charge can make it possible to modify behaviour and therefore to move the demand curve for transport. In other words, certain users can, for example, decide to postpone the trip that they would have otherwise envisaged or to use another less encumbered network. The charge, accompanied by a larger supply of transport alternatives, which would increase demand elasticities, can make it possible to reduce the pressure on the network of a particular mode of transport.

Other modes

For those modes of transport where services are provided on the basis of schedules, such as rail or air transport, one speaks about scarcity cost in that the train/the aircraft cannot have the "slot" desired. In those cases, the alternatives can be to impose a charge linked to this scarcity or to allocate the desired slot by auction, possibly on the basis of priority rules.

2.3.2. Methodological principles to calculate the congestion cost

Road transport

The handbook published in January 2008 relies on the studies and recent research carried out at European level – UNIT, TRENEN-II-STRAN, MC-ICAM, GRACE, INFRAS/IWW and COMPETE. These methods have in common the evaluation of the time lost as a function of the characteristics of the speed flow (interurban), traffic jam (urban) and the calculation of the appropriate costs for scarce slots (rail and aviation).

With a view to taking the local dimension of these costs into account, the following main steps are recommended:

(1) classification of the network (urban, interurban…). This makes it possible to take the local dimension into account since congestion varies from one type of network to the other. An even more disaggregated approach taking into account single road sections could be preferable.

(2) establishment of the average speed as a function of the volume of traffic (speed flow function). These values also have a strong local dimension and vary between various infrastructures.

(3) valuation of the time spent in transport. These values depend in particular on the characteristics of demand. Default values are proposed in the Handbook according to the HEATCO research project (p. 30 of the Handbook).

(4) computation of marginal external cost functions

$MCE_{cong}=VOT.Q/V\ (Q)^{2}.\ (v\ (Q) - v\ (Q- \bullet\ Q\ ))\ /\bullet\ Q$

Where VOT=value of time (€/veh-h)

Q = current traffic level (veh/h)

v (Q) = speed flow function Q (km/h)

• Q = variation of the volume of traffic with respect to the current traffic Q level

MCE_{cong} = external marginal cost of congestion

(5) estimate of elasticities of local demand and of reaction patterns. Elasticity corresponds to the change of demand related to a change of prices. It depends in particular on the type of trip (for work, leisure, carriage of goods, etc…) and of the initial level of traffic. The trips related to leisure are in general more sensitive to the price than the trips related to work. These elasticities have a strong local component because they can also depend on the existing transport alternatives. If no other transport supply exists at a given place, demand will not be very sensitive to the variation in price.

(6) iterative calculation of the charge level. This stage makes it possible to take into account changes of elasticity of demand and of the resulting congestion levels. Models make it possible to give the optimum charge level, typically by iterative methods. Generally, the level of the price is below the calculated cost. In the absence of modelling, it is recommended to have a progressive approach over time and to adjust the price gradually to the level of the external congestion cost. Certain studies showed that the optimum price is 30 to 50% below the external marginal congestion cost.

Other modes of transport

The handbook did not identify best practices for the other modes. Literature in the field underlines to what extent it is difficult to arrive at a consensus on the matter. In the rail sector, thinking continues[3]. To estimate a scarcity cost, the cost of a slot could serve as a base in order to answer concretely the problems raised by the costs shared by several market segments (passengers and freight in particular).

2.3.3. Values of the external congestion costs

Proposal for default values

Since the external congestion costs have a high local dimension, the national, or even regional values, are preferable. For example, the use of a local "speed flow function" is preferable since the traffic varies widely according to capacity and the characteristics of the infrastructure.

---

[3] RAILCAC project: http://ec.europa.eu/transport/rail/legislation/infrastructure_en.htm

On the other hand, the values proposed below can be used by default if the Member State does not have such values at regional level. These values propose a low, central and maximum range.

Table 1: Proposed ranges of marginal social cost prices (optimal external costs) of congestion by road class and type of area (€/vkm 2000)

Area and road type	**Passenger cars**			**Goods vehicles**			**HGV**
	Min.	Central	Max	Min.	Central	Max.	PCU
Large urban areas (> 2 000 000)							
Urban motorways	0.30	0.50	0.90	1.05	1.75	3.15	3.5
Urban collectors	0.20	0.50	1.20	0.50	1.25	3.00	2.5
Local streets centre	1.50	2.00	3.00	3.00	4.00	6.00	2.0
Local streets cordon	0.50	0.75	1.00	1.00	1.50	2.00	2.0
Small and medium urban areas (< 2 000 000)							
Urban motorways	0.10	0.25	0.40	0.35	0.88	1.40	3.5
Urban collectors	0.05	0.30	0.50	0.13	0.75	1.25	2.5
Local streets cordon	0.10	0.30	0.50	0.20	0.60	1.00	2.0
Rural areas							
Motorways*	0.00	0.10	0.20	0.00	0.35	0.70	3.5
Trunk roads*	0.00	0.05	0.15	0.00	0.13	0.23	2.5

vkm = vehicle-kilometre, HGV = Heavy Goods Vehicle, PCU = Passenger Car Unit.

* Calculated with a price elasticity of demand of -0.3.

This data takes account of the adjustment of demand.

Source: Handbook on estimation of external costs in the transport sector. p. 34

Transfer procedure

Behaviour between the transport users in Europe is considered to be the same. Only adjustment by income proves to be necessary given the income disparities between Member States. This is why the transfer value based on the GDP per capita in purchasing power parity is proposed.

