CLEVER
Clean Vehicle Research

External Costs
Task 4.1

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December 2010

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LIST OF ACRONYMS

ACEA	European Automobile Manufacturers Association
CC	Climate change
CEESE	Centre for economic and social studies of the environment
CLEVER	Clean Vehicle research
CNG	Compressed natural gas
CRF	Concentration-response function
c€	Euro cent
DRF	Dose-response function
EC	European Commission
ECMT	European Conference of Ministers of Transport
ETEC	Electric engineering and energy technology
GHGs	Greenhouse Gases
GW	Global warming
GWP	Global warming potential
HA	Hospital admission
IPA	Impact pathway analysis, or approach
LCA	Life cycle analysis
LOAEL	Lowest observed adverse effect level
LPG	Light petroleum gas
LRS	Lower respiratory symptom
MAC	Marginal avoidance costs
MRAD	Minor restricted activity days
NOAEL	No observed adverse effect level
OECD	Organisation for economic co-operation and development
PM	Particulate matter
RHA	Respiratory hospital admissions
RR	Relative Risk
SCC	Social costs of carbon
TSP	Total suspended particles
TTW	Tank to wheel
URD	Upper respiratory diseases
VPF	Value of a prevented fatality
VOLY	Value of a life year

VSL	Value of a statistical life
VUB	Vrije Universiteit Brussel
WHO	World Health Organisation
WLD	Work loss days
WP	Work package
WTP	Willingness to pay
WTT	Well to tank
WTW	Well to wheel
YOLL	Years of life lost

SECTION I. GENERAL CONTEXT, METHODOLOGY AND SCOPE OF THE WORK

I.1 General Context

It is known that transport activities give rise to environmental impacts. In contrast to the travelling benefits, the costs of these effects of transport are generally not borne by the transport users. Without policy intervention, these so called external costs are not taken into account by the transport users when they make a transport decision.

The idea to take the external costs of transport into consideration within the transport costs was formalised by the European Conference of Ministers of Transport (ECMT, 1998) which adopted a resolution 1998/1 on “the policy approach to internalising the external costs of transport”. In this resolution, Ministers of Transports of all ECMT member countries agreed that full internalisation is an important transport policy objective in order to improve economic efficiency, and that it should be seen as a long term and gradually met objective. They recommend governments to provide incentives for internalisation in the framework of national legislation and to develop economic instruments for the internalisation of transport externalities. These ideas were confirmed at the Gothenburg Summit of 2001, as well as by the European Parliament, which has adopted the principle (CEC, 2008).

In preparation of its policy, the European Commission has supported the development and application of a framework for assessing external costs of energy use. The ExternE (Externalities of Energy) project started in 1991 as the European part of a collaboration with the US Department of Energy in the “EC/US Fuel Cycles Study”. The scope of the ExternE Project is to value the external costs, i.e. the major impacts of economic activities, both referred to production and consumption (ExternE, 1999; ExternE, 2001).

An external cost, also known as an externality, arises when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group. The potential value of the ExternE project therefore lies in valuing external costs in order for those values to be included in the design of policy to correct the present lack of such property rights and markets.

There are several ways for 'internalising' external costs. One possibility would be via eco-taxes, i.e. by taxing damaging fuels and technologies according to the external costs caused. Another solution would be to encourage or subsidise cleaner technologies thus avoiding socio-environmental costs. Besides that, in many other widely accepted evaluation methods such as multicriteria analysis, life-cycle analysis and technology comparison, the quantitative results of external costs are an important contribution to the overall results. Another application is the use of external cost estimates in cost-benefit-analysis. In such an analysis the costs to establish measures to reduce a certain environmental burden are compared with the benefits, i.e. the avoided damage due to this reduction. The avoided externalities can then be calculated with the methods described here.

The **impact pathway** analysis (IPA) has been developed, improved and applied for calculating externalities from electricity and heat production as well as transport (ExternE, 2001). Continued funding allowed the European study team to expand, bringing additional expertise and broadening the geographical coverage of the study. The impact pathway analysis was extended to the environmental media soil and water. New scientific knowledge from in depth meta-analysis was included, above all in the areas of health impact quantification, modelling of climate change effects, and monetary valuation (ExternE, 2005).

The objective of the Task 4.1 is to assess some main environmental externalities of current vehicles using conventional and alternative fuels, and/or alternative propulsion system and to compare the related external costs in urban areas. The results will contribute towards providing useful information for selection of new types of cars – and so to orientate choices in taking measures that reduce environmental and health impacts, as well as to help policy makers to promote cleaner cars.

Favrel *et al.* (2001) performed an overall assessment of external costs of traffic in the Brussels Capital Region. The present study takes into account the latest developments related to the impact pathway methodology, (Torfs et al, 2007, Miller, 2009) and new contributions of the literature (EC, 2008, Baum et al., 2008, OECD, 2008) and in a way consist in an update of Favrel's research. However, it is important to note that, where Favrel's work on external costs concerned the impacts of car fleet taken as a whole, the present task lies within the scope of a more specific purpose: contributing to a complete **Life Cycle Analysis** (LCA) of vehicles with conventional and alternative fuels, and/or alternative propulsion system. This LCA will allow policy makers to promote the purchase and use of cleaner vehicles.

Apart from this specificity, the improvements brought by Favrel *et al.* (2001) are, mainly: (i) the consideration of WTT emissions in the assessment of climate change impact; (ii) the consideration of non-exhaust emissions in the assessment of health and soiling impacts; (iii) the proposition of a dB-based ranking for noise disturbance valuation.

However, estimation of external costs requires defining the scope of the assessment in terms of geographic area covered I.2, in terms of considered externalities I.3 and issues for transferability aspects I.4.

I.2 Geographic area

Achieving such a study requires a complete analysis of all emissions related to the vehicles (from cradle-to-grave) and all emission impacts related that are themselves related to many factors such as population characteristics (density, age, morbidity, etc.) and the environment (buildings, climate, wind, rain, etc.).

In order to obtain usable data within the limited timeframe of this task, we have limited the geographical zone of this study to the Brussels-Capital Region. It is indeed in densely populated (6,250 inhabitants per km^2) and built environments that impacts are the highest. Moreover, the available dispersion models have proven to be quite effective in this region (Favrel, 2001).

Finally, institutionally, air pollution issues are managed by local regional institutions (IBGE, 2003).

I.3 Methodology and considered externalities

The Impact Pathway Analysis (IPA) is used to quantify the environmental impacts as defined above. It relies on a four step bottom-up approach (Figure 1), that can be summarized as follows:

- **Emissions:** identification and assessment of the relevant pollutants emitted in relation with each vehicle technology, e.g. g of SO_2 per kilometre driven by a particular car;
- **Dispersion:** calculation of air pollutant concentrations due to emission, using models of atmospheric dispersion;

- **Impact:** calculation of the cumulated exposure from the air pollutant concentration, followed by calculation of impacts (damage in physical units) from this exposure using a dose-response function;
- **Cost:** valuation of these impacts in monetary terms.

This methodology provides a general framework for assessing impacts that are expressed in different units into a common unit – monetary values. It aims to cover all relevant (*i.e.* not negligible) external effects. IPA requires the development of a number of functions and the availability of data as well as the calculation tasks for numerous parameters, which turns out to be very time consuming.

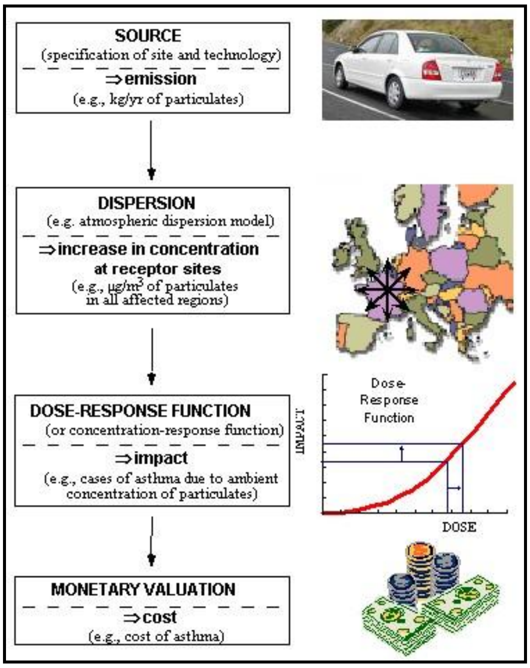


Figure 1: IPA steps (Source: ExternE 2005)

The ExternE (2005) methodology has the merit of gathering an international recognition and benefits from an appreciable status of development. It has been improving constantly with respect to the knowledge of the emissions of pollutants, their dispersion, the dose-response relationships as well as the economic valuation of damage produced (NEEDS, 2007). It seemed important to take into consideration these improvements.

The goal of this task 4.1 (WP) is to take into account some of these elements and on the base of previous studies achieved by CEESE-ULB, to assess the external air pollution costs of specific sources like new modes of motorisation thanks to transferability calculations (see I.4).

I.3.A. Considered externalities

The **ExternE** methodology provides a general framework for assessing impacts that are expressed in different units into a common unit – monetary value. It aims to cover all relevant (*i.e.* not negligible) external effects. Currently, the following impact categories are included in the methodology:

- **Air pollutants environmental impacts**: Impacts that are caused by releasing volatile compounds (*e.g.* particulate matter, gases) into the air. In this paper, a full IPA is performed for the assessment of health costs and building damage costs mainly from the most important air pollutants (*e.g.* PM, NO_x, SO_2, O_3). The knowledge of pollutant emissions of vehicles (TTW emissions), the dispersion modelling as well as the inventory of the exposed stock at risk in the Brussels-Capital Region allowed us to make local monetary valuations with this approach (Favrel et al., 2001, Favrel and Hecq, 2001). Moreover, the available dispersion models used have proven to be quite effective in this region (Favrel et al, 2001, Hecq et al., 1994). The high pollution levels in the nineties allowed the models to have a better capture of emissions.

- **Noise impacts**: for amenity losses due to noise emission, the actual state of knowledge on sound emission, propagation, and receptor density within the geographical zone of this report didn't allow us to follow the IPA. A second best approach is proposed in point II.4 They have non-negligible effects on health and well-being. The lack of knowledge on amenity losses due to noise emission, sound propagation, and receptor density within the geographical zone, did not allow us to follow the complete sequence of IPA. A second best approach is proposed.

Climate change (CC) impacts: for greenhouse gases (mainly CO_2, N_2O, CH_4), IPA is not yet relevant, as CC impacts are complex and must be assessed globally and for long periods. Therefore, the total emissions related to the energy consumption of vehicles are taken into account. Two approaches are followed. First, results of studies on quantifiable damage are taken into account. However, due to large uncertainties and possible gaps in quantifying the damages, results from avoidance cost approach are also tested. For emissions having impact on climate change (mainly CO_2, N_2O, CH_4), there is no need to proceed with the same methodology as climate change can be assessed as a whole. Therefore, the total emissions related to the energy consumption of vehicles (WTT and TTW) are taken into account.

Another objective of the assessment is to implement the methodology with realistic means considering the high level of work requested. A transferability approach is used for lightening and updating the method and improving the results of the previous study (Favrel and Hecq, 2001) which was performed on the same spatial area.

I.4 Transferability

Transferability is a way of applying results (models, functions and data) from one place and time to a different context, to assess different steps of an evaluation sequence. Transferability can be particularly convenient for IPA methodology implementation for calculating pollution impacts in physical and monetary terms (Navrud, 2009, Miller and Hurley, 2009).

Transferability has the advantage of reducing the means and the time it takes to assess each step of a sequence like in IPA methodology, where it is a question of assessing the following stages: emissions, concentration and impacts.

In the context of this study, transferability concerns the same location, i.e. Brussels-Capital Region, as in the original study. It focuses on temporal evolution and has thus a notable bearing on the following aspects:

1. Regarding data from previous studies (Favrel et al., 2001, Favrel and Hecq, 2001), they have to be updated at current times. This requires considering specific emissions assessment for current vehicles or temporal differences in the exposed stock at risk (buildings) as well as in the exposed population.
2. Concerning updated concentration-response functions for air pollutants in particular, the adequacy of the modelling methodology must be considered within the Belgian context.

It should be noted that for damages to health, meta-analyses show that differences for relative risk coefficients remain noticeably small wherever the location may be (Miller and Hurley, 2009). They have been kept in this study. The same is true for the damage functions to buildings.

3. Monetary data have to be updated, as unit damages are often expressed in $ or € from the beginning of 2000, even from the 1990s. The way this is done is to update the value of the dollar or euro from the earlier studies to the correct year using the Consumer or Health Price Indexes and exchange rates. (Navrud, 2009).

I.5 Scope and issues

An overall assessment of externalities from vehicles requires a complete life-cycle analysis (LCA), commonly called a Well-To-Wheels (WTW) analysis. In such a WTW study, the largest part of the energy use and emissions are related to the vehicle operation (Tank-To-Wheels or TTW). It should also be pointed out that, except for climate change, WTW (Well-To-Wheels) emissions will not be taken into account as these emissions are produced in power plants located far away from Brussels-Capital Region and thus have a limited local impact that we have not taken into consideration.

Similarly, we have chosen not to include the externalities related to the production and disposal of vehicles, although they could be non negligible, for two reasons. First, energy required and pollutants generated during these phases should be more or less proportional to the weight of the car, which can vary by a factor 3. Second, some technologies could have higher externalities than others during these phases. Attention is sometimes given to hybrid vehicles for the extra batteries and technical equipments that are required for their operation. The evaluation of these costs should be part of a more complete study that would include a more complete LCA of the different technologies (Boureima et al., 2009, Timmermans et al., 2006). The assessment did not allow direct comparison of Flexifuel and Biofuel vehicles as the emissions have been measured according to different homologation procedures.

Other externalities that are not directly related to car technologies, such as road accidents, infrastructure costs, etc. are not evaluated. This can be justified by the fact that changing the motorisation system of a vehicle should not have any significant impact on the externalities of transportation as the required infrastructures remain the same.

The effects of air pollutants on the soil or in water are not assessed. Some air pollutants have not been taken into account for the evaluation of externalities. This is the case for CO (limited direct health impact), HC and VOC (direct health impact or indirect impact on O_3 concentrations) because of the lack of data.

Similarly, given the short time frame, we have chosen not to include the externalities related to the production and disposal of vehicles, although they could be non negligible for two reasons: First, energy required and pollutants generated during these phases should be more or less proportional to the weight of the car, which can vary by a factor 3. Second, some technologies could have higher externalities than others during these phases. Hybrid vehicles, for example, are sometimes pointed out for the extra batteries and technical equipments that are required for their operation. The evaluation of these costs should be part a more complete study that would include a more complete LCA of the different technologies.

Finally, except for climate change contribution, only impacts in the Brussels Capital Regional are considered.

I.6 Differential approach

As the CLEVER project is aiming at providing data to help policy makers to promote cleaner cars, only differences in impacts of different technologies need to be assessed. Externalities that are similar for all technologies, such as social costs of vehicles (infrastructure costs, road accidents, traffic jams, etc.) are not evaluated.

In a later phase, one could argue that the size and maximum speed of a vehicle could respectively have an impact on traffic jams and gravity of accidents, but this has not been taken into account in this study. It should also be noted replacing long cars by small ones can lead to significant reduction of traffic and parking congestions in cities as these phenomena are sometimes non-linear.

Adopting a differential approach also allows us to simplify a number of models and formulas, as the exact absolute value of the externalities is really not required. Only the **differences in the externalities** need to be as precise as possible.

These differences will allows us achieving the general aim of the paper that is finding out the principal weaknesses and strengths of each technology, by telling the ecological truth of car usage – and so to orientate choices in taking measures that reduce environmental and health impacts.

SECTION II. EXTERNAL COSTS ASSESSMENT

This section aims at evaluating the external costs of the selected set of vehicles according to the methodology described previously.

The Figure 2 gives a global overview of the different steps taken to perform the final valuation of the external costs in this assessment. It shows that for some pollutants (*e.g.* CO_2, CH_4, N_2O) only emissions can be considered, while for other (*e.g.* PM, NOx, SO_2), it is necessary to estimate air concentrations in order evaluate the damages to health or to buildings.

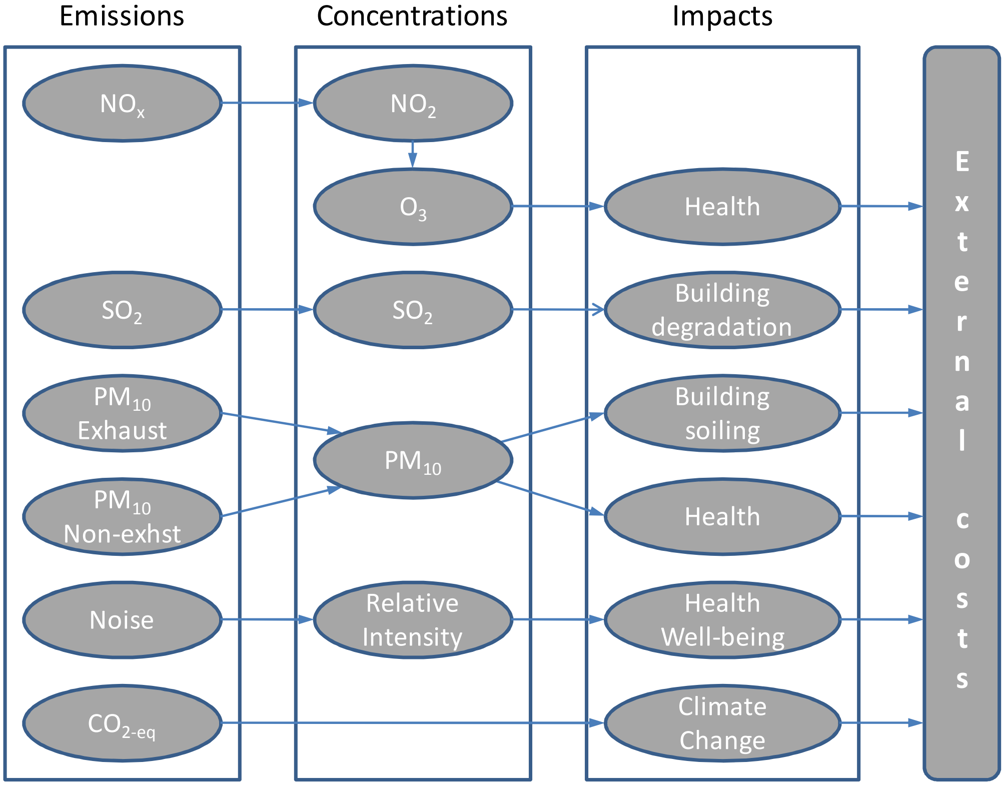


Figure 2: main steps of external costs evaluation

The next chapter covers the quantification of exhaust and non-exhaust emissions and models the emission-air concentration relationship. This model will allow us to compute independently the marginal contribution of each pollutant to the regional air pollution.

II.1 Modelling the Contribution to Air Pollution

Modelling the marginal change of pollutant concentration in the air due to vehicle usage requires several steps:

- First we have to know the emissions generated by the traffic taken as a whole. This must include the exhaust and non-exhaust emissions. As the study analyses the local impact of the pollution, only TTW emissions will be considered here.
- Secondly, the proportion of pollutant concentration in the air due to the traffic must be evaluated, *i.e.* air concentrations of the car fleet need to be assessed, and separated from the other sources contributing to the average levels of air concentrations. These two elements (emissions of the car fleet and part of the total air concentrations due to the car fleet) can be then linked thanks to linear regressions.
- Finally, the so obtained emission-air concentrations relationship can finally be used to calculate the marginal contribution to air concentrations per kilometre driven for selected vehicles (see II.1.C).

II.1.A. Exhaust emission quantification

In the "sustainable mobility in Brussels Region" project, the CEESE developed a specific approach allowing the assessment of road traffic emissions on a national or regional scale, and on a yearly or monthly basis. The model was called AMORTEC (Aggregate Model for Road Traffic Emissions Calculation) (Favrel et al., 2001) and was based on COPERT III methodology (EEA, 2000).

Based on this model, pollutant emissions and fuel consumption linked to road traffic were calculated for the 1990-1999 period and for the different vehicle categories composing the Brussels fleet, taking into account its evolution throughout the period.

AMORTEC distinguishes the following types of emissions:

- Emissions from hot engines;
- Over-emissions from cold engines;
- Emissions after engines stop running;
- Evaporation losses while the vehicle is in motion.

The calculation is based on the following inputs:

- Vehicle fleet composition (four main car categories);
- Number of vehicle.km driven on different classes of road;
- Vehicle speed on these classes of road;
- Emission and consumption factors of the different vehicle categories;
- Local temperature and its monthly variations;
- Fuel characteristics.

II.1.B. Non-exhaust emission quantification

The emissions of primary particles of road traffic are not only caused by fuel combustion (exhaust pipe emissions). Mechanical wearing of brakes, clutches, tyres and abrasion of the road itself also produces small particulates that are emitted by the traffic and are categorised as non-exhaust emissions. Not to be neglected either, the fact that traffic is also responsible for reputing in suspension particulates that were deposited on the road. This is called the resuspension process and is also part of the non-exhausts emissions.

The emission factors for non exhaust particle emissions used in this report (Table 1) are based on assumptions and data presented in EMEP/CORINAIR (2003). Three categories of non-exhaust emissions are distinguished: tyre wear, brake wear and road abrasion. Vehicle-induced resuspended particles are not included in this study.

Category	**PM10 emission**
Tyre wear	0.0064 g/v.km
Brake wear	0.0074 g/v.km
Road abrasion	0.0075 g/ v.km
Total	0.0209 g/v. km

Table 1: Non-exhaust emission data due to tyre and brake wear and road abrasion [g/v.km]

This data is reported to have been developed on the basis of information collected by literature review, and on wear rate experiments. The emission factor values proposed have also been cross-checked with inventory activities and, as a rule of thumb, an uncertainty in the order of ±50% is expected for tyre wear and brake wear. For road surface emissions uncertainties are expected to be significantly higher, as they depend of the quality of the road surface.

As these values are roughly proportional to the weight of the vehicle, we assigned the average value (0.0209 g/v.km) to an average weight vehicle and built a linear relation between the weight of the vehicle and these three non-exhaust emissions.

It has also been assumed that electric vehicles (plug-in and hybrid) have an energy recovery system while braking, reducing de facto the energy dissipated in the brakes and therefore also of the brake wear. The PM emissions related to brake wear on such vehicles have been halved.

Concerning the amount of resuspended particulates, no clearly established models are available. A study carried out in UK urban atmosphere (Harrison et al., 2001) concludes that vehicle-induced re-suspension provides a source-strength approximately equal to that of exhaust emissions. It should however be noted that the time constant for particulate deposition is quite long compared to the mean time between two vehicles in an urban environment. As consequence, the marginal effect of resuspension for each vehicle is quite low and the difference between different vehicle types is probably negligible. We have therefore decided not to include this factor in the study.

Finally, although these non-exhaust emissions generally consist in relatively coarser particles than exhaust emissions (Gehrig *et al.*, 2004), they are assumed to behave alike. As consequence, the same emission-air concentration relationships defined below will also be applies to the non-exhaust emissions.

II.1.C. Air concentration modelling

Since 1998 (Fierens, A), the CEESE developed a statistical dispersion model, called "Bruxelles-Air". This model is based on a non-linear multiple regression analysis, and on daily concentration measurements. It uses two groups of explanatory variables in order to explain the levels of pollutant concentration (SO_2, NO, NO_2, CO, VOCs, PM) due to vehicle emissions in Brussels air:

- **Economic variables:** estimated daily emissions from building heating, road traffic and other sources;
- **Meteorological variables:** daily mean wind velocity, precipitation, mixed layer height, daily sunlight period.

A set of equations is used to allow an individual modelling of the air concentration of different pollutants. These equations link the estimated emissions to the measured concentration of pollutant [i] with a linear relationship, while the meteorological variables are linked to the measured concentration with an exponential relationship. The general form is as follows:

$$\boxed{[POL_i] = [b0 + b1 * EmiDTAj + b2 * EmiTrj] * (1/Vvit)^f \, e^{(g\,\mathrm{Pr}eci)} * e^{(jHmel)} * e^{(kSun)} \quad [1]}$$

where:

POL_i is the daily mean concentration of pollutant [i] (immission);

$EmiDTA_j$ and EmiTrj are the daily emissions of pollutant [i], from building heating and transport, respectively;

Vvit is the mean wind velocity in m/sec;

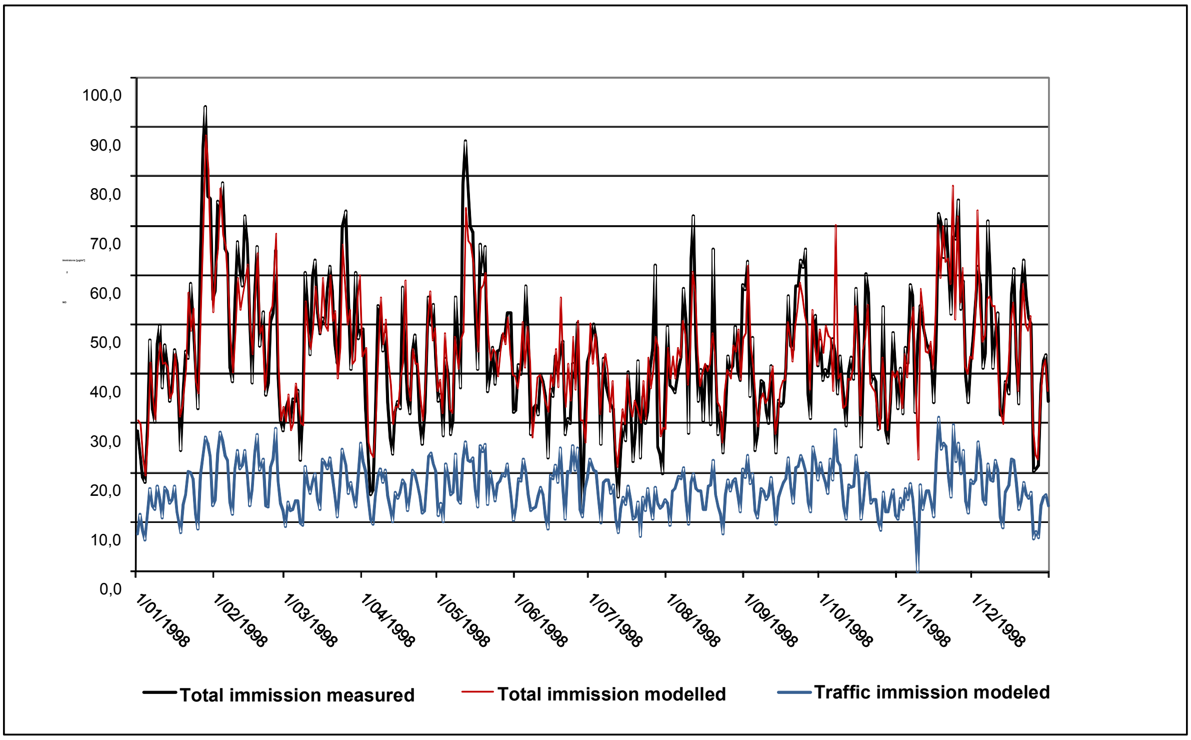
Preci are the daily precipitations in mm;

Hmel is the daily mean height of mixed layer height and Sun is the daily period of sunlight (%);

b0, b1, b2, f, g, j, and k are regression parameters.

This special form of equation allows the estimated road traffic emissions to be separated from the other sources of emissions, and so to calculate the part of the air concentration that is due to road transport only.

Graph 1 illustrates model outputs for NO_2 air concentration modelling.



Graph 1: NO_2 air concentration modelling: total air concentration, modelled total air concentration, modelled traffic air concentration [time (months); µg/m³]

(Source: Favrel et al., 2001)

II.1.D. Emission-Air concentration modelling of SO_2, NO, NO_2, CO, VOCs, PM

Given the good correlation between the measured and the modelled air concentrations using the dispersion model, the latter can be used for building the emission-air concentration relationship for each individual pollutant. This has been done by establishing a linear regression between monthly emissions of the car fleet and average monthly air concentrations due to car fleet activity (see Table 2).

Given the good correlation between the measured and the modelled air pollutant concentration using the dispersion model, the latter has been used for building yearly emission-concentration relationships for SO_2, NO_2 , NO and PM_{10}. About PM_{10}, although the non-exhaust emissions generally consist in relatively coarser particles than exhaust emissions (Gehrig et al., 2004), they are assumed to behave alike. As a consequence, the same emission-concentration relationships defined below have also been applied to the non-exhaust emissions. From the relationships, it is possible to calculate contributions in air concentration per kilometre driven by cars.

Note that these equations are only applicable to TTW emissions. WTT emissions occur at higher up than tailpipe emission, mainly in refineries or power plant located outside of the Brussels Capital Region and would therefore need special modelling.

Table 2 shows emission-air concentration relationships for the Brussels Capital Region:

Pollutant	Results	Coefficient
SO2	y = 0.01546 x	R^2= 1.00
NO2	y = 0.0226725 x	R^2= 0.66
NO	y = 0.0106142 x	R^2 = 0.46
CO	y = 0.00244167 x	R^2 = 0.94
VOC	y = 0.00252475 x	R^2 = 0.53
PM	y = 0.05987 x	R^2 = 0.88

Table 2: Emission of car fleet [x, t/year] – Air concentration due to cars [y, µg/m³] relationships for the Brussels Capital Region

These regressions have been calculated during summer months over a period of 4 years (1994 to 1998). Indeed, better correlations are obtained in summer when the background emissions, mainly related household heating, are much lower.

For NO_2, an extra parameter needed to be introduced. Indeed, NO_2 air concentrations are required to model ozone concentrations (as described below), but only NOx emissions of vehicles are available in the database. However, NO_2/NOx ratio can be roughly estimated to 25%. Though this figure could approach 40% or more for recent diesel engines with particulate filters, changing the NO_2/NOx ratio within this range has a very small impact on the final ozone concentrations and hence, on the general conclusions of this assessment.

II.1.E. Emission-Air concentration modelling of ozone

Ozone (O_3) is a secondary pollutant whose formation results in complex non-linear phenomena between precursor pollutants NO_x ($NO+NO_2$), VOC (NMHC), CO and meteorological factors (EEA, 1998). Therefore, the assessment of ozone air concentration had to be performed separately, not following the same pathway as other pollutants.

Ozone is the mean component of photochemical smog, the type of air pollution that is associated with reactions related to sunlight. Typically, the highest ozone levels are found in suburban locations downwind from the city centre, rather than in the city centre itself. In some situations plumes with high ozone have been found 500 km distant from the apparent emission sources (Sillman S., 2009).

(i) OZONE CHEMISTRY

Ozone is associated with creative-destructive processes along with NO_x. During the daytime, the formation of O_3 results in the decomposition of NO_2 into NO and O_3 by photolysis (sunlight, [2]):

$$\boxed{NO_2 + O_2 + h\nu\ (400\ nm) \Rightarrow NO + O_3} \quad [2]$$

At the same time, VOCs and photolysis can reactivate NO_2 from NO, due to free radicals (HO^{-}, RO^{-}) which regenerate partially:

$$\boxed{(R^{-})\ HO_2^{-} + NO + h\nu \Rightarrow NO_2 + HO^{-}} \quad [3]$$

Reaction [2] can be reversed and bring about the rapid destruction of O_3 by NO, to form NO_2:

$$\boxed{NO + O_3 \Rightarrow NO_2 + O_2} \quad [4]$$

This latter phenomenon, called titration, is fast, and becomes dominant when sunlight is weak or again when there is a high concentration of NO. The result of this is that during the night and in wintertime, the presence of ozone is less than during the day or in summertime. Similarly, in city centres during peak periods, the high quantity of NO emitted by traffic plays a part in the destruction of O_3 [4]. On the other hand, the concentration of NO is reduced in places far away from the city, and the excess in NO_2 goes through the process of photolysis via the reaction in [2], thereby increasing the concentration in O_3. A similar phenomenon can also be observed during holiday periods in urban areas (weekend effect).

There is competition between the reactions towards unpredictable kinetics which are guided by meteorological conditions and the emissions of NO_x/VOC in situ, but also by long distance transport of pollutants. This can explain the various concentration profiles of pollution peaks or background concentration in O_3.

By considering these patterns which are very briefly outlined here, we can see that vehicles contribute both to the formation of ozone, by their emissions of precursor pollutants NO_x ($NO+NO_2$) and VOC (and CO), and to its destruction, when the quantity of NO emitted in situ is high, as is the case in cities during the working days, or when weather conditions are unfavourable. This means that measures concerning vehicle emissions reduction can produce conflicting results, according to study zones and time periods.

Deterministic or statistical models have been developed to explain and to simulate the link between emissions of precursors and the formation of ozone. At the present time, it is difficult for these models to explain the relations between emissions from precursors and the concentration of O_3, especially at peak periods, despite their degree of complexity. (Beekmann and Vautard, 2009). However, sunlight does show a clear correlation with the peaks of ozone concentration in the city.

(ii) OZONE MODELLING

Since close relations between emissions of NO_x and concentration of O_3 are yet to be fully understood, on account of their complexity, their full impact has not been considered in this study. Our assessment has only been able to focus on the impact that vehicles have on the background concentration in O_3, a field where scientific literature shows that these concentrations can be dependent on NO_x concentrations (EEA, 1998). The parallelism in the development over time of the NO_2/NO_x-ratio and ozone points to a photochemical correlation between nitrogen oxides and ozone (Clapp and Jenkin, 2001, Scholz and Rabl, 2006, Derwent, 2008) for urban areas in the west part of Europe.. A simple approach is the well-known photo-stationary equilibrium [5]:

$$\boxed{NO2 + O2 \leftrightarrow NO + O3} \quad [5]$$

According to this equation, we chose a simple empirical approach and considered that a negative correlation exists between ozone and NO_2 due to traffic (Clapp and Jenkin, 2001,) which can be explained by radical loss and titration..

The following equation [6] is proposed as an alternative to ozone modelling:

$$\boxed{[O_3] = \frac{-0.6152 + 0.7162\,p}{1-p}\,[NO_x]_m + 69.62} \quad [6]$$

Where

$$\boxed{p = \frac{[NO]_m}{[NO_x]_m}}$$

And where

$$\boxed{[NO_2]_m = 0.681\ [NO_x]_m} \quad [7]$$

Equation [7] was found by linear regression and is used to model ozone air concentration due to traffic on a yearly base as it cannot reflect the monthly variations. This final formula must therefore be considered with precaution, and its results will necessarily be surrounded by a great margin of uncertainty. Many studies, in particular those of Kourtidis (1999) and Al-Alawi (2008), prove that ozone modelling requires to take into consideration many other precursor parameters such as CO/NOx and NMHC/NOx ratios.

Hopefully, as we will see later on when evaluating the total external costs (III.2), local positive externalities related to ozone remain very low compared to other costs. Even an important variation of the factor in equation [7] does not have a significant effect on the total external costs of vehicles.

Moreover, monthly temperature averages, as used in this assessment, are insufficient for correct modelling, especially for ozone peaks.

II.2 Health impacts

In terms of economic costs, following ExternE methodology, health impacts contribute the largest part of the damage. There seem to be a consensus among public health experts that air pollution, even at current levels, aggravates morbidity (especially respiratory and cardiovascular diseases) and leads to premature mortality.

Specific causes are difficult to identify, but most recent epidemiologic studies have determined that fine particles and ozone are directly implicated. The most important cost comes from chronic mortality due to particles. Another important contribution comes from chronic bronchitis due to particles (Abbey et al., 1995). Evidence of direct impacts related to SO_2 and NOx is less convincing.

Dose-response functions (DRFs) have been used as basis for analysing impacts of particulate matter and ozone. The health impacts of NO_2 and SO_2 are assumed to arise indirectly from the particulate aerosols. Uncertainties are important because there is insufficient evidence for the effects of the individual components or characteristics of particulate air pollution. All DRFs for health impacts have been assumed to be linear at population level, as a consequence of the lack of evidence of the existence of thresholds at current ambient concentrations.