$ME_{CMS} = MEC_{EU} * GDP_{MS.} PPP_{MS}/GDP_{EU25.} PPP_{EU25}$

2.3.4. How to use the calculated values?

Differentiate in time and space

In all cases, a congestion charge should be differentiated in time (peak and off-peak hour) and location (urban area, not urban) in order to influence the choices of the transport users. The waste of time related to traffic jams constitutes a cost for the economy and society. But certain trips could be deferred or simply be cancelled if the user has the choice between the payment at a peak hour and the payment at an off-peak hour.

Take into account the infrastructure policy

The use of these values depends in practice on the infrastructure policy.

If no infrastructure expansion is envisaged, the congestion charge aims at modifying demand. This is generally the case in urban areas where infrastructures cannot be modified *in extenso*. Urban road pricing can be set up and will correspond to the external congestion cost calculated on the basis of the methodological principles described above.

The payment for congestion could be a very useful element to finance the development of the infrastructure. In this case, complementarity with the charges which allow the recovery of the cost of the infrastructure should be ensured.

2.4. The costs of noise in Europe

The impact on health of the noise generated by transport is largely recognised today and affects the most vulnerable people more heavily. The costs related to noise will increase in relation to the increase in traffic.

2.4.1. What does one expect from charge related to noise?

The internalisation of the costs related to noise aims to give an incentive to the transport users to modify their behaviour in the short term, for example, avoid protected areas, but especially, in the long term, this price signal has to encourage the users to use less noisy vehicles and therefore to renew the vehicle fleet.

2.4.2. Methodological principles to calculate the cost of the noise

European legislation (Directive 2002/49/EC) has already envisaged a certain harmonisation concerning the evaluation and the management of the noise in the environment[4]. The recommended methodological stages take account of the data relating to noise exposure in the environment that Member States are required to produce and to publish pursuant to this legislation:

<u>Number of people exposed to noise</u>: Directive 2002/49/EC provides a common approach concerning the determination of noise exposure in the environment thanks to the establishment of strategic mapping of noise according to indicators and evaluation methods common to the Member States. These strategic noise maps aim at informing the public on the

[4] This Directive had to be transposed by all the Member States before 18 July 2004.

exposure to noise in the environment and to provide a base of evaluation for the elaboration of an action plan, which is also required by this directive.

The directive must be applied in several stages for all the major road highways, rail lines and large airports, as well as the agglomerations of more than 100,000 inhabitants determined by the Member States in accordance with the requirements of the Directive[5].

The maps have to provide the number of people exposed to the noise (by noise level class according to the common indicators Lden and Lnight at least, for the road, rail and air transport modes). In numerous cases, the methods used for the carrying out of the strategic noise maps make it possible also to have information on noise exposure more detailed than required by the directive (people exposed by categories of vehicles of the same mode of transport, for each period day/evening/night taken for the evaluation of the Lden).

Evaluation of the costs of noise: The data concerning the exposed population determined pursuant to Directive 2002/49/CE and the unit costs by person by noise level given by HEATCO (2006) can serve as a base to the evaluations of external costs by vehicle-kilometre.

The average external cost by vehicle-km due to the noise of a mode (m) of transport along an axis (j) during a period (p) should be evaluated according to the following principles of calculation:

$$CME_{noise\ j,\ m,\ p} = Pop_{j,\ m,\ p} * C_{db\ (A)\ m,p} / (Veh*km)_{\ j,p}$$

$Pop_{j,m,p}$: number of people exposed to the noise determined in accordance with the methodology presented in Directive 2002/49/EC for the elaboration of the strategic maps.

$C_{db(A)m,p}$: unit cost of the noise for the mode (m) of transport by person exposed (€/db(A)/persons) for the period p[6].

$(Veh*km)_{\ j,p}$: number of vehicles multiplied by the number of kilometres along the main axis j for the period p.

$CME_{noise\ veh/km}$: cost of the noise by vehicle km

---

5 The strategic noise maps and action plans should initially (2007-2008) be drawn up for 162 agglomerations having more than 250 000 inhabitants, 82 575 km of main roads having more than 6 million vehicle passage a year, 12 315 km of rail axes the traffic of which exceeds 60000 train passages a year and 74 large civil airports having more than 50 000 movements a year. Secondly (2012-2013), the applicable thresholds for the carrying out of the strategic noise maps and of the action plans will be: 100 000 inhabitants for the agglomerations, 3 million vehicle passages a year for the main roads and 30 000 train passages a year for the rail axes. The strategic noise maps and the action plans have to be re-examined and if necessary revised every five years following their establishment.

6 Report D5 of the HEATCO project (http://heatco.ier.uni-stuttgart.de/HEATCO_D5.pdf) provides these unit values for the exposure for 24 hours (Lden). The unit cost in the night period (23H-7H) by default can be determined according to the methodology retained by HEATCO on the basis of the rates of persons whose sleep is very disturbed (function of the Lnight noise level). The document drawn up by the group of WG experts HSEA (http://ec.europa.eu/environment/noise/pdf/positionpaper.pdf) provides these recommended rates in the absence of locally ascertained values. For the evening period (19H-23H by default) it is recommended to apply the unit costs of the night period in the absence of better values. For the day period (7H-19H by default), it is recommended to apply by default the average unit costs on 24 hours (Lden).

Box 3: Marginal cost pricing and the cost of noise

Pricing at the marginal social cost is the best way to take into account the local conditions and the variation of the costs as a function of the time and the place of use of the infrastructure. Such an approach is however less straightforward regarding the costs of noise. The marginal cost of noise decreases with the intensity of the traffic. In other words, if the traffic is already very high, an additional vehicle will almost not result in any increase in the cost of noise. Accordingly, in the event of heavy traffic, the marginal cost of noise can be equal to or lower than the average cost. At the opposite, a vehicle which crosses a deserted area during the night will have a very high marginal cost of noise. In addition, owing to this complex relation between noise level and traffic, the marginal cost estimate remains in practice difficult and requires complex modelling methods.

The approach proposed here takes into account existing legislation on noise which proposes the establishment of strategic noise maps. This approach takes into account local data, per period, on the population exposed to noise (issued from the strategic maps). It makes it possible to calculate an average cost per vehicle-kilometre for the mode (road/rail/air). This data is also available by axis (rail and road) and per period (24 hours (Lden) and night (Lnight)). The average cost could also be evaluated by category of vehicle of a mode if one has the breakdown by category of the data on exposure of a particular mode.

In the absence of the breakdown by category of the data on exposure of a given mode, it is possible to calculate a factor of differentiation of the cost/vehicle-kilometre of a given mode which would take account of the noise category of the vehicle. The European project Imagine[7] makes it possible to evaluate the noise level E_m of a vehicle in a given mode and the average sound emissions E_i from each category i of the mode m under the conditions of displacement (speed, pace) of the road axis under consideration by retaining a reference point for the evaluation of this emission (7.50 metres from the road, at a 4 metres height).

The differentiation factor $D_{i,m}$ for the category of vehicle i of the mode m can be calculated:

$D_{i,m} = [E_{i,m} + 10 \log Q_{i,m}] / [\ E_m + 10 \log Q_m\ ]$

where

$Q_{i,m}$: vehicle-kilometres of the category i of the mode m under consideration

Q_m: Total vehicle-kilometres of the mode m under consideration

The cost $C_{i,m}$ by vehicle-kilometre of the category i of the mode m: $C_{i,m} = D_{i,m} * C_m$

This approach could make it possible to bring the calculation closer to the marginal cost by quantifying the noise impact of an additional vehicle. Pricing at the marginal cost remains suitable if Member States have the information necessary to calculate it. The proposed default values are marginal costs and can therefore give an indication between the difference between average cost and marginal cost.

[7] http://www.imagine-project.orghttp://www.imagine-project.org/

2.4.3. *External cost values of noise*

Proposal for default values

The elaboration of a common approach makes it possible to have national values which will be soon available with the drawing up of the maps of the noise. In the absence of such data, the following values are proposed by default.

Table 2: Unit values for marginal* costs for different network types (€ct/vkm) for road and rail traffic

	Time of day	Urban	Suburban	Rural
Car	Day	**0.76** (0.76 – 1.85)	**0.12** (0.04 – 0.12)	**0.01** (0.01 – 0.014)
	Night	**1.39** (1.39 – 3.37)	**0.22** (0.08 – 0.22)	**0.03** (0.01 – 0.03)
Motor cycle	Day	**1.53** (1.53 – 3.70)	**0.24** (0.09 – 0.24)	**0.03** (0.01 – 0.03)
	Night	**2.78** (2.78 – 6.74)	**0.44** (0.16 – 0.44)	**0.05** (0.02 – 0.05)
Bus	Day	**3.81** (3.81 – 9.25)	**0.59** (0.21 – 0.59)	**0.07** (0.03 – 0.07)
	Night	**6.95** (6.95 – 16.84)	**1.1** (0.39 – 1.10)	**0.13** (0.06 – 0.13)
Light goods vehicle	Day	**3.81** (3.81 – 9.25)	**0.59** (0.21 – 0.59)	**0.07** (0.03 – 0.07)
	Night	**6.95** (6.95 – 16.84)	**1.1** (0.39 – 1.10)	**0.13** (0.06 - 0.13)
Heavy goods vehicle	Day	**7.01** (7.01 – 17.00)	**1.1** (0.39 – 1.10)	**0.13** (0.06 – 0.13)
	Night	**12.78** (12.78-30.98)	**2** (0.72 – 2.00)	**0.23** (0.11 – 0.23)
Passenger train	Day	**23.65** (23.65 – 46.73)	**20.61** (10.43 – 20.61)	**2.57** (1.30 – 2.57)
	Night	**77.99**	**34.4**	**4.29**
Freight train	Day	**41.93** (41.93 – 101.17)	**40.06** (20.68 – 40.06)	**5** (2.58 – 5.00)
	Night	**171.06**	**67.71**	**8.45**

* Central values in bold, ranges in brackets

Note: The lower limit of the bandwidth is based on dense traffic, while the upper limit is based on light traffic conditions. Central values (in bold) are chosen based on the predominant traffic condition in the respective regional cluster: urban = dense; suburban/rural = light.

Source: Handbook. Table 22 p. 69

Transfer procedure

Here again, the transfer value based on the GDP per capita in purchasing power parity is proposed.

$ME_{CMS} = MEC_{EU} * GDP_{MS.}\ PPP_{MS}/GDP_{EU25.}\ PPP_{EU25}$

2.4.4. How to use the calculated values?

Based on the calculation of these costs, charging has to take account of the local character of the noise.