From the epidemiologic point of view, the leading causes of death in OECD countries in 2001-2002 were related to cardiovascular diseases, cancer, diseases of the respiratory system, and external causes of premature death (OECD, 2005). As described in WHO (2004), these health outcomes can be, in some measure, attributable to exposure to air pollution. On the morbidity side, prevalence of asthma and allergies, in particular among children, has been steadily increasing in most OECD countries since 1995. As such, environmental degradation, and more particularly air pollution, may be a significant contributor to ill-health and death in OECD countries.

The short-term effects of exposure to PM, SO_2, NO_2 and other air pollutants include increased respiratory morbidity, a higher rate of hospital admission for respiratory and cardiovascular diseases and mortality. The long term effects of exposure to these air pollutants include increased mortality and reduced life expectancy of the entire population. Both short-term and long-term exposures have also been linked with premature mortality and reduced life expectancy, to the order of 1-2 years but the most severe effects in terms of the overall health burden are linked to the long-term exposure to high levels of air pollution with PM (WHO, 2004).

More specifically, a large number of epidemiological studies have demonstrated the links between short and long-term exposure to airborne PM and a number of significant health problems, including: premature death, respiratory-related hospital admissions and emergency room visit; cardiovascular hospital admissions; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficult or painful breathing; chronic bronchitis; and, restricted activity days (WHO, 2004). Numerous studies have attempted to quantify the amount of deaths that can be attributed to airborne PM pollution.

Ozone levels in urban areas during pollution events are believed to be high enough to affect human health, most notably the respiratory system. More specifically, in WHO (2004), short-term exposure to ozone is reported to cause lung inflammatory reactions and eye irritation, to induce an increase in medication usage, hospital admissions, and mortality. Furthermore, long-term exposure to ozone reduces the development of the lung function.

Ozone is also a pollutant of concern because it can affect both forest and agricultural crops (Sillman S., 2009). However, these last two elements are not taken in consideration in ExternE at the current state of knowledge.

All the health effects described above are especially true for vulnerable populations such as: children, the elderly, pregnant women, people with pre-existing poor health conditions, such as heart or lung disease, and people with weakened immune systems. People working or exercising outdoors may also be especially sensitive (OECD, 2008).

II.2.A. Quantification of the impacts

Fuel combustion in vehicle engines generates a number of primary pollutants such as PM, NO, NO_2, CO, SO_2, VOC, etc. (tail-pipe or exhaust emissions). But, at the same time, PM, NO_2 and VOC are also involved in the production of tropospheric ozone, a secondary pollutant, as described in II.2.E. Moreover, PMs also adsorb SO_2 and NO_2 so that they must considered as primary and secondary pollutants. It should also be recalled that PM are not only generated by engines, but are also produced by other sources, such as tyre or break wear. These non-exhaust emissions are described in II.2.B.

This multi-pollutant characteristic of air pollution makes it difficult for epidemiologists to attribute a particular health impact to a particular pollutant, because populations are exposed to a mix of different pollutants that tend to be highly correlated to each other (OECD, 2007). For instance, the apparent effects of airborne PM could be in reality partly attributed to NO_2 or SO_2 (or vice versa).

Therefore, the conclusion that air pollution damages health is much more certain than the attribution of damage to a particular pollutant. For these reasons some epidemiologists, especially in France, keep emphasising that any individual pollutant is merely an indicator of pollution and that the attribution of an impact to a specific pollutant is very uncertain (ERPURS, 1997).

Health damages are quantified through concentration-response functions (CRFs), linking pollutant concentration in the air to specific health damages[1]. Such functions are determined

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[1] In ExternE, CRF are by definition linear with no threshold

either from epidemiological studies or from laboratory studies. Unfortunately, for many pollutants and in the case of many impacts, the CRFs are very uncertain or not even known at all. For most substances and non-cancer impacts, the only available information covers thresholds (typically, the NOAEL, no observed adverse effect level; or the LOAEL, lowest observed adverse effect level), which are not sufficient for quantifying impacts (ExternE, 2005).

For all these reasons, the current position of ExternE is to use only CRFs for airborne PM and O_3, but none for SO_2 or NO_2. The assumptions about the toxicity of the different PM types have also been changed after a careful review of the latest epidemiological and toxicological literature.

Evidence has been accumulating which underlines the high toxicity of combustion particles and especially of particles from internal combustion engines (particles from internal combustion engines are mainly $PM_{2.5}$). For nitrates there is still not much evidence for harmful effects, whereas for sulphate quite a few studies, including the very important cohort study of Pope *et al.* (2002), do find associations.

Therefore ExternE now treats:

- nitrates as equivalent to 0.5 times the toxicity of PM_{10} [2];
- sulphates as equivalent to PM_{10} [3];
- primary particles from power stations as equivalent to PM_{10};
- primary particles from vehicles as equivalent to 1.5 times the toxicity of $PM_{2.5}$

Effects of O_3 are considered independent of PM and added, whereas direct effects of CO, SO_2 or NO_x are not taken into account. In equation this can be written for the ExternE results of 2004 as:

$$\boxed{\Delta I = s_{PM10}\,\Delta c_{PMpower} + 1.5\, s_{PM2,5}\,\Delta c_{PMtrans} + s_{PM10}\,\Delta c_{sulph} + 0.5\, s_{PM10}\,\Delta c_{nitr} + s_{O3}\,\Delta c_{O3},}$$

where:

ΔI: incremental impact (e.g.: number of new cases of bronchitis/year.km)

s_{PM10}: concentration-response function slope

Δc: air concentration variation (e.g.: increased PM concentration per km driven by vehicle [$\mu g/m^3$.km])

And with: $s_{PM10}/s_{PM2,5} = 0.6$

These positions and statements are confirmed in NEEDS (2007).

In this task 4.1, only TTW emissions-related health impacts were assessed. Indeed, as WTT emissions are (i) released far away from where the activity (traffic) takes place and (ii) released far away from the receptors (affected population), the local dispersion model we used would not have suited well. For further integration of the WTT emissions, regional dispersion models are

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[2] In the previous ExternE reports (European Commission, 1999; ExternE 2000), the assumption was made that the toxicity of all sulphates was equal to that of $PM_{2.5}$.

[3] In the previous ExternE reports (European Commission, 1999; ExternE 2000), the assumption was made that the toxicity of particulate nitrates was equal to that of PM_{10}.

needed, which could help assess the contribution of fuel or electricity production to the background concentrations, and hence, to the local health impacts.

Similarly, as sulphates and nitrates are secondary long distance pollutants of transport activities, their contribution to health effects was not taken into consideration either. In conclusion, only the second and last terms of the above equation were taken into account, but on the other hand, non-exhaust emissions-related health impacts were assessed.

All the concentration-response functions presented below come from ExternE (2005) and were used in the calculations. They were more recently confirmed as still being up-to-date in NEEDS (2007).

(i) CRF FOR PM10

1) Mortality

- Loss of life expectancy for chronic[4] mortality of adults (above 30 years)

$$S_{CR} = 4*10^{-4} \text{ YOLL / (pers.yr.}\mu\text{g/m}^3\text{) for } PM_{10}.$$

S_{CR} = slope for chronic mortality.

- Loss of life expectancy for acute[5] mortality of adults

The mortality observed by short-term (acute mortality) studies is at most a small contribution to the total impact and is in any case included in the results of the long-term studies by their very design. Therefore they are not taken into consideration.

- Infant mortality (0-1 month)

The post neonatal infant mortality, between the ages of one month and one year, was associated with mean outdoor concentration of PM_{10} in the first two months of life, giving:

CRF for change in all-cause infant mortality of 4% per 10 $\mu g/m^3$ PM_{10} (95% CI 2%-7%)

2) Morbidity

To estimate the effects of PM (or O_3) on morbidity, ExternE uses the relative risk found in epidemiological studies, expressed as % change in end-point per 10 $\mu g/m^3$ PM_{10} (or $PM_{2,5}$) and links this with (i) the background rates of the health end-point in the target population, expressed as new cases (or events) per year per unit population – say per 100,000 people; (ii) the population size and (iii) the relevant pollution increment, expressed in $\mu g/m^3$ PM. Results are then expressed as estimated new or "extra" cases, events or days per year attributed to PM.

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[4] Immediate death

[5] Delayed premature death

- New cases of chronic bronchitis

CRF : new cases of chronic bronchitis per year per 100,000 adults aged 27+ = 26.5 (95% CI – 1.9; 54.1) per 10 μg/m^3 PM$_{10}$.

- Hospital admissions (HAs)

CRF: annual rate of attributable respiratory HAs = 7.03 (95% CI 3.83 ; 10.30) per 10 μg/m^3 PM$_{10}$ per 100,000 people (all ages)

- Cardiac hospital admissions.

CRF: annual rate of attributable cardiac HAs = 4.35 (95% CI 2.17 ; 6.51) per 10 μg/m^3 PM10 per 100,000 people (all ages).

- Consultations with primary care physicians (general practitioners)

Consultation for asthma:

CRF:
1.18 consultations (95% CI 0 ; 2.45) for asthma, per 1,000 children aged 0-14
0.51 consultations (95% CI 0.2 ; 0.82) for asthma, per 1,000 adults aged 15-64
0.95 consultations (95% CI 0.32 ; 1.69) for asthma, per 1,000 adults aged 65+

Per 10 μg/m^3 PM$_{10}$, per year.

Consultation for upper respiratory diseases (URD), excluding allergic rhinitis:

CRF:
4 consultations (95% CI-0.6 ; 8.0) per 1,000 children aged 0-14
3.2 consultations (95% CI-1.6 ; 5.0) per 1,000 adults aged 15-64
4.7 consultations (95% CI-2.4; 7.1) per 1,000 adults aged 65+

Per 10 μg/m^3 PM$_{10}$ per year.

- Minor restricted activity days (MRADs) and work loss days (WLDs):

CRF:
Change of 207 WLDs (95% CI 176-238) per 10 μg/m^3 PM$_{2,5}$ per year per 1,000 people aged 15-64 in the general population.

Change of 577 MRADs (95% CI 468-686) per 10 μg/m^3 PM$_{2,5}$ per year per 1,000 adults aged 18-64.

- Medication (Bronchodilator) usage by people with asthma:

CRF:
Annual change in days of bronchodilator usage = 180
(95% CI -690; 1060) per 10 μg/m^3 PM_{10} per 1,000 children aged 5-14 years.

Change in bronchodilator usage days = 912
(95% CI -912.; 2774) per year per 10 μg/m^3 PM_{10} per 1,000 adults aged 20+
with well-established asthma (4.5% of the adult population).

- Lower respiratory symptoms (LRS), including cough, in adults with chronic respiratory disease

CRF:
Annual increase of 1.3 (95% CI 0.15; 2.43) symptoms days (LRS, including cough)
per 10 μg/m^3 PM_{10} per adult with chronic respiratory symptoms
(approx 30% of the adult population).

- Lower respiratory symptoms (LRS), including cough, in children in the general population

CRF:
Change of 1.86 (95% CI 0.92; 2.77) extra symptoms days
per year per child aged 5-14, per 10 μg/m^3 PM_{10}.

(ii) CRF FOR OZONE

1) Mortality

- Respiratory Hospital Admissions (RHAs)

CRF:
Annual rate of attributable emergency RHAs per 100,000 people at age 65+ = 12.5
(95% CI -5.0 ; 30.0) per 10 μg/m^3 O_3 (8-hr daily average).

- Cardiovascular hospital admissions

There is no strong evidence that daily variations in O_3 are associated with cardiovascular hospital admissions or, indeed, with other cardiovascular morbidity end-points.

- Minor restricted activity days (MRADs):

CRF:
Increase in MRADs =115

(95% CI 44 ; 186) per 10 μg/m^3 O_3 (8-hr daily average)
per 1,000 adults 18-64 per year.

- Medication (Bronchodilator) usage by people with asthma:

CRF:
Change in days of bronchodilator use of 730
(95% CI -255 ; 1,570) per 10 μg/m^3 O_3 per 1,000 adults aged 20+
with well-established asthma (approximately 4.5% of the adult population).

- Acute respiratory symptoms in children in the general population:

CRF:
Change of 0.93 (95% CI -0.19 ; 2.22) cough days
and 0.16 (95% CI -0.43 ; 0.81) days of LRS (excluding cough)
per child aged 5-14 years (general population), per 10 μg/m^3 O_3, per year.

2) Morbidity

- Mortality at all ages from short-term exposure to O_3

Relative risk (RR) of an increase in all cause mortality of 0.3%
(95% CI 0.1 – 0.43%) per 10 μg/m^3 increase in the daily maximum 8-hour mean O_3,
all ages.

II.2.B. Monetization of the impacts

(i) MORTALITY

Previously, ExternE used VPF (value of a prevented fatality) derived from available literature in order to asses mortality costs, but the values that existed were generally not believed to represent accurately the willingness to pay (WTP) that individuals might express, e.g. for the introduction of a new air quality regulation.

Therefore, and after considerable debate within the ExternE team[6], it was decided that the value of a prevented fatality (VPF) should be replaced by the value of life years (VOLY) as the principal metric by which to value the incidence of premature death from air pollution.

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[6] Rabl (2002) proposed a key argument in this debate. He shows that the number of deaths that can be attributed to this cause is only observable in mortality statistics when the exposure-death effect is sufficiently instantaneous that the initial increase in death rate is not obscured by the subsequent depletion of the population who would otherwise die later.

Rabl argues that the usual case is that the impact of air pollution is not instantaneous but is the cumulative result after years of exposure, so that the number of deaths is not observable. As a

Unit values to account in monetary terms for the incidence of premature deaths were derived from three surveys undertaken simultaneously in the UK, France and Italy, using a survey instrument.

The survey generates VPFs, based on the contingent valuation method. Basically, respondents are asked to value an annual reduction in risk of death of 5 in 10,000. Their willingness to pay (WTP) for this risk reduction is then transformed in VOLY, through a relationship based on empirical life-tables (Rabl, 2002) predicting the equivalent change in life expectancy associated with the 5-in-10,000 change risk of premature death.

Final ExternE recommendations are to take €50,000 as a central and robust estimate for VOLY. Upper and lower boundary estimates (€225,000 and €27,240 respectively) were not taken into account here for sensitivity analyses as "*they are considerably less robust than the central value because they are based upon survey results themselves derived from much more smaller sample sizes (322 and 50 respectively)*". Moreover, *"the VOLY of €50,000 is derived from an annual payment made over a ten-year period and as such does not require further discounting since we assumes that the respondents have implicitly done this when giving their answer*" (ExternE, 2005).

€75,000 can be interpreted as a value for acute mortality (ExternE, 2005) and was used here to value acute mortality in children aged one month to one year.

These values have been submitted to a new assessment in the framework of the last NEEDS report (2007). The VOLY estimate has been lowered to being €40,000 for UE25 and is recommended for application by ExternE. As for confidence intervals, it is argued that VOLY is at least €25,000 and at most €100,000. The €40,000 VOLY value was thus used in this study.

(ii) MORBIDITY

The values for morbidity impacts expressed in monetary terms are derived from former values used in ExternE, with major input from a new empirical study on their valuation covering five countries across Europe. Table 3 summarises the main outputs used in this study, discounted from ExternE (2005) on a 2008 base price using the Belgian health index[7]. The 2007 NEEDS report recommends also to use these values.

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result, it is impossible to tell whether a given exposure has resulted in a small number of people losing a large amount of life expectancy or a lot of people losing a small amount of life expectancy. In this case only the average number of years of life lost is calculable and so makes a strong case for the use of VOLYs in the context of air pollution (ExternE, 2005).

[7] http://statbel.fgov.be

HEALTH END-POINT	UNIT	€ price year 2000	€ price year 2008
Chronic mortality	VOLY		40,000
Accute mortality	VSL		75,000
Hospital admission	Cost/admission	2,000	2,352
Hospital emergency health care for respiration issues	Cost/out patient	19	22
	Cost/in patient.day	241	283
Hospital emergency health care for cardiology	Cost/out patient	36,48	43
	Cost/in patient.day	462,72	544
Chonic bronchitis	Cost/new case	190,000	223,459
Primary care physician	Cost/consultation for asthma	53	62
	Cost/LRS consultation	75	88
Symptoms in asthmatics	Cost/event adult	130	153
	Cost/event children	280	329
Work loss days (WLD)	Cost/day	82	96
Restricted activity days (RAD)	Cost/day	130	153
Cough, symptom or minor restricted days (MRAD)	Cost/day	38	45
Bronchodilator usage (adults and children)	Cost/day	1	1

Table 3: Unit values for morbidity impacts of air pollution

II.3 Building damage

Air pollutants emitted by the burning of fossil fuels have a serious impact on buildings: on one hand, loss of mechanical strength, leakage and failure of protective coating due to **degradation of materials**; and on the other, **soiling** due to deposition of particulate matter.

SO_2 and its combination with other gaseous pollutants (NO_2, O_3) are prime culprit in material corrosion. Indeed, these pollutants accelerate the natural rate of corrosion of metallic and non-metallic surfaces. Two types of deposition processes (wet and dry deposition) are recognised in atmospheric corrosion, depending on the way in which pollutants are transported from the atmosphere to the corroding surface.

Wet deposition refers to corrosion caused by rain acidity, itself correlated to the SO_2 and NO_2 content of the air. Depending on its acidity level, rain can have either a positive or negative effect on building damage. If the rain acidity is low, the rain washing effect dominates over the corrosion effect – clearing up soiling by PM and washing away the chemically active compounds deposed at the surface of the building. On the other hand, if the rain acidity is high, the detrimental effect of corrosion dominates on the beneficial effect of rain washing.

Dry deposition lies in the contact of the air with the building surface and occurs only in the presence of a moisture layer at the surface of the building. Gaseous SO_2 is dissolved in the moisture layer, engendering acidification of this moisture layer, which itself enhance the corrosion of the underlying material.

Soiling is the effect of particle deposition that results in darkening the surface and can be measured as a change in light reflectance. It mainly occurs by deposition and diffusion processes; deposition involves particles larger than a few microns and occurs on horizontal surfaces while diffusion involves smaller particles and happens on any surface (*i.e.* not only horizontal surfaces). Talking about building soiling, diffusion processes are thus mainly concerned. In particular, sub-micron particles contain soot, and therefore have a relatively high soiling effect.

II.3.A. Quantification of the impacts

Building degradation by acid rain and soiling by particulate matter occur at different rates depending on the type of material concerned. Dose-response functions are material-specific and therefore one needs to assess the current stock-at-risk to be considered.

Stock-at-risk assessment is a two step process: (i) determination of the total exposed surface; (ii) decomposition of the total exposed surface into smaller surfaces, each referring to a specific material. This has been done in a former CEESE project (Fierens *et al.*, 1998). In this study, we considered that the 1998 estimated stock-at-risk was a good approximation of the current stock-at-risk (Table 4).

Brussels	m^2	%
Brick	11,195,939	38.7%
Wall paint	5,097,771	17.6%
Concrete	3,374,796	11.7%
Limestone	3,123,515	10.8%
Galvanized steel	2,710,162	9.4%
Zinc	1,989,900	6.9%
Cement and rendering	914,045	3.2%
Door paint	429,705	1.5%
Sandstone	97,957	0.3%
Total	**28,933,790**	**100%**

Table 4: Building material stock-at-risk of Brussels (source: Fierens et al, 1998)

For several materials that are frequently used in buildings, dose-response functions have been obtained. These dose-response functions link the dose of pollution, measured in ambient concentration and/or deposition, to the rate of material corrosion.

In ExternE (2005), special attention was brought to transforming dose-response functions into exposure-response functions linking pollutant concentration to maintenance frequency. This is done through defining performance requirements, expressed in terms of critical degradation levels.

(i) EXPOSURE-RESPONSE FUNCTIONS FOR CORROSION

The exposure response functions, reflecting the corrosion processes described here above contains two additive terms: $K_{dry} + K_{wet}$.

The dry deposition term is quantified in terms of the parameters SO_2, relative humidity and temperature, whereas the wet deposition is quantified in terms of total amount of precipitation and precipitation acidity.

The concentration-response relations are of the form where the corrosion attack, K, is described in terms of dry and wet deposition effects separated as additive terms:

$$\boxed{K = K_{dry} + K_{wet}}$$

Similarly to the concentration-response functions, the dry deposition term is quantified in terms of the parameters SO_2, relative humidity and temperature, whereas the wet deposition is quantified in terms of total amount of precipitation and precipitation acidity.

The equations (ExternE, 2005) used for assessing the required maintenance frequency (1/t) of limestone, sandstone, and galvanised steel are presented here under. Table 5 lists the useful parameters involved in the equations, and their respective units.

Symbols	Description	Unit
1/t	Maintenance frequency	1/year
T	Temperature	°C
Rh	Relative humidity	%
$[SO_2]$	SO_2 concentration in the air	$\mu g/m^3$
Rain	Rainfall	mm/year
$[H^+]$	H+ concentration in precipitations	mg/l
R	Recession of surface	μm

Table 5: Parameters used in corrosion concentration-response functions

- Limestone:

$$1/t = [\,(2.7 * [SO_2]^{0.48}\, e^{-0.018\,T} + 0.019 * Rain * [H^+]\,) \,/\, R\,]^{1/0.96}$$

- Sandstone :

$$1/t = [\,(2.0 * [SO_2]^{0.52}\, e^{f(T)} + 0.028 * Rain * [H^+]\,) \,/\, R\,]^{1/0.91}$$

Where f(T) is a function of temperature in °C, equal to 0 when T<10°C and equal to -0.013(T-10) when T>10°C.

- Zinc and Galvanised Steel

$$1/t = 0.14*[SO_2]^{0.26}\, e^{0.021}\, Rh\, e^{f(T)} \,/\, R^{1.18} + 0.0041\, Rain\, [H^+] \,/\, R$$

$$f(T) = 0.073*(T-10) \text{ if } T<10°C \text{ and } f(T) = -0.025*(T-10) \text{ when } T>10°C.$$

In ExternE (2005), it is said that the sandstone equation could be used for other stone materials like rendering and mortar, however introducing a higher degree of uncertainty, and probably underestimating the maintenance frequency. We chose not to apply the equation to such material.

(ii) EXPOSURE-RESPONSE FUNCTIONS FOR DEGRADATION BY SOILING

All soiling dose-response functions include concentration of particles in $\mu g/m^3$ as an explanatory variable. The available dose-response functions are based on two types of models, the exponential model and the square root model. The exponential model has a theoretical foundation, whereas the square root model has an empirical background. For this reason, and also because empirical studies are more recent than theoretical studies, we chose to use exposure-response functions coming from the square root model as much as possible.

Basically, the exponential and square root model have the following form. Respectively:

$$\boxed{R = R_0 \cdot \exp\{-k_e \cdot C \cdot t\}}$$

and

$$\boxed{R = R_0 - k_s\,(C \cdot t)^{1/2}}$$

Where:

R: actual reflectance [%];

R_0: reflectance of an unexposed surface [%];

k_e, $k_{s:}$ constants for the exponential model, square root model;

C: particle concentration, TSP (total suspended particle) [$\mu g/m^3$] ;

t: time of exposure [years].

These dose-response functions, transformed into concentration-response functions, become, respectively:

$$\boxed{1/t = C \cdot k_e / \ln(R_0 / R_{crit})}$$

and

$$\boxed{1/t = C \cdot k_s^2 / (R_0 - R_{crit})^2}$$

Where:

1/t: maintenance frequency;

R_{crit}: critical reflectance, when maintenance is considered necessary.

ExternE proposes a wide set of k_e and k_s constants, from the international literature. After a careful review and estimation of the applicability of these constants to our particular case, we chose to use mentioned in (Table 6):

K	Surface type
$k_s = 1.1$	Paint
$k_s = 1.6$	Limestone
$k_e = 0.0092$	Others

Table 6: Summary of constants chosen for assessing soiling damage of buildings by particle emissions (source: ExternE, 2005)

All these constants were adjusted to R_0=100% and maintenance frequency is usually triggered when R=70%. However, ExternE now suggests considering a modification of the R_{crit} = 70% criterion. This is because *"when people judge the soiling status of an object, they do so compared to a surface in the surroundings, which is considered to be white. In reality, this white surface may also be soiled to a lesser extend depending on the general pollution level* (ExternE, 2005)". In practice, the maintenance frequencies are divided by a 1.1 factor (exponential model) or by a 1.6 factor (square root model), lowering the total soiling costs.

In order to take the amenity loss into account, we also introduced a second correction factor. Indeed, it is commonly accepted that:

Total soiling costs = cleaning costs + amenity loss

But as we can evaluate amenity loss to be close to the cleaning costs (Rabl, 2007), we can use the following formula:

Total soiling costs = 2 x cleaning costs

Finally, we considered that only 75% of the surfaces were affected by soiling, as a consequence of the main rain washing effect (Favrel, 2001). The impacts arising from non-exhaust emissions were also assessed.

II.3.B. Monetisation of the impacts

Table 7 presents the unit values used in this task to assess cleaning and repairing costs of buildings (€/m²). They represent average national data and were gathered from three main sources (UPA-BUA, 2009; www.livios.be; Favrel, 2001).

Degradation type	Maintenance action	Price (euro/m²)
Soiling	Sandblasting (a)	18.20
	Water repellent coating (b)	25.25
	Scaffolding (b)	29.50
	Sheet (b)	3.54
	Total	**76.49**
Corrosion	Natural stone replacement (c)	408.84
	Zinc replacement (b)	71.30
	Galvanised steel replacement (b)	66.55
	Cement, rendering replacement (b)	39.50

Table 7: Unit prices for building damage [€/m²]

Sources: (a) www.livios.be; (b) UPA – BUA, 2009; (c) Favrel, 2001 (1995 prices discounted into 2008 prices)

An issue about building damage monetisation was that all buildings are subject to impact both by deterioration and by soiling. So far, it was not possible to combine costs estimates related to degradation and soiling into a single cost estimate representative of the total impact to materials. Instead, the separate estimates represented two extreme cases: (i) soiling is prevalent and all maintenance decisions are cleaning decisions occurring at the calculated frequency and (ii), corrosion is prevalent and all maintenance decisions are repairing decisions occurring at the calculated frequency.

Rabl (2007) found that renovation expenditures in France increase with concentration of particulates, and not with SO_2 concentrations. He therefore concludes that in France it is the soiling of facades rather than erosion due to SO_2 that determines a decision whether or not to renovate. This is coherent with the fact that SO_2 concentration in the air have been considerably decreasing with the decreasing content of sulphur in fuels and the desulphurisation of flue gases (IBGE, 2009).

In this task, we took the hypothesis that the French and Belgian situations are comparable, and that therefore the soiling effect should prevail over the corrosion effect regarding maintenance decision in Belgium. The impacts of SO_2 have then been neglected because calculations showed that impacts related to corrosion are three orders of magnitude below other external costs.

Corrosion related costs are presented for the record.

II.4 Noise impacts

In general, two types of negative impacts of transport noise can be distinguished:

- **Costs of annoyance**: transport noise imposes undesired social disturbances, which result in social and economic costs such as restrictions on enjoyment of desired leisure activities, discomfort or inconvenience (suffering pain), etc.
- **Health costs**: noise from transport can also cause physical health damages. Damage to hearing can be caused by noise levels above 85 dB(A), while lower levels (above 60 dB(A) may result in nervous stress reactions, such as change in heart beat frequency, increase in blood pressure and hormonal changes. In addition, exposure to noise increases the risk of cardiovascular diseases (heart and blood circulation). Finally, noise from transport can result in a decrease of subjective sleep quality. The negative impacts of noise on human health result in various types of costs, such as medical costs, costs of productivity loss, and the costs of increased mortality (Maibach *et al*, 2008).

It can be assumed that these two effects are independent, i.e. the potential long term health risk is not taken into account in people's perceived noise annoyance.

The logarithmic nature of noise transmission is reflected in the relationship between noise intensity and traffic volume. By halving or doubling the amount of traffic the noise level will be changed by 3 dB, irrespective of the existing flow. This means that an increase of traffic volume from 50 to 100 vehicles per hour will result in the same increase in the noise level (3 dB) as a doubling of the transport volume from 500 to 1,000 vehicles per hour.

Due to the logarithmic nature of the relationship between noise level and traffic volume, marginal noise costs are sensitive to existing traffic flows or more generally to existing (background) noise. Marginal noise costs are defined as the additional costs of noise caused by adding one vehicle to the existing traffic flow. If the existing traffic levels are already high, adding one extra vehicle to the traffic will result in almost no increase in the existing noise level. Due to this decreasing cost function marginal noise costs can fall below average costs for medium to high traffic volumes (Maibach *et al,* 2008).

For the estimation of noise costs data on the number of exposed people is needed. For many European countries exposure figures are not yet available. However, this will change by the introduction of the strategic noise maps required by Directive 2002/49/EC. These maps will provide data on exposure to noise (number of people per band of noise levels) in every agglomeration with more than 100,000 inhabitants, roads with more than 3 million vehicles per annum, railways with more than 30,000 trains per year and airports with more than 50,000 movements per year.

Three general key cost drivers for noise costs can be distinguished:

- **Time of the day:** noise disturbances at night will lead to higher marginal costs than at other times of the day.
- Receptor density close to the emission source: amount of population exposed to noise.
- **Existing noise levels (depending on traffic volume, traffic mix and speed):** Along an already busy road the marginal noise costs of an additional vehicle are small in comparison with a rural road. The higher the existing background noise level, the lower the marginal costs of additional vehicles (Maibach *et al, 2008*).

In road transport the sound emitted is made up by the sound of the propulsion system, the sound of rolling and the aerodynamic sound. The ratio of these sources depends on the speed of the vehicle. Besides vehicle speed, other important cost drivers are vehicle type, the kind of tyres and road surface, the vehicle's state of maintenance. Closely related to these are cost drivers like vehicle age, the slope of the road, and the kind of surface (including the presence of noise walls). In urban areas the driving behaviour (such as speeding up) is also a relevant cost driver.

Two major approaches are applied in the studies available on noise costs: top-down and bottom-up. The results of both studies differ. The top-down method produces average cost estimates, while marginal cost estimates are found by the bottom-up approach. From a scientific point of view, marginal cost estimates are preferred above average cost estimates for internalisation strategies. However, due to the big impact of local factors (initial noise levels, traffic levels, etc.) on marginal noise costs it will be questionable whether internalisation strategies based on marginal costs are feasible. Thus, for practical reasons, this assessment follows the top-down approach and is be based on average noise costs (Maibach *et al,* 2008).

II.4.A. Monetisation of the impacts

Table 8 presents the unit values considered in this WP to value noise costs. Urban and rural values, for day and night situations are recommended values from Maibach *et* al (2008). The average situation was calculated as a weighted average of urban and rural noise emission, using the national mileage split factor (95% of km driven in urban environments, and 95% during the day.

	Noise Costs		
	Urban	Rural	Average
Day	0.00760	0.00010	0.00723
Night	0.01390	0.00030	0.01322

Table 8: Unit values for marginal noise costs in urban, rural and for the mean mileage driven in Belgium [€/km]

(Sources: Urban and rural: Maibach et al. (2008); average situation: own set-up)

Noise costs corresponding to a 75 dB level of emissions are five times higher than noise costs of a 68 dB emission, which is proportional to the difference in annoyance level experienced by people. We also note that noise costs impacts are highly differentiated depending on the location and time were noise emissions take place.

For a given environment (urban, rural, or average), night emission costs are higher than day emission costs, because the background noise level is lower. The difference between day and night situations increases as the emitted noise gets louder.

Rural noise emission costs are close to zero and can roughly considered negligible. This is a consequence of the low population density in this kind of environment.

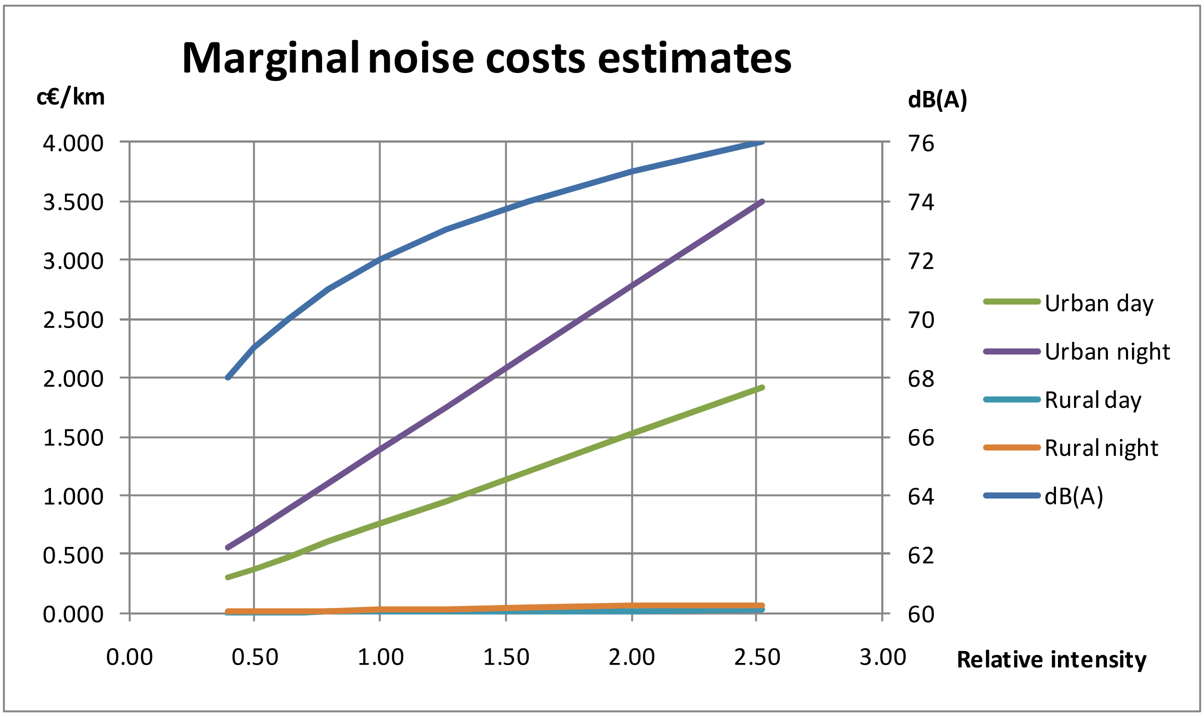
Using these costs as central values, we derived equations (Table 9) reflecting the annoyance level induced by car noise emissions. We derived noise costs proportional to a linearised perceived relative intensity scale reflecting the logarithmic nature of noise, rather than to emitted noise in decibel.

The relative intensity of 1.00 has been mapped on average noise level of the selected car set (72 dB) and corresponds to the average noise costs given in Table 8. Similar approaches can be found in Nellthorp *et al* (2007).

Urban day	y = 0.00760 x
Urban night	y = 0.01390 x
Rural day	y = 0.00010 x
Rural night	y = 0.00030 x

Table 9: Noise emission-cost relationships derived from Maibach [y= €/km ; x= noise intensity relative to 72dB]

Graph 2 gives a full representation of this linearization and the link with the emitted noise values expressed in dB(A).



Graph 2: Marginal noise costs estimates [€/km]

II.5 Climate change impacts

International literature abounds on the subject of climate change and the monetary valuation of greenhouse gases emission impacts (Quinet et al. 2008, IPCC 2007, Stern 2006, Tol et al. 2002, etc).

Climate change impacts have a high level of complexity due to the fact that they are both long term and global, and that risk patterns are very difficult to anticipate. However, one can say that main economic effects arising from climate change are related to (i) direct losses from weather disasters (droughts, floods, storms, heat waves, etc); (ii) impacts on agriculture and forestry (change in crop yield, response of plant species, pests and diseases); (iii) loss of biodiversity and ecosystem services; (iv) impacts on human health and welfare, (v) impacts on coastal zones (erosion, salinity). Contrary to the other pollutants considered in this study which have a important proximity impact, greenhouse gases impacts are mainly global taking into account their long atmospheric lifetime (IPCC, 2007). Therefore there is no justification for limiting the assessment to the Brussels-Capital Region. Moreover, no figures could be found currently on such impacts for urban areas such as the Brussels-Capital Region.

II.5.A. Values for external costs of climate change

International literature provides useful information about the valuation of greenhouse gases impacts (Quinet *et al.* 2008, Anthoff, 2007, 2009, IPCC 2007, Stern 2006, NEEDS 2006, ExternE 2005, Tol *et al* 2006, 2002, etc).

For the estimation of external costs related to climate change, two main methodologies are followed. On the one hand, models like FUND are applied to estimate **damage costs** occurring due to impacts from climate change and, on the other hand, **avoidance costs** are estimated as an equivalent for the preferences followed when focusing on concentration reduction target (mitigation) or temperature rise.