Differentiate in time and space

Noise has a strong local dimension. A single lorry which crosses an urban area in the middle of the night would generate more noise than if it used a very busy motorway at 8 a.m. In addition, the charge linked to the noise should be able to vary according to the time of day - day (7H-19H), evening (19H-23H) or night (23H-7H). Similarly, charges should be differentiated according to the type of network (urban, interurban)[8].

Differentiate according to the category of vehicle

Charges should be differentiated according to the category of vehicles if information is available.

2.5. The costs of air pollution in Europe

Although the harmful effects related to air pollution decreased in recent years, in particular in road transport, they remain a subject of concern because of the serious effects on health. An increase in the costs related to air pollution is expected in the years ahead, notwithstanding that measures are currently being proposed to improve air quality[9].

2.5.1. What does one expect from a charge related to air pollution?

A charge related to air pollution makes it possible to take into account the characteristics of the vehicles and to encourage the renewal of the fleet towards cleaner vehicles. At present, a "clean" vehicle pays the same price as a polluting vehicle.

2.5.2. Methodological principles to calculate the cost of air pollution

In recent years, the evaluation methods of external pollution costs have made enormous progress, in particular thanks to the ExternE work which made it possible to set up a recognised methodology – "impact pathway approach" – IPA. This approach is recommended by the handbook.

The IPA method makes it possible to identify the following steps:
- identification of the volume of traffic.
- emission by type of vehicle.
- data on the population density, the type of environment, etc…
- monetary evaluation.

On this basis, the proposed formula is as follows:

$CP_{AP,T} = EF_{ki} * C_{kj}$

where:

---

[8] A correction factor can be applied in sensitive areas, for example in mountain regions.

[9] The EURO VI proposal for December 2007 aims in particular to reduce the emissions of pollutants from lorries.

EF_{ki}: corresponds to the emission factor of the pollutant k for a vehicle i (g/vkm). The database CORINAIR makes it possible to give national values for road transport and the other modes.

C_{kj}: cost of the pollutant k for a network j (€/g). These values can be provided by table 13 of the handbook.

CP_T: corresponds to the external cost of pollution of the mode of transport T.

2.5.3. Values of external costs of air pollution

Proposal for default values

Here too, the use of national values is preferable. Otherwise, the values derived on the basis of the data available for Germany are proposed by default.

Table 3: Air pollution costs in €ct/vkm (€2000) for passenger cars and heavy duty vehicles

(Example Germany, Emissions from TREMOVE model, HEATCO and CAFE CBA cost factors for Germany used), Price base 2000

Vehicle	Size	EURO-Class	Metropolitan	Urban	Interurban	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Passenger Car Petrol	<1.4L	EURO-0	5.9	2.3	1.7	1.9	2.0
		EURO-1	1.7	1.4	0.6	0.8	0.9
		EURO-2	0.9	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.3	0.1	0.1	0.1	0.1
		EURO-5	0.3	0.1	0.1	0.0	0.1
	1.4-2L	EURO-0	5.1	1.8	1.4	1.6	1.6
		EURO-1	1.7	1.5	0.6	0.8	0.9
		EURO-2	0.9	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.3	0.1	0.1	0.1	0.1
		EURO-5	0.3	0.1	0.1	0.0	0.1
	>2L	EURO-1	1.4	1.2	0.6	0.8	0.8
		EURO-2	0.8	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.2	0.1	0.1	0.1	0.1
		EURO-5	0.2	0.1	0.1	0.0	0.1
Passenger Car Diesel	<1.4L	EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4
	1.4-2L	EURO-0	13.8	4.8	1.4	1.5	2.4
		EURO-1	4.8	2.0	1.0	1.3	1.4
		EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4
	>2L	EURO-0	14.1	5.1	1.7	1.8	2.7
		EURO-1	4.8	2.0	1.0	1.3	1.4
		EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4

Vehicle	Size	EURO-Class	Metropolitan	Urban	Interurban	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Trucks	<7.5t	EURO-0	20.1	11.3	9.1	9.0	9.1
		EURO-1	12.0	6.7	5.4	5.3	5.4
		EURO-2	8.1	5.6	5.0	5.0	5.0
		EURO-3	7.5	4.8	4.0	3.9	4.0
		EURO-4	3.2	2.5	2.3	2.3	2.3
		EURO-5	2.3	1.6	1.4	1.4	1.4
	7.5-16t	EURO-0	28.2	15.7	11.9	11.1	11.6
		EURO-1	18.4	10.6	8.1	7.6	7.9
		EURO-2	12.4	8.5	7.2	6.9	7.1
		EURO-3	10.2	7.2	6.0	5.5	5.8
		EURO-4	5.3	4.1	3.5	3.3	3.4
		EURO-5	3.8	2.7	2.2	2.0	2.1
	16-32t	EURO-0	29.0	16.5	12.7	11.8	12.1
		EURO-1	16.3	9.9	7.8	7.3	7.5
		EURO-2	12.9	9.1	7.5	7.1	7.2
		EURO-3	9.4	7.0	5.8	5.3	5.5
		EURO-4	5.2	4.1	3.5	3.2	3.3
		EURO-5	3.8	2.7	2.2	2.0	2.1
	>32t	EURO-0	38.3	22.3	16.8	14.9	15.3
		EURO-1	28.1	16.1	12.0	10.6	10.9
		EURO-2	18.9	13.2	10.7	9.6	9.8
		EURO-3	14.6	10.6	8.5	7.6	7.7
		EURO-4	7.4	6.1	5.1	4.5	4.6
		EURO-5	5.2	3.8	3.1	2.8	2.8

Source emission factors: TREMOVE Base Case (model version 2.4.1).
Notes: metropolitan: cities with >0.5 million inhabitants,
urban: cities with < 0.5 million inhabitants

Emissions of air pollutants vary considerably depending on average speed. The above presented values assume the following average speed for passenger cars on the different types of network: urban/metropolitan: 37 km/h, interurban: 75 km/h, motorways: 106-125 km/h, depending on vehicle size.

Source: Handbook on estimation of external costs in the transport sector. p. 57

Table 4: Air pollution costs in €ct/train-km passenger and freight trains (Example Germany, HEATCO and CAFE CBA cost factors for Germany used)

			Metropolitan			**Other Urban**			**Non Urban**		
			Indirect emissions	Direct emissions	**Total**	Indirect emissions	Direct emissions	**Total**	Indirect emissions	Direct emissions	**Total**
			€ct/ train-km	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*
Passenger	Electric	Locomotive	4.9	0.0	**4.9**	4.9	0.0	**4.9**	4.9	0.0	**4.9**
		Railcar	7.6	0.0	**7.6**	7.7	0.0	**7.7**			
		High Speed Train							9.2	0.0	**9.2**
	Diesel	Locomotive	8.7	204.7	**213.3**	8.7	108.8	**117.5**	8.7	90.7	**99.4**
		Railcar	11.5	271.0	**282.4**	11.5	144.8	**156.4**			
Freight	Electric	Locomotive	13.7	0.0	**13.7**	13.7	0.0	**13.7**	13.7	0.0	**13.7**
	Diesel	Locomotive	29.2	690.0	**719.2**	29.2	366.8	**396.0**	29.2	305.8	**335.0**

Source emission factors: TREMOVE Base Case (model version 2.4.1).

Notes:

1) Direct emissions do not include emissions of abrasion processes and thus only apply to diesel traction. Indirect emissions are caused by electricity production for electric traction and fuel production and transport for Diesel traction.
2) Metropolitan: cities with >0.5 Mill. inhabitants, other urban: cities with < 0.5 Mill. Inhabitants.
3) Values for metropolitan and other urban freight trains estimated based on the ratio 'metropolitan/non urban' and 'other urban/non urban' for passenger trains (electric and diesel locomotive traction). Values for metropolitan and urban freight trains are not included in the TREMOVE database.

Source: Handbook on estimation of external costs in the transport sector. p. 59

Table 5: Air pollution costs in €/ship-km for Inland Waterways (Example Germany, HEATCO and CAFE CBA cost factors for Germany used)

Ship Type		Direct Emissions *€/ship-km*
Dry Cargo	<250 ton	0.89
	250-400 ton	0.89
	400-650 ton	1.22
	650-1,000 ton	1.86
	1,000-1,500 ton	2.54
	1,500-3,000 ton	4.63
	> 3,000 ton	4.63
Push barge	<250 ton	6.05
	250-400 ton	6.05
	400-650 ton	6.06
	650-1,000 ton	6.04
	1,000-1,500 ton	6.05
	1,500-3,000 ton	6.05
	> 3,000 ton	12.60
Tanker	<250 ton	0.89
	250-400 ton	0.90
	400-650 ton	1.22
	650-1,000 ton	1.86
	1,000-1,500 ton	2.54
	1,500-3,000 ton	7.28
	> 3,000 ton	7.28

Source emission factors: TREMOVE Base Case (model version 2.4.1)

Source: Handbook on estimation of external costs in the transport sector. p. 59

Table 6: Air pollution costs in €ct/pkm and €/LTO respectively for air transport (Example Germany, HEATCO and CAFE CBA cost factors for Germany used)

Flight distance	**Direct emissions**	
	€ct/pkm	*€/LTO*
< 500 km	0. 21	45
500-1000 km	0. 12	70
1000-1500 km	0. 08	117
1500-2000 km	0. 06	138
> 2000 km	0. 03	300

Source emission factors: TREMOVE basic Scenario (version 2.4.1)
Source: Handbook on estimation of external costs in the transport sector. p. 60

Transfer procedure

The transfer value based on the GDP per capita in purchasing power parity and on the population density is proposed.

$MEC_{MS} = MEC_{EU} * GDP_{MS.} PPP_{MS}/GDP_{EU25.} PPP_{EU25} * Pop/km^2_{MS} / Pop/km^2_{EU25}$

2.5.4. *How to use the calculated values?*

Differentiation according to location and the vehicle

Air pollution differs between urban and non urban areas, but also between the cities. Air quality of a city like Warsaw or Paris differs from that of Athens or of Madrid due to traffic or weather condition differences, etc. Therefore, the charges applied should be differentiated according to the type of vehicle and the location (urban, rural areas) in order to take account of the local conditions[10].

2.6. The costs of climate change in Europe

Contrary to the previously described external costs, the costs related to climate change are global and are directly related to fuel consumption. CO_2 emissions constitute the major challenge for transport. Between 1990 and 2005, the emissions of CO_2 from transport increased by 32% while they stabilised in other sectors of the economy (industry, households). It is especially in air and maritime transport that the increase in these emissions was greatest. Projections show that these emissions will continue increasing despite the inclusion of air transport in the European trading scheme.