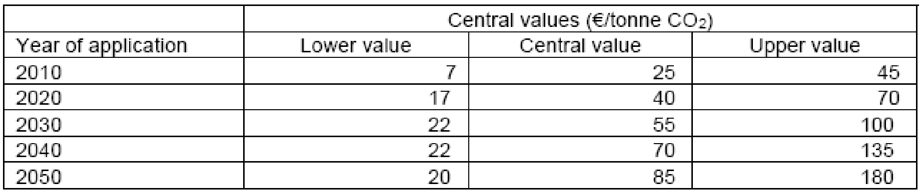
The damage cost approach follows the **impact pathway approach** and uses detailed modelling to assess the physical and monetary impacts of climate change. However, a great deal of controversial issues still lie in this kind of approach because on one hand of the uncertainties in assessing future technological development that may lead to lower emissions, uncertainties in the physical impacts of climate change, uncertainties in monetary valuation of these impacts, etc and on the other hand of the assumptions which are used in the modelling (equity weighting, discounting rate, etc).

For these reasons, studies explores other **approaches based on avoidance / abatement costs** which can be associated with less uncertainty than for damage costs (Maibach, 2008). The method uses cost-effectiveness analysis that determines the least-cost option to achieve a required level of greenhouse gas (GHGs) emission reduction, e.g. related to a policy target such as limiting the temperature increase to 2°C. As a conclusion of these analyses, ExternE “confirms the use of €19/t CO_2 as a central value” for **avoidance/abatement costs.**

These avoidance costs strongly depend on the target level of the current policies. At a time when nations world-wide are engaged in preparing an agreement on post-Kyoto targets, the relevance of avoidance costs estimates based on the Kyoto-target is diminishing.

In this situation, Maibach (2008) states that: “A differentiated approach (looking both at the damages and the avoiding strategy) is necessary”. The report recommends to “base external cost factors for emissions in the short term on the avoidance cost approach and to use damage costs as a basis for assessing the external costs of greenhouse gas emissions occurring in the longer term".

After performing a meta-study of the available literature, Maibach *et al.* (2008) propose the values presented in Table 10. Similar values are found from those of other analyses (Van Regemorter et al. 2008*;* DEFRA, 2007).



	Central values (€/tonne CO_2)		
Year of application	Lower value	Central value	Upper value
2010	7	25	45
2020	17	40	70
2030	22	55	100
2040	22	70	135
2050	20	85	180

Table 10: Recommended values for the external costs of climate change [€ 2008], expressed as single values for a central estimate and lower and upper values

Where:

- For the short term (2010 and 2020) the recommended values are based on the bandwidth of studies based on avoidance costs. The reasons for using values based on avoidance costs for 2010 and 2020 are the following:
    - For the 2010-2020 there are policy goals available to which avoidance costs can be related.
    - The uncertainty range for avoidance costs is smaller than for damage costs. This makes the use of avoidance costs more acceptable from a political and practical point of view.
- For the longer term (2030 to 2050) the values presented in Table 10 are based on damage costs. This is done for the following reasons:
    - From the perspective of consistency with external cost valuations of other environmental impacts the concept of damage costs is preferred over the use of avoidance costs. Also in the field of environmental cost-benefit analysis, in which external costs are used to derive a monetary value for the benefits of assessed policies or investment, a tendency is observed to move from avoidance costs to damage costs.
    - For the long term no agreed policy goals are available yet for which avoidance costs can be assessed.

In this study, the €25/t CO_2 value presented in Table 10 was chosen as a lower estimate for CO_2 pricing. It represents the central European avoidance cost value and is applicable for a short term scenario (2010).

However, in ExternE (2005), it is also said that "depending on the context, sector or country, specific marginal abatement costs may be better than the European marginal abatement cost. This is specially the case for decision with a short time impact, and limited to a specific sector or country". This study being limited to a specific country (Belgium) and to a specific sector (traffic), we chose to use €90/t CO_2 as a second optional value. €90/t CO_2 is the marginal abatement cost for Belgium (Blok *et al.,* 2001). Moreover, this value almost corresponds to the central European value based on a damage cost approach for a longer term scenario (2050) (table12). In comparison for complying with a policy target such as limiting the CO_2e to 500 ppm, which is rather ambitious, Tol (2006) suggests values of €46/t CO_2e for 2020 and of €198/t CO_2e for 2050 as marginal abatement costs.

As far as internalizing the GHGs related external costs is concerned, it is important to keep the opinion of the automobile sector in mind. In its Critical Review of the EC Internalization Policy (Baum, 2008), the European Automobile Manufacturers Association (ACEA) states that: "*It is doubtful whether there is a need for internalization of* CO_2 *costs at all, since those are already charged through high petrol and diesel taxes. Excise duties on petrol and diesel are generally in the region of €0.40/litre in the EU. In contrast, the external* CO_2 *costs of 0.08/litre (2020) range clearly below these taxes. Therefore, the argument that external* CO_2 *costs are already internalized over the fuel price is valid for Europe.*"

The main drivers for marginal climate cost of transport are the fossil fuel consumption and carbon content of the fuel. However, greenhouse gases emissions due to fuel production and oil refining do also occur and influence the climate change impact of car use. This is particularly the case with electric vehicles, which do not release any gases in the TTW phase, but indeed contribute to climate change in the WTT phase.

Well-to-tank and tank-to-wheel emissions of CO_2, N_2O and CH_4 were considered and analysed separately. The relative contribution of these emissions to global climate change is assessed through Global Warming Potential (GWP). GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to climate change. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by definition 1).

A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless. The adequacy of the GWP concept has been widely debated, however, "*GWPs remain the recommended metric to compare future climate impacts of emissions of long-lived climate gases*" (Forster *et al.*, 2007). According to Forster *et al* (2007), and using a 100-year time horizon as in the Kyoto Protocol, the global warming potentials used to value CO_2, N_2O and CH_4 emissions are, respectively: 1, 310 and 21. In this assessment we have used the most recent updated values that are those defined in the European Directive on renewable energy[8], respectively 1, 296 and 23. In any case, the difference in the results when using one or other set of values is totally negligible, as the main driver of climate change is by far the CO_2.

Regarding climate change impacts of HFCs emissions, a previous study (Guignard, A. et al., 2005) shows that global external costs associated to air conditioning equipment of private cars in Brussels-Capital Region are not very important: between c€ 0.035 and c€ 0.072/km for a whole life cycle. This contribution has therefore not been integrated in this assessment.

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[8] Values used in Directive 2009/28/EC

SECTION III. APPLICATION AND RESULTS

The above methodological developments have been applied to a set of selected vehicles.

III.1 Typology of the selected vehicles

As a systematic survey of all vehicles on the today's' market would require an unrealistic amount of time, it was decided in the frame of CLEVER to calculate the externalities for a specific selection of cars provided by ETEC (W.P.2.2). These externalities are expressed in Eurocents (c€) per kilometre driven by each vehicle type (c€/km). As mentioned above, externalities considered here are travel-related. Externalities related to production and recycling of the vehicles are not assessed in this WP. The impacts categories considered are: health damage, building soiling and degradation by corrosion, noise and climate change.

The selected set considered in this study is composed of 53 cars covering all relevant technologies available (type of fuel, propulsion system, power train) and car category (supermini, small city car, small family car, big family car, small monovolume, mono-volume, exclusive car, sport and SUV).

The selected set of car covers all relevant technologies available (type of fuel, propulsion system, power train) and car sizes (from the supermini type of car, to the SUV). External costs will be presented regarding these criteria's.

The CLEVER project is in many aspects based on a vehicle classification, performed by ETEC – VUB (W.P.2.2). The classification is based on vehicle size, ecoscore and FEDERAUTO segmentation.

Table 11 presents the set of cars analysed throughout the CLEVER project (ETEC classification, made of car, model and version). In this particular ask 4.1 , a special code has been attributed to each car. This code gives a generic name to each car and aims at easing the readability of the results. This name is composed of (i) the vehicle class, as defined by ETEC (*e.g.* Supermini, SUV); (ii) the type of fuel or motorisation system (*e.g.* Supermini D (diesel), Supermini E (electric)).

Full emission data, as provided by W.P.2.2 and used in this task can be found in Appendix 1.

Exhaust emission functions for the selected vehicles have been used for assessing emissions of SO_2, NO_x, PM_{10}, CO_2, N_2O and CH_4. They have been developed and evaluated in the framework of the CLEVER project (Boureima et al., 2009). The emission and consumption data of the vehicles with diesel, petrol, hybrid, CNG and LPG have been measured for the New European Driving Cycle (NEDC).

Class[1]	Brand	Model	Version	Technology[2]
Supermini	CITROEN	C1	1.0 TENTATION	P
	CITROEN	C1	1.4HDI SEDUCTION	D
	CITROEN	C2	1.6HDI FAP VTS	D PF
	CITROEN	C1	1.0 TENTATION LPG	LPG
	FIAT	PANDA	1.2 NATURAL POWER	CNG
	PEUGEOT	106	Electric	E
	SMART	FORTWO	1.0 52 MHD PULSE	P
Small City Car	FIAT	PUNTO	1.4 DUALOGIC 360°	P
	FIAT	PUNTO	1.3MJTD51	D
	FIAT	PUNTO	1.3MJTD55 DPF 360°	D PF
	FIAT	PUNTO	1.4 DUALOGIC LPG	LPG
	FIAT	PUNTO	1.2 Classic Natural Power	CNG
Small Family Car	FORD	FOCUS	1.4 AMBIENTE	P
	FORD	FOCUS	1.6TDCI66 GHIA	D
	FORD	FOCUS	1.6TDCI80 DPF GHIA	D PF
	FORD	FOCUS	1.4 AMBIENTE LPG	LPG
	CITROEN	C4	1.6HDI80 DPF diesel	D PF
	CITROEN	C4	1.6 HDI B5	B5 PF
	CITROEN	C4	1.6 HDI B10	B10 PF
	CITROEN	C4	1.6 HDI B30	B30 PF
	CITROEN	C4	1.6 HDI B100	B100 PF
	MERCEDES	B-KLASSE	B 170 NGT	CNG
	OPEL	ASTRA	Impuls "Zebra"	E
	HONDA	CIVIC	1.3 HYBRID Comfort	P H
Big Family Car	VOLVO	S40	1.8 SUMMUM	P
	VOLVO	S40	2.0 diesel 100 kW	D
	VOLVO	S40	2.0D FAP SUMMUM	D PF
	VOLVO	S40	1.8 SUMMUM LPG	LPG
	TOYOTA	PRIUS	1.5VVT-I HYBRID ECVT LUNA	P H
	VOLVO	V50	1.8 FLEXIFUEL Euro95	P
	VOLVO	V50	1.8 FLEXIFUEL E5	FlexE5
	VOLVO	V50	1.8 FLEXIFUEL E10	FlexE10
	VOLVO	V50	1.8 FLEXIFUEL E20	FlexE20
	VOLVO	V50	1.8 FLEXIFUEL E85	FlexE85
Small Monovolume	FORD	FOCUS	1.6l AMBIENTE	P
	FORD	FOCUS	1.6TDCI66 TREND	D
	FORD	FOCUS	1.6TDCI80 DURASH. CVT AMBIENTE	D PF
	FORD	FOCUS	1.6l AMBIENTE LPG	LPG
	OPEL	ZAFIRA	1.6 CNG ENJOY	CNG
Mono-volume	FORD	GALAXY	2.0l AMBIENTE	P
	FORD	GALAXY	2.0TDCI103 AMBIENTE	D
	FORD	GALAXY	2.0TDCI103 DPF AMBIENTE	D PF
	FORD	GALAXY	2.0l AMBIENTE LPG	LPG
Exclusive Car	MERCEDES	S-KLASSE	S 500	P
	MERCEDES	S-KLASSE	S 420CDI	D PF
	MERCEDES	S-KLASSE	S 500 LPG	LPG
	LEXUS	LS	600H	P H
Sport	PORSCHE	911	3.8 CARRERA 2 S TIPTRONIC	P
SUV	MERCEDES	M-KLASSE	ML 350	P
	MERCEDES	M-KLASSE	ML 320CDI165	D
	MERCEDES	M-KLASSE	ML 320CDI165 DPF	D PF
	MERCEDES	M-KLASSE	ML 350 LPG	LPG
	LEXUS	RX	400H	P H

(1) Classification as defined by ETEC

(2) Technology P = petrol; D = diesel; PF = particulate filter; LPG = liquefied petroleum gas;
CNG= compressed natural gas; E = electric; H = hybrid;
Exx = flexifuel xx% of ethanol; Bxx = biodiesel xx%;

Table 11: Car typology

Considering the methodological approaches developed here, a first assessment has been carried out on the selected set of 53 vehicles presented in the Table 11.

However, as described previously (I.5 Scope and issues), some vehicles of the selected have been measured with different procedures and can therefore not be directly compared to the other vehicles of the set. They are shaded in the Table 11. Note that the Ford Galaxy 20TDCI103 AMBIENTE is also shaded its performance is soo bad that either the received data is incorrect or should not be considered as a recent vehicle.

In futher sections, calculations are always made for the complete set of the 53 vehicles, but discussions conclusions in Section III are sometimes limited to the set of 43 vehicles.

III.2 Health external costs of PM_{10} and O_3

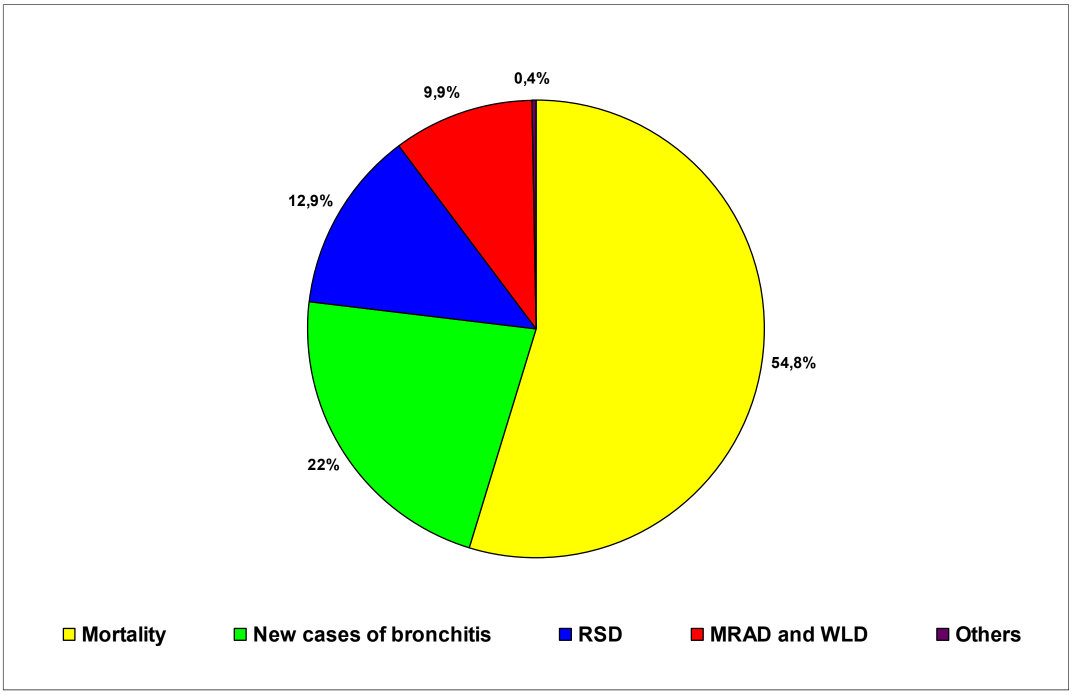
(i) AIRBORNE PARTICULATE MATTER

The results show that the external costs of PM_{10} emissions on health are important for all types of cars, even for electric vehicles. This is a direct consequence of the fact that non-exhaust emissions are taken into account for the modelling of health damages.

For the average, Graph 3: shows the contribution of the different impact categories to the total health costs. This repartition of costs is the same for every vehicle type.

The largest contribution to damage costs comes from mortality due to airborne particulate matter (54.8% of the total PM health costs). The second most important contribution arises from chronic bronchitis due to particulate matter (22% of the total health costs). These observations are in line with the ExternE predictions.

Note that minor restricted activity days and work loss days account for 12.9% of the total health costs, whereas hospital admissions, primary care physician consultations, upper respiratory diseases, and bronchodilator usage, gathered in the "others" category only account for 0.4% of the total costs.



Graph 3: Share of impacts categories of PM health costs [%]

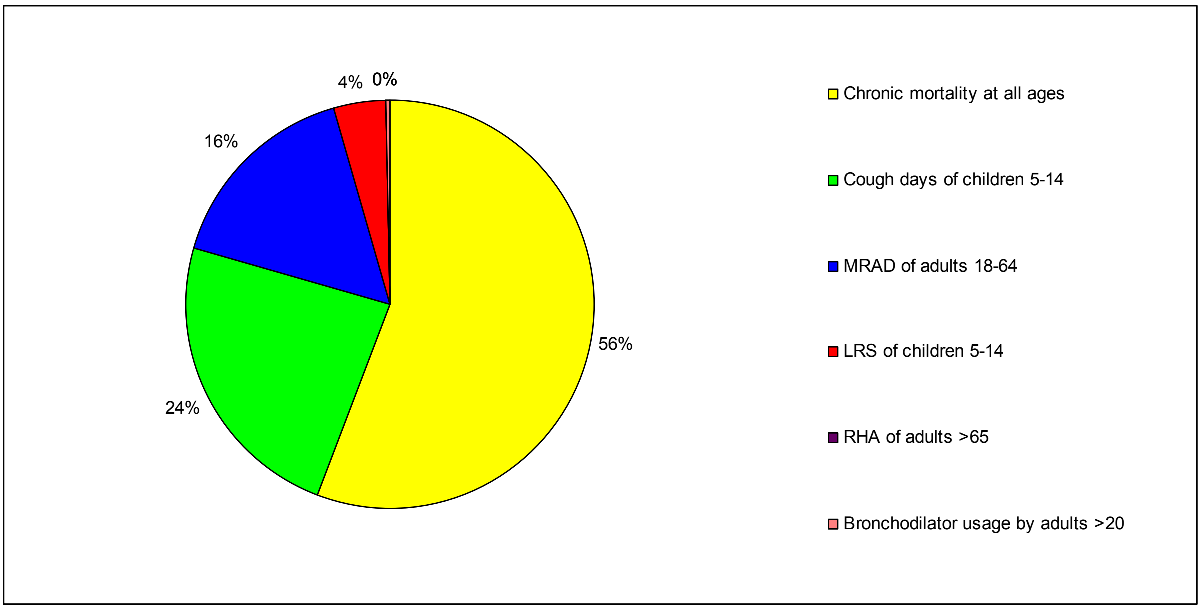
As discussed before, mechanically produced particles differ from direct emission in composition and size. Whereas exhaust particles primarily consist of very fine soot and organic compounds (partly known as carcinogenic), the fraction of particles produced mechanically is dominated by relatively coarse mineral and metallic particles (Gehrig *et al,* 2004).

It has been shown (Laden *et al.*, 2002) that a certain PM concentration from a traffic related site caused higher mortality than the same concentration of mineral dust. Gehrig *et al.* (2004) also conclude that "the current knowledge of the mechanisms, which are responsible for adverse effects of fine particles, does not allow for a conclusive judgment concerning the relative importance of the emissions stemming from exhaust pipe as compared to abrasion and re-suspension".

However, in this particular case, adverse effects of mechanically produced particles were assessed using the same concentration-response functions as for assessing the adverse effects of direct tailpipe emissions. This is consistent with the fact that the concentration-response functions were originally established through epidemiological studies held in environments containing a realistic mixture of both exhaust and non-exhaust PM. From our understanding, health costs from direct and non exhaust PM emissions should be added in order to take into account the full adverse effects of car emissions on human health.

(ii) OZONE

Chronic mortality at all ages is the largest health impact caused by ozone (56% of ozone health costs). Cough days for children and minor restricted activity days for adults aged 18 to 64 constitute respectively 24 and 16% of the total ozone health costs. Lower respiratory syndrome of children aged 5 to 14 counts for up 4% of the total health costs, whereas respiratory hospital admissions and bronchodilator usage are negligible. This is represented in Graph 4.



Graph 4: Share of impact categories of ozone related health costs [%]

However, using the model described in II.1.E, all cars, except the electric vehicle have the effect of decreasing the ozone concentration, hence a positive effect on health costs in urban zones.

Appendix 3 clearly shows that the effect is significant for diesel engines that generated a health benefit of c€ 0.71/km and c€ 0.62/km respectively for vehicles with and without filters. Other engine types have a very small ozone-related health benefits, ranging from c€ 0.03/km for hybrid vehicles to c€ 0.08/km for other types of engines (petrol, CNG, LPG.

From the figures of Appendix 3, we can conclude that particulate filters increase ozone related benefits by about 14% as these filter increase NO_2 emissions and hence decreases O_3 air concentrations.

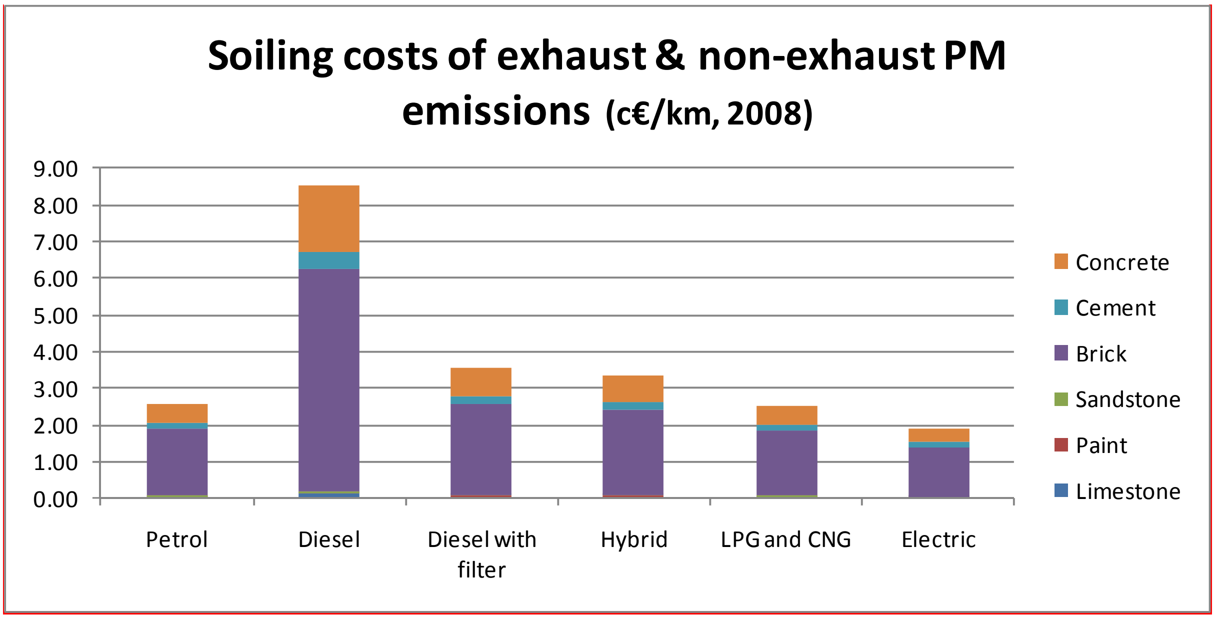
However, we should keep in mind the uncertainties surrounding ozone modelling and these conclusions would require further investigations.

III.3 Building damage

(i) Soiling

Graph 5 presents the building soiling costs due to exhaust PM emissions of diesel vehicles, as computed in the baseline scenario, thus including 50% of the non-exhaust PM emissions (see II.1.B).

The columns show the relative contribution of the material types to the total soiling costs. Note that these contributions are proportional to surfaces exposed, i.e. soiling rates are the same for every material. The predominance of brick soiling is therefore related to the surfaces of the stock-at-risk of Brussels-Capital Region.

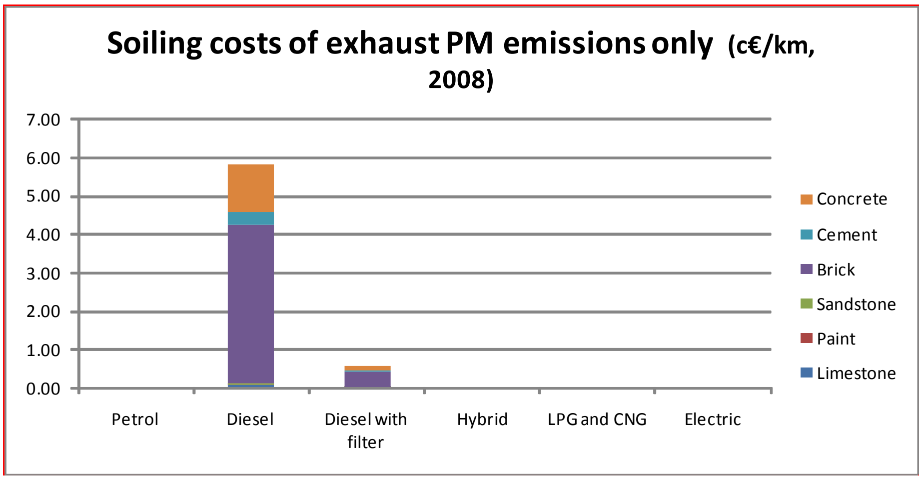


Graph 5: Soiling costs of exhaust and non-exhaust PM emissions

Once again, diesel cars are clearly generating the highest external costs, c€ 8.59/km. The other motorisation systems remain roughly between c€ 2.0/km to c€ 3.5/km. This is mainly due to the non-exhaust emissions that are relatively independent of the engine type.

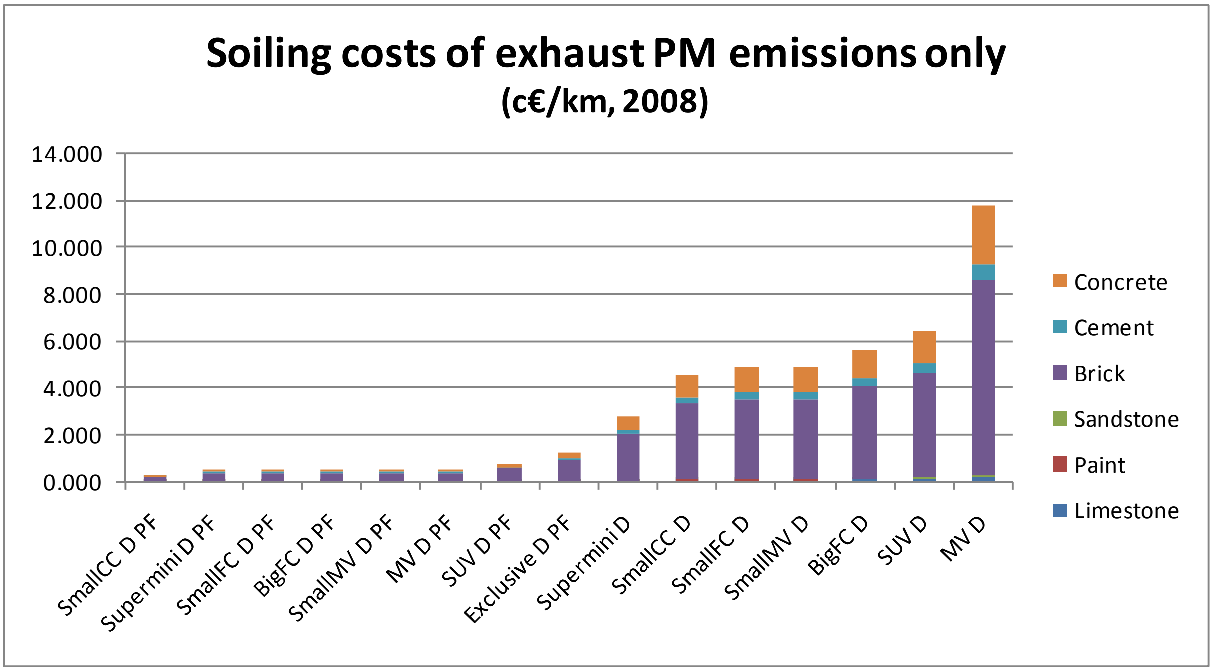
It can be argued that abrasion particles probably cause less soiling than end-pipe emissions (containing soot) and therefore should not be assessed or valued as other PMs. However, as with other health DRFs, soiling, dose-response functions were obtained under current atmospheric conditions where both exhaust and non-exhaust PMs are present in the air.

Graph 6 is similar to Graph 5, but the contribution of these non-exhaust emissions has not been included. Considering exhaust emissions only, average soiling costs of cars equipped with a PM filter are 10.2 times smaller than the average soiling costs of cars without a PM filter (c€ 0.57/km compared to c€ 5.84/km, respectively).



Graph 6: Soiling costs of exhaust PM emissions only

Graph 7 represents the soiling costs (exhaust emissions only) for the 16 diesel vehicles of the selected car set. It illustrates the effect of the car size on the costs (the larger the vehicle, the higher the costs), but also clearly shows that even a Supermini diesel still has soiling costs over two times higher than an SUV equipped with a filter (c€ 2.81/km and c€ 1.28/km respectively).



Graph 7: Soiling costs of exhaust PM emissions only for diesel vehicles

(ii) *CORROSION*

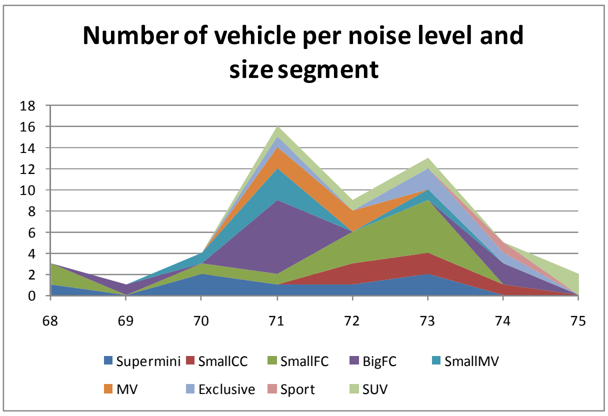
Building degradation by acid rain mainly affects limestone (95% of the total corrosion costs). Other costs gather galvanized steel, zinc, and sandstone corrosion impacts. These costs are linked with SO_2 emissions of vehicles and range from c€ 0.00032/km for a supermini LPG up to c€ 0.0031/km for a sports petrol car (Porshe Carrera). These costs are negligible in comparison to soiling costs.

III.4 Noise

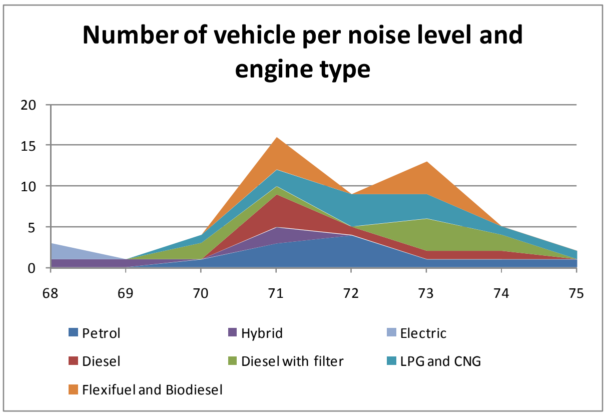
Graph 8 and Graph 9 both present the noise emission level of the set of selected cars organised by car size segment and by engine type. We notice that the emitted noise is not clearly linked either to a specific propulsion mode or to car size. This may seem natural, given the fact that noise is mainly emitted by three sources: the engine, the tyres and the aerodynamics characteristics of the vehicle. The acoustic isolation of the engine also plays an important role and will be dependent of the quality (and price) of the vehicle.

Nonetheless, we can observe that the lowest noise emissions are obtained by small vehicles (Supermini and SmallFC) and by electric or hybrid cars.

Only 15% of the selected set has emissions lower or equal to 70 dB and 13% produce 74 dB or more. Therefore, 72% of the vehicles generate between 71 and 73 dB.



Graph 8: Number of vehicle per noise level and size segment



Graph 9: Number of vehicle per noise level and engine type

Table 12 shows marginal noise emission cost for rural, average, and urban situation during day time for the different noise emission levels of the car set.

During the day, values range from c€ 0.004/km for the quietest car in rural environment to c€ 1.52/km for the worst case in a city. If we consider the mean values (i.e. marginal noise cost related to a 72dB emission), we note that emission representing the average situation cost about 20 times more than rural emissions, and roughly 4 times less than urban emissions.

dB(A)	N	Urban day	Urban night	Rural day	Rural night	Average day	Average night
68	3	0.302	0.552	0.004	0.012	0.078	0.147
69	1	0.380	0.695	0.005	0.015	0.099	0.185
70	4	0.479	0.876	0.006	0.019	0.124	0.233
71	16	0.603	1.103	0.008	0.024	0.157	0.294
72	**9**	**0.760**	**1.390**	**0.010**	**0.030**	**0.198**	**0.370**
73	13	0.958	1.751	0.013	0.038	0.249	0.466
74	5	1.206	2.206	0.016	0.048	0.314	0.587
75	2	1.520	2.780	0.020	0.060	0.395	0.740

Table 12: Marginal noise costs [c€/km, 2008] for day time emissions in rural, average or urban environment (source: own set-up)

During the night, values range from c€ 0.012/km in rural environment in the best case to c€ 2.78/km in the worst case (urban environment). Once again, considering the mean values corresponding to 72 dB, we notice that emission representing the average situation cost about 12 times more than rural emissions, and roughly 4 times less than urban emissions.

Comparing day and night, we note that marginal noise costs for the night time period are 3 times higher than during the day in a rural environment, but this ratio is slightly below 2 in an urban environment.

III.5 Climate change

Appendix 5 details the contribution of each greenhouse gas on the climate change costs, while Appendix 6 and Appendix 7 present synthetic information organised respectively by car motorisation systems, and by the car segmentation by size. These costs are evaluated considering € 25/t CO_2 eq and € 90/t CO_2 eq.

However, costs discussed here below are obtained using the price of €90/t CO_2 eq.

N_2O and CH_4 contributions to total climate change costs are small, as they remain between 1.1% and 2.5% of the total GHG external costs, except for vehicles running on CNG. For these vehicles, CH_4 WTW emissions account for 10% of the total emissions.

The VOLVO 1.8 FLEXIFUEL E85 shows a ratio of 20%. This strange result is related to the very high N_2O TTW emissions. However, as explained I.5, this value, as all the other related to Flexifuel and Biofuel cars should not be compared to others as the measurements have been done with different standards. Therefore, these motorisation systems will not be considered further in this discussion.

Overall, CO_2 TTW contribution to climate change costs is by far the most pre-eminent.

Except for electric cars, WTT contribution to the climate change costs range from 7% to 14% of the total costs for all vehicles. The highest ratios of 14% are all related to the CNG engines. This comes from the important CH4 emissions in the WTT phase of CNG preparation.

Electric cars do not produce any TTW emissions. The WTT contribution is therefore logically 100%, as all emissions are related to electricity production.

Once again, excluding electric cars, WTW climate change costs quite comparable for all engine types. The lowest values are obtained by the diesel cars (c€ 1.50/km), but hybrid, LPG/CNG and diesel with particulate filter all remain in the c€ 1.54/km to c€ 1.65/km. Petrol cars reach the significantly higher cost of c€ 1.91/km

Taking the car segmentation view angle, we can observe that the WTW climate change costs tend to increase with the car size, from c€ 1.01/km for the superminis to c€ 2.93/km for sport car.

The 10 cars with the highest climate change costs (above c€ 2.00/km) are all sports, SUVs or exclusive vehicles. The lowest climate change costs are by far the electric cars (below c€ 0.45/km), followed by supermini vehicles with different motorisation systems (petrol, LPG, hybrid or diesel).

III.6 Total external costs

Given the number of parameters and uncertainties in the assessment of the external costs, we have defined two sets of three scenarios for computing the total external costs.

III.7 External costs scenarios

The two sets correspond to the price of the ton of CO_2. Comparing those sets will allow us to get a feeling of the importance of the cost of climate change in relation with the other costs. The first set is based on the valuation of €90/t CO_2 eq, while in the second set we assume a price of €25/t CO_2 eq.