2.6.1. *What does one expect from a tax or from a system of emission rights related to climate change?*

The fight against the climate change passes through the reduction of greenhouse gases. Transport represents more than one quarter of CO_2 emissions and the reduction of emissions must also form part of the political agenda. A tax or a system of emission rights is intended to encourage transport users to reduce their fuel consumption and therefore to limit the emissions of greenhouse gas.

2.6.2. *Methodological principles to calculate external costs of climate change*

The following formula makes it possible to calculate the external cost of the climate change.

$C_{cc} = E_{GES\ vkm} * Equiv_{Co2} * C_{CO2}$

E_{GES}: greenhouse gas emissions for a vehicle-kilometre (g/veh km)

$Equiv_{CO2}$: cost of CO_2 equivalent. The Handbook suggests the use of the Global Warming Potentials method.

C_{CO2}: cost of CO_2 (€/g). The Handbook gives recommended values (table 26 p. 80).

[10]Here again, a correction factor can be applied in sensitive areas like the mountains.

2.6.3. *Values of external costs of climate change*

Table 7: Costs of climate change in €/ct/vkm for passenger cars and lorries

Vehicle	Size	EURO class	Metropo-litan area	Urban area	Iinter-urban area	Motorway	Average
			(€ct/vkm)	*(€ct/vkm)*	*(€ct/vkm)*	*(€ct/vkm)*	*(€ct/vkm)*
Passenger cars Petrol	<1,4L	EURO-0	0.7 (0.2-1.2)	0.6 (0.2-1.1)	0.4 (0.1-0.8)	0.5 (0.2-1)	0.5 (0.1-0.9)
		EURO-1	0.6 (0.2-1.2)	0.6 (0.2-1.2)	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-2	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-3	0.6 (0.2-1.1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-4	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
		EURO-5	0.5 (0.1-0.9)	0.5 (0.1-0.8)	0.3 (0.1-0.6)	0.3 (0.1-0.6)	0.4 (0.1-0.7)
	1,4-2L	EURO-0	0.9 (0.2-1.5)	0.7 (0.2-1.3)	0.5 (0.1-0.9)	0.7 (0.2-1.2)	0.6 (0.2-1.1)
		EURO-1	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-2	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-3	0.7 (0.2-1.2)	0.7 (0.2-1.2)	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-4	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.4 (0.1-0.7)	0.4 (0.1-0.8)	0.5 (0.1-0.8)
		EURO-5	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
	>2L	EURO-1	1.0 (0.3-1.8)	1 (0.3-1.8)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.3)
		EURO-2	1.0 (0.3-1.7)	1 (0.3-1.7)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.3)
		EURO-3	0.8 (0.2-1.5)	0.8 (0.2-1.4)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-4	0.9 (0.2-1.6)	0.8 (0.2-1.5)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1.1)
		EURO-5	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.5 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.2-1)
Passenger cars Diesel	<1,4L	EURO-2	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.3 (0.1-0.6)	0.3 (0.1-0.6)	0.3 (0.1-0.6)
		EURO-3	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.6)
		EURO-4	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.5)
		EURO-5	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.6)
	1,4-2L	EURO-0	0.5 (0.1-1)	0.5 (0.1-0.9)	0.3 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
		EURO-1	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.8)	0.5 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-2	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.8)	0.5 (0.1-0.8)
		EURO-3	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-4	0.5 (0.1-0.8)	0.5 (0.1-0.8)	0.3 (0.1-0.6)	0.4 (0.1-0.6)	0.4 (0.1-0.7)

		EURO-5	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
	>2L	EURO-0	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.2-1)
		EURO-1	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.2)
		EURO-2	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.6 (0.2-1)	0.6 (0.2-1.1)	0.6 (0.2-1.1)
		EURO-3	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-4	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.1-0.9)
		EURO-5	0.6 (0.2-1.2)	0.6 (0.2-1.2)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.1-0.9)
Lorries	<7,5t	EURO-0	1.3 (0.4-2.4)	1.3 (0.4-2.4)	1.2 (0.3-2.2)	1.2 (0.3-2.1)	1.2 (0.3-2.2)
		EURO-1	1.1 (0.3-2)	1.1 (0.3-2)	1 (0.3-1.9)	1 (0.3-1.9)	1 (0.3-1.9)
		EURO-2	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
		EURO-3	1.1 (0.3-2.1)	1.1 (0.3-2)	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1.1 (0.3-1.9)
		EURO-4	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
		EURO-5	1.1 (0.3-2)	1.1 (0.3-2)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
	7,5-16t	EURO-0	2 (0.6-3.7)	2 (0.6-3.7)	1.8 (0.5-3.2)	1.7 (0.5-3)	1.7 (0.5-3.1)
		EURO-1	1.8 (0.5-3.2)	1.7 (0.5-3.1)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-2	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.6)	1.5 (0.4-2.6)
		EURO-3	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-4	1.6 (0.5-3)	1.6 (0.5-2.9)	1.5 (0.4-2.6)	1.4 (0.4-2.5)	1.4 (0.4-2.5)
		EURO-5	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.6)
	16-32t	EURO-0	2 (0.6-3.7)	2 (0.6-3.7)	1.8 (0.5-3.2)	1.7 (0.5-3)	1.7 (0.5-3.1)
		EURO-1	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-2	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.6)
		EURO-3	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-4	1.6 (0.5-3)	1.6 (0.5-2.9)	1.5 (0.4-2.6)	1.4 (0.4-2.4)	1.4 (0.4-2.5)
		EURO-5	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.5)
	>32t	EURO-0	2.9 (0.8-5.3)	2.9 (0.8-5.3)	2.5 (0.7-4.6)	2.3 (0.6-4.1)	2.3 (0.6-4.2)
		EURO-1	2.6 (0.7-4.7)	2.6 (0.7-4.7)	2.2 (0.6-4)	2 (0.6-3.6)	2 (0.6-3.7)
		EURO-2	2.5 (0.7-4.5)	2.5 (0.7-4.5)	2.2 (0.6-3.9)	2 (0.5-3.5)	2 (0.6-3.6)
		EURO-3	2.6 (0.7-4.7)	2.6 (0.7-4.7)	2.2 (0.6-4)	2 (0.6-3.6)	2 (0.6-3.7)
		EURO-4	2.4	2.4	2.1	1.9	1.9