For each set, we propose three scenarios that correspond either to choices on how to assess noise impacts, or more importantly, how to integrate the uncertainties about the impacts of non-exhaust particulate matter (PM) emissions on the soling of the buildings facades:

- **the baseline scenario** for which: (i) all non-exhaust PM10 emissions are included in the computation of health impacts, but only 50% of these emissions are taken into account for building soiling impacts; (ii) the "urban day" option is taken to value noise costs. This last option was chosen for consistency with the dispersion model and air concentrations input data used (the model was developed for the Brussels Capital Region, Favrel et al. 2001);
- **the low scenario** for which: (i) non-exhaust PM10 emissions are included for the health impacts, but are not taken into account for building soiling impacts; (ii) the "average day" option is taken to value noise costs;
- **the high scenario** for which: (i) all non-exhaust PM10 emissions are considered for the valuations of health impacts and building soiling impacts (ii) the "urban day" option is taken to value noise costs.

For each scenario, analysis is carried out following conventional car size segmentation and the motorisation system.

Appendix 2: External costs per vehicle for each scenario presents the total external costs for all the 53 vehicles selected for this assessment, including the details of the different costs (health, buildings, noise and climate change). This is done for the two sets of three scenarios.

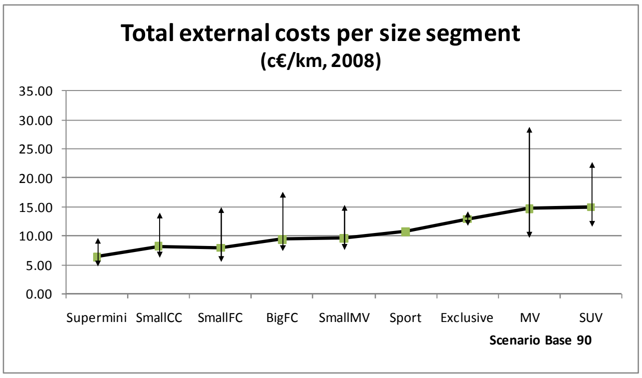
Appendix 3 and Appendix 4 provide the same information grouped by engine type and by car size segmentation for each scenario.

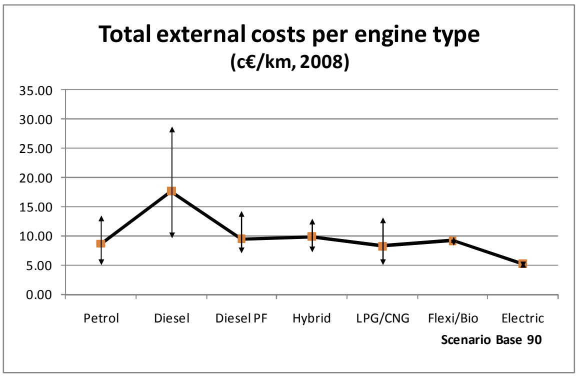
III.7.A. The baseline scenario

In the baseline scenario where the value of a ton $CO_{2\ eq}$ corresponds to € 90, the total environmental external costs range from c€ 4.81/km per year for a supermini electric car to c€ 28.88/km per year for a diesel monovolume (MV) without particulate filter. The average total external yearly cost of the selected set of vehicles is c€ 9.79/km. However, the high standard deviation of the set (4.40) indicates that the average can only be seen as a very rough estimation of the average external cost of a recent car fleet. Indeed, in this assessment, the selected car set has been chosen to cover the complete range of vehicle size and motorisation systems and is therefore not representative of any particular vehicle fleet.

When analysing more in detail the dispersion of the estimated external costs, we come to the conclusion that it essentially depends on two important factors: the size of the vehicle and the engine type.

Graph 10 shows the average total external costs for the different categories of cars with the minimum and maximum values within each category. One can easily observe a progressive increase of the external costs with the size of the car when moving from the Supermini category (c€ 6.37/km) to the SmallMV one (c€ 9.60/km). Exclusive, large MV and SUV categories are high above, with averages ranging from c€ 12.90/km to c€ 14.97/km. It is worth noting that MV and SUV have very close results.





Graph 10: Total external costs per category

Graph 11: Total external costs per engine type

The dispersion of the estimated external costs in each vehicle size segment is mainly a consequence of the motorisation system, especially in the MV and SUV segments.

The impact of the engine type is better grasped with Graph 11, where one can clearly see the very low external costs of electric cars (average c€ 5.22/km) and the very high external costs of diesel car (average c€ 17.67/km), while other motorisation systems (Petrol, Diesel with particulate filter, hybrid, LPG, CNG, Flexifuel and Biofuel) remain between c€ 8/km to c€ 10/km. The variability in theses average values are in this case related to the size of the car.

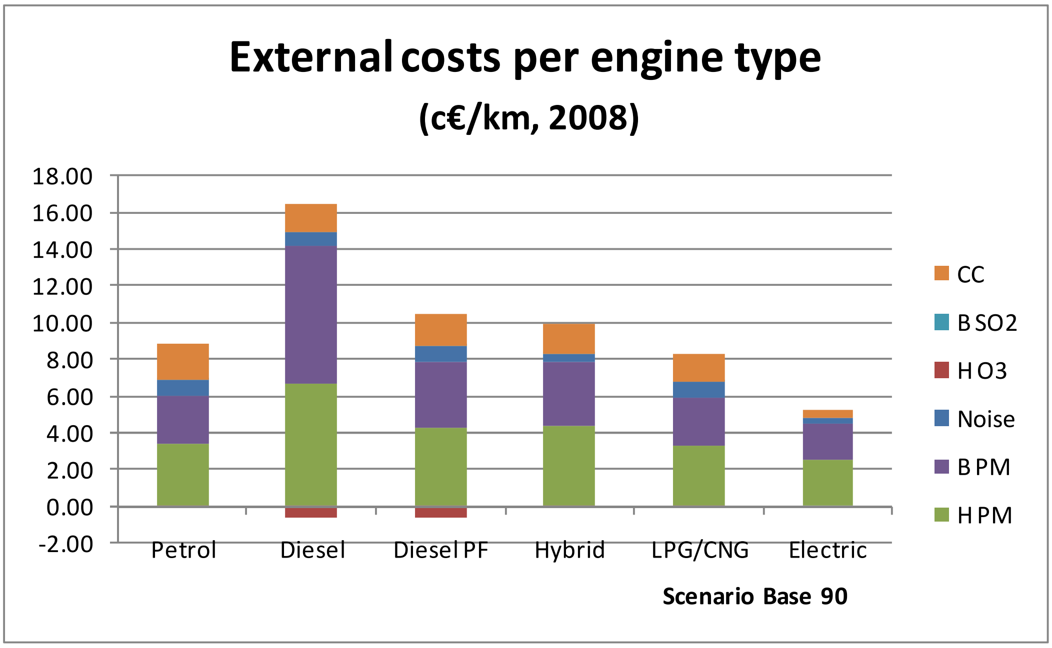
The very positive impact of particulate filters on diesel motorisation is however very obvious.

One can be surprised that hybrid cars seem to have higher externals costs than standard petrol cars. This comes from the fact that there are many small cars in the selected set of petrol cars, while hybrid technology is, for the time being, mostly used for large vehicles. It should therefore be clear that these two graphs should not be used to draw conclusions independently on the categories or motorisation system. III.9.A in the following chapter, provides a better illustration of the impacts of the engine type and the size of the vehicle.

Graph 12 shows the external cost structure for the different motorisation systems. For all types of engines, the main cost driver is related to **particulate matter** (PM), partly by its impact on human health (H PM in the graph) and partly as a result of building soiling (B PM in the graph Graph 12), with a slightly higher cost for the latter. The external costs related to PM range from c€ 4.49/km for electric cars up to c€ 15.99/km for diesel cars. These figures include the impact of non-exhaust PM emissions (brakes, tyres and road abrasion). This explains why electric cars also have an external cost related to PM, though much lower than other types of vehicles.

As a whole, for PM_{10}, the average marginal external costs represents 69% to 90% of the total marginal external costs. The proportion of the external costs related to PM is close to 50% for health and 50% for building soiling.

This graph confirms that diesel cars without a particulate filter clearly have the highest societal cost, whilst electric cars have the lowest one.



Graph 12: Structure of marginal external costs per engine type

In this baseline scenario, the second main cost driver is related to the climate change impacts (CC), ranging in average from c€ 0.42/km for electric cars up to c€ 1.91/km for petrol cars. These figures take into account the total emissions, thus both WTT and TTW contributions, and not just the exhaust emissions. Costs related to climate change are roughly between 10% and 20% of the total externals costs (assuming € 90/ton CO_2 eq) and are generally below 10% of the total costs for all vehicles when considering the price of € 25/ton $CO_{2\ eq}$. Electric car are always best in class for this aspect as climate change costs never exceed 8% of the total marginal external costs.

Flexifuel and Biofuel vehicles on Graph 11 and Graph 12, seem to show high external costs, particularly for greenhouse gases for which they appear to be worse than any other type of vehicle. As described in I.5, this is a consequence of the different measurement techniques and these vehicles should therefore not be compared with the other vehicle models which were homologated differently.

The last significant external cost contribution is related to noise emission and ranges from c€ 0.32/km to c€ 1.59/km, a stays generally below 10% of the total costs. Noise levels are quite similar for most cars, with the exception of electric cars that are among the quietest.

Finally, we can observe that the cost of health impact related to the ozone induced by NOx emission is associated with positive externalities for all cars, at the local level. These benefits remain however very low with regards to the total external costs. The highest value for the selected diesel cars amounts to c€ 0.87/km. For the other types of vehicles, the values do not go beyond c€ 0.14/km.

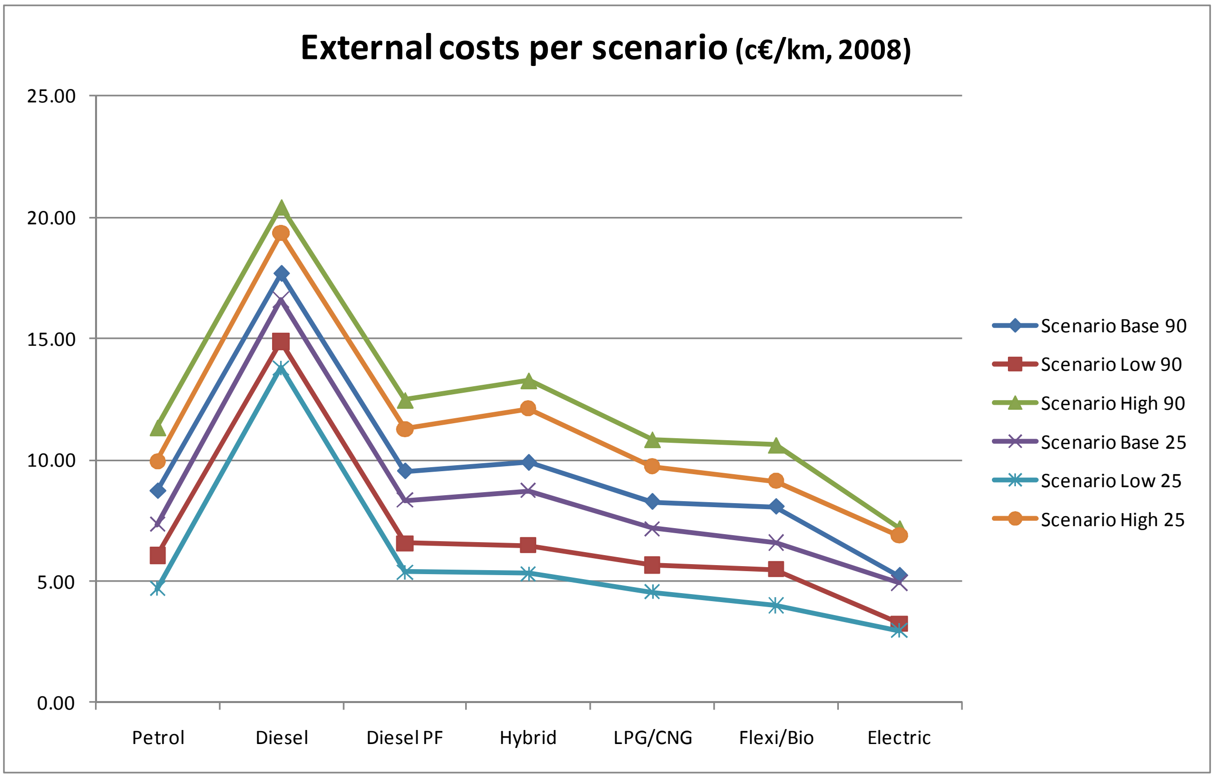
Costs related to building damage as a result of acidification produced by SO_2 emissions are nowadays completely negligible. The highest value for all cars in this survey is c€ 0.0031/km.

III.7.B. Impact of the six scenarios on the total external costs

In this study two sets of three scenarios have been evaluated. The two sets correspond to an external parameter, the price of the emission of a ton of CO_2 equivalent greenhouse gases (€ 25/ton and € 90/ton). On the other side, the three scenarios represent a choice in the way to evaluate noise impacts and uncertainties on the impacts of different nature of particulate matter (PM). Indeed, as described above, non-exhaust emissions of particulate matter represent a large part of the total PM emissions for most vehicles. However, although impact of exhaust on health and building soiling PM is well-known, characteristics of non-exhaust PM is lacking of scientific measurements and analysis, resulting in important uncertainties both for health and building soiling impacts.

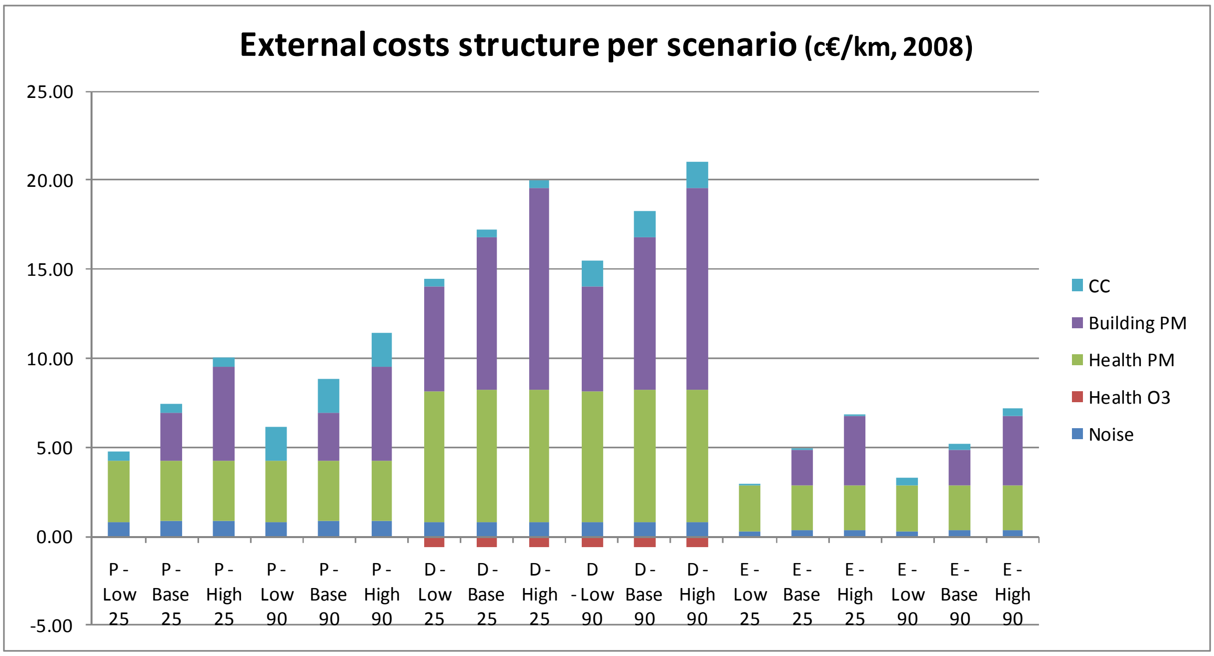
Graph 13 shows the total external costs of the different engine types for the six scenarios/sets. From this graph, we can make a number of observations:

- The price of the ton of $CO_{2\ eq}$ has more or less the same impact on all motorisation systems, with the noticeable exception of the electric cars for which the effect is negligible.
- The impact of the price of the ton of $CO_{2\ eq}$ (from € 25 to € 90) has less effect on the total external cost than the choice of the scenario. This comes from the high uncertainties of the impacts of non-exhaust PM emissions.
- The selection of a scenario or another has an effect of translating the curb up or down, showing that the absolute external costs are not well known, but that the differences between the different motorisation systems are meaningful.
- In all scenarios, diesel cars have the highest societal costs, while electric cars always remain the lowest.



Graph 13: Impact of scenarios on the total external costs

As the difference between the three scenarios is mainly dependent on the evaluation of the costs related to non-exhaust PM, the structure of these external costs, expressed in percentages, will vary significantly. This can be best seen on Graph 14, for petrol car (P), diesel cars (D) and electric cars (E), where the cost structure is shown for each scenario.



Graph 14: Evolution of external cost structure by scenario

Noise levels are very similar for all types of cars, except for electric cars that are significantly more silent. Differences that appear in noise costs in the graph below are a direct result of taking the costs "urban day" (Base and High scenario) or "average day" (Low scenario), as described above.

In all cases, the health benefits related to decreased ozone air concentrations due to vehicles appear quite negligible. It should however be stressed that this study is based on average air concentrations and is limited to city areas where ozone concentrations are lower than in peri-urban zones. Moreover, the effect of peak concentrations is not considered in this study.

The impacts of PM emissions on health are important for all types of cars, even for electric vehicles. This is a direct consequence of the fact that non-exhaust emissions are taken into account for the modelling of health damages. Diesel cars with their high exhaust PM emissions are roughly twice as damaging as electric cars. This remains true for all scenarios.

Comparing the impact of PM on building soiling for the different scenarios clearly shows the lack of knowledge about non-exhaust emissions. The 'Low' scenario does not integrate these emissions for the evaluation in building soiling. As consequence, the only motorisation system with non negligible external costs related to building soiling is the diesel engine (without particulate filter). The other scenarios that partly (baseline scenario) or totally (high scenario) integrate non-exhaust emissions in the modelling show that these emissions could be one of the main external costs of vehicles.

The high uncertainties related to the amount, the composition and the impacts of non-exhaust emissions essentially reflect the lack of scientific publications on this subject. Future evaluations of environmental external costs of vehicle should concentrate on the evolution of knowledge in this domain.

In all scenarios, external costs related to building damage resulting from the SO_2 emissions are so low that they cannot be seen on the chart. This is a direct consequence of environmental policies of these past years.

Finally, costs related to climate change are generally below 10% of the total costs for all vehicles when considering the price of € 25/ton $CO_{2\ eq}$. However, it can represent up to 34% of the costs in the 'Low 90' scenario for petrol cars. Electric car are always best in class for this aspect as climate change costs never exceed 13% of the total costs.

III.7.C. *Analysis of external costs by engine type and vehicle weight*

The analysis of the external costs per type of engine and per vehicle category results in important dispersions as can be seen in Graph 10 and Graph 11. For instance, the average of the costs of the diesel vehicles studied in this sample is not really significant as it includes Supermini cars and SUV vehicles. Similarly, the average of one category such as SmallMV will include a large variety of different engine types and will therefore not allow to draw very precise conclusions.

Considering first there is a large variance of the emissions within each car category and, second, there is no full independence between car category and the engine type, we have therefore also carried out this study using the weight of the vehicle, rather than the category, as explanatory parameter.

For this assessment, the subset of 43 vehicles (see III.1) has been grouped using six engine types: Petrol, Diesel, Diesel with particulate filter, LPG and CNG, hybrid and electric. Flexifuel and Biofuel vehicles have not be assessed, as consequence of the different measurement techniques used for emissions and these vehicles should therefore not be compared with the other vehicle models which were homologated differently.

The following table summarises the selected car set for our second assessment:

Engine type	Weight (kg)	Nbr	Euro
Petrol	750 - 2060	11	4
Diesel	880 - 2110	6	4
Diesel with filter	1055 - 2110	8	4
Hybrid	1293 - 2270	4	4
LPG and CNG	790 - 2060	12	4
Electric	1087 - 1300	2	-

Table 13: Selected car subset and weight ranges

The relation between external costs and vehicle weight has been analysed for the different engine types. Table 14 represents these relations. It clearly shows that, for each engine type, a linear relation exists between external costs and weight. Only one vehicle (Ford 2.0 TDCI103 AMBIENTE), is outside the linear relation. It will be considered as an odd value (measurement error or obsolete technology) and will not be taken into account in this analysis.

A linear regression on these series gives the following equations:

Engine type	Y = Total external cost [c€/km] X = Vehicle weight [tons]	R^2
Diesel	Y = 9.94 X + 2.47	0.944
Diesel with filter	Y = 6.61 X – 0.14	0.976
LPG/CNG	Y = 6.40 X + 0.42	0.989
Petrol	Y = 6.58 X + 0.07	0.986
Hybrid	Y = 5.72 X – 0.52	0.998
Electric	Y = 3.93 X + 0.52	0.993

Table 14: Total external costs per vehicle weight and engine type (€ 2008)

Once again, diesel engines clearly have the highest societal cost while electric vehicles have the lowest.

Comparing the other technologies, excluding electric vehicles, Table 14 shows that hybrid cars provide better environmental performances, between 13% and 48% better than any other motorisation system. However, due to the extra weight required by the additional electric motor and the batteries, this technology is limited to larger vehicles. This explains why the average external cost of the hybrid vehicles was higher than the average of the external costs of the petrol ones, although the technology is clearly better from the external costs point of view.

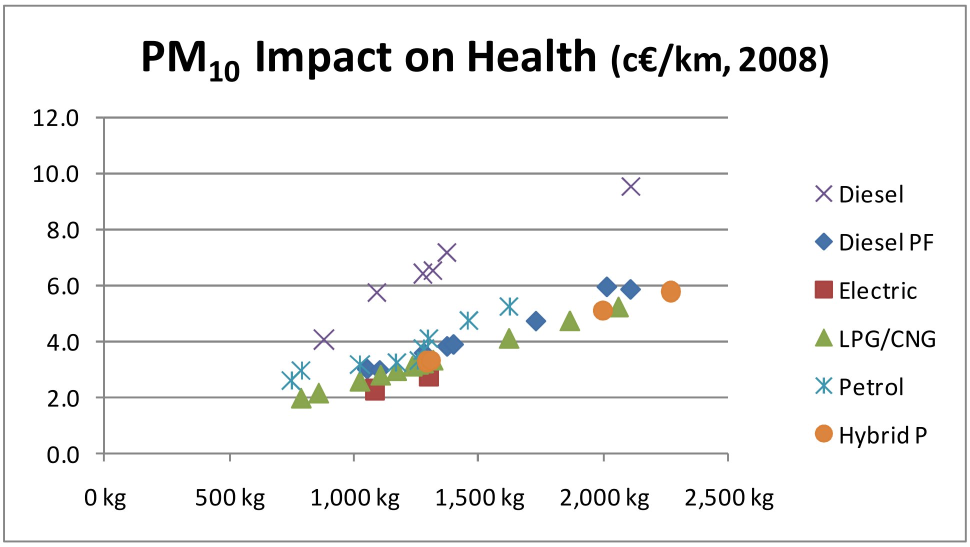
Table 14 is given for scenario 'Base 90', but remain very similar for other scenarios. The conclusions given above remain the same in all scenarios.

III.8 Marginal External Costs Comparison

A detailed analysis of the estimated marginal external costs shows that they depend on two main factors: the weight of the vehicle and the engine type. For each scenario, comparison is carried out on the base of these two parameters.

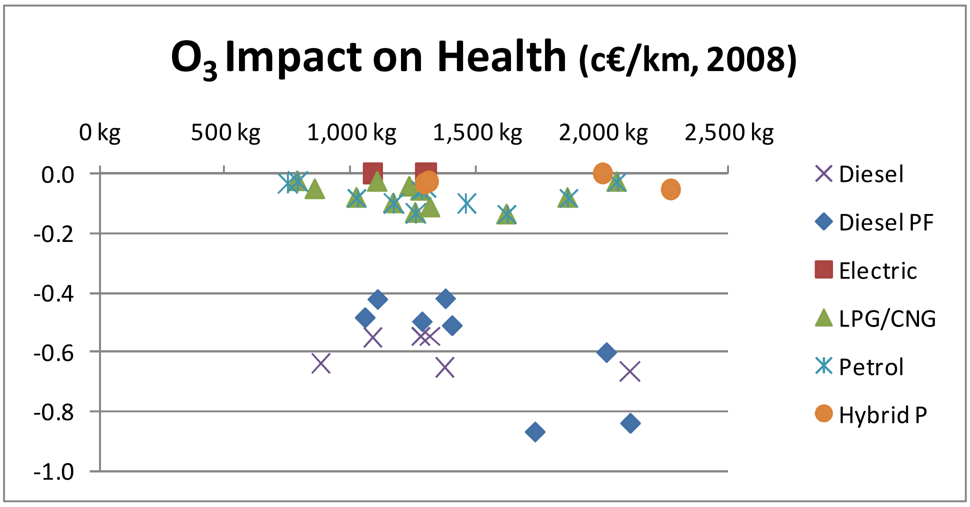
III.8.A. Impact of PM_{10} and O_3 on Health

The impacts of PM_{10} emissions on health are important for all types of cars, even for electric vehicles (Graph 15). This is a direct consequence of the fact that non-exhaust emissions are taken into account for the modelling of health damages. For the average marginal external costs, two clear correlations are observed with the weight of the vehicles. Diesel cars without particulate filters (c€ 4.1 - 9.5 /km) are roughly twice as damaging as other cars (c€ 1.9 – 5.95 /km), including electric vehicles. This ratio remains true for all scenarios.



Graph 15: PM_{10} Impact on Health

For ozone, in all cases, health benefits are related to decreased ozone concentrations due to vehicles precursor emissions (Graph 16), but the amounts appear quite negligible. Benefits induced by NO_x emissions are less than c€ 0.2/km for all cars, except for diesel ones for which this cost is approximately c€ 0.42 - 0.87 /km. It should however be stressed that the cost assessment is based on yearly concentration and the effect of peak concentrations is not considered in this study as well as impacts outside the city.

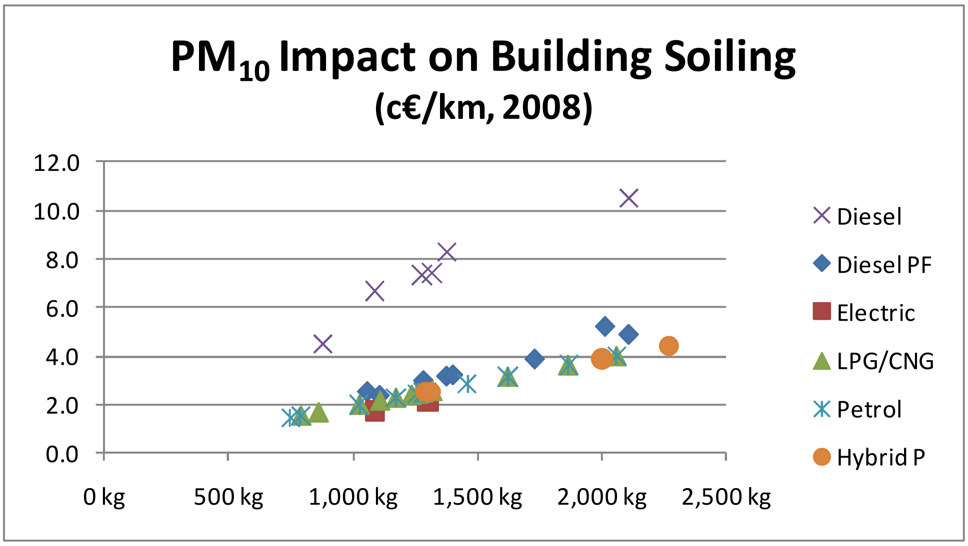


Graph 16: O_3 Impact on Health

III.8.B. Impact of PM_{10} on Buildings

The impacts of PM_{10} emissions on buildings follow the same pattern as for health impacts. For this case, non-exhaust emissions are integrated in the modelling. The results show that these emissions could be one of the main external costs of vehicles. But high uncertainties are related to the amount, the composition and the impacts of non-exhaust emissions and essentially reflect the lack of scientific publications on this subject. Future evaluations of environmental external costs of vehicle should concentrate on the evolution of knowledge in this domain. At the opposite, impact of exhaust emissions of PM_{10} on health and building soiling is rather well-known.

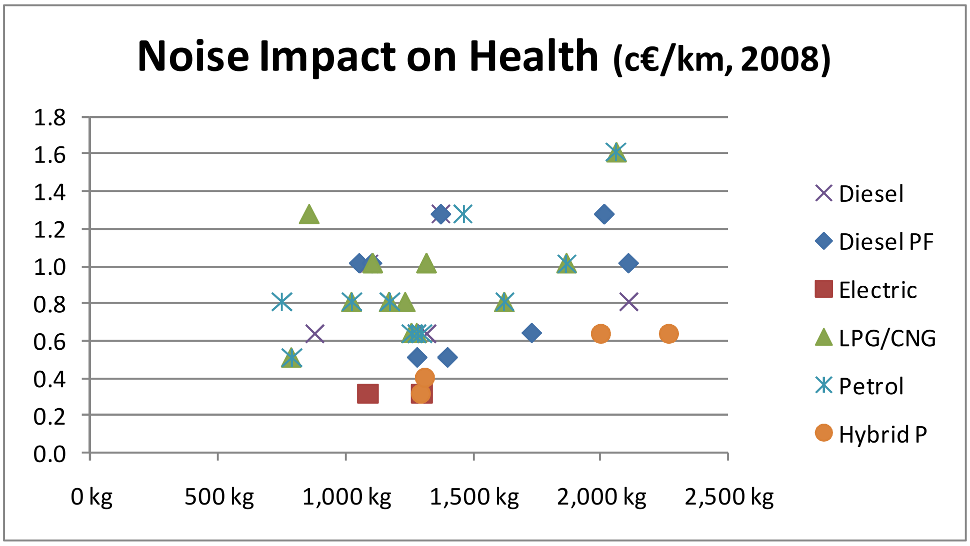
The average marginal external costs are again important for all types of cars (c€ 1.5 – 10.5 /km), and are well correlated with the weight of the cars (Graph 17). Diesel cars with their high exhaust PM emissions are roughly three times as damaging as electric cars.



Graph 17: PM_{10} Impact on Building Soiling

III.8.C. Impact of Noise on health

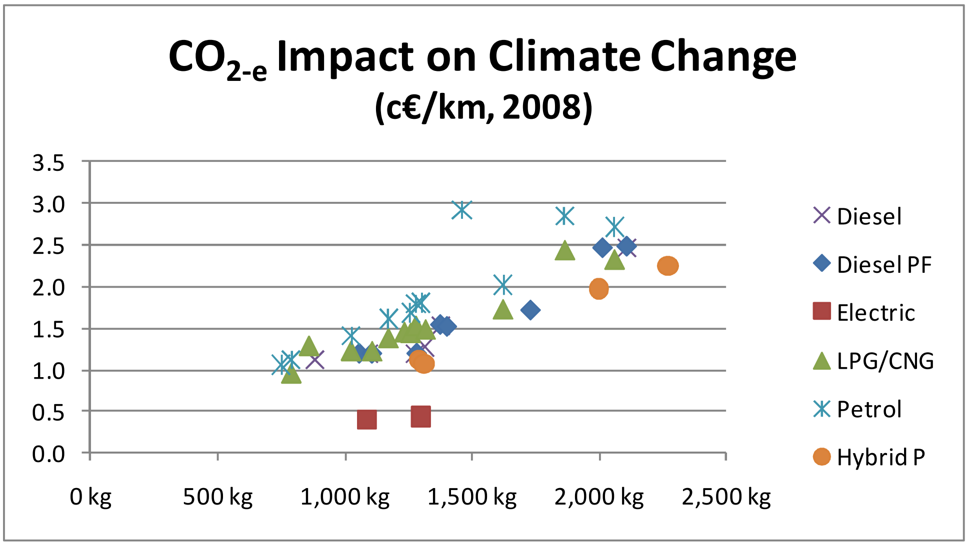
Graph 18 clearly shows that <u>there are no clear links between noise</u> levels from all types of cars, except for electric cars that are the most silent.



Graph 18. Noise Impact on Health

III.8.D. Impact of GHG

In the baseline scenario where the valuation of a ton CO_2 e corresponds to € 90, the marginal external costs of the emissions of the selected set of vehicles are more or less in the range (c€ 0.96 – 2.93 /km) for all motorisation systems, with the noticeable exception of the electric cars for which costs are around (around c€ 0.4 /km).



Graph 19. CO2 Impact on Climate Change

III.9 Total Marginal External Costs

III.9.A. Analysis of external costs by engine type and vehicle weight

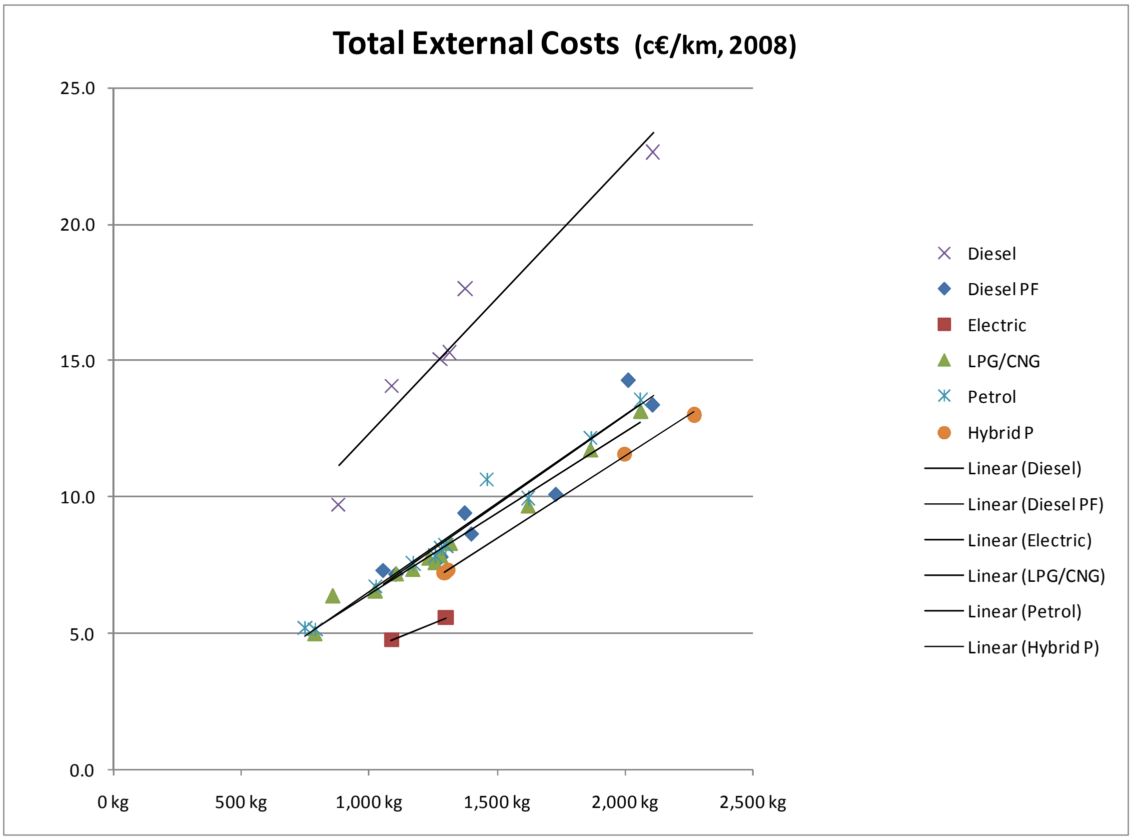
To get a better idea of the impact of the motorisation system on the total marginal external costs, the relation between external costs and vehicle weight has been analysed for the different engine types. Graph 20 represents this relation. It clearly shows that, for each engine type, a linear relationship exists between external costs and weight.

From this graph, we can make a number of observations:

The total marginal external costs range from c€ 4.75/km for a supermini electric car to c€ 22.6/km for a diesel SUV without particulate filter.

One can easily observe a progressive increase of the external costs with the size and thus the weight of the car.

In all scenarios, diesel cars without a particulate filter clearly give the highest marginal external costs, while costs for electric cars always remain the lowest. The positive impact of particulate filters on diesel motorisation is also obvious.



Graph 20: Total external costs per engine type and vehicle weight

Comparing the other technologies, Graph 20 indicates that, for a given weight, hybrid cars show better environmental performances, approximately 15% better than conventional motorisation system (Diesel PF, LPG/CNG, Petrol). Similarly, electric vehicles have external costs about 35% below those technologies.

However, both hybrid and electric vehicles carry extra weight related to their technology (additional electric motor, batteries, etc.). If a hybrid vehicle requires 225 kg of additional equipment compared to a conventional motorisation system, the benefit of this technology becomes insignificant. For electric vehicle, the equivalence of external costs is reached if the electric vehicle is 400 kg heavier than the conventional motorisation systems of the same size.

These results are confirmed for the six scenarios as a whole

III.9.B. Impact of the six scenarios on the total marginal external costs

When comparing evaluation of total marginal external costs of the different engine types for the six scenarios/sets, we can draw a number of observations:

- The impact of the price of the ton of CO_2 e (from € 25 to € 90) is relatively low on the total external costs. Indeed, the costs related to climate change are around 10% using the €90/t.
- Changing scenario mainly has an effect of increasing all figures and changing the proportion between different components of the external cost, but the conclusions that can be drawn while comparing technologies remain the same.
- In all scenarios, diesel cars without particulate filter have the highest environmental costs, while costs for electric cars always remain the lowest.
- The very positive impact of particulate filters on diesel motorisation is very obvious in all scenarios.

SECTION IV. CONCLUSION

The Brussels Capital Region is committed to cutting its air pollutant emissions significantly, in order to improve the urban air quality and to reduce the emissions of its greenhouse gases. Among the policy measures to be taken, the choice of clean vehicles has been considered as an interesting option.

External costs for two samples of cars (53, 43) were assessed following the impact pathway methodology (ExternE, 2005). Impact categories assessed cover (i) health costs due to exhaust and non-exhaust particulate matter, and to ozone; (ii) building damage costs arising from exhaust and non-exhaust particulate matter and SO_2; (iii) noise costs; (iv) climate change costs. These external costs were assessed for the particular case of the Brussels Capital Region (meaning that most impacts outside the city are not taken into account) and compared according to the main characteristics of the car sample: car size segmentation and fuel type or motorisation system aswell as expressed per weight. Only for the climate change aspects we have considered the total emissions, WTT and TTW as climate change is related to the total GHG emissions. For all other aspects, health, building soiling and noise, only the local emissions impacts (TTW) have been assessed.

Diesel cars not equipped with a particulate filter are associated with the highest total external cost, reaching c€ 22.6/km for a SUV in the most realistic scenario. Diesel vehicles equipped with particulate filters have the second highest total external cost, though they are much closer to those of the petrol, LPG, CNG, Flexifuel and Biofuel engines. At the opposite, electric cars 5seem to generate the lowest impacts (c€ 4.75/km). Hybrid car also prove to have lower external costs than any other technology for vehicles of same weight. This assessment does not allow direct comparison of Flexifuel and Biofuel vehicles as the emissions have been measured according to different homologation procedures.

Globally, external costs are proportional to the weight of the vehicle and are thus highly correlated with the car size. A good correlation between the marginal external costs and the vehicle weight is also observed for PM_{10}, GHG, but not for noise. For ozone, mainly diesel vehicles are the source of local marginal benefits correlated with the car weight.

As a whole, the total marginal external costs are proportional to the weight of the vehicle and are thus highly correlated with the car size for the different engine types. Diesel cars not equipped with a particulate filter are associated with the highest total marginal external cost, reaching c€ 22.6/km for a diesel SUV in the most realistic scenario. Diesel vehicles equipped with particulate filters have the second highest total marginal external cost, though they are much closer to those of the petrol, LPG and CNG engines. At the opposite, electric cars seem to generate the lowest impacts (c€ 4.81/km). Hybrid car also prove to have lower external costs than any other technology for vehicles of same weight, but the advantage can be lost in this technology requires more than 225 kg of additional equipments.

Considering the pollution category, health represent 39% of the total marginal external costs, followed by building damage and climate change costs (33 and 17%, respectively). Noise costs account for about 9% of the total external cost. Ozone related health benefits represent ~1% of the average total amount. This last figure must probably be re-estimated because the simple dispersion model used which does not reflect the reality of ozone summer peaks and which concerns only the impact on the Brussels Capital population. This should be improved in further studies.

The study also clearly shows the predominance of PM related impacts in the total societal costs. More specifically, non-exhaust PM could be the main cost driver. At the current stage of knowledge, however, non-exhaust PM emissions and their specific impacts on health and building damage are surrounded by a great margin of uncertainty. Further scientific evidence in these matters should be taken into consideration in future similar studies. The effects of re-suspended particles, especially in densely populated areas, should also be included in such analyses.

Other ways of refining the results may be: (i) to enlarge the area covered by the dispersion model - this can be done either through developing new models (for other cities, for the countryside, or on a national scale) or by applying an updated benefit-transfer method to the present results; (ii) to improve integration of TTW emissions in the overall assessment - this also implies developing long-range/high altitude dispersion models; (iii) to include more impact categories in the external costs assessment, particularly impacts on ecosystem degradation. The assessment remains delicate, given the complexities and unknowns surrounding the mechanisms associated with the impact of pollution by vehicles.

This study demonstrates that the implementation of transfer approach for assessing external costs of air pollution remains a delicate exercise, given the number of uncertainties and unknown features surrounding the mechanisms associated with the impact of pollution by vehicles. The results of this study can give an interesting signal to the decision makers concerned about the quality of the urban environment and its relationship with vehicles categories but should be considered with great caution.

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APPENDICES

Appendix 1: Data used for the external costs assessment

			Global warming (WTW)			Exhaust emmissions (TTW)			Non-exhaust emmissions (particulate matter)			Other data	
			g/km	g/km	g/km	g/km	g/km	g/km	g/km	g/km	g/km	kg	dB(A)
Id	**Nom/DB**	**Group**	**CO2**	**N20**	**CH4**	**PM10**	**NOx**	**SO2**	**Road**	**Brake**	**Tyre**	**Weight**	**Noise Level**
1	CITROEN 1.0 TENTATION	Supermini P	121.3	0.005	0.045	0.000	0.010	0.003	0.0043	0.0042	0.0037	790	70
2	CITROEN 1.4HDI SEDUCTION	Supermini D	121.1	0.008	0.033	0.011	0.240	0.004	0.0048	0.0047	0.0041	880	71
3	CITROEN 1.6HDI FAP VTS	Supermini D PF	130.0	0.008	0.036	0.002	0.183	0.004	0.0058	0.0056	0.0049	1,055	73
4	CITROEN 1.0 TENTATION LPG	Supermini LPG	103.7	0.005	0.043	0.000	0.010	0.001	0.0043	0.0042	0.0037	790	70
5	FIAT 1.2 NATURAL POWER	Supermini CNG	121.2	0.005	0.572	0.000	0.011	0.000	0.0060	0.0059	0.0052	1,108	73
6	PEUGEOT Electric	Supermini E	43.6	0.000	0.038	0.000	0.000	0.000	0.0059	0.0029	0.0051	1,087	68
7	SMART 1.0 52 MHD PULSE	Supermini P	115.7	0.005	0.044	0.000	0.012	0.003	0.0041	0.0040	0.0035	750	72
8	FIAT 1.4 DUALOGIC 360°	SmallCC P	153.2	0.005	0.053	0.000	0.031	0.004	0.0056	0.0054	0.0048	1,025	72
9	FIAT 1.3MJTD51	SmallCC D	130.0	0.008	0.036	0.018	0.207	0.004	0.0059	0.0058	0.0051	1,090	73
10	FIAT 1.3MJTD55 DPF 360°	SmallCC D PF	130.0	0.008	0.036	0.001	0.160	0.004	0.0060	0.0059	0.0051	1,105	73
11	FIAT 1.4 DUALOGIC LPG	SmallCC LPG	133.6	0.005	0.050	0.000	0.031	0.001	0.0056	0.0054	0.0048	1,025	72
12	FIAT 1.2 Classic Natural Power	SmallCC CNG	127.8	0.005	0.601	0.000	0.020	0.000	0.0047	0.0046	0.0040	860	74
13	FORD 1.4 AMBIENTE	SmallFC P	176.5	0.005	0.057	0.000	0.038	0.005	0.0064	0.0062	0.0055	1,172	72
14	FORD 1.6TDCI66 GHIA	SmallFC D	129.0	0.008	0.036	0.019	0.205	0.004	0.0070	0.0068	0.0059	1,277	71
15	FORD 1.6TDCI80 DPF GHIA	SmallFC D PF	130.0	0.008	0.036	0.002	0.188	0.004	0.0070	0.0068	0.0060	1,282	70
16	FORD 1.4 AMBIENTE LPG	SmallFC LPG	150.8	0.005	0.054	0.000	0.038	0.001	0.0064	0.0062	0.0055	1,172	72
17	CITROEN 1.6HDI80 DPF diesel	SmallFC D PF	166.6	0.008	0.043	0.001	0.638	0.001	0.0070	0.0068	0.0060	1,280	73
18	CITROEN 1.6 HDI B5	SmallFC B5 PF	177.2	0.008	0.043	0.001	0.613	0.000	0.0070	0.0068	0.0060	1,280	73
19	CITROEN 1.6 HDI B10	SmallFC B10 PF	177.2	0.008	0.040	0.001	0.580	0.000	0.0070	0.0068	0.0060	1,280	73
20	CITROEN 1.6 HDI B30	SmallFC B30 PF	185.4	0.008	0.033	0.001	0.632	0.000	0.0070	0.0068	0.0060	1,280	73
21	CITROEN 1.6 HDI B100	SmallFC B100 PF	233.0	0.008	0.010	0.001	0.712	0.000	0.0070	0.0068	0.0060	1,280	73
22	MERCEDES B 170 NGT	SmallFC CNG	144.8	0.005	0.659	0.000	0.017	0.000	0.0067	0.0066	0.0057	1,235	72
23	OPEL Impuls "Zebra"	SmallFC E	47.5	0.000	0.042	0.000	0.000	0.000	0.0071	0.0035	0.0061	1,300	68
24	HONDA 1.3 HYBRID Comfort	SmallFC P H	122.6	0.005	0.046	0.000	0.012	0.003	0.0071	0.0069	0.0060	1,293	68
25	VOLVO 1.8 SUMMUM	BigFC P	195.6	0.005	0.061	0.000	0.022	0.005	0.0070	0.0068	0.0060	1,280	71
26	VOLVO 2.0 diesel 100 kW	BigFC D	167.2	0.008	0.043	0.022	0.245	0.005	0.0075	0.0073	0.0064	1,375	74
27	VOLVO 2.0D FAP SUMMUM	BigFC D PF	168.2	0.008	0.043	0.002	0.159	0.005	0.0075	0.0073	0.0064	1,375	74
28	VOLVO 1.8 SUMMUM LPG	BigFC LPG	167.1	0.005	0.058	0.000	0.022	0.002	0.0070	0.0068	0.0060	1,280	71
29	TOYOTA 1.5VVT-I HYBRID ECVT LUNA	BigFC P H	116.7	0.005	0.044	0.000	0.010	0.003	0.0071	0.0070	0.0061	1,310	69
30	VOLVO 1.8 FLEXIFUEL Euro95	BigFC P	197.5	0.005	0.062	0.000	0.017	0.006	0.0071	0.0069	0.0060	1,299	71
31	VOLVO 1.8 FLEXIFUEL E5	BigFC FlexE5	201.6	0.014	0.061	0.000	0.017	0.000	0.0071	0.0069	0.0060	1,299	71
32	VOLVO 1.8 FLEXIFUEL E10	BigFC FlexE10	207.1	0.025	0.060	0.000	0.020	0.000	0.0071	0.0069	0.0060	1,299	71
33	VOLVO 1.8 FLEXIFUEL E20	BigFC FlexE20	219.0	0.047	0.059	0.000	0.019	0.000	0.0071	0.0069	0.0060	1,299	71
34	VOLVO 1.8 FLEXIFUEL E85	BigFC FlexE85	301.3	0.260	0.030	0.000	0.029	0.000	0.0071	0.0069	0.0060	1,299	71
35	FORD 1.6I AMBIENTE	SmallMV P	184.4	0.005	0.059	0.000	0.050	0.005	0.0069	0.0067	0.0059	1,259	71
36	FORD 1.6TDCI66 TREND	SmallMV D	138.5	0.008	0.037	0.019	0.205	0.004	0.0072	0.0070	0.0061	1,316	71
37	FORD 1.6TDCI80 DURASH. CVT AMBIENTE	SmallMV D PF	165.7	0.008	0.037	0.002	0.193	0.004	0.0076	0.0074	0.0065	1,401	70
38	FORD 1.6I AMBIENTE LPG	SmallMV LPG	157.5	0.005	0.055	0.000	0.050	0.001	0.0069	0.0067	0.0059	1,259	71
39	OPEL 1.6 CNG ENJOY	SmallMV CNG	148.1	0.005	0.674	0.000	0.043	0.000	0.0072	0.0070	0.0061	1,318	73
40	FORD 2.0I AMBIENTE	MV P	221.3	0.005	0.066	0.000	0.052	0.006	0.0088	0.0086	0.0075	1,622	72
41	FORD 2.0TDCI103 AMBIENTE	MV D	187.4	0.008	0.046	0.046	0.279	0.005	0.0094	0.0092	0.0080	1,724	71
42	FORD 2.0TDCI103 DPF AMBIENTE	MV D PF	187.4	0.008	0.046	0.002	0.327	0.005	0.0094	0.0092	0.0081	1,731	71
43	FORD 2.0I AMBIENTE LPG	MV LPG	189.1	0.005	0.062	0.000	0.052	0.002	0.0088	0.0086	0.0075	1,622	72
44	MERCEDES S 500	Exclusive P	313.6	0.005	0.086	0.000	0.031	0.009	0.0102	0.0099	0.0087	1,865	73
45	MERCEDES S 420CDI	Exclusive D PF	270.0	0.008	0.063	0.005	0.227	0.008	0.0110	0.0107	0.0094	2,015	74
46	MERCEDES S 500 LPG	Exclusive LPG	268.0	0.005	0.080	0.000	0.031	0.001	0.0102	0.0099	0.0087	1,865	73
47	LEXUS 600H	Exclusive P H	246.2	0.005	0.071	0.000	0.020	0.007	0.0124	0.0121	0.0106	2,270	71
48	PORSCHE 3.8 CARRERA 2 S TIPTRONIC	Sport P	321.5	0.005	0.088	0.000	0.038	0.009	0.0080	0.0078	0.0068	1,460	74
49	MERCEDES ML 350	SUV P	298.9	0.005	0.082	0.000	0.011	0.008	0.0112	0.0109	0.0096	2,060	75
50	MERCEDES ML 320CDI165	SUV D	271.0	0.008	0.063	0.025	0.250	0.002	0.0115	0.0112	0.0098	2,110	72
51	MERCEDES ML 320CDI165 DPF	SUV D PF	272.0	0.008	0.063	0.003	0.316	0.002	0.0115	0.0112	0.0098	2,110	73
52	MERCEDES ML 350 LPG	SUV LPG	255.5	0.005	0.077	0.000	0.011	0.002	0.0112	0.0109	0.0096	2,060	75
53	LEXUS 400H	SUV P H	216.0	0.005	0.065	0.000	0.000	0.006	0.0109	0.0106	0.0093	2,000	71
	Min		43.6	0.000	0.010	0.000	0.000	0.000	0.0041	0.0029	0.0035	750	68
	Max		321.5	0.260	0.674	0.046	0.712	0.009	0.0124	0.0121	0.0106	2,270	75
	Average		179.7	0.012	0.095	0.003	0.138	0.003	0.0075	0.0072	0.0064	1,375	72
	Standard deviation		63.1	0.035	0.155	0.009	0.188	0.003	0.0020	0.0021	0.0017	366	2

Appendix 2: External costs per vehicle for each scenario

Scenario Base 90

				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Id	Nom/DB		Weight	Noise	H O3[1]	H PM[2]	B PM[3]	B SO2[4]	CC[5]	Total	%Noise	%H O3	%H PM	%B PM	%B SO2	%CC
1	CITROEN 1.0 TENTATION	Petrol	790	0.500	-0.027	2.033	1.557	1.15E-03	1.115	**5.18**	10%	-1%	39%	30%	0%	22%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.630	-0.640	4.101	4.547	1.19E-03	1.118	**9.76**	6%	-7%	42%	47%	0%	11%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	1.000	-0.488	3.049	2.591	1.30E-03	1.199	**7.35**	14%	-7%	41%	35%	0%	16%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.500	-0.027	2.033	1.557	3.18E-04	0.956	**5.02**	10%	-1%	41%	31%	0%	19%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	1.000	-0.029	2.851	2.184		1.223	**7.23**	14%	0%	39%	30%	0%	17%
6	PEUGEOT Electric	Electric	1,087	0.315	0.000	2.316	1.774		0.401	**4.81**	7%	0%	48%	37%	0%	8%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.794	-0.032	1.930	1.478	1.09E-03	1.064	**5.24**	15%	-1%	37%	28%	0%	20%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.794	-0.083	2.638	2.020	1.49E-03	1.403	**6.77**	12%	-1%	39%	30%	0%	21%
9	FIAT 1.3MJTD51	Diesel	1,090	1.000	-0.552	5.776	6.699	1.30E-03	1.199	**14.12**	7%	-4%	41%	47%	0%	8%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	1.000	-0.426	3.011	2.434	1.30E-03	1.199	**7.22**	14%	-6%	42%	34%	0%	17%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.794	-0.083	2.638	2.020	4.10E-04	1.226	**6.60**	12%	-1%	40%	31%	0%	19%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.260	-0.053	2.213	1.695		1.288	**6.40**	20%	-1%	35%	26%	0%	20%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.794	-0.101	3.016	2.310	1.68E-03	1.614	**7.63**	10%	-1%	40%	30%	0%	21%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.630	-0.546	6.458	7.375	1.29E-03	1.190	**15.11**	4%	-4%	43%	49%	0%	8%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.500	-0.501	3.633	3.038	1.30E-03	1.199	**7.87**	6%	-6%	46%	39%	0%	15%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.794	-0.101	3.016	2.310	4.64E-04	1.381	**7.40**	11%	-1%	41%	31%	0%	19%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	1.000	-1.701	3.461	2.779	2.71E-04	1.529	**7.07**	14%	-24%	49%	39%	0%	22%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	1.000	-1.633	3.461	2.779		1.625	**7.23**	14%	-23%	48%	38%	0%	22%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	1.000	-1.546	3.461	2.779		1.624	**7.32**	14%	-21%	47%	38%	0%	22%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	1.000	-1.685	3.461	2.779		1.697	**7.25**	14%	-23%	48%	38%	0%	23%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	1.000	-1.897	3.461	2.779		2.121	**7.46**	13%	-25%	46%	37%	0%	28%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.794	-0.045	3.178	2.434		1.453	**7.81**	10%	-1%	41%	31%	0%	19%
23	OPEL Impuls "Zebra"	Electric	1,300	0.315	0.000	2.770	2.121		0.437	**5.64**	6%	0%	49%	38%	0%	8%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.315	-0.032	3.327	2.548	1.17E-03	1.126	**7.29**	4%	0%	46%	35%	0%	15%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.630	-0.059	3.294	2.523	1.86E-03	1.786	**8.18**	8%	-1%	40%	31%	0%	22%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.260	-0.653	7.211	8.335	1.67E-03	1.535	**17.69**	7%	-4%	41%	47%	0%	9%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.260	-0.424	3.872	3.221	1.68E-03	1.544	**9.48**	13%	-4%	41%	34%	0%	16%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.630	-0.059	3.294	2.523	5.15E-04	1.529	**7.92**	8%	-1%	42%	32%	0%	19%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.397	-0.027	3.371	2.582	1.11E-03	1.073	**7.40**	5%	0%	46%	35%	0%	15%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.630	-0.046	3.343	2.560	1.89E-03	1.804	**8.29**	8%	-1%	40%	31%	0%	22%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.630	-0.044	3.343	2.560		1.865	**8.35**	8%	-1%	40%	31%	0%	22%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.630	-0.053	3.343	2.560		1.942	**8.42**	7%	-1%	40%	30%	0%	23%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.630	-0.050	3.343	2.560		2.109	**8.59**	7%	-1%	39%	30%	0%	25%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.630	-0.078	3.343	2.560		3.410	**9.87**	6%	-1%	34%	26%	0%	35%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.630	-0.133	3.240	2.481	1.75E-03	1.685	**7.91**	8%	-2%	41%	31%	0%	21%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.630	-0.546	6.558	7.452	1.35E-03	1.275	**15.37**	4%	-4%	43%	48%	0%	8%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.500	-0.514	3.939	3.273	1.38E-03	1.521	**8.72**	6%	-6%	45%	38%	0%	17%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.630	-0.133	3.240	2.481	4.84E-04	1.443	**7.66**	8%	-2%	42%	32%	0%	19%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	1.000	-0.115	3.392	2.598		1.485	**8.36**	12%	-1%	41%	31%	0%	18%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.794	-0.139	4.174	3.197	2.11E-03	2.018	**10.05**	8%	-1%	42%	32%	0%	20%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.630	-0.743	12.115	15.159	1.80E-03	1.717	**28.88**	2%	-3%	42%	52%	0%	6%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.630	-0.871	4.788	3.923	1.80E-03	1.717	**10.19**	6%	-9%	47%	39%	0%	17%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.794	-0.139	4.174	3.197	5.83E-04	1.729	**9.76**	8%	-1%	43%	33%	0%	18%
44	MERCEDES S 500	Petrol	1,865	1.000	-0.083	4.800	3.676	2.98E-03	2.854	**12.25**	8%	-1%	39%	30%	0%	23%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.260	-0.605	6.020	5.250	2.69E-03	2.464	**14.39**	9%	-4%	42%	36%	0%	17%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	1.000	-0.083	4.800	3.676	3.78E-04	2.442	**11.84**	8%	-1%	41%	31%	0%	21%
47	LEXUS 600H	Hybrid P	2,270	0.630	-0.053	5.842	4.474	2.34E-03	2.244	**13.14**	5%	0%	44%	34%	0%	17%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.260	-0.101	3.757	2.878	3.06E-03	2.925	**10.72**	12%	-1%	35%	27%	0%	27%
49	MERCEDES ML 350	Petrol	2,060	1.588	-0.029	5.301	4.060	2.85E-03	2.720	**13.64**	12%	0%	39%	30%	0%	20%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.794	-0.666	9.603	10.551	5.41E-04	2.473	**22.75**	3%	-3%	42%	46%	0%	11%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	1.000	-0.842	5.931	4.926	5.41E-04	2.482	**13.50**	7%	-6%	44%	36%	0%	18%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.588	-0.029	5.301	4.060	7.86E-04	2.329	**13.25**	12%	0%	40%	31%	0%	18%
53	LEXUS 400H	Hybrid P	2,000	0.630	0.000	5.147	3.942	2.05E-03	1.971	**11.69**	5%	0%	44%	34%	0%	17%
	Min		750	0.315	-1.897	1.930	1.478	2.71E-04	0.401	**4.81**	2%	-25%	34%	26%	0%	6%
	Max		2,270	1.588	0.000	12.115	15.159	3.06E-03	3.410	**28.88**	20%	0%	49%	52%	0%	35%
	Average		1,375	0.812	-0.369	4.098	3.582	1.38E-03	1.669	**9.79**	**9%**	**-4%**	**42%**	**35%**	**0%**	**18%**
	Standard deviation		366	0.294	0.501	1.845	2.418	7.58E-04	0.599	**4.40**	4%	7%	3%	6%	0%	6%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Scenario Low 90

				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Id	**Nom/DB**		**Weight**	**Noise**	**H O3[1]**	**H PM[2]**	**B PM[3]**	**B SO2[4]**	**CC[5]**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
1	CITROEN 1.0 TENTATION	Petrol	790	0.475	-0.027	2.033		1.15E-03	1.115	**3.60**	13%	-1%	57%	0%	0%	31%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.599	-0.640	4.101	2.812	1.19E-03	1.118	**7.99**	7%	-8%	51%	35%	0%	14%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	0.951	-0.488	3.049	0.511	1.30E-03	1.199	**5.22**	18%	-9%	58%	10%	0%	23%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.475	-0.027	2.033		3.18E-04	0.956	**3.44**	14%	-1%	59%	0%	0%	28%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	0.951	-0.029	2.851			1.223	**5.00**	19%	-1%	57%	0%	0%	24%
6	PEUGEOT Electric	Electric	1,087	0.300	0.000	2.316			0.401	**3.02**	10%	0%	77%	0%	0%	13%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.755	-0.032	1.930		1.09E-03	1.064	**3.72**	20%	-1%	52%	0%	0%	29%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.755	-0.083	2.638		1.49E-03	1.403	**4.71**	16%	-2%	56%	0%	0%	30%
9	FIAT 1.3MJTD51	Diesel	1,090	0.951	-0.552	5.776	4.551	1.30E-03	1.199	**11.93**	8%	-5%	48%	38%	0%	10%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	0.951	-0.426	3.011	0.256	1.30E-03	1.199	**4.99**	19%	-9%	60%	5%	0%	24%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.755	-0.083	2.638		4.10E-04	1.226	**4.54**	17%	-2%	58%	0%	0%	27%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.198	-0.053	2.213			1.288	**4.65**	26%	-1%	48%	0%	0%	28%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.755	-0.101	3.016		1.68E-03	1.614	**5.29**	14%	-2%	57%	0%	0%	31%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.599	-0.546	6.458	4.858	1.29E-03	1.190	**12.56**	5%	-4%	51%	39%	0%	9%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.475	-0.501	3.633	0.511	1.30E-03	1.199	**5.32**	9%	-9%	68%	10%	0%	23%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.755	-0.101	3.016		4.64E-04	1.381	**5.05**	15%	-2%	60%	0%	0%	27%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	0.951	-1.701	3.461	0.256	2.71E-04	1.529	**4.50**	21%	-38%	77%	6%	0%	34%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	0.951	-1.633	3.461	0.256		1.625	**4.66**	20%	-35%	74%	5%	0%	35%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	0.951	-1.546	3.461	0.256		1.624	**4.75**	20%	-33%	73%	5%	0%	34%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	0.951	-1.685	3.461	0.256		1.697	**4.68**	20%	-36%	74%	5%	0%	36%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	0.951	-1.897	3.461	0.256		2.121	**4.89**	19%	-39%	71%	5%	0%	43%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.755	-0.045	3.178			1.453	**5.34**	14%	-1%	60%	0%	0%	27%
23	OPEL Impuls "Zebra"	Electric	1,300	0.300	0.000	2.770			0.437	**3.51**	9%	0%	79%	0%	0%	12%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.300	-0.032	3.327		1.17E-03	1.126	**4.72**	6%	-1%	70%	0%	0%	24%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.599	-0.059	3.294		1.86E-03	1.786	**5.62**	11%	-1%	59%	0%	0%	32%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.198	-0.653	7.211	5.625	1.67E-03	1.535	**14.92**	8%	-4%	48%	38%	0%	10%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.198	-0.424	3.872	0.511	1.68E-03	1.544	**6.70**	18%	-6%	58%	8%	0%	23%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.599	-0.059	3.294		5.15E-04	1.529	**5.36**	11%	-1%	61%	0%	0%	29%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.377	-0.027	3.371		1.11E-03	1.073	**4.80**	8%	-1%	70%	0%	0%	22%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.599	-0.046	3.343		1.89E-03	1.804	**5.70**	11%	-1%	59%	0%	0%	32%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.599	-0.044	3.343			1.865	**5.76**	10%	-1%	58%	0%	0%	32%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.599	-0.053	3.343			1.942	**5.83**	10%	-1%	57%	0%	0%	33%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.599	-0.050	3.343			2.109	**6.00**	10%	-1%	56%	0%	0%	35%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.599	-0.078	3.343			3.410	**7.27**	8%	-1%	46%	0%	0%	47%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.599	-0.133	3.240		1.75E-03	1.685	**5.39**	11%	-2%	60%	0%	0%	31%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.599	-0.546	6.558	4.858	1.35E-03	1.275	**12.75**	5%	-4%	51%	38%	0%	10%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.475	-0.514	3.939	0.511	1.38E-03	1.521	**5.93**	8%	-9%	66%	9%	0%	26%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.599	-0.133	3.240		4.84E-04	1.443	**5.15**	12%	-3%	63%	0%	0%	28%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	0.951	-0.115	3.392			1.485	**5.71**	17%	-2%	59%	0%	0%	26%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.755	-0.139	4.174		2.11E-03	2.018	**6.81**	11%	-2%	61%	0%	0%	30%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.599	-0.743	12.115	11.761	1.80E-03	1.717	**25.45**	2%	-3%	48%	46%	0%	7%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.599	-0.871	4.788	0.511	1.80E-03	1.717	**6.75**	9%	-13%	71%	8%	0%	25%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.755	-0.139	4.174		5.83E-04	1.729	**6.52**	12%	-2%	64%	0%	0%	27%
44	MERCEDES S 500	Petrol	1,865	0.951	-0.083	4.800		2.98E-03	2.854	**8.52**	11%	-1%	56%	0%	0%	33%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.198	-0.605	6.020	1.278	2.69E-03	2.464	**10.36**	12%	-6%	58%	12%	0%	24%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	0.951	-0.083	4.800		3.78E-04	2.442	**8.11**	12%	-1%	59%	0%	0%	30%
47	LEXUS 600H	Hybrid P	2,270	0.599	-0.053	5.842		2.34E-03	2.244	**8.63**	7%	-1%	68%	0%	0%	26%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.198	-0.101	3.757		3.06E-03	2.925	**7.78**	15%	-1%	48%	0%	0%	38%
49	MERCEDES ML 350	Petrol	2,060	1.509	-0.029	5.301		2.85E-03	2.720	**9.50**	16%	0%	56%	0%	0%	29%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.755	-0.666	9.603	6.392	5.41E-04	2.473	**18.56**	4%	-4%	52%	34%	0%	13%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	0.951	-0.842	5.931	0.767	5.41E-04	2.482	**9.29**	10%	-9%	64%	8%	0%	27%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.509	-0.029	5.301		7.86E-04	2.329	**9.11**	17%	0%	58%	0%	0%	26%
53	LEXUS 400H	Hybrid P	2,000	0.599	0.000	5.147		2.05E-03	1.971	**7.72**	8%	0%	67%	0%	0%	26%
	Min		750	0.300	-1.897	1.930	0.256	2.71E-04	0.401	**3.02**	2%	-39%	46%	0%	0%	7%
	Max		2,270	1.509	0.000	12.115	11.761	3.06E-03	3.410	**25.45**	26%	0%	79%	46%	0%	47%
	Average		1,375	0.772	-0.369	4.098	2.350	1.38E-03	1.669	**7.06**	**13%**	**-6%**	**60%**	**7%**	**0%**	**26%**
	Standard deviation		366	0.280	0.501	1.845	3.079	7.58E-04	0.599	**3.97**	5%	10%	8%	13%	0%	8%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Scenario High 90

				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Id	**Nom/DB**		**Weight**	**Noise**	**H O3**[1]	**H PM**[2]	**B PM**[3]	**B SO2**[4]	**CC**[5]	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
1	CITROEN 1.0 TENTATION	Petrol	790	0.500	-0.027	2.033	3.114	1.15E-03	1.115	**6.74**	7%	0%	30%	46%	0%	17%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.630	-0.640	4.101	6.281	1.19E-03	1.118	**11.49**	5%	-6%	36%	55%	0%	10%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	1.000	-0.488	3.049	4.670	1.30E-03	1.199	**9.43**	11%	-5%	32%	50%	0%	13%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.500	-0.027	2.033	3.114	3.18E-04	0.956	**6.58**	8%	0%	31%	47%	0%	15%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	1.000	-0.029	2.851	4.368		1.223	**9.41**	11%	0%	30%	46%	0%	13%
6	PEUGEOT Electric	Electric	1,087	0.315	0.000	2.316	3.547		0.401	**6.58**	5%	0%	35%	54%	0%	6%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.794	-0.032	1.930	2.956	1.09E-03	1.064	**6.71**	12%	0%	29%	44%	0%	16%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.794	-0.083	2.638	4.041	1.49E-03	1.403	**8.79**	9%	-1%	30%	46%	0%	16%
9	FIAT 1.3MJTD51	Diesel	1,090	1.000	-0.552	5.776	8.848	1.30E-03	1.199	**16.27**	6%	-3%	35%	54%	0%	7%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	1.000	-0.426	3.011	4.612	1.30E-03	1.199	**9.40**	11%	-5%	32%	49%	0%	13%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.794	-0.083	2.638	4.041	4.10E-04	1.226	**8.62**	9%	-1%	31%	47%	0%	14%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.260	-0.053	2.213	3.390		1.288	**8.10**	16%	-1%	27%	42%	0%	16%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.794	-0.101	3.016	4.620	1.68E-03	1.614	**9.94**	8%	-1%	30%	46%	0%	16%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.630	-0.546	6.458	9.892	1.29E-03	1.190	**17.62**	4%	-3%	37%	56%	0%	7%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.500	-0.501	3.633	5.565	1.30E-03	1.199	**10.40**	5%	-5%	35%	54%	0%	12%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.794	-0.101	3.016	4.620	4.64E-04	1.381	**9.71**	8%	-1%	31%	48%	0%	14%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	1.000	-1.701	3.461	5.301	2.71E-04	1.529	**9.59**	10%	-18%	36%	55%	0%	16%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	1.000	-1.633	3.461	5.301		1.625	**9.75**	10%	-17%	35%	54%	0%	17%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	1.000	-1.546	3.461	5.301		1.624	**9.84**	10%	-16%	35%	54%	0%	17%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	1.000	-1.685	3.461	5.301		1.697	**9.77**	10%	-17%	35%	54%	0%	17%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	1.000	-1.897	3.461	5.301		2.121	**9.99**	10%	-19%	35%	53%	0%	21%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.794	-0.045	3.178	4.868		1.453	**10.25**	8%	0%	31%	48%	0%	14%
23	OPEL Impuls "Zebra"	Electric	1,300	0.315	0.000	2.770	4.242		0.437	**7.76**	4%	0%	36%	55%	0%	6%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.315	-0.032	3.327	5.097	1.17E-03	1.126	**9.83**	3%	0%	34%	52%	0%	11%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.630	-0.059	3.294	5.046	1.86E-03	1.786	**10.70**	6%	-1%	31%	47%	0%	17%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.260	-0.653	7.211	11.045	1.67E-03	1.535	**20.40**	6%	-3%	35%	54%	0%	8%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.260	-0.424	3.872	5.932	1.68E-03	1.544	**12.19**	10%	-3%	32%	49%	0%	13%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.630	-0.059	3.294	5.046	5.15E-04	1.529	**10.44**	6%	-1%	32%	48%	0%	15%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.397	-0.027	3.371	5.164	1.11E-03	1.073	**9.98**	4%	0%	34%	52%	0%	11%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.630	-0.046	3.343	5.121	1.89E-03	1.804	**10.85**	6%	0%	31%	47%	0%	17%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.630	-0.044	3.343	5.121		1.865	**10.91**	6%	0%	31%	47%	0%	17%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.630	-0.053	3.343	5.121		1.942	**10.98**	6%	0%	30%	47%	0%	18%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.630	-0.050	3.343	5.121		2.109	**11.15**	6%	0%	30%	46%	0%	19%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.630	-0.078	3.343	5.121		3.410	**12.43**	5%	-1%	27%	41%	0%	27%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.630	-0.133	3.240	4.963	1.75E-03	1.685	**10.39**	6%	-1%	31%	48%	0%	16%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.630	-0.546	6.558	10.046	1.35E-03	1.275	**17.96**	4%	-3%	37%	56%	0%	7%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.500	-0.514	3.939	6.034	1.38E-03	1.521	**11.48**	4%	-4%	34%	53%	0%	13%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.630	-0.133	3.240	4.963	4.84E-04	1.443	**10.14**	6%	-1%	32%	49%	0%	14%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	1.000	-0.115	3.392	5.196		1.485	**10.96**	9%	-1%	31%	47%	0%	14%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.794	-0.139	4.174	6.394	2.11E-03	2.018	**13.24**	6%	-1%	32%	48%	0%	15%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.630	-0.743	12.115	18.557	1.80E-03	1.717	**32.28**	2%	-2%	38%	57%	0%	5%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.630	-0.871	4.788	7.335	1.80E-03	1.717	**13.60**	5%	-6%	35%	54%	0%	13%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.794	-0.139	4.174	6.394	5.83E-04	1.729	**12.95**	6%	-1%	32%	49%	0%	13%
44	MERCEDES S 500	Petrol	1,865	1.000	-0.083	4.800	7.352	2.98E-03	2.854	**15.93**	6%	-1%	30%	46%	0%	18%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.260	-0.605	6.020	9.221	2.69E-03	2.464	**18.36**	7%	-3%	33%	50%	0%	13%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	1.000	-0.083	4.800	7.352	3.78E-04	2.442	**15.51**	6%	-1%	31%	47%	0%	16%
47	LEXUS 600H	Hybrid P	2,270	0.630	-0.053	5.842	8.948	2.34E-03	2.244	**17.61**	4%	0%	33%	51%	0%	13%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.260	-0.101	3.757	5.755	3.06E-03	2.925	**13.60**	9%	-1%	28%	42%	0%	22%
49	MERCEDES ML 350	Petrol	2,060	1.588	-0.029	5.301	8.120	2.85E-03	2.720	**17.70**	9%	0%	30%	46%	0%	15%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.794	-0.666	9.603	14.710	5.41E-04	2.473	**26.91**	3%	-2%	36%	55%	0%	9%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	1.000	-0.842	5.931	9.085	5.41E-04	2.482	**17.66**	6%	-5%	34%	51%	0%	14%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.588	-0.029	5.301	8.120	7.86E-04	2.329	**17.31**	9%	0%	31%	47%	0%	13%
53	LEXUS 400H	Hybrid P	2,000	0.630	0.000	5.147	7.884	2.05E-03	1.971	**15.63**	4%	0%	33%	50%	0%	13%
	Min		750	0.315	-1.897	1.930	2.956	2.71E-04	0.401	**6.58**	2%	-19%	27%	41%	0%	5%
	Max		2,270	1.588	0.000	12.115	18.557	3.06E-03	3.410	**32.28**	16%	0%	38%	57%	0%	27%
	Average		1,375	0.812	-0.369	4.098	6.277	1.38E-03	1.669	**12.49**	**7%**	**-3%**	**32%**	**50%**	**0%**	**14%**
	Standard deviation		366	0.294	0.501	1.845	2.826	7.58E-04	0.599	**4.89**	3%	5%	3%	4%	0%	4%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Scenario Base 25