			(0.7-4.3)	(0.7-4.3)	(0.6-3.7)	(0.5-3.3)	(0.5-3.4)
		EURO-5	2.5 (0.7-4.4)	2.4 (0.7-4.4)	2.1 (0.6-3.8)	1.9 (0.5-3.4)	1.9 (0.5-3.5)

Source of the emission factors: TREMOVE basic Scenario (version model 2.4.1).

The central value is based on the factor costs given in table 27 of the handbook for 2010. The maximum and minimum values are also calculated from those of table 27 of the Handbook.
The emission data represent the values of emissions of the average fleet in 2005 for Germany, for various categories of vehicles. Within each category of vehicle (Example: petrol passenger car 1.4-2L) values are representative of the average emissions in Europe for each category.
For the rail and the river navigation, the emission factors of transport for Germany come from the database TREMOVE.

Table 8: Costs of climate change in €ct/km-train for passenger trains and freight trains

			Metropolitan			**Other Urban**			**Non Urban**		
			Indirect emissions	Direct emissions	**Total**	Indirect emissions	Direct emissions	**Total**	Indirect emissions	Direct emissions	**Total**
			€ct/ train-km	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*
Passenger	Electric	Locomotive	11 (3. 1-19. 8)	0 (0-0)	11 (3. 1-19. 8)	11 (3. 1-19. 8)	0 (0-0)	11 (3. 1-19. 8)	11 (3. 1-19. 8)	0 (0-0)	11 (3. 1-19. 8)
		Railcar	17. 1 (4. 8-30. 8)	0 (0-0)	17. 1 (4. 8-30. 8)	17. 2 (4. 8-30. 9)	0 (0-0)	17. 2 (4. 8-30. 9)			
		High Speed Train							20. 6 (5. 8-37. 1)	0 (0-0)	20. 6 (5. 8-37. 1)
	Diesel	Locomotive	1. 7 (0. 5-3)	8. 6 (2. 4-15. 5)	10. 3 (2. 9-18. 5)	1. 7 (0. 5-3)	8. 6 (2. 4-15. 5)	10. 3 (2. 9-18. 5)	1. 7 (0. 5-3)	8. 6 (2. 4-15. 5)	10. 3 (2. 9-18. 5)
		Railcar	2. 2 (0. 6-4)	11. 3 (3. 2-20. 4)	13. 6 (3. 8-24. 4)	2. 2 (0. 6-4)	11. 4 (3. 2-20. 6)	13. 7 (3. 8-24. 6)			
Freight	Electric	Locomotive	30. 7 (8. 6-55. 2)	0 (0-0)	30. 7 (8. 6-55. 2)	30. 7 (8. 6-55. 2)	0 (0-0)	30. 7 (8. 6-55. 2)	30. 7 (8. 6-55. 2)	0 (0-0)	30. 7 (8. 6-55. 2)
	Diesel	Locomotive	5. 6 (1. 6-10. 1)	29 (8. 1-52. 1)	34. 6 (9. 7-62. 2)	5. 6 (1. 6-10. 1)	28. 9 (8. 1-52. 1)	34. 6 (9. 7-62. 2)	5. 6 (1. 6-10. 1)	28. 9 (8. 1-52. 1)	34. 6 (9. 7-62. 2)

Source of the emission factors: TREMOVE basic Scenario (version model 2.4.1).

The central value is based on the factor costs given in table 27 of the Handbook for 2010. The maximum and minimum values are also calculated from those of table 27 of the Handbook.
Notes:
1) the indirect emissions are due to the electricity production for electric traction and to the production and the carriage of fuel for diesel traction.

2) the values for the metropolitan areas and other urban areas for the freight trains are considered on the basis of the ratio “metropolitan/not urban” and “another urban/non urban area” for the momentary trains (electric traction engine and diesel). The values for the freight trains in the metropolitan and urban areas are not included in the database TREMOVE.