				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Id	**Nom/DB**		**Weight**	**Noise**	**H O3^1**	**H PM^2**	**B PM^3**	**B SO2^4**	**CC^5**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
1	CITROEN 1.0 TENTATION	Petrol	790	0.500	-0.027	2.033	1.557	1.15E-03	0.310	**4.37**	11%	-1%	46%	36%	0%	7%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.630	-0.640	4.101	4.547	1.19E-03	0.311	**8.95**	7%	-7%	46%	51%	0%	3%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	1.000	-0.488	3.049	2.591	1.30E-03	0.333	**6.49**	15%	-8%	47%	40%	0%	5%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.500	-0.027	2.033	1.557	3.18E-04	0.265	**4.33**	12%	-1%	47%	36%	0%	6%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	1.000	-0.029	2.851	2.184		0.340	**6.35**	16%	0%	45%	34%	0%	5%
6	PEUGEOT Electric	Electric	1,087	0.315	0.000	2.316	1.774		0.111	**4.52**	7%	0%	51%	39%	0%	2%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.794	-0.032	1.930	1.478	1.09E-03	0.296	**4.47**	18%	-1%	43%	33%	0%	7%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.794	-0.083	2.638	2.020	1.49E-03	0.390	**5.76**	14%	-1%	46%	35%	0%	7%
9	FIAT 1.3MJTD51	Diesel	1,090	1.000	-0.552	5.776	6.699	1.30E-03	0.333	**13.26**	8%	-4%	44%	51%	0%	3%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	1.000	-0.426	3.011	2.434	1.30E-03	0.333	**6.35**	16%	-7%	47%	38%	0%	5%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.794	-0.083	2.638	2.020	4.10E-04	0.340	**5.71**	14%	-1%	46%	35%	0%	6%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.260	-0.053	2.213	1.695		0.358	**5.47**	23%	-1%	40%	31%	0%	7%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.794	-0.101	3.016	2.310	1.68E-03	0.448	**6.47**	12%	-2%	47%	36%	0%	7%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.630	-0.546	6.458	7.375	1.29E-03	0.330	**14.25**	4%	-4%	45%	52%	0%	2%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.500	-0.501	3.633	3.038	1.30E-03	0.333	**7.00**	7%	-7%	52%	43%	0%	5%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.794	-0.101	3.016	2.310	4.64E-04	0.384	**6.40**	12%	-2%	47%	36%	0%	6%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	1.000	-1.701	3.461	2.779	2.71E-04	0.425	**5.96**	17%	-29%	58%	47%	0%	7%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	1.000	-1.633	3.461	2.779		0.451	**6.06**	17%	-27%	57%	46%	0%	7%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	1.000	-1.546	3.461	2.779		0.451	**6.14**	16%	-25%	56%	45%	0%	7%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	1.000	-1.685	3.461	2.779		0.471	**6.03**	17%	-28%	57%	46%	0%	8%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	1.000	-1.897	3.461	2.779		0.589	**5.93**	17%	-32%	58%	47%	0%	10%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.794	-0.045	3.178	2.434		0.404	**6.76**	12%	-1%	47%	36%	0%	6%
23	OPEL Impuls "Zebra"	Electric	1,300	0.315	0.000	2.770	2.121		0.121	**5.33**	6%	0%	52%	40%	0%	2%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.315	-0.032	3.327	2.548	1.17E-03	0.313	**6.47**	5%	0%	51%	39%	0%	5%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.630	-0.059	3.294	2.523	1.86E-03	0.496	**6.89**	9%	-1%	48%	37%	0%	7%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.260	-0.653	7.211	8.335	1.67E-03	0.426	**16.58**	8%	-4%	43%	50%	0%	3%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.260	-0.424	3.872	3.221	1.68E-03	0.429	**8.36**	15%	-5%	46%	39%	0%	5%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.630	-0.059	3.294	2.523	5.15E-04	0.425	**6.81**	9%	-1%	48%	37%	0%	6%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.397	-0.027	3.371	2.582	1.11E-03	0.298	**6.62**	6%	0%	51%	39%	0%	5%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.630	-0.046	3.343	2.560	1.89E-03	0.501	**6.99**	9%	-1%	48%	37%	0%	7%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.630	-0.044	3.343	2.560		0.518	**7.01**	9%	-1%	48%	37%	0%	7%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.630	-0.053	3.343	2.560		0.539	**7.02**	9%	-1%	48%	36%	0%	8%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.630	-0.050	3.343	2.560		0.586	**7.07**	9%	-1%	47%	36%	0%	8%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.630	-0.078	3.343	2.560		0.947	**7.40**	9%	-1%	45%	35%	0%	13%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.630	-0.133	3.240	2.481	1.75E-03	0.468	**6.69**	9%	-2%	48%	37%	0%	7%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.630	-0.546	6.558	7.452	1.35E-03	0.354	**14.45**	4%	-4%	45%	52%	0%	2%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.500	-0.514	3.939	3.273	1.38E-03	0.422	**7.62**	7%	-7%	52%	43%	0%	6%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.630	-0.133	3.240	2.481	4.84E-04	0.401	**6.62**	10%	-2%	49%	37%	0%	6%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	1.000	-0.115	3.392	2.598		0.413	**7.29**	14%	-2%	47%	36%	0%	6%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.794	-0.139	4.174	3.197	2.11E-03	0.561	**8.59**	9%	-2%	49%	37%	0%	7%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.630	-0.743	12.115	15.159	1.80E-03	0.477	**27.64**	2%	-3%	44%	55%	0%	2%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.630	-0.871	4.788	3.923	1.80E-03	0.477	**8.95**	7%	-10%	54%	44%	0%	5%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.794	-0.139	4.174	3.197	5.83E-04	0.480	**8.51**	9%	-2%	49%	38%	0%	6%
44	MERCEDES S 500	Petrol	1,865	1.000	-0.083	4.800	3.676	2.98E-03	0.793	**10.19**	10%	-1%	47%	36%	0%	8%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.260	-0.605	6.020	5.250	2.69E-03	0.684	**12.61**	10%	-5%	48%	42%	0%	5%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	1.000	-0.083	4.800	3.676	3.78E-04	0.678	**10.07**	10%	-1%	48%	36%	0%	7%
47	LEXUS 600H	Hybrid P	2,270	0.630	-0.053	5.842	4.474	2.34E-03	0.623	**11.52**	5%	0%	51%	39%	0%	5%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.260	-0.101	3.757	2.878	3.06E-03	0.813	**8.61**	15%	-1%	44%	33%	0%	9%
49	MERCEDES ML 350	Petrol	2,060	1.588	-0.029	5.301	4.060	2.85E-03	0.756	**11.68**	14%	0%	45%	35%	0%	6%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.794	-0.666	9.603	10.551	5.41E-04	0.687	**20.97**	4%	-3%	46%	50%	0%	3%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	1.000	-0.842	5.931	4.926	5.41E-04	0.689	**11.70**	9%	-7%	51%	42%	0%	6%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.588	-0.029	5.301	4.060	7.86E-04	0.647	**11.57**	14%	0%	46%	35%	0%	6%
53	LEXUS 400H	Hybrid P	2,000	0.630	0.000	5.147	3.942	2.05E-03	0.547	**10.27**	6%	0%	50%	38%	0%	5%
	Min		750	0.315	-1.897	1.930	1.478	2.71E-04	0.111	**4.33**	2%	-32%	40%	31%	0%	2%
	Max		2,270	1.588	0.000	12.115	15.159	3.06E-03	0.947	**27.64**	23%	0%	58%	55%	0%	13%
	Average		1,375	0.812	-0.369	4.098	3.582	1.38E-03	0.464	**8.59**	**11%**	**-5%**	**48%**	**40%**	**0%**	**6%**
	Standard deviation		366	0.294	0.501	1.845	2.418	7.58E-04	0.166	**4.24**	4%	8%	4%	6%	0%	2%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Scenario Low 25

				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Id	**Nom/DB**		**Weight**	**Noise**	**H O3[1]**	**H PM[2]**	**B PM[3]**	**B SO2[4]**	**CC[5]**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
1	CITROEN 1.0 TENTATION	Petrol	790	0.475	-0.027	2.033		1.15E-03	0.310	**2.79**	17%	-1%	73%	0%	0%	11%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.599	-0.640	4.101	2.812	1.19E-03	0.311	**7.18**	8%	-9%	57%	39%	0%	4%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	0.951	-0.488	3.049	0.511	1.30E-03	0.333	**4.36**	22%	-11%	70%	12%	0%	8%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.475	-0.027	2.033		3.18E-04	0.265	**2.75**	17%	-1%	74%	0%	0%	10%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	0.951	-0.029	2.851			0.340	**4.11**	23%	-1%	69%	0%	0%	8%
6	PEUGEOT Electric	Electric	1,087	0.300	0.000	2.316			0.111	**2.73**	11%	0%	85%	0%	0%	4%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.755	-0.032	1.930		1.09E-03	0.296	**2.95**	26%	-1%	65%	0%	0%	10%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.755	-0.083	2.638		1.49E-03	0.390	**3.70**	20%	-2%	71%	0%	0%	11%
9	FIAT 1.3MJTD51	Diesel	1,090	0.951	-0.552	5.776	4.551	1.30E-03	0.333	**11.06**	9%	-5%	52%	41%	0%	3%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	0.951	-0.426	3.011	0.256	1.30E-03	0.333	**4.12**	23%	-10%	73%	6%	0%	8%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.755	-0.083	2.638		4.10E-04	0.340	**3.65**	21%	-2%	72%	0%	0%	9%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.198	-0.053	2.213			0.358	**3.72**	32%	-1%	60%	0%	0%	10%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.755	-0.101	3.016		1.68E-03	0.448	**4.12**	18%	-2%	73%	0%	0%	11%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.599	-0.546	6.458	4.858	1.29E-03	0.330	**11.70**	5%	-5%	55%	42%	0%	3%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.475	-0.501	3.633	0.511	1.30E-03	0.333	**4.45**	11%	-11%	82%	11%	0%	7%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.755	-0.101	3.016		4.64E-04	0.384	**4.05**	19%	-2%	74%	0%	0%	9%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	0.951	-1.701	3.461	0.256	2.71E-04	0.425	**3.39**	28%	-50%	102%	8%	0%	13%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	0.951	-1.633	3.461	0.256		0.451	**3.49**	27%	-47%	99%	7%	0%	13%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	0.951	-1.546	3.461	0.256		0.451	**3.57**	27%	-43%	97%	7%	0%	13%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	0.951	-1.685	3.461	0.256		0.471	**3.45**	28%	-49%	100%	7%	0%	14%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	0.951	-1.897	3.461	0.256		0.589	**3.36**	28%	-56%	103%	8%	0%	18%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.755	-0.045	3.178			0.404	**4.29**	18%	-1%	74%	0%	0%	9%
23	OPEL Impuls "Zebra"	Electric	1,300	0.300	0.000	2.770			0.121	**3.19**	9%	0%	87%	0%	0%	4%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.300	-0.032	3.327		1.17E-03	0.313	**3.91**	8%	-1%	85%	0%	0%	8%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.599	-0.059	3.294		1.86E-03	0.496	**4.33**	14%	-1%	76%	0%	0%	11%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.198	-0.653	7.211	5.625	1.67E-03	0.426	**13.81**	9%	-5%	52%	41%	0%	3%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.198	-0.424	3.872	0.511	1.68E-03	0.429	**5.59**	21%	-8%	69%	9%	0%	8%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.599	-0.059	3.294		5.15E-04	0.425	**4.26**	14%	-1%	77%	0%	0%	10%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.377	-0.027	3.371		1.11E-03	0.298	**4.02**	9%	-1%	84%	0%	0%	7%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.599	-0.046	3.343		1.89E-03	0.501	**4.40**	14%	-1%	76%	0%	0%	11%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.599	-0.044	3.343			0.518	**4.42**	14%	-1%	76%	0%	0%	12%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.599	-0.053	3.343			0.539	**4.43**	14%	-1%	75%	0%	0%	12%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.599	-0.050	3.343			0.586	**4.48**	13%	-1%	75%	0%	0%	13%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.599	-0.078	3.343			0.947	**4.81**	12%	-2%	69%	0%	0%	20%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.599	-0.133	3.240		1.75E-03	0.468	**4.18**	14%	-3%	78%	0%	0%	11%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.599	-0.546	6.558	4.858	1.35E-03	0.354	**11.82**	5%	-5%	55%	41%	0%	3%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.475	-0.514	3.939	0.511	1.38E-03	0.422	**4.84**	10%	-11%	81%	11%	0%	9%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.599	-0.133	3.240		4.84E-04	0.401	**4.11**	15%	-3%	79%	0%	0%	10%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	0.951	-0.115	3.392			0.413	**4.64**	20%	-2%	73%	0%	0%	9%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.755	-0.139	4.174		2.11E-03	0.561	**5.35**	14%	-3%	78%	0%	0%	10%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.599	-0.743	12.115	11.761	1.80E-03	0.477	**24.21**	2%	-3%	50%	49%	0%	2%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.599	-0.871	4.788	0.511	1.80E-03	0.477	**5.51**	11%	-16%	87%	9%	0%	9%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.755	-0.139	4.174		5.83E-04	0.480	**5.27**	14%	-3%	79%	0%	0%	9%
44	MERCEDES S 500	Petrol	1,865	0.951	-0.083	4.800		2.98E-03	0.793	**6.46**	15%	-1%	74%	0%	0%	12%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.198	-0.605	6.020	1.278	2.69E-03	0.684	**8.58**	14%	-7%	70%	15%	0%	8%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	0.951	-0.083	4.800		3.78E-04	0.678	**6.35**	15%	-1%	76%	0%	0%	11%
47	LEXUS 600H	Hybrid P	2,270	0.599	-0.053	5.842		2.34E-03	0.623	**7.01**	9%	-1%	83%	0%	0%	9%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.198	-0.101	3.757		3.06E-03	0.813	**5.67**	21%	-2%	66%	0%	0%	14%
49	MERCEDES ML 350	Petrol	2,060	1.509	-0.029	5.301		2.85E-03	0.756	**7.54**	20%	0%	70%	0%	0%	10%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.755	-0.666	9.603	6.392	5.41E-04	0.687	**16.77**	5%	-4%	57%	38%	0%	4%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	0.951	-0.842	5.931	0.767	5.41E-04	0.689	**7.50**	13%	-11%	79%	10%	0%	9%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.509	-0.029	5.301		7.86E-04	0.647	**7.43**	20%	0%	71%	0%	0%	9%
53	LEXUS 400H	Hybrid P	2,000	0.599	0.000	5.147		2.05E-03	0.547	**6.30**	10%	0%	82%	0%	0%	9%
	Min		750	0.300	-1.897	1.930	0.256	2.71E-04	0.111	**2.73**	2%	-56%	50%	0%	0%	2%
	Max		2,270	1.509	0.000	12.115	11.761	3.06E-03	0.947	**24.21**	32%	0%	103%	49%	0%	20%
	Average		1,375	0.772	-0.369	4.098	2.350	1.38E-03	0.464	**5.85**	**16%**	**-8%**	**75%**	**8%**	**0%**	**9%**
	Standard deviation		366	0.280	0.501	1.845	3.079	7.58E-04	0.166	**3.85**	7%	14%	12%	14%	0%	4%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Scenario High 25

Id	Nom/DB		Weight	Noise	H O3[1]	H PM[2]	B PM[3]	B SO2[4]	CC[5]	Total	%Noise	%H O3	%H PM	%B PM	%B SO2	%CC
				c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
1	CITROEN 1.0 TENTATION	Petrol	790	0.500	-0.027	2.033	3.114	1.15E-03	0.310	**5.93**	8%	0%	34%	53%	0%	5%
2	CITROEN 1.4HDI SEDUCTION	Diesel	880	0.630	-0.640	4.101	6.281	1.19E-03	0.311	**10.68**	6%	-6%	38%	59%	0%	3%
3	CITROEN 1.6HDI FAP VTS	Diesel PF	1,055	1.000	-0.488	3.049	4.670	1.30E-03	0.333	**8.57**	12%	-6%	36%	55%	0%	4%
4	CITROEN 1.0 TENTATION LPG	LPG/CNG	790	0.500	-0.027	2.033	3.114	3.18E-04	0.265	**5.89**	8%	0%	35%	53%	0%	5%
5	FIAT 1.2 NATURAL POWER	LPG/CNG	1,108	1.000	-0.029	2.851	4.368		0.340	**8.53**	12%	0%	33%	51%	0%	4%
6	PEUGEOT Electric	Electric	1,087	0.315	0.000	2.316	3.547		0.111	**6.29**	5%	0%	37%	56%	0%	2%
7	SMART 1.0 52 MHD PULSE	Petrol	750	0.794	-0.032	1.930	2.956	1.09E-03	0.296	**5.95**	13%	-1%	32%	50%	0%	5%
8	FIAT 1.4 DUALOGIC 360°	Petrol	1,025	0.794	-0.083	2.638	4.041	1.49E-03	0.390	**7.78**	10%	-1%	34%	52%	0%	5%
9	FIAT 1.3MJTD51	Diesel	1,090	1.000	-0.552	5.776	8.848	1.30E-03	0.333	**15.41**	6%	-4%	37%	57%	0%	2%
10	FIAT 1.3MJTD55 DPF 360°	Diesel PF	1,105	1.000	-0.426	3.011	4.612	1.30E-03	0.333	**8.53**	12%	-5%	35%	54%	0%	4%
11	FIAT 1.4 DUALOGIC LPG	LPG/CNG	1,025	0.794	-0.083	2.638	4.041	4.10E-04	0.340	**7.73**	10%	-1%	34%	52%	0%	4%
12	FIAT 1.2 Classic Natural Power	LPG/CNG	860	1.260	-0.053	2.213	3.390		0.358	**7.17**	18%	-1%	31%	47%	0%	5%
13	FORD 1.4 AMBIENTE	Petrol	1,172	0.794	-0.101	3.016	4.620	1.68E-03	0.448	**8.78**	9%	-1%	34%	53%	0%	5%
14	FORD 1.6TDCI66 GHIA	Diesel	1,277	0.630	-0.546	6.458	9.892	1.29E-03	0.330	**16.77**	4%	-3%	39%	59%	0%	2%
15	FORD 1.6TDCI80 DPF GHIA	Diesel PF	1,282	0.500	-0.501	3.633	5.565	1.30E-03	0.333	**9.53**	5%	-5%	38%	58%	0%	3%
16	FORD 1.4 AMBIENTE LPG	LPG/CNG	1,172	0.794	-0.101	3.016	4.620	4.64E-04	0.384	**8.71**	9%	-1%	35%	53%	0%	4%
17	CITROEN 1.6HDI80 DPF diesel	Diesel PF	1,280	1.000	-1.701	3.461	5.301	2.71E-04	0.425	**8.49**	12%	-20%	41%	62%	0%	5%
18	CITROEN 1.6 HDI B5	Biodiesel	1,280	1.000	-1.633	3.461	5.301		0.451	**8.58**	12%	-19%	40%	62%	0%	5%
19	CITROEN 1.6 HDI B10	Biodiesel	1,280	1.000	-1.546	3.461	5.301		0.451	**8.67**	12%	-18%	40%	61%	0%	5%
20	CITROEN 1.6 HDI B30	Biodiesel	1,280	1.000	-1.685	3.461	5.301		0.471	**8.55**	12%	-20%	40%	62%	0%	6%
21	CITROEN 1.6 HDI B100	Biodiesel	1,280	1.000	-1.897	3.461	5.301		0.589	**8.45**	12%	-22%	41%	63%	0%	7%
22	MERCEDES B 170 NGT	LPG/CNG	1,235	0.794	-0.045	3.178	4.868		0.404	**9.20**	9%	0%	35%	53%	0%	4%
23	OPEL Impuls "Zebra"	Electric	1,300	0.315	0.000	2.770	4.242		0.121	**7.45**	4%	0%	37%	57%	0%	2%
24	HONDA 1.3 HYBRID Comfort	Hybrid P	1,293	0.315	-0.032	3.327	5.097	1.17E-03	0.313	**9.02**	3%	0%	37%	56%	0%	3%
25	VOLVO 1.8 SUMMUM	Petrol	1,280	0.630	-0.059	3.294	5.046	1.86E-03	0.496	**9.41**	7%	-1%	35%	54%	0%	5%
26	VOLVO 2.0 diesel 100 kW	Diesel	1,375	1.260	-0.653	7.211	11.045	1.67E-03	0.426	**19.29**	7%	-3%	37%	57%	0%	2%
27	VOLVO 2.0D FAP SUMMUM	Diesel PF	1,375	1.260	-0.424	3.872	5.932	1.68E-03	0.429	**11.07**	11%	-4%	35%	54%	0%	4%
28	VOLVO 1.8 SUMMUM LPG	LPG/CNG	1,280	0.630	-0.059	3.294	5.046	5.15E-04	0.425	**9.34**	7%	-1%	35%	54%	0%	5%
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	Hybrid P	1,310	0.397	-0.027	3.371	5.164	1.11E-03	0.298	**9.20**	4%	0%	37%	56%	0%	3%
30	VOLVO 1.8 FLEXIFUEL Euro95	Petrol	1,299	0.630	-0.046	3.343	5.121	1.89E-03	0.501	**9.55**	7%	0%	35%	54%	0%	5%
31	VOLVO 1.8 FLEXIFUEL E5	Flexifuel	1,299	0.630	-0.044	3.343	5.121		0.518	**9.57**	7%	0%	35%	54%	0%	5%
32	VOLVO 1.8 FLEXIFUEL E10	Flexifuel	1,299	0.630	-0.053	3.343	5.121		0.539	**9.58**	7%	-1%	35%	53%	0%	6%
33	VOLVO 1.8 FLEXIFUEL E20	Flexifuel	1,299	0.630	-0.050	3.343	5.121		0.586	**9.63**	7%	-1%	35%	53%	0%	6%
34	VOLVO 1.8 FLEXIFUEL E85	Flexifuel	1,299	0.630	-0.078	3.343	5.121		0.947	**9.96**	6%	-1%	34%	51%	0%	10%
35	FORD 1.6I AMBIENTE	Petrol	1,259	0.630	-0.133	3.240	4.963	1.75E-03	0.468	**9.17**	7%	-1%	35%	54%	0%	5%
36	FORD 1.6TDCI66 TREND	Diesel	1,316	0.630	-0.546	6.558	10.046	1.35E-03	0.354	**17.04**	4%	-3%	38%	59%	0%	2%
37	FORD 1.6TDCI80 DURASH. CVT AMB	Diesel PF	1,401	0.500	-0.514	3.939	6.034	1.38E-03	0.422	**10.38**	5%	-5%	38%	58%	0%	4%
38	FORD 1.6I AMBIENTE LPG	LPG/CNG	1,259	0.630	-0.133	3.240	4.963	4.84E-04	0.401	**9.10**	7%	-1%	36%	55%	0%	4%
39	OPEL 1.6 CNG ENJOY	LPG/CNG	1,318	1.000	-0.115	3.392	5.196		0.413	**9.89**	10%	-1%	34%	53%	0%	4%
40	FORD 2.0I AMBIENTE	Petrol	1,622	0.794	-0.139	4.174	6.394	2.11E-03	0.561	**11.79**	7%	-1%	35%	54%	0%	5%
41	FORD 2.0TDCI103 AMBIENTE	Diesel	1,724	0.630	-0.743	12.115	18.557	1.80E-03	0.477	**31.04**	2%	-2%	39%	60%	0%	2%
42	FORD 2.0TDCI103 DPF AMBIENTE	Diesel PF	1,731	0.630	-0.871	4.788	7.335	1.80E-03	0.477	**12.36**	5%	-7%	39%	59%	0%	4%
43	FORD 2.0I AMBIENTE LPG	LPG/CNG	1,622	0.794	-0.139	4.174	6.394	5.83E-04	0.480	**11.70**	7%	-1%	36%	55%	0%	4%
44	MERCEDES S 500	Petrol	1,865	1.000	-0.083	4.800	7.352	2.98E-03	0.793	**13.86**	7%	-1%	35%	53%	0%	6%
45	MERCEDES S 420CDI	Diesel PF	2,015	1.260	-0.605	6.020	9.221	2.69E-03	0.684	**16.58**	8%	-4%	36%	56%	0%	4%
46	MERCEDES S 500 LPG	LPG/CNG	1,865	1.000	-0.083	4.800	7.352	3.78E-04	0.678	**13.75**	7%	-1%	35%	53%	0%	5%
47	LEXUS 600H	Hybrid P	2,270	0.630	-0.053	5.842	8.948	2.34E-03	0.623	**15.99**	4%	0%	37%	56%	0%	4%
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Petrol	1,460	1.260	-0.101	3.757	5.755	3.06E-03	0.813	**11.49**	11%	-1%	33%	50%	0%	7%
49	MERCEDES ML 350	Petrol	2,060	1.588	-0.029	5.301	8.120	2.85E-03	0.756	**15.74**	10%	0%	34%	52%	0%	5%
50	MERCEDES ML 320CDI165	Diesel	2,110	0.794	-0.666	9.603	14.710	5.41E-04	0.687	**25.13**	3%	-3%	38%	59%	0%	3%
51	MERCEDES ML 320CDI165 DPF	Diesel PF	2,110	1.000	-0.842	5.931	9.085	5.41E-04	0.689	**15.86**	6%	-5%	37%	57%	0%	4%
52	MERCEDES ML 350 LPG	LPG/CNG	2,060	1.588	-0.029	5.301	8.120	7.86E-04	0.647	**15.63**	10%	0%	34%	52%	0%	4%
53	LEXUS 400H	Hybrid P	2,000	0.630	0.000	5.147	7.884	2.05E-03	0.547	**14.21**	4%	0%	36%	55%	0%	4%
	Min		750	0.315	-1.897	1.930	2.956	2.71E-04	0.111	**5.89**	2%	-22%	31%	47%	0%	2%
	Max		2,270	1.588	0.000	12.115	18.557	3.06E-03	0.947	**31.04**	18%	0%	41%	63%	0%	10%
	Average		1,375	0.812	-0.369	4.098	6.277	1.38E-03	0.464	**11.28**	**8%**	**-4%**	**36%**	**55%**	**0%**	**4%**
	Standard deviation		366	0.294	0.501	1.845	2.826	7.58E-04	0.166	**4.70**	3%	6%	2%	3%	0%	1%

(1) Costs of health damage related to ozone
(2) Costs of damage related to particulate matter
(3) Costs of building soiling related to particulate matter
(4) Costs of building damage related to SO2
(5) Costs of climate change related to greenhouse gases

Appendix 3: External costs per motorisation system

Scenario Base 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.500	-0.139	1.930	1.478	1.09E-03	1.064	**5.18**	8%	-2%	35%	27%	0%	20%
	Max	2,060	1.588	-0.027	5.301	4.060	3.06E-03	2.925	**13.64**	15%	0%	42%	32%	0%	27%
	Average	1,326	0.856	-0.076	3.411	2.613	1.99E-03	1.908	**8.71**	10%	-1%	39%	30%	0%	22%
	Std dev	409	0.319	0.040	1.053	0.807	6.93E-04	0.660	**2.71**	2%	0%	2%	1%	0%	2%
	Count	11													
Diesel	Min	880	0.630	-0.743	4.101	4.547	5.41E-04	1.118	**9.76**	2%	-7%	41%	46%	0%	6%
	Max	2,110	1.260	-0.546	12.115	15.159	1.80E-03	2.473	**28.88**	7%	-3%	43%	52%	0%	11%
	Average	1,396	0.796	-0.621	7.403	8.588	1.30E-03	1.501	**17.67**	5%	-4%	42%	48%	0%	9%
	Std dev	408	0.247	0.076	2.653	3.410	4.03E-04	0.479	**6.31**	2%	1%	1%	2%	0%	2%
	Count	7													
Diesel with filter	Min	1,055	0.500	-1.701	3.011	2.434	2.71E-04	1.199	**7.07**	6%	-24%	41%	34%	0%	15%
	Max	2,110	1.260	-0.424	6.020	5.250	2.69E-03	2.482	**14.39**	14%	-4%	49%	39%	0%	22%
	Average	1,484	0.906	-0.708	4.189	3.493	1.36E-03	1.650	**9.53**	10%	-8%	44%	37%	0%	17%
	Std dev	381	0.294	0.408	1.142	1.006	7.02E-04	0.502	**2.72**	4%	6%	3%	2%	0%	2%
	Count	9													
Hybrid	Min	1,293	0.315	-0.053	3.327	2.548	1.11E-03	1.073	**7.29**	4%	0%	44%	34%	0%	15%
	Max	2,270	0.630	0.000	5.842	4.474	2.34E-03	2.244	**13.14**	5%	0%	46%	35%	0%	17%
	Average	1,718	0.493	-0.028	4.422	3.387	1.67E-03	1.603	**9.88**	5%	0%	45%	34%	0%	16%
	Std dev	494	0.162	0.022	1.271	0.973	6.23E-04	0.593	**2.99**	1%	0%	1%	1%	0%	1%
	Count	4													
LPG and CNG	Min	790	0.500	-0.139	2.033	1.557	3.18E-04	0.956	**5.02**	8%	-2%	35%	26%	0%	17%
	Max	2,060	1.588	-0.027	5.301	4.060	7.86E-04	2.442	**13.25**	20%	0%	43%	33%	0%	21%
	Average	1,300	0.899	-0.075	3.344	2.561	4.92E-04	1.540	**8.27**	11%	-1%	40%	31%	0%	19%
	Std dev	380	0.299	0.040	0.978	0.749	1.44E-04	0.439	**2.32**	3%	0%	2%	2%	0%	1%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.630	-1.897	3.343	2.560	0.00E+00	1.624	**7.23**	6%	-25%	34%	26%	0%	22%
	Max	1,299	1.000	-0.044	3.461	2.779	0.00E+00	3.410	**9.87**	14%	-1%	48%	38%	0%	35%
	Average	1,290	0.815	-0.873	3.402	2.669	0.00E+00	2.049	**8.06**	10%	-12%	43%	34%	0%	25%
	Std dev	10	0.198	0.879	0.063	0.117	0.00E+00	0.584	**0.93**	3%	12%	5%	5%	0%	4%
	Count	8													
Electric	Min	1,087	0.315	0.000	2.316	1.774	0.00E+00	0.401	**4.81**	6%	0%	48%	37%	0%	8%
	Max	1,300	0.315	0.000	2.770	2.121	0.00E+00	0.437	**5.64**	7%	0%	49%	38%	0%	8%
	Average	1,194	0.315	0.000	2.543	1.947	0.00E+00	0.419	**5.22**	6%	0%	49%	37%	0%	8%
	Std dev	151	0.000	0.000	0.321	0.246	0.00E+00	0.026	**0.59**	1%	0%	1%	0%	0%	0%
	Count	2													

Scenario Base 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.500	-0.139	1.930	1.478	1.09E-03	0.296	**4.37**	9%	-2%	43%	33%	0%	6%
	Max	2,060	1.588	-0.027	5.301	4.060	3.06E-03	0.813	**11.68**	18%	0%	49%	37%	0%	9%
	Average	1,326	0.856	-0.076	3.411	2.613	1.99E-03	0.530	**7.34**	12%	-1%	46%	36%	0%	7%
	Std dev	409	0.319	0.040	1.053	0.807	6.93E-04	0.183	**2.26**	3%	1%	2%	1%	0%	1%
	Count	11													
Diesel	Min	880	0.630	-0.743	4.101	4.547	5.41E-04	0.311	**8.95**	2%	-7%	43%	50%	0%	2%
	Max	2,110	1.260	-0.546	12.115	15.159	1.80E-03	0.687	**27.64**	8%	-3%	46%	55%	0%	3%
	Average	1,396	0.796	-0.621	7.403	8.588	1.30E-03	0.417	**16.59**	5%	-4%	45%	51%	0%	3%
	Std dev	408	0.247	0.076	2.653	3.410	4.03E-04	0.133	**6.07**	2%	1%	1%	2%	0%	1%
	Count	7													
Diesel with filter	Min	1,055	0.500	-1.701	3.011	2.434	2.71E-04	0.333	**5.96**	7%	-29%	46%	38%	0%	5%
	Max	2,110	1.260	-0.424	6.020	5.250	2.69E-03	0.689	**12.61**	17%	-5%	58%	47%	0%	7%
	Average	1,484	0.906	-0.708	4.189	3.493	1.36E-03	0.458	**8.34**	11%	-9%	50%	42%	0%	6%
	Std dev	381	0.294	0.408	1.142	1.006	7.02E-04	0.139	**2.38**	4%	7%	4%	3%	0%	1%
	Count	9													
Hybrid	Min	1,293	0.315	-0.053	3.327	2.548	1.11E-03	0.298	**6.47**	5%	0%	50%	38%	0%	5%
	Max	2,270	0.630	0.000	5.842	4.474	2.34E-03	0.623	**11.52**	6%	0%	51%	39%	0%	5%
	Average	1,718	0.493	-0.028	4.422	3.387	1.67E-03	0.445	**8.72**	6%	0%	51%	39%	0%	5%
	Std dev	494	0.162	0.022	1.271	0.973	6.23E-04	0.165	**2.56**	1%	0%	1%	0%	0%	0%
	Count	4													
LPG and CNG	Min	790	0.500	-0.139	2.033	1.557	3.18E-04	0.265	**4.33**	9%	-2%	40%	31%	0%	5%
	Max	2,060	1.588	-0.027	5.301	4.060	7.86E-04	0.678	**11.57**	23%	0%	49%	38%	0%	7%
	Average	1,300	0.899	-0.075	3.344	2.561	4.92E-04	0.428	**7.16**	13%	-1%	47%	36%	0%	6%
	Std dev	380	0.299	0.040	0.978	0.749	1.44E-04	0.122	**2.01**	4%	1%	2%	2%	0%	0%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.630	-1.897	3.343	2.560	0.00E+00	0.451	**5.93**	9%	-32%	45%	35%	0%	7%
	Max	1,299	1.000	-0.044	3.461	2.779	0.00E+00	0.947	**7.40**	17%	-1%	58%	47%	0%	13%
	Average	1,290	0.815	-0.873	3.402	2.669	0.00E+00	0.569	**6.58**	13%	-14%	52%	41%	0%	9%
	Std dev	10	0.198	0.879	0.063	0.117	0.00E+00	0.162	**0.60**	4%	15%	6%	5%	0%	2%
	Count	8													
Electric	Min	1,087	0.315	0.000	2.316	1.774	0.00E+00	0.111	**4.52**	6%	0%	51%	39%	0%	2%
	Max	1,300	0.315	0.000	2.770	2.121	0.00E+00	0.121	**5.33**	7%	0%	52%	40%	0%	2%
	Average	1,194	0.315	0.000	2.543	1.947	0.00E+00	0.116	**4.92**	6%	0%	52%	40%	0%	2%
	Std dev	151	0.000	0.000	0.321	0.246	0.00E+00	0.007	**0.57**	1%	0%	0%	0%	0%	0%
	Count	2													

Scenario Low 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.475	-0.139	1.930	0.000	1.09E-03	1.064	**3.60**	11%	-2%	48%	0%	0%	29%
	Max	2,060	1.509	-0.027	5.301	0.000	3.06E-03	2.925	**9.50**	20%	0%	61%	0%	0%	38%
	Average	1,326	0.814	-0.076	3.411	0.000	1.99E-03	1.908	**6.06**	14%	-1%	56%	0%	0%	31%
	Std dev	409	0.303	0.040	1.053	0.000	6.93E-04	0.660	**1.90**	3%	1%	4%	0%	0%	3%
	Count	11													
Diesel	Min	880	0.599	-0.743	4.101	2.812	5.41E-04	1.118	**7.99**	2%	-8%	48%	34%	0%	7%
	Max	2,110	1.198	-0.546	12.115	11.761	1.80E-03	2.473	**25.45**	8%	-3%	52%	46%	0%	14%
	Average	1,396	0.757	-0.621	7.403	5.837	1.30E-03	1.501	**14.88**	6%	-5%	50%	38%	0%	11%
	Std dev	408	0.235	0.076	2.653	2.833	4.03E-04	0.479	**5.65**	2%	2%	2%	4%	0%	2%
	Count	7													
Diesel with filter	Min	1,055	0.475	-1.701	3.011	0.256	2.71E-04	1.199	**4.50**	8%	-38%	58%	5%	0%	23%
	Max	2,110	1.198	-0.424	6.020	1.278	2.69E-03	2.482	**10.36**	21%	-6%	77%	12%	0%	34%
	Average	1,484	0.861	-0.708	4.189	0.568	1.36E-03	1.650	**6.56**	14%	-12%	65%	8%	0%	25%
	Std dev	381	0.280	0.408	1.142	0.307	7.02E-04	0.502	**2.01**	5%	10%	7%	2%	0%	4%
	Count	9													
Hybrid	Min	1,293	0.300	-0.053	3.327	0.000	1.11E-03	1.073	**4.72**	6%	-1%	67%	0%	0%	22%
	Max	2,270	0.599	0.000	5.842	0.000	2.34E-03	2.244	**8.63**	8%	0%	70%	0%	0%	26%
	Average	1,718	0.469	-0.028	4.422	0.000	1.67E-03	1.603	**6.47**	7%	0%	69%	0%	0%	24%
	Std dev	494	0.154	0.022	1.271	0.000	6.23E-04	0.593	**2.01**	1%	0%	2%	0%	0%	2%
	Count	4													
LPG and CNG	Min	790	0.475	-0.139	2.033	0.000	3.18E-04	0.956	**3.44**	11%	-3%	48%	0%	0%	24%
	Max	2,060	1.509	-0.027	5.301	0.000	7.86E-04	2.442	**9.11**	26%	0%	64%	0%	0%	30%
	Average	1,300	0.854	-0.075	3.344	0.000	4.92E-04	1.540	**5.66**	15%	-1%	59%	0%	0%	27%
	Std dev	380	0.284	0.040	0.978	0.000	1.44E-04	0.439	**1.57**	4%	1%	4%	0%	0%	1%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.599	-1.897	3.343	0.256	0.00E+00	1.624	**4.66**	8%	-39%	46%	0%	0%	32%
	Max	1,299	0.951	-0.044	3.461	0.256	0.00E+00	3.410	**7.27**	20%	-1%	74%	5%	0%	47%
	Average	1,290	0.775	-0.873	3.402	0.256	0.00E+00	2.049	**5.48**	15%	-18%	64%	3%	0%	37%
	Std dev	10	0.188	0.879	0.063	0.000	0.00E+00	0.584	**0.92**	6%	19%	11%	3%	0%	5%
	Count	8													
Electric	Min	1,087	0.300	0.000	2.316	0.000	0.00E+00	0.401	**3.02**	9%	0%	77%	0%	0%	12%
	Max	1,300	0.300	0.000	2.770	0.000	0.00E+00	0.437	**3.51**	10%	0%	79%	0%	0%	13%
	Average	1,194	0.300	0.000	2.543	0.000	0.00E+00	0.419	**3.26**	9%	0%	78%	0%	0%	13%
	Std dev	151	0.000	0.000	0.321	0.000	0.00E+00	0.026	**0.35**	1%	0%	2%	0%	0%	1%
	Count	2													

Scenario Low 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.475	-0.139	1.930	0.000	1.09E-03	0.296	**2.79**	14%	-3%	65%	0%	0%	10%
	Max	2,060	1.509	-0.027	5.301	0.000	3.06E-03	0.813	**7.54**	26%	0%	78%	0%	0%	14%
	Average	1,326	0.814	-0.076	3.411	0.000	1.99E-03	0.530	**4.68**	18%	-2%	73%	0%	0%	11%
	Std dev	409	0.303	0.040	1.053	0.000	6.93E-04	0.183	**1.45**	4%	1%	4%	0%	0%	1%
	Count	11													
Diesel	Min	880	0.599	-0.743	4.101	2.812	5.41E-04	0.311	**7.18**	2%	-9%	50%	38%	0%	2%
	Max	2,110	1.198	-0.546	12.115	11.761	1.80E-03	0.687	**24.21**	9%	-3%	57%	49%	0%	4%
	Average	1,396	0.757	-0.621	7.403	5.837	1.30E-03	0.417	**13.79**	6%	-5%	54%	41%	0%	3%
	Std dev	408	0.235	0.076	2.653	2.833	4.03E-04	0.133	**5.43**	2%	2%	3%	3%	0%	1%
	Count	7													
Diesel with filter	Min	1,055	0.475	-1.701	3.011	0.256	2.71E-04	0.333	**3.39**	10%	-50%	69%	6%	0%	7%
	Max	2,110	1.198	-0.424	6.020	1.278	2.69E-03	0.689	**8.58**	28%	-7%	102%	15%	0%	13%
	Average	1,484	0.861	-0.708	4.189	0.568	1.36E-03	0.458	**5.37**	17%	-15%	79%	10%	0%	9%
	Std dev	381	0.280	0.408	1.142	0.307	7.02E-04	0.139	**1.68**	7%	13%	11%	3%	0%	2%
	Count	9													
Hybrid	Min	1,293	0.300	-0.053	3.327	0.000	1.11E-03	0.298	**3.91**	8%	-1%	82%	0%	0%	7%
	Max	2,270	0.599	0.000	5.842	0.000	2.34E-03	0.623	**7.01**	10%	0%	85%	0%	0%	9%
	Average	1,718	0.469	-0.028	4.422	0.000	1.67E-03	0.445	**5.31**	9%	-1%	84%	0%	0%	8%
	Std dev	494	0.154	0.022	1.271	0.000	6.23E-04	0.165	**1.58**	1%	0%	1%	0%	0%	1%
	Count	4													
LPG and CNG	Min	790	0.475	-0.139	2.033	0.000	3.18E-04	0.265	**2.75**	14%	-3%	60%	0%	0%	8%
	Max	2,060	1.509	-0.027	5.301	0.000	7.86E-04	0.678	**7.43**	32%	0%	79%	0%	0%	11%
	Average	1,300	0.854	-0.075	3.344	0.000	4.92E-04	0.428	**4.55**	19%	-2%	73%	0%	0%	9%
	Std dev	380	0.284	0.040	0.978	0.000	1.44E-04	0.122	**1.26**	5%	1%	5%	0%	0%	1%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.599	-1.897	3.343	0.256	0.00E+00	0.451	**3.36**	12%	-56%	69%	0%	0%	12%
	Max	1,299	0.951	-0.044	3.461	0.256	0.00E+00	0.947	**4.81**	28%	-1%	103%	8%	0%	20%
	Average	1,290	0.775	-0.873	3.402	0.256	0.00E+00	0.569	**4.00**	20%	-25%	87%	4%	0%	14%
	Std dev	10	0.188	0.879	0.063	0.000	0.00E+00	0.162	**0.59**	8%	26%	14%	4%	0%	3%
	Count	8													
Electric	Min	1,087	0.300	0.000	2.316	0.000	0.00E+00	0.111	**2.73**	9%	0%	85%	0%	0%	4%
	Max	1,300	0.300	0.000	2.770	0.000	0.00E+00	0.121	**3.19**	11%	0%	87%	0%	0%	4%
	Average	1,194	0.300	0.000	2.543	0.000	0.00E+00	0.116	**2.96**	10%	0%	86%	0%	0%	4%
	Std dev	151	0.000	0.000	0.321	0.000	0.00E+00	0.007	**0.33**	1%	0%	1%	0%	0%	0%
	Count	2													

Scenario High 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.500	-0.139	1.930	2.956	1.09E-03	1.064	**6.71**	6%	-1%	28%	42%	0%	15%
	Max	2,060	1.588	-0.027	5.301	8.120	3.06E-03	2.925	**17.70**	12%	0%	32%	48%	0%	22%
	Average	1,326	0.856	-0.076	3.411	5.226	1.99E-03	1.908	**11.33**	8%	-1%	30%	46%	0%	17%
	Std dev	409	0.319	0.040	1.053	1.614	6.93E-04	0.660	**3.50**	2%	0%	1%	2%	0%	2%
	Count	11													
Diesel	Min	880	0.630	-0.743	4.101	6.281	5.41E-04	1.118	**11.49**	2%	-6%	35%	54%	0%	5%
	Max	2,110	1.260	-0.546	12.115	18.557	1.80E-03	2.473	**32.28**	6%	-2%	38%	57%	0%	10%
	Average	1,396	0.796	-0.621	7.403	11.340	1.30E-03	1.501	**20.42**	4%	-3%	36%	55%	0%	8%
	Std dev	408	0.247	0.076	2.653	4.064	4.03E-04	0.479	**6.99**	2%	1%	1%	1%	0%	1%
	Count	7													
Diesel with filter	Min	1,055	0.500	-1.701	3.011	4.612	2.71E-04	1.199	**9.40**	4%	-18%	32%	49%	0%	12%
	Max	2,110	1.260	-0.424	6.020	9.221	2.69E-03	2.482	**18.36**	11%	-3%	36%	55%	0%	16%
	Average	1,484	0.906	-0.708	4.189	6.417	1.36E-03	1.650	**12.46**	8%	-6%	34%	52%	0%	13%
	Std dev	381	0.294	0.408	1.142	1.750	7.02E-04	0.502	**3.45**	3%	4%	2%	2%	0%	1%
	Count	9													
Hybrid	Min	1,293	0.315	-0.053	3.327	5.097	1.11E-03	1.073	**9.83**	3%	0%	33%	50%	0%	11%
	Max	2,270	0.630	0.000	5.842	8.948	2.34E-03	2.244	**17.61**	4%	0%	34%	52%	0%	13%
	Average	1,718	0.493	-0.028	4.422	6.773	1.67E-03	1.603	**13.27**	4%	0%	33%	51%	0%	12%
	Std dev	494	0.162	0.022	1.271	1.946	6.23E-04	0.593	**3.96**	0%	0%	0%	1%	0%	1%
	Count	4													
LPG and CNG	Min	790	0.500	-0.139	2.033	3.114	3.18E-04	0.956	**6.58**	6%	-1%	27%	42%	0%	13%
	Max	2,060	1.588	-0.027	5.301	8.120	7.86E-04	2.442	**17.31**	16%	0%	32%	49%	0%	16%
	Average	1,300	0.899	-0.075	3.344	5.123	4.92E-04	1.540	**10.83**	9%	-1%	31%	47%	0%	14%
	Std dev	380	0.299	0.040	0.978	1.499	1.44E-04	0.439	**3.06**	3%	0%	1%	2%	0%	1%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.630	-1.897	3.343	5.121	0.00E+00	1.624	**9.75**	5%	-19%	27%	41%	0%	17%
	Max	1,299	1.000	-0.044	3.461	5.301	0.00E+00	3.410	**12.43**	10%	0%	35%	54%	0%	27%
	Average	1,290	0.815	-0.873	3.402	5.211	0.00E+00	2.049	**10.60**	8%	-9%	32%	50%	0%	19%
	Std dev	10	0.198	0.879	0.063	0.097	0.00E+00	0.584	**0.94**	2%	9%	3%	5%	0%	4%
	Count	8													
Electric	Min	1,087	0.315	0.000	2.316	3.547	0.00E+00	0.401	**6.58**	4%	0%	35%	54%	0%	6%
	Max	1,300	0.315	0.000	2.770	4.242	0.00E+00	0.437	**7.76**	5%	0%	36%	55%	0%	6%
	Average	1,194	0.315	0.000	2.543	3.895	0.00E+00	0.419	**7.17**	4%	0%	35%	54%	0%	6%
	Std dev	151	0.000	0.000	0.321	0.491	0.00E+00	0.026	**0.84**	1%	0%	0%	1%	0%	0%
	Count	2													

Scenario High 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Engine type		**Weight**	**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Petrol	Min	750	0.500	-0.139	1.930	2.956	1.09E-03	0.296	**5.93**	7%	-1%	32%	50%	0%	5%
	Max	2,060	1.588	-0.027	5.301	8.120	3.06E-03	0.813	**15.74**	13%	0%	35%	54%	0%	7%
	Average	1,326	0.856	-0.076	3.411	5.226	1.99E-03	0.530	**9.95**	9%	-1%	34%	52%	0%	5%
	Std dev	409	0.319	0.040	1.053	1.614	6.93E-04	0.183	**3.06**	2%	0%	1%	2%	0%	1%
	Count	11													
Diesel	Min	880	0.630	-0.743	4.101	6.281	5.41E-04	0.311	**10.68**	2%	-6%	37%	57%	0%	2%
	Max	2,110	1.260	-0.546	12.115	18.557	1.80E-03	0.687	**31.04**	7%	-2%	39%	60%	0%	3%
	Average	1,396	0.796	-0.621	7.403	11.340	1.30E-03	0.417	**19.34**	5%	-3%	38%	59%	0%	2%
	Std dev	408	0.247	0.076	2.653	4.064	4.03E-04	0.133	**6.74**	2%	1%	1%	1%	0%	0%
	Count	7													
Diesel with filter	Min	1,055	0.500	-1.701	3.011	4.612	2.71E-04	0.333	**8.49**	5%	-20%	35%	54%	0%	3%
	Max	2,110	1.260	-0.424	6.020	9.221	2.69E-03	0.689	**16.58**	12%	-4%	41%	62%	0%	5%
	Average	1,484	0.906	-0.708	4.189	6.417	1.36E-03	0.458	**11.26**	8%	-7%	37%	57%	0%	4%
	Std dev	381	0.294	0.408	1.142	1.750	7.02E-04	0.139	**3.10**	3%	5%	2%	3%	0%	0%
	Count	9													
Hybrid	Min	1,293	0.315	-0.053	3.327	5.097	1.11E-03	0.298	**9.02**	3%	0%	36%	55%	0%	3%
	Max	2,270	0.630	0.000	5.842	8.948	2.34E-03	0.623	**15.99**	4%	0%	37%	56%	0%	4%
	Average	1,718	0.493	-0.028	4.422	6.773	1.67E-03	0.445	**12.11**	4%	0%	37%	56%	0%	4%
	Std dev	494	0.162	0.022	1.271	1.946	6.23E-04	0.165	**3.53**	0%	0%	0%	0%	0%	0%
	Count	4													
LPG and CNG	Min	790	0.500	-0.139	2.033	3.114	3.18E-04	0.265	**5.89**	7%	-1%	31%	47%	0%	4%
	Max	2,060	1.588	-0.027	5.301	8.120	7.86E-04	0.678	**15.63**	18%	0%	36%	55%	0%	5%
	Average	1,300	0.899	-0.075	3.344	5.123	4.92E-04	0.428	**9.72**	9%	-1%	34%	53%	0%	4%
	Std dev	380	0.299	0.040	0.978	1.499	1.44E-04	0.122	**2.75**	3%	0%	1%	2%	0%	0%
	Count	12													
Flexifuel and Biodiesel	Min	1,280	0.630	-1.897	3.343	5.121	0.00E+00	0.451	**8.45**	6%	-22%	34%	51%	0%	5%
	Max	1,299	1.000	-0.044	3.461	5.301	0.00E+00	0.947	**9.96**	12%	0%	41%	63%	0%	10%
	Average	1,290	0.815	-0.873	3.402	5.211	0.00E+00	0.569	**9.12**	9%	-10%	37%	57%	0%	6%
	Std dev	10	0.198	0.879	0.063	0.097	0.00E+00	0.162	**0.61**	3%	10%	3%	5%	0%	1%
	Count	8													
Electric	Min	1,087	0.315	0.000	2.316	3.547	0.00E+00	0.111	**6.29**	4%	0%	37%	56%	0%	2%
	Max	1,300	0.315	0.000	2.770	4.242	0.00E+00	0.121	**7.45**	5%	0%	37%	57%	0%	2%
	Average	1,194	0.315	0.000	2.543	3.895	0.00E+00	0.116	**6.87**	5%	0%	37%	57%	0%	2%
	Std dev	151	0.000	0.000	0.321	0.491	0.00E+00	0.007	**0.82**	1%	0%	0%	0%	0%	0%
	Count	2													

Appendix 4: External costs per car size segmentation

Scenario Base 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.315	-0.640	1.930	1.478	3.18E-04	0.401	**4.81**	6%	-7%	37%	28%	0%	8%
	Max	1,108	1.000	0.000	4.101	4.547	1.30E-03	1.223	**9.76**	15%	0%	48%	47%	0%	22%
	Average	923	0.677	-0.177	2.616	2.241	1.01E-03	1.011	**6.37**	11%	-2%	41%	34%	0%	16%
	Std dev	156	0.264	0.268	0.784	1.094	3.94E-04	0.283	**1.83**	4%	3%	4%	6%	0%	5%
	Count	7													
SmallCC	Min	860	0.794	-0.552	2.213	1.695	4.10E-04	1.199	**6.40**	7%	-6%	35%	26%	0%	8%
	Max	1,105	1.260	-0.053	5.776	6.699	1.49E-03	1.403	**14.12**	20%	-1%	42%	47%	0%	21%
	Average	1,021	0.970	-0.239	3.255	2.974	1.12E-03	1.263	**8.22**	13%	-3%	39%	34%	0%	17%
	Std dev	97	0.192	0.233	1.437	2.099	4.84E-04	0.086	**3.31**	5%	2%	3%	8%	0%	5%
	Count	5													
SmallFC	Min	1,172	0.315	-1.897	2.770	2.121	2.71E-04	0.437	**5.64**	4%	-25%	40%	30%	0%	8%
	Max	1,300	1.000	0.000	6.458	7.375	1.68E-03	2.121	**15.11**	14%	0%	49%	49%	0%	28%
	Average	1,261	0.762	-0.816	3.559	3.002	1.03E-03	1.416	**7.92**	10%	-11%	45%	37%	0%	19%
	Std dev	44	0.265	0.796	0.947	1.402	5.43E-04	0.411	**2.33**	4%	11%	3%	5%	0%	6%
	Count	12													
BigFC	Min	1,280	0.397	-0.653	3.294	2.523	5.15E-04	1.073	**7.40**	5%	-4%	34%	26%	0%	9%
	Max	1,375	1.260	-0.027	7.211	8.335	1.89E-03	3.410	**17.69**	13%	0%	46%	47%	0%	35%
	Average	1,312	0.733	-0.149	3.776	3.199	1.45E-03	1.860	**9.42**	8%	-1%	40%	33%	0%	21%
	Std dev	35	0.287	0.212	1.219	1.817	5.39E-04	0.616	**2.99**	2%	1%	3%	6%	0%	7%
	Count	10													
SmallMV	Min	1,259	0.500	-0.546	3.240	2.481	4.84E-04	1.275	**7.66**	4%	-6%	41%	31%	0%	8%
	Max	1,401	1.000	-0.115	6.558	7.452	1.75E-03	1.685	**15.37**	12%	-1%	45%	48%	0%	21%
	Average	1,311	0.678	-0.288	4.074	3.657	1.24E-03	1.482	**9.60**	8%	-3%	42%	36%	0%	17%
	Std dev	58	0.189	0.221	1.418	2.147	5.37E-04	0.148	**3.25**	3%	2%	2%	7%	0%	5%
	Count	5													
MV	Min	1,622	0.630	-0.871	4.174	3.197	5.83E-04	1.717	**9.76**	2%	-9%	42%	32%	0%	6%
	Max	1,731	0.794	-0.139	12.115	15.159	2.11E-03	2.018	**28.88**	8%	-1%	47%	52%	0%	20%
	Average	1,675	0.712	-0.473	6.313	6.369	1.57E-03	1.795	**14.72**	6%	-3%	43%	39%	0%	15%
	Std dev	61	0.095	0.390	3.879	5.870	6.75E-04	0.149	**9.44**	3%	3%	3%	10%	0%	6%
	Count	4													
Exclusive	Min	1,865	0.630	-0.605	4.800	3.676	3.78E-04	2.244	**11.84**	5%	-4%	39%	30%	0%	17%
	Max	2,270	1.260	-0.053	6.020	5.250	2.98E-03	2.854	**14.39**	9%	0%	44%	36%	0%	23%
	Average	2,004	0.973	-0.206	5.365	4.269	2.10E-03	2.501	**12.90**	8%	-1%	42%	33%	0%	20%
	Std dev	191	0.259	0.266	0.657	0.755	1.18E-03	0.255	**1.13**	2%	2%	2%	3%	0%	3%
	Count	4													
Sport	Min	1,460	1.260	-0.101	3.757	2.878	3.06E-03	2.925	**10.72**	12%	-1%	35%	27%	0%	27%
	Max	1,460	1.260	-0.101	3.757	2.878	3.06E-03	2.925	**10.72**	12%	-1%	35%	27%	0%	27%
	Average	1,460	1.260	-0.101	3.757	2.878	3.06E-03	2.925	**10.72**	12%	-1%	35%	27%	0%	27%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.630	-0.842	5.147	3.942	5.41E-04	1.971	**11.69**	3%	-6%	39%	30%	0%	11%
	Max	2,110	1.588	0.000	9.603	10.551	2.85E-03	2.720	**22.75**	12%	0%	44%	46%	0%	20%
	Average	2,068	1.120	-0.313	6.257	5.508	1.35E-03	2.395	**14.97**	8%	-2%	42%	35%	0%	17%
	Std dev	45	0.447	0.407	1.895	2.847	1.04E-03	0.276	**4.42**	4%	3%	2%	7%	0%	3%
	Count	5													

Scenario Low 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.300	-0.640	1.930	0.511	3.18E-04	0.401	**3.02**	7%	-9%	51%	0%	0%	13%
	Max	1,108	0.951	0.000	4.101	2.812	1.30E-03	1.223	**7.99**	20%	0%	77%	35%	0%	31%
	Average	923	0.644	-0.177	2.616	1.662	1.01E-03	1.011	**4.57**	15%	-3%	59%	6%	0%	23%
	Std dev	156	0.251	0.268	0.784	1.627	3.94E-04	0.283	**1.72**	5%	4%	9%	13%	0%	7%
	Count	7													
SmallCC	Min	860	0.755	-0.552	2.213	0.256	4.10E-04	1.199	**4.54**	8%	-9%	48%	0%	0%	10%
	Max	1,105	1.198	-0.053	5.776	4.551	1.49E-03	1.403	**11.93**	26%	-1%	60%	38%	0%	30%
	Average	1,021	0.922	-0.239	3.255	2.403	1.12E-03	1.263	**6.16**	17%	-4%	54%	9%	0%	24%
	Std dev	97	0.183	0.233	1.437	3.037	4.84E-04	0.086	**3.23**	6%	3%	6%	17%	0%	8%
	Count	5													
SmallFC	Min	1,172	0.300	-1.897	2.770	0.256	2.71E-04	0.437	**3.51**	5%	-39%	51%	0%	0%	9%
	Max	1,300	0.951	0.000	6.458	4.858	1.68E-03	2.121	**12.56**	21%	0%	79%	39%	0%	43%
	Average	1,261	0.724	-0.816	3.559	0.950	1.03E-03	1.416	**5.44**	14%	-17%	68%	6%	0%	28%
	Std dev	44	0.252	0.796	0.947	1.726	5.43E-04	0.411	**2.30**	6%	17%	9%	11%	0%	10%
	Count	12													
BigFC	Min	1,280	0.377	-0.653	3.294	0.511	5.15E-04	1.073	**4.80**	8%	-6%	46%	0%	0%	10%
	Max	1,375	1.198	-0.027	7.211	5.625	1.89E-03	3.410	**14.92**	18%	-1%	70%	38%	0%	47%
	Average	1,312	0.697	-0.149	3.776	3.068	1.45E-03	1.860	**6.80**	10%	-2%	57%	5%	0%	30%
	Std dev	35	0.273	0.212	1.219	3.616	5.39E-04	0.616	**2.93**	3%	2%	7%	12%	0%	10%
	Count	10													
SmallMV	Min	1,259	0.475	-0.546	3.240	0.511	4.84E-04	1.275	**5.15**	5%	-9%	51%	0%	0%	10%
	Max	1,401	0.951	-0.115	6.558	4.858	1.75E-03	1.685	**12.75**	17%	-2%	66%	38%	0%	31%
	Average	1,311	0.645	-0.288	4.074	2.685	1.24E-03	1.482	**6.99**	10%	-4%	60%	9%	0%	24%
	Std dev	58	0.179	0.221	1.418	3.073	5.37E-04	0.148	**3.23**	4%	3%	6%	17%	0%	8%
	Count	5													
MV	Min	1,622	0.599	-0.871	4.174	0.511	5.83E-04	1.717	**6.52**	2%	-13%	48%	0%	0%	7%
	Max	1,731	0.755	-0.139	12.115	11.761	2.11E-03	2.018	**25.45**	12%	-2%	71%	46%	0%	30%
	Average	1,675	0.677	-0.473	6.313	6.136	1.57E-03	1.795	**11.38**	8%	-5%	61%	13%	0%	22%
	Std dev	61	0.090	0.390	3.879	7.955	6.75E-04	0.149	**9.38**	4%	5%	10%	22%	0%	10%
	Count	4													
Exclusive	Min	1,865	0.599	-0.605	4.800	1.278	3.78E-04	2.244	**8.11**	7%	-6%	56%	0%	0%	24%
	Max	2,270	1.198	-0.053	6.020	1.278	2.98E-03	2.854	**10.36**	12%	-1%	68%	12%	0%	33%
	Average	2,004	0.925	-0.206	5.365	1.278	2.10E-03	2.501	**8.91**	10%	-2%	60%	3%	0%	28%
	Std dev	191	0.246	0.266	0.657	0.000	1.18E-03	0.255	**0.99**	2%	2%	5%	6%	0%	4%
	Count	4													
Sport	Min	1,460	1.198	-0.101	3.757	0.000	3.06E-03	2.925	**7.78**	15%	-1%	48%	0%	0%	38%
	Max	1,460	1.198	-0.101	3.757	0.000	3.06E-03	2.925	**7.78**	15%	-1%	48%	0%	0%	38%
	Average	1,460	1.198	-0.101	3.757	0.000	3.06E-03	2.925	**7.78**	15%	-1%	48%	0%	0%	38%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.599	-0.842	5.147	0.767	5.41E-04	1.971	**7.72**	4%	-9%	52%	0%	0%	13%
	Max	2,110	1.509	0.000	9.603	6.392	2.85E-03	2.720	**18.56**	17%	0%	67%	34%	0%	29%
	Average	2,068	1.065	-0.313	6.257	3.580	1.35E-03	2.395	**10.84**	11%	-3%	59%	9%	0%	24%
	Std dev	45	0.425	0.407	1.895	3.977	1.04E-03	0.276	**4.37**	5%	4%	6%	15%	0%	6%
	Count	5													

Scenario High 90

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.315	-0.640	1.930	2.956	3.18E-04	0.401	**6.58**	5%	-6%	29%	44%	0%	6%
	Max	1,108	1.000	0.000	4.101	6.281	1.30E-03	1.223	**11.49**	12%	0%	36%	55%	0%	17%
	Average	923	0.677	-0.177	2.616	4.007	1.01E-03	1.011	**8.13**	8%	-2%	32%	49%	0%	13%
	Std dev	156	0.264	0.268	0.784	1.201	3.94E-04	0.283	**1.98**	3%	2%	3%	4%	0%	4%
	Count	7													
SmallCC	Min	860	0.794	-0.552	2.213	3.390	4.10E-04	1.199	**8.10**	6%	-5%	27%	42%	0%	7%
	Max	1,105	1.260	-0.053	5.776	8.848	1.49E-03	1.403	**16.27**	16%	-1%	35%	54%	0%	16%
	Average	1,021	0.970	-0.239	3.255	4.986	1.12E-03	1.263	**10.24**	10%	-2%	31%	48%	0%	13%
	Std dev	97	0.192	0.233	1.437	2.202	4.84E-04	0.086	**3.41**	3%	2%	3%	5%	0%	4%
	Count	5													
SmallFC	Min	1,172	0.315	-1.897	2.770	4.242	2.71E-04	0.437	**7.76**	3%	-19%	30%	46%	0%	6%
	Max	1,300	1.000	0.000	6.458	9.892	1.68E-03	2.121	**17.62**	10%	0%	37%	56%	0%	21%
	Average	1,261	0.762	-0.816	3.559	5.451	1.03E-03	1.416	**10.37**	8%	-8%	34%	52%	0%	14%
	Std dev	44	0.265	0.796	0.947	1.451	5.43E-04	0.411	**2.38**	3%	8%	2%	3%	0%	4%
	Count	12													
BigFC	Min	1,280	0.397	-0.653	3.294	5.046	5.15E-04	1.073	**9.98**	4%	-3%	27%	41%	0%	8%
	Max	1,375	1.260	-0.027	7.211	11.045	1.89E-03	3.410	**20.40**	10%	0%	35%	54%	0%	27%
	Average	1,312	0.733	-0.149	3.776	5.784	1.45E-03	1.860	**12.00**	6%	-1%	31%	48%	0%	16%
	Std dev	35	0.287	0.212	1.219	1.867	5.39E-04	0.616	**3.04**	2%	1%	2%	3%	0%	5%
	Count	10													
SmallMV	Min	1,259	0.500	-0.546	3.240	4.963	4.84E-04	1.275	**10.14**	4%	-4%	31%	47%	0%	7%
	Max	1,401	1.000	-0.115	6.558	10.046	1.75E-03	1.685	**17.96**	9%	-1%	37%	56%	0%	16%
	Average	1,311	0.678	-0.288	4.074	6.240	1.24E-03	1.482	**12.19**	6%	-2%	33%	51%	0%	13%
	Std dev	58	0.189	0.221	1.418	2.172	5.37E-04	0.148	**3.27**	2%	1%	2%	4%	0%	3%
	Count	5													
MV	Min	1,622	0.630	-0.871	4.174	6.394	5.83E-04	1.717	**12.95**	2%	-6%	32%	48%	0%	5%
	Max	1,731	0.794	-0.139	12.115	18.557	2.11E-03	2.018	**32.28**	6%	-1%	38%	57%	0%	15%
	Average	1,675	0.712	-0.473	6.313	9.670	1.57E-03	1.795	**18.02**	5%	-3%	34%	52%	0%	12%
	Std dev	61	0.095	0.390	3.879	5.941	6.75E-04	0.149	**9.51**	2%	3%	3%	4%	0%	4%
	Count	4													
Exclusive	Min	1,865	0.630	-0.605	4.800	7.352	3.78E-04	2.244	**15.51**	4%	-3%	30%	46%	0%	13%
	Max	2,270	1.260	-0.053	6.020	9.221	2.98E-03	2.854	**18.36**	7%	0%	33%	51%	0%	18%
	Average	2,004	0.973	-0.206	5.365	8.218	2.10E-03	2.501	**16.85**	6%	-1%	32%	49%	0%	15%
	Std dev	191	0.259	0.266	0.657	1.007	1.18E-03	0.255	**1.36**	1%	1%	1%	2%	0%	2%
	Count	4													
Sport	Min	1,460	1.260	-0.101	3.757	5.755	3.06E-03	2.925	**13.60**	9%	-1%	28%	42%	0%	22%
	Max	1,460	1.260	-0.101	3.757	5.755	3.06E-03	2.925	**13.60**	9%	-1%	28%	42%	0%	22%
	Average	1,460	1.260	-0.101	3.757	5.755	3.06E-03	2.925	**13.60**	9%	-1%	28%	42%	0%	22%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.630	-0.842	5.147	7.884	5.41E-04	1.971	**15.63**	3%	-5%	30%	46%	0%	9%
	Max	2,110	1.588	0.000	9.603	14.710	2.85E-03	2.720	**26.91**	9%	0%	36%	55%	0%	15%
	Average	2,068	1.120	-0.313	6.257	9.584	1.35E-03	2.395	**19.04**	6%	-2%	33%	50%	0%	13%
	Std dev	45	0.447	0.407	1.895	2.902	1.04E-03	0.276	**4.48**	3%	2%	2%	4%	0%	2%
	Count	5													