Table 9: Costs of climate change in €ct/boat for the carriage of goods by inland waterways

Ship Type		Direct Emissions *€/ship-km*
Dry Cargo	<250 ton	0. 08 (0.02 - 0.15)
	250-400 ton	0. 08 (0.02 - 0.15)
	400-650 ton	0. 11 (0.03 - 0.2)
	650-1,000 ton	0.17 (0.05 - 0.3)
	1,000-1,500 ton	0. 23 (0.07 - 0.42)
	1,500-3,000 ton	0. 42 (0.12 - 0.75)
	> 3,000 ton	0. 42 (0.12 - 0.75)
Push barge	<250 ton	0. 56 (0.16-1)
	250-400 ton	0. 56 (0.16-1)
	400-650 ton	0. 56 (0.16-1)
	650-1,000 ton	0. 56 (0.16-1)
	1,000-1,500 ton	0. 56 (0.16-1)
	1,500-3,000 ton	0. 56 (0.16-1)
	> 3,000 ton	1. 14 (0.32 - 2.05)
Tanker	<250 ton	0. 08 (0.02 - 0.15)
	250-400 ton	0. 08 (0.02 - 0.15)
	400-650 ton	0. 11 (0.03 - 0.2)
	650-1,000 ton	0. 17 (0.05 - 0.3)
	1,000-1,500 ton	0. 23 (0.07 - 0.42)
	1,500-3,000 ton	0. 65 (0.18 - 1.18)
	> 3,000 ton	0. 65 (0.18 - 1.18)

Source of the emission factors: TREMOVE basic Scenario (version model 2.4.1).
The central value is based on the factor costs given in table 27 of the Handbook for 2010. The maximum and minimum values are also calculated from those of the table 27 of the Handbook.

Table 10: Costs of climate change in €ct/pkm and in €/flight for air transport

Flight distance	Direct emissions (without the impact on the emissions of other gases than CO_2)	
	€ct/pkm	*€/flight*
< 500 km	0. 62 (0.17 -1.11)	130 (40-230)
500-1000 km	0. 46 (0.13 - 0.83)	280 (80-500)
1000-1500 km	0.35 (0.1 - 0.62)	530 (150-960)
1500-2000 km	0. 33 (0.09 - 0.6)	790 (220-1430)
> 2000 km	0.35 (0.1 - 0.62)	3710 (1040-6680)

Source of emission factors: TREMOVE basic Scenario (version model 2.4.1).
The central value is based on the factor costs given in table 27 of the Handbook for 2010.

2.6.4. The fight against climate change

Section 2 showed that the most suitable instruments to combat climate change were taxation and/or trading schemes. Indeed, given the global character of climate change, the European Union as a whole must act and take up the challenge.

Taxation and the exchange of emission rights are instruments which already exist at European level.

The fuel taxes represent a possible instrument. In road transport, they account for 2.6% of GDP of the EU 25. On average, the European cars consume less energy than the American cars, which suggests that on the long term taxation has had a positive effect.

Trading schemes, in addition to encouraging the actors to reduce their emissions, would also determine a cap for all the emissions of the sector. For road haulage, the emission exchange system could be considered, but such a system should necessarily raise the question of the high number of individual operators and the potential presence of transaction costs and high administrative costs. However, in the modes of transport involving a much more reduced number of actors and governed by international rules (aviation, maritime), it can constitute a useful instrument.

Box 4: Summary of the sources recommended for the calculation of external costs

I. Data to calculate the congestion costs

Traffic (Q):national data

Value of the time (VOT): HEATCO. http://heatco.ier.uni-stuttgart.de://heatco.ier.uni-stuttgart.de

Speed as a function of the traffic (v (Q)): national data

II Default values of the congestion costs

Table 1 of this document

III. Data to calculate the costs of the noise

Number of exposed people (MGP): Strategic maps of noise. Directive 2002/49/EC.

Unit cost of noise (Cdba): HEATCO.

http://heatco.ier.uni-stuttgart.de/HEATCO_D5.pdfhttp:

Vehicle-kilometres: national data

IV. Default values of the costs of the noise

Table 2 of this document

V. Data to calculate the costs of air pollution

Emission factor of the pollutant k by a vehicle: Database CORINAIR http://reports.eea.europa.eu/EMEPCORINAIR5/en/page002.html for road transport and the other modes.

Cost of the pollutants (C): table 13 of the Handbook. http://ec.europa.eu/transport/costs/handbook/index_en.htm

VI. Default values

Tables 3-6 of this document.

VII. Data to calculate the costs of climate change

Emission factor.

CO_2 equivalent: http://ec.europa.eu/transport/costs/handbook/index_en.htm

Cost of CO_2: table 26 of the Handbook. http://ec.europa.eu/transport/costs/handbook/index_en.htm

VIII Default values

Tables 7-10 of this document.

3. CONCLUSIONS AND NEXT STAGES

Given the local and variable character of the data, a differentiated approach is recommended because it makes it possible to approach the conditions of traffic. The revision proposed for 2013 could make it possible to go in two precise directions: extend the method to other external costs, refine the approach.

3.1. Extend the method to other external costs

Transport generates other external factors than those analysed in this document. External costs related to the biodiversity, on nature and on the landscape could be treated. These costs are related to the provision of infrastructure and should be envisaged within the framework of reflection on infrastructure policy in Europe. Similarly, external costs related to land use could be analysed.

3.2. Refine the approach

The scarcity costs in the non-road modes of transport should also be the subject of elaboration of methodological principles. Indeed, the handbook has demonstrated the progress of scientific work in the field. An assessment in 2013 will make it possible to see further progress and to adjust proposed the methodology and to update the proposed external cost values.