Scenario Base 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.315	-0.640	1.930	1.478	3.18E-04	0.111	**4.33**	7%	-8%	43%	33%	0%	2%
	Max	1,108	1.000	0.000	4.101	4.547	1.30E-03	0.340	**8.95**	18%	0%	51%	51%	0%	7%
	Average	923	0.677	-0.177	2.616	2.241	1.01E-03	0.281	**5.64**	12%	-2%	47%	38%	0%	5%
	Std dev	156	0.264	0.268	0.784	1.094	3.94E-04	0.079	**1.74**	4%	3%	2%	6%	0%	2%
	Count	7													
SmallCC	Min	860	0.794	-0.552	2.213	1.695	4.10E-04	0.333	**5.47**	8%	-7%	40%	31%	0%	3%
	Max	1,105	1.260	-0.053	5.776	6.699	1.49E-03	0.390	**13.26**	23%	-1%	47%	51%	0%	7%
	Average	1,021	0.970	-0.239	3.255	2.974	1.12E-03	0.351	**7.31**	15%	-3%	45%	38%	0%	5%
	Std dev	97	0.192	0.233	1.437	2.099	4.84E-04	0.024	**3.34**	6%	2%	3%	7%	0%	2%
	Count	5													
SmallFC	Min	1,172	0.315	-1.897	2.770	2.121	2.71E-04	0.121	**5.33**	4%	-32%	45%	36%	0%	2%
	Max	1,300	1.000	0.000	6.458	7.375	1.68E-03	0.589	**14.25**	17%	0%	58%	52%	0%	10%
	Average	1,261	0.762	-0.816	3.559	3.002	1.03E-03	0.393	**6.90**	12%	-13%	52%	43%	0%	6%
	Std dev	44	0.265	0.796	0.947	1.402	5.43E-04	0.114	**2.35**	5%	14%	5%	5%	0%	2%
	Count	12													
BigFC	Min	1,280	0.397	-0.653	3.294	2.523	5.15E-04	0.298	**6.62**	6%	-5%	43%	35%	0%	3%
	Max	1,375	1.260	-0.027	7.211	8.335	1.89E-03	0.947	**16.58**	15%	0%	51%	50%	0%	13%
	Average	1,312	0.733	-0.149	3.776	3.199	1.45E-03	0.517	**8.08**	9%	-1%	47%	38%	0%	7%
	Std dev	35	0.287	0.212	1.219	1.817	5.39E-04	0.171	**3.03**	2%	2%	2%	4%	0%	3%
	Count	10													
SmallMV	Min	1,259	0.500	-0.546	3.240	2.481	4.84E-04	0.354	**6.62**	4%	-7%	45%	36%	0%	2%
	Max	1,401	1.000	-0.115	6.558	7.452	1.75E-03	0.468	**14.45**	14%	-2%	52%	52%	0%	7%
	Average	1,311	0.678	-0.288	4.074	3.657	1.24E-03	0.412	**8.53**	9%	-3%	48%	41%	0%	5%
	Std dev	58	0.189	0.221	1.418	2.147	5.37E-04	0.041	**3.33**	4%	2%	2%	7%	0%	2%
	Count	5													
MV	Min	1,622	0.630	-0.871	4.174	3.197	5.83E-04	0.477	**8.51**	2%	-10%	44%	37%	0%	2%
	Max	1,731	0.794	-0.139	12.115	15.159	2.11E-03	0.561	**27.64**	9%	-2%	54%	55%	0%	7%
	Average	1,675	0.712	-0.473	6.313	6.369	1.57E-03	0.499	**13.42**	7%	-4%	49%	43%	0%	5%
	Std dev	61	0.095	0.390	3.879	5.870	6.75E-04	0.041	**9.48**	3%	4%	4%	8%	0%	2%
	Count	4													
Exclusive	Min	1,865	0.630	-0.605	4.800	3.676	3.78E-04	0.623	**10.07**	5%	-5%	47%	36%	0%	5%
	Max	2,270	1.260	-0.053	6.020	5.250	2.98E-03	0.793	**12.61**	10%	0%	51%	42%	0%	8%
	Average	2,004	0.973	-0.206	5.365	4.269	2.10E-03	0.695	**11.10**	9%	-2%	48%	38%	0%	6%
	Std dev	191	0.259	0.266	0.657	0.755	1.18E-03	0.071	**1.20**	2%	2%	2%	3%	0%	1%
	Count	4													
Sport	Min	1,460	1.260	-0.101	3.757	2.878	3.06E-03	0.813	**8.61**	15%	-1%	44%	33%	0%	9%
	Max	1,460	1.260	-0.101	3.757	2.878	3.06E-03	0.813	**8.61**	15%	-1%	44%	33%	0%	9%
	Average	1,460	1.260	-0.101	3.757	2.878	3.06E-03	0.813	**8.61**	15%	-1%	44%	33%	0%	9%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.630	-0.842	5.147	3.942	5.41E-04	0.547	**10.27**	4%	-7%	45%	35%	0%	3%
	Max	2,110	1.588	0.000	9.603	10.551	2.85E-03	0.756	**20.97**	14%	0%	51%	50%	0%	6%
	Average	2,068	1.120	-0.313	6.257	5.508	1.35E-03	0.665	**13.24**	9%	-2%	48%	40%	0%	5%
	Std dev	45	0.447	0.407	1.895	2.847	1.04E-03	0.077	**4.36**	4%	3%	3%	6%	0%	1%
	Count	5													

Scenario Low 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.300	-0.640	1.930	0.511	3.18E-04	0.111	**2.73**	8%	-11%	57%	0%	0%	4%
	Max	1,108	0.951	0.000	4.101	2.812	1.30E-03	0.340	**7.18**	26%	0%	85%	39%	0%	11%
	Average	923	0.644	-0.177	2.616	1.662	1.01E-03	0.281	**3.84**	18%	-3%	71%	7%	0%	8%
	Std dev	156	0.251	0.268	0.784	1.627	3.94E-04	0.079	**1.63**	6%	5%	8%	15%	0%	3%
	Count	7													
SmallCC	Min	860	0.755	-0.552	2.213	0.256	4.10E-04	0.333	**3.65**	9%	-10%	52%	0%	0%	3%
	Max	1,105	1.198	-0.053	5.776	4.551	1.49E-03	0.390	**11.06**	32%	-1%	73%	41%	0%	11%
	Average	1,021	0.922	-0.239	3.255	2.403	1.12E-03	0.351	**5.25**	21%	-4%	66%	9%	0%	8%
	Std dev	97	0.183	0.233	1.437	3.037	4.84E-04	0.024	**3.25**	8%	4%	9%	18%	0%	3%
	Count	5													
SmallFC	Min	1,172	0.300	-1.897	2.770	0.256	2.71E-04	0.121	**3.19**	5%	-56%	55%	0%	0%	3%
	Max	1,300	0.951	0.000	6.458	4.858	1.68E-03	0.589	**11.70**	28%	0%	103%	42%	0%	18%
	Average	1,261	0.724	-0.816	3.559	0.950	1.03E-03	0.393	**4.41**	19%	-22%	86%	8%	0%	10%
	Std dev	44	0.252	0.796	0.947	1.726	5.43E-04	0.114	**2.33**	9%	24%	15%	11%	0%	4%
	Count	12													
BigFC	Min	1,280	0.377	-0.653	3.294	0.511	5.15E-04	0.298	**4.02**	9%	-8%	52%	0%	0%	3%
	Max	1,375	1.198	-0.027	7.211	5.625	1.89E-03	0.947	**13.81**	21%	-1%	84%	41%	0%	20%
	Average	1,312	0.697	-0.149	3.776	3.068	1.45E-03	0.517	**5.45**	13%	-2%	73%	5%	0%	11%
	Std dev	35	0.273	0.212	1.219	3.616	5.39E-04	0.171	**2.97**	3%	2%	8%	13%	0%	4%
	Count	10													
SmallMV	Min	1,259	0.475	-0.546	3.240	0.511	4.84E-04	0.354	**4.11**	5%	-11%	55%	0%	0%	3%
	Max	1,401	0.951	-0.115	6.558	4.858	1.75E-03	0.468	**11.82**	20%	-2%	81%	41%	0%	11%
	Average	1,311	0.645	-0.288	4.074	2.685	1.24E-03	0.412	**5.92**	13%	-5%	73%	10%	0%	8%
	Std dev	58	0.179	0.221	1.418	3.073	5.37E-04	0.041	**3.32**	6%	3%	10%	18%	0%	3%
	Count	5													
MV	Min	1,622	0.599	-0.871	4.174	0.511	5.83E-04	0.477	**5.27**	2%	-16%	50%	0%	0%	2%
	Max	1,731	0.755	-0.139	12.115	11.761	2.11E-03	0.561	**24.21**	14%	-3%	87%	49%	0%	10%
	Average	1,675	0.677	-0.473	6.313	6.136	1.57E-03	0.499	**10.09**	10%	-6%	74%	14%	0%	8%
	Std dev	61	0.090	0.390	3.879	7.955	6.75E-04	0.041	**9.42**	6%	7%	16%	23%	0%	4%
	Count	4													
Exclusive	Min	1,865	0.599	-0.605	4.800	1.278	3.78E-04	0.623	**6.35**	9%	-7%	70%	0%	0%	8%
	Max	2,270	1.198	-0.053	6.020	1.278	2.98E-03	0.793	**8.58**	15%	-1%	83%	15%	0%	12%
	Average	2,004	0.925	-0.206	5.365	1.278	2.10E-03	0.695	**7.10**	13%	-3%	76%	4%	0%	10%
	Std dev	191	0.246	0.266	0.657	0.000	1.18E-03	0.071	**1.03**	3%	3%	5%	7%	0%	2%
	Count	4													
Sport	Min	1,460	1.198	-0.101	3.757	0.000	3.06E-03	0.813	**5.67**	21%	-2%	66%	0%	0%	14%
	Max	1,460	1.198	-0.101	3.757	0.000	3.06E-03	0.813	**5.67**	21%	-2%	66%	0%	0%	14%
	Average	1,460	1.198	-0.101	3.757	0.000	3.06E-03	0.813	**5.67**	21%	-2%	66%	0%	0%	14%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.599	-0.842	5.147	0.767	5.41E-04	0.547	**6.30**	5%	-11%	57%	0%	0%	4%
	Max	2,110	1.509	0.000	9.603	6.392	2.85E-03	0.756	**16.77**	20%	0%	82%	38%	0%	10%
	Average	2,068	1.065	-0.313	6.257	3.580	1.35E-03	0.665	**9.11**	13%	-3%	72%	10%	0%	8%
	Std dev	45	0.425	0.407	1.895	3.977	1.04E-03	0.077	**4.32**	7%	5%	10%	17%	0%	2%
	Count	5													

Scenario High 25

			c€/km	c€/km	c€/km	c€/km	c€/km	c€/km	c€/km						
Car size segmentation			**Noise**	**H O3**	**H PM**	**B PM**	**B SO2**	**CC**	**Total**	**%Noise**	**%H O3**	**%H PM**	**%B PM**	**%B SO2**	**%CC**
Supermini	Min	750	0.315	-0.640	1.930	2.956	3.18E-04	0.111	**5.89**	5%	-6%	32%	50%	0%	2%
	Max	1,108	1.000	0.000	4.101	6.281	1.30E-03	0.340	**10.68**	13%	0%	38%	59%	0%	5%
	Average	923	0.677	-0.177	2.616	4.007	1.01E-03	0.281	**7.40**	9%	-2%	35%	54%	0%	4%
	Std dev	156	0.264	0.268	0.784	1.201	3.94E-04	0.079	**1.88**	3%	3%	2%	3%	0%	1%
	Count	7													
SmallCC	Min	860	0.794	-0.552	2.213	3.390	4.10E-04	0.333	**7.17**	6%	-5%	31%	47%	0%	2%
	Max	1,105	1.260	-0.053	5.776	8.848	1.49E-03	0.390	**15.41**	18%	-1%	37%	57%	0%	5%
	Average	1,021	0.970	-0.239	3.255	4.986	1.12E-03	0.351	**9.32**	11%	-2%	34%	53%	0%	4%
	Std dev	97	0.192	0.233	1.437	2.202	4.84E-04	0.024	**3.44**	4%	2%	2%	4%	0%	1%
	Count	5													
SmallFC	Min	1,172	0.315	-1.897	2.770	4.242	2.71E-04	0.121	**7.45**	3%	-22%	34%	53%	0%	2%
	Max	1,300	1.000	0.000	6.458	9.892	1.68E-03	0.589	**16.77**	12%	0%	41%	63%	0%	7%
	Average	1,261	0.762	-0.816	3.559	5.451	1.03E-03	0.393	**9.35**	9%	-9%	38%	58%	0%	4%
	Std dev	44	0.265	0.796	0.947	1.451	5.43E-04	0.114	**2.39**	3%	10%	3%	4%	0%	2%
	Count	12													
BigFC	Min	1,280	0.397	-0.653	3.294	5.046	5.15E-04	0.298	**9.20**	4%	-4%	34%	51%	0%	2%
	Max	1,375	1.260	-0.027	7.211	11.045	1.89E-03	0.947	**19.29**	11%	0%	37%	57%	0%	10%
	Average	1,312	0.733	-0.149	3.776	5.784	1.45E-03	0.517	**10.66**	7%	-1%	35%	54%	0%	5%
	Std dev	35	0.287	0.212	1.219	1.867	5.39E-04	0.171	**3.08**	2%	1%	1%	2%	0%	2%
	Count	10													
SmallMV	Min	1,259	0.500	-0.546	3.240	4.963	4.84E-04	0.354	**9.10**	4%	-5%	34%	53%	0%	2%
	Max	1,401	1.000	-0.115	6.558	10.046	1.75E-03	0.468	**17.04**	10%	-1%	38%	59%	0%	5%
	Average	1,311	0.678	-0.288	4.074	6.240	1.24E-03	0.412	**11.12**	6%	-2%	36%	56%	0%	4%
	Std dev	58	0.189	0.221	1.418	2.172	5.37E-04	0.041	**3.36**	2%	2%	2%	3%	0%	1%
	Count	5													
MV	Min	1,622	0.630	-0.871	4.174	6.394	5.83E-04	0.477	**11.70**	2%	-7%	35%	54%	0%	2%
	Max	1,731	0.794	-0.139	12.115	18.557	2.11E-03	0.561	**31.04**	7%	-1%	39%	60%	0%	5%
	Average	1,675	0.712	-0.473	6.313	9.670	1.57E-03	0.499	**16.72**	5%	-3%	37%	57%	0%	4%
	Std dev	61	0.095	0.390	3.879	5.941	6.75E-04	0.041	**9.55**	2%	3%	2%	3%	0%	1%
	Count	4													
Exclusive	Min	1,865	0.630	-0.605	4.800	7.352	3.78E-04	0.623	**13.75**	4%	-4%	35%	53%	0%	4%
	Max	2,270	1.260	-0.053	6.020	9.221	2.98E-03	0.793	**16.58**	8%	0%	37%	56%	0%	6%
	Average	2,004	0.973	-0.206	5.365	8.218	2.10E-03	0.695	**15.05**	7%	-1%	36%	55%	0%	5%
	Std dev	191	0.259	0.266	0.657	1.007	1.18E-03	0.071	**1.45**	2%	2%	1%	1%	0%	1%
	Count	4													
Sport	Min	1,460	1.260	-0.101	3.757	5.755	3.06E-03	0.813	**11.49**	11%	-1%	33%	50%	0%	7%
	Max	1,460	1.260	-0.101	3.757	5.755	3.06E-03	0.813	**11.49**	11%	-1%	33%	50%	0%	7%
	Average	1,460	1.260	-0.101	3.757	5.755	3.06E-03	0.813	**11.49**	11%	-1%	33%	50%	0%	7%
	Std dev	0	0.000	0.000	0.000	0.000	0.00E+00	0.000	**0.00**	0%	0%	0%	0%	0%	0%
	Count	1													
SUV	Min	2,000	0.630	-0.842	5.147	7.884	5.41E-04	0.547	**14.21**	3%	-5%	34%	52%	0%	3%
	Max	2,110	1.588	0.000	9.603	14.710	2.85E-03	0.756	**25.13**	10%	0%	38%	59%	0%	5%
	Average	2,068	1.120	-0.313	6.257	9.584	1.35E-03	0.665	**17.31**	7%	-2%	36%	55%	0%	4%
	Std dev	45	0.447	0.407	1.895	2.902	1.04E-03	0.077	**4.42**	3%	2%	2%	3%	0%	1%
	Count	5													

Appendix 5: Detailed climate change costs

			Greenhouse gases emissions											Externalities	
			Detailed emissions						Total CO_2 eq emissions					Total costs	
			g/km	g/km	g/km	g/km	g/km	g/km	g/km	g/km	**g/km**	%	%	c€/km	c€/km
Id	**Nom/DB**		**CO2 - WTT**	**CO2 - TTW**	**N20 - WTT**	**N20 - TTW**	**CH4 - WTT**	**CH4 - TTW**	**CO2eq - WTT**	**CO2 eq- TTW**	**CO2eq-WTW**	**Non-CO2/ CO2 eq**	**WTT/ WTW**	**€ 25/t**	**€ 90/t**
1	CITROEN 1.0 TENTATION	Supermini P	13.3	108.0	0.000	0.005	0.025	0.020	13.90	109.94	**123.84**	2.0%	11%	0.31	1.11
2	CITROEN 1.4HDI SEDUCTION	Supermini D	12.1	109.0	0.000	0.008	0.023	0.010	12.67	111.60	**124.27**	2.5%	10%	0.31	1.12
3	CITROEN 1.6HDI FAP VTS	Supermini D PF	11.0	119.0	0.000	0.008	0.026	0.010	11.58	121.60	**133.17**	2.4%	9%	0.33	1.20
4	CITROEN 1.0 TENTATION LPG	Supermini LPG	8.7	95.0	0.000	0.005	0.023	0.020	9.19	96.98	**106.17**	2.3%	9%	0.27	0.96
5	FIAT 1.2 NATURAL POWER	Supermini CNG	8.2	113.0	0.000	0.005	0.448	0.124	18.54	117.33	**135.87**	10.8%		0.34	1.22
6	PEUGEOT Electric	Supermini E	43.6	0.0	0.000	0.000	0.038	0.000	44.53	0.00	**44.53**	2.2%		0.11	0.40
7	SMART 1.0 52 MHD PULSE	Supermini P	12.7	103.0	0.000	0.005	0.024	0.020	13.29	104.94	**118.23**	2.1%	11%	0.30	1.06
8	FIAT 1.4 DUALOGIC 360°	SmallCC P	14.2	139.0	0.000	0.005	0.033	0.020	14.92	140.94	**155.86**	1.7%	10%	0.39	1.40
9	FIAT 1.3MJTD51	SmallCC D	11.0	119.0	0.000	0.008	0.026	0.010	11.58	121.60	**133.17**	2.4%	9%	0.33	1.20
10	FIAT 1.3MJTD55 DPF 360°	SmallCC D PF	11.0	119.0	0.000	0.008	0.026	0.010	11.58	121.60	**133.17**	2.4%	9%	0.33	1.20
11	FIAT 1.4 DUALOGIC LPG	SmallCC LPG	11.2	122.3	0.000	0.005	0.030	0.020	11.93	124.26	**136.19**	1.9%	9%	0.34	1.23
12	FIAT 1.2 Classic Natural Power	SmallCC CNG	8.8	119.0	0.000	0.005	0.477	0.124	19.73	123.33	**143.06**	10.7%	14%	0.36	1.29
13	FORD 1.4 AMBIENTE	SmallFC P	19.5	157.0	0.000	0.005	0.037	0.020	20.39	158.94	**179.33**	1.6%	11%	0.45	1.61
14	FORD 1.6TDCI66 GHIA	SmallFC D	11.0	118.0	0.000	0.008	0.026	0.010	11.58	120.60	**132.17**	2.4%	9%	0.33	1.19
15	FORD 1.6TDCI80 DPF GHIA	SmallFC D PF	11.0	119.0	0.000	0.008	0.026	0.010	11.58	121.60	**133.17**	2.4%	9%	0.33	1.20
16	FORD 1.4 AMBIENTE LPG	SmallFC LPG	12.6	138.2	0.000	0.005	0.034	0.020	13.38	140.10	**153.48**	1.8%	9%	0.38	1.38
17	CITROEN 1.6HDI80 DPF diesel	SmallFC D PF	14.1	152.4	0.000	0.008	0.033	0.010	14.90	155.02	**169.92**	2.0%	9%	0.42	1.53
18	CITROEN 1.6 HDI B5	SmallFC B5 PF	18.1	159.1	0.000	0.008	0.033	0.010	18.87	161.68	**180.55**	1.9%	10%	0.45	1.62
19	CITROEN 1.6 HDI B10	SmallFC B10 PF	21.2	156.0	0.000	0.008	0.030	0.010	21.90	158.59	**180.49**	1.8%	12%	0.45	1.62
20	CITROEN 1.6 HDI B30	SmallFC B30 PF	34.1	151.3	0.000	0.008	0.023	0.010	34.64	153.87	**188.51**	1.7%	18%	0.47	1.70
21	CITROEN 1.6 HDI B100	SmallFC B100 PF	83.3	149.7	0.000	0.008	0.000	0.010	83.31	152.31	**235.62**	1.1%	35%	0.59	2.12
22	MERCEDES B 170 NGT	SmallFC CNG	9.8	135.0	0.000	0.005	0.535	0.124	22.12	139.33	**161.45**	10.3%	14%	0.40	1.45
23	OPEL Impuls "Zebra"	SmallFC E	47.5	0.0	0.000	0.000	0.042	0.000	48.58	0.00	**48.58**	2.2%	100%	0.12	0.44
24	HONDA 1.3 HYBRID Comfort	SmallFC P H	13.6	109.0	0.000	0.005	0.026	0.020	14.20	110.94	**125.14**	2.0%	11%	0.31	1.13
25	VOLVO 1.8 SUMMUM	BigFC P	21.6	174.0	0.000	0.005	0.041	0.020	22.55	175.94	**198.49**	1.5%	11%	0.50	1.79
26	VOLVO 2.0 diesel 100 kW	BigFC D	14.2	153.0	0.000	0.008	0.033	0.010	14.92	155.60	**170.52**	2.0%	9%	0.43	1.53
27	VOLVO 2.0D FAP SUMMUM	BigFC D PF	14.2	154.0	0.000	0.008	0.033	0.010	14.92	156.60	**171.52**	2.0%	9%	0.43	1.54
28	VOLVO 1.8 SUMMUM LPG	BigFC LPG	14.0	153.1	0.000	0.005	0.038	0.020	14.83	155.06	**169.89**	1.6%	9%	0.42	1.53
29	TOYOTA 1.5VVT-I HYBRID ECVT LUN	BigFC P H	12.7	104.0	0.000	0.005	0.024	0.020	13.27	105.94	**119.21**	2.1%	11%	0.30	1.07
30	VOLVO 1.8 FLEXIFUEL Euro95	BigFC P	21.9	175.6	0.000	0.005	0.042	0.020	22.83	177.57	**200.39**	1.4%	11%	0.50	1.80
31	VOLVO 1.8 FLEXIFUEL E5	BigFC FlexE5	25.3	176.3	0.009	0.005	0.041	0.020	28.99	178.25	**207.23**	2.7%	14%	0.52	1.87
32	VOLVO 1.8 FLEXIFUEL E10	BigFC FlexE10	29.0	178.1	0.020	0.005	0.040	0.020	35.74	180.01	**215.75**	4.0%	17%	0.54	1.94
33	VOLVO 1.8 FLEXIFUEL E20	BigFC FlexE20	37.3	181.7	0.042	0.005	0.039	0.020	50.68	183.65	**234.32**	6.5%	22%	0.59	2.11
34	VOLVO 1.8 FLEXIFUEL E85	BigFC FlexE85	108.4	192.9	0.255	0.005	0.010	0.020	184.04	194.84	**378.89**	20.5%	49%	0.95	3.41
35	FORD 1.6I AMBIENTE	SmallMV P	20.4	164.0	0.000	0.005	0.039	0.020	21.32	165.94	**187.26**	1.5%	11%	0.47	1.69
36	FORD 1.6TDCI66 TREND	SmallMV D	11.5	127.0	0.000	0.008	0.027	0.010	12.09	129.60	**141.69**	2.3%	9%	0.35	1.28
37	FORD 1.6TDCI80 DURASH. CVT AME	SmallMV D PF	11.7	154.0	0.000	0.008	0.027	0.010	12.35	156.60	**168.95**	1.9%	7%	0.42	1.52
38	FORD 1.6I AMBIENTE LPG	SmallMV LPG	13.2	144.3	0.000	0.005	0.035	0.020	14.02	146.26	**160.28**	1.7%	9%	0.40	1.44
39	OPEL 1.6 CNG ENJOY	SmallMV CNG	10.1	138.0	0.000	0.005	0.550	0.124	22.72	142.33	**165.05**	10.3%	14%	0.41	1.49
40	FORD 2.0I AMBIENTE	MV P	24.3	197.0	0.000	0.005	0.046	0.020	25.33	198.94	**224.27**	1.3%	11%	0.56	2.02
41	FORD 2.0TDCI103 AMBIENTE	MV D	15.4	172.0	0.000	0.008	0.036	0.010	16.21	174.60	**190.80**	1.8%	8%	0.48	1.72
42	FORD 2.0TDCI103 DPF AMBIENTE	MV D PF	15.4	172.0	0.000	0.008	0.036	0.010	16.21	174.60	**190.80**	1.8%	8%	0.48	1.72
43	FORD 2.0I AMBIENTE LPG	MV LPG	15.8	173.4	0.000	0.005	0.042	0.020	16.76	175.30	**192.06**	1.5%	9%	0.48	1.73
44	MERCEDES S 500	Exclusive P	34.6	279.0	0.000	0.005	0.066	0.020	36.15	280.94	**317.09**	1.1%	11%	0.79	2.85
45	MERCEDES S 420CDI	Exclusive D PF	23.0	247.0	0.000	0.008	0.053	0.010	24.18	249.60	**273.78**	1.4%	9%	0.68	2.46
46	MERCEDES S 500 LPG	Exclusive LPG	22.5	245.5	0.000	0.005	0.060	0.020	23.85	247.46	**271.31**	1.2%	9%	0.68	2.44
47	LEXUS 600H	Exclusive P H	27.2	219.0	0.000	0.005	0.051	0.020	28.40	220.94	**249.34**	1.3%	11%	0.62	2.24
48	PORSCHE 3.8 CARRERA 2 S TIPTRON	Sport P	35.5	286.0	0.000	0.005	0.068	0.020	37.08	287.94	**325.02**	1.1%	11%	0.81	2.93
49	MERCEDES ML 350	SUV P	32.9	266.0	0.000	0.005	0.062	0.020	34.29	267.94	**302.23**	1.1%	11%	0.76	2.72
50	MERCEDES ML 320CDI165	SUV D	23.0	248.0	0.000	0.008	0.053	0.010	24.18	250.60	**274.78**	1.4%	9%	0.69	2.47
51	MERCEDES ML 320CDI165 DPF	SUV D PF	23.0	249.0	0.000	0.008	0.053	0.010	24.18	251.60	**275.78**	1.4%	9%	0.69	2.48
52	MERCEDES ML 350 LPG	SUV LPG	21.4	234.1	0.000	0.005	0.057	0.020	22.73	236.02	**258.75**	1.3%	9%	0.65	2.33
53	LEXUS 400H	SUV P H	24.0	192.0	0.000	0.005	0.045	0.020	25.00	193.94	**218.94**	1.4%	11%	0.55	1.97
	Min		8.2	0.0	0.000	0.000	0.000	0.000	9.19	0.00	**44.53**	1.1%	7%	0.11	0.40
	Max		108.4	286.0	0.255	0.008	0.550	0.124	184.04	287.94	**378.89**	20.5%	100%	0.95	3.41
	Average		22.0	157.7	0.006	0.006	0.072	0.023	25.45	160.03	**185.48**	3%	14%	0.46	1.67
	Standard deviation		17.6	57.7	0.035	0.002	0.126	0.030	25.71	57.83	**66.53**	3%	14%	0.17	0.60

Appendix 6: Climate change costs per engine type

		Greenhouse gases emissions											**Externalities**	
		Detailed emissions						Total CO_2 eq emissions					Total costs	
		g/km	g/km	g/km	g/km	g/km	g/km	g/km	g/km	**g/km**	%	%	c€/km	c€/km
Engine type		CO2 - WTT	CO2 - TTW	N20 - WTT	N20 - TTW	CH4 - WTT	CH4 - TTW	CO2eq - WTT	CO2 eq- TTW	CO2eq-WTW	Non-CO2/ CO2 eq	WTT/ WTW	€ 25/t	€ 90/t
Petrol	Min	12.7	103.0	0.000	0.005	0.024	0.020	13.29	104.94	**118.23**	**1%**	9.6%	0.30	1.06
	Max	35.5	286.0	0.000	0.005	0.068	0.020	37.08	287.94	**325.02**	**2%**	11.4%	0.81	2.93
	Average	22.8	186.2	0.000	0.005	0.044	0.020	23.82	188.18	**212.00**	**1%**	11.2%	0.53	1.91
	Std dev	0.4	0.3	0.000	0.000	0.347	0.000	0.36	0.34	**0.35**	**24%**	4.8%	0.35	0.35
	Count													
Diesel	Min	11.0	109.0	0.000	0.008	0.023	0.010	11.58	111.60	**124.27**	**1%**	8.5%	0.31	1.12
	Max	23.0	248.0	0.000	0.008	0.053	0.010	24.18	250.60	**274.78**	**3%**	10.2%	0.69	2.47
	Average	14.0	149.4	0.000	0.008	0.032	0.010	14.74	152.03	**166.77**	**2%**	8.9%	0.42	1.50
	Std dev	0.3	0.3	0.000	0.000	0.330	0.000	0.31	0.32	**0.32**	**19%**	6.6%	0.32	0.32
	Count													
Diesel with filter	Min	11.0	119.0	0.000	0.008	0.026	0.010	11.58	121.60	**133.17**	**1%**	7.3%	0.33	1.20
	Max	23.0	249.0	0.000	0.008	0.053	0.010	24.18	251.60	**275.78**	**2%**	8.8%	0.69	2.48
	Average	14.9	165.0	0.000	0.008	0.035	0.010	15.72	167.64	**183.36**	**2%**	8.5%	0.46	1.65
	Std dev	0.3	0.3	0.000	0.000	0.324	0.000	0.32	0.30	**0.30**	**20%**	5.6%	0.30	0.30
	Count													
Hybrid	Min	12.7	104.0	0.000	0.005	0.024	0.020	13.27	105.94	**119.21**	**1%**	11.1%	0.30	1.07
	Max	27.2	219.0	0.000	0.005	0.051	0.020	28.40	220.94	**249.34**	**2%**	11.4%	0.62	2.24
	Average	19.4	156.0	0.000	0.005	0.037	0.020	20.22	157.94	**178.16**	**2%**	11.3%	0.45	1.60
	Std dev	0.4	0.4	0.000	0.000	0.377	0.000	0.38	0.37	**0.37**	**26%**	1.1%	0.37	0.37
	Count													
LPG and CNG	Min	8.2	95.0	0.000	0.005	0.023	0.020	9.19	96.98	**106.17**	**1%**	8.7%	0.27	0.96
	Max	22.5	245.5	0.000	0.005	0.550	0.124	23.85	247.46	**271.31**	**11%**	13.8%	0.68	2.44
	Average	13.0	150.9	0.000	0.005	0.194	0.055	17.48	153.65	**171.13**	**5%**	10.1%	0.43	1.54
	Std dev	0.4	0.3	0.000	0.000	1.181	0.937	0.28	0.30	**0.29**	**94%**	23.2%	0.29	0.29
	Count													
Electric	Min	43.6	0.0	0.000	0.000	0.038	0.000	44.53	0.00	**44.53**	**2%**	100.0%	0.11	0.40
	Max	47.5	0.0	0.000	0.000	0.042	0.000	48.58	0.00	**48.58**	**2%**	100.0%	0.12	0.44
	Average	45.5	0.0	0.000	0.000	0.040	0.000	46.55	0.00	**46.55**	**2%**	100.0%	0.12	0.42
	Std dev	0.1	0.0	0.061	0.000	0.061	0.000	0.06	0.00	**0.06**	**0%**	0.0%	0.06	0.06
	Count													

Appendix 7: Climate change costs per car size segmentation

		Greenhouse gases emissions											Externalities	
		Detailed emissions						Total CO$_2$ eq emissions					Total costs	
		g/km	g/km	g/km	g/km	g/km	g/km	g/km	g/km	**g/km**	**g/km**	%	c€/km	c€/km
Car size segmentation		**CO2 - WTT**	**CO2 - TTW**	**N20 - WTT**	**N20 - TTW**	**CH4 - WTT**	**CH4 - TTW**	**CO2eq - WTT**	**CO2 eq- TTW**	**CO2eq-WTW**	**n-CO2/CO2**	**WTT/WTW**	**€ 25/t**	**€ 90/t**
Supermini	Min	8.2	0.0	0.000	0.000	0.023	0.000	9.19	0.00	**44.53**	**2%**	9%	0.11	0.40
	Max	43.6	119.0	0.000	0.008	0.448	0.124	44.53	121.60	**135.87**	**11%**	11%	0.34	1.22
	Average	15.7	92.4	0.000	0.005	0.087	0.029	17.67	94.63	**112.30**	**3%**	10%	0.28	1.01
	Std dev	12.5	41.4	0.000	0.003	0.160	0.042	12.18	42.49	**31.45**	**3%**	1%	0.08	0.28
	Count													
SmallCC	Min	8.8	119.0	0.000	0.005	0.026	0.010	11.58	121.60	**133.17**	**2%**	9%	0.33	1.20
	Max	14.2	139.0	0.000	0.008	0.477	0.124	19.73	140.94	**155.86**	**11%**	14%	0.39	1.40
	Average	11.2	123.7	0.000	0.006	0.118	0.037	13.95	126.35	**140.29**	**4%**	10%	0.35	1.26
	Std dev	1.9	8.7	0.000	0.002	0.201	0.049	3.53	8.24	**9.59**	**4%**	2%	0.02	0.09
	Count													
SmallFC	Min	9.8	0.0	0.000	0.000	0.000	0.000	11.58	0.00	**48.58**	**1%**	9%	0.12	0.44
	Max	83.3	159.1	0.000	0.008	0.535	0.124	83.31	161.68	**235.62**	**10%**	100%	0.59	2.12
	Average	24.7	128.7	0.000	0.006	0.070	0.021	26.29	131.08	**157.37**	**3%**	21%	0.39	1.42
	Std dev	21.5	44.0	0.000	0.002	0.147	0.033	20.93	44.67	**45.66**	**2%**	26%	0.11	0.41
	Count													
BigFC	Min	12.7	104.0	0.000	0.005	0.010	0.010	13.27	105.94	**119.21**	**1%**	9%	0.30	1.07
	Max	108.4	192.9	0.255	0.008	0.042	0.020	184.04	194.84	**378.89**	**20%**	49%	0.95	3.41
	Average	29.8	164.3	0.033	0.006	0.034	0.018	40.28	166.34	**206.62**	**4%**	16%	0.52	1.86
	Std dev	28.7	25.1	0.079	0.001	0.010	0.004	51.86	25.04	**68.44**	**6%**	12%	0.17	0.62
	Count													
SmallMV	Min	10.1	127.0	0.000	0.005	0.027	0.010	12.09	129.60	**141.69**	**2%**	7%	0.35	1.28
	Max	20.4	164.0	0.000	0.008	0.550	0.124	22.72	165.94	**187.26**	**10%**	14%	0.47	1.69
	Average	13.4	145.5	0.000	0.006	0.136	0.037	16.50	148.15	**164.65**	**4%**	10%	0.41	1.48
	Std dev	4.1	14.3	0.000	0.002	0.232	0.049	5.12	13.87	**16.40**	**4%**	3%	0.04	0.15
	Count													
MV	Min	15.4	172.0	0.000	0.005	0.036	0.010	16.21	174.60	**190.80**	**1%**	8%	0.48	1.72
	Max	24.3	197.0	0.000	0.008	0.046	0.020	25.33	198.94	**224.27**	**2%**	11%	0.56	2.02
	Average	17.7	178.6	0.000	0.007	0.040	0.015	18.63	180.86	**199.49**	**2%**	9%	0.50	1.80
	Std dev	4.4	12.3	0.000	0.002	0.005	0.006	4.48	12.06	**16.54**	**0%**	1%	0.04	0.15
	Count													
Exclusive	Min	22.5	219.0	0.000	0.005	0.051	0.010	23.85	220.94	**249.34**	**1%**	9%	0.62	2.24
	Max	34.6	279.0	0.000	0.008	0.066	0.020	36.15	280.94	**317.09**	**1%**	11%	0.79	2.85
	Average	26.8	247.6	0.000	0.006	0.058	0.018	28.15	249.73	**277.88**	**1%**	10%	0.69	2.50
	Std dev	5.6	24.6	0.000	0.002	0.007	0.005	5.72	24.55	**28.35**	**0%**	1%	0.07	0.26
	Count													
Sport	Min	35.5	286.0	0.000	0.005	0.068	0.020	37.08	287.94	**325.02**	**1%**	11%	0.81	2.93
	Max	35.5	286.0	0.000	0.005	0.068	0.020	37.08	287.94	**325.02**	**1%**	11%	0.81	2.93
	Average	35.5	286.0	0.000	0.005	0.068	0.020	37.08	287.94	**325.02**	**1%**	11%	0.81	2.93
	Std dev	0.0	0.0	0.000	0.000	0.000	0.000	0.00	0.00	**0.00**	**0%**	0%	0.00	0.00
	Count													
SUV	Min	21.4	192.0	0.000	0.005	0.045	0.010	22.73	193.94	**218.94**	**1%**	9%	0.55	1.97
	Max	32.9	266.0	0.000	0.008	0.062	0.020	34.29	267.94	**302.23**	**1%**	11%	0.76	2.72
	Average	24.8	237.8	0.000	0.006	0.054	0.016	26.08	240.02	**266.10**	**1%**	10%	0.67	2.39
	Std dev	4.6	28.0	0.000	0.002	0.006	0.005	4.67	28.13	**30.63**	**0%**	1%	0.08	0.28
	Count													