CLEVER

Clean Vehicle Research

External Costs

Task 4.1

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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.

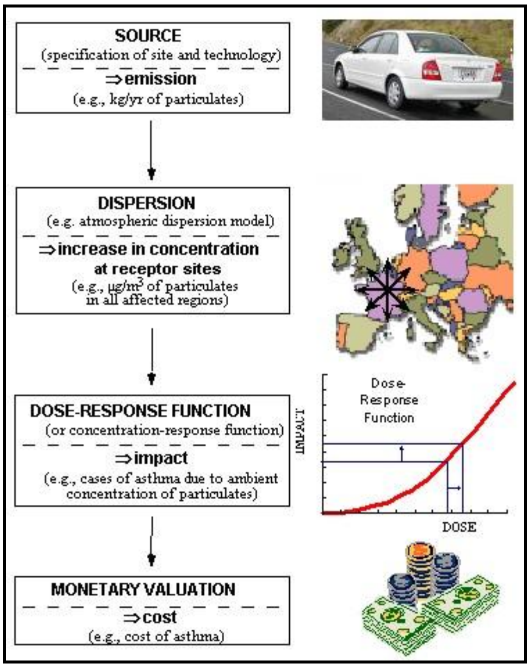


Figure 1: IPA steps (Source: ExternE 2005)

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.

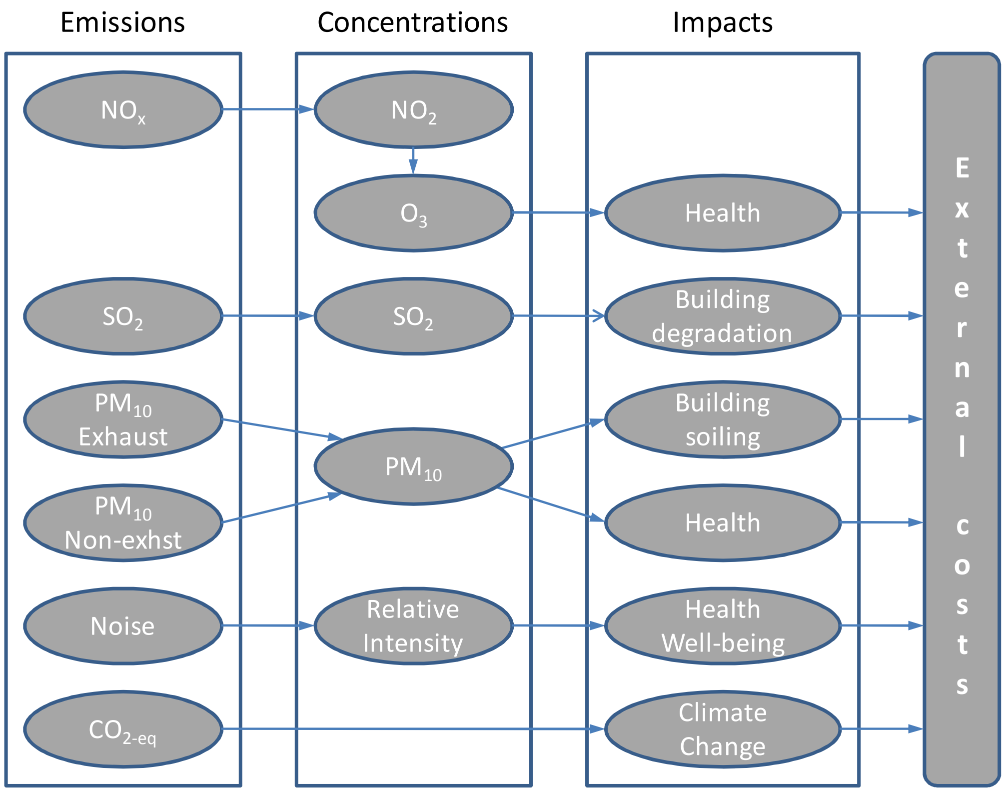


Figure 2: main steps of external costs evaluation

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:

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

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;

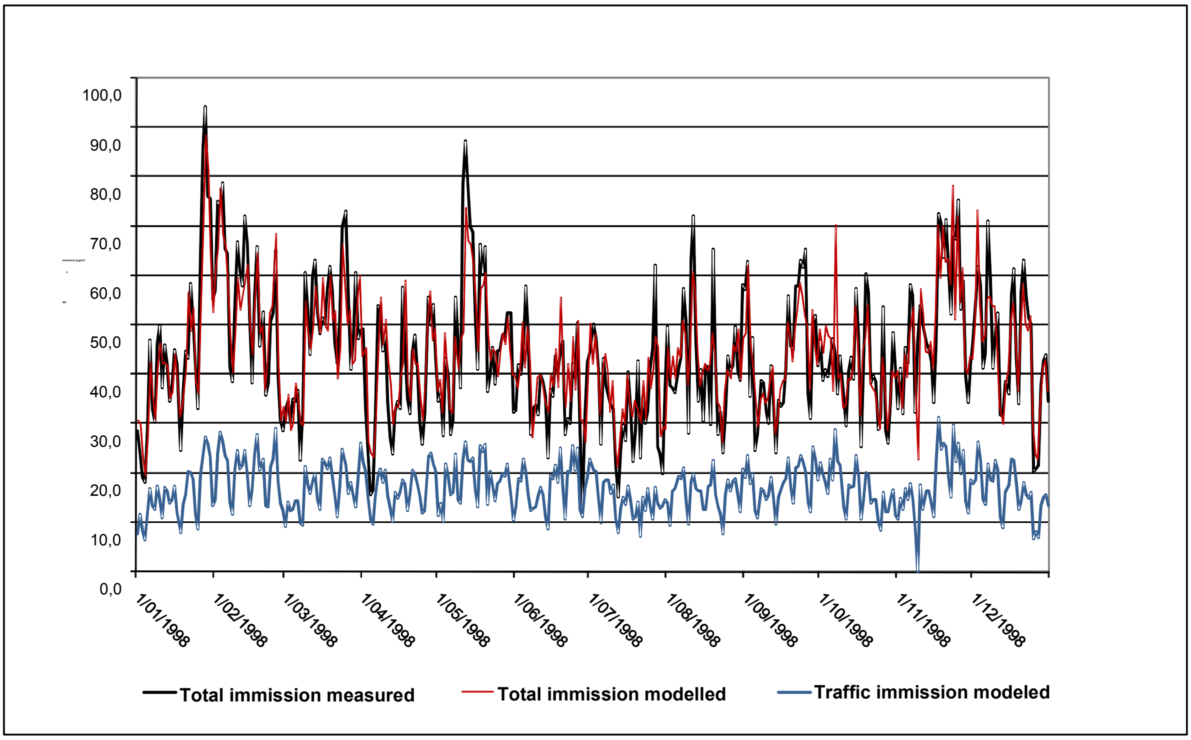
Preci are the daily precipitations in mm;

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

[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)

$S_{CR} = 4*10^{-4}$ YOLL / (pers.yr.μg/m^3) 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 μg/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 μg/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 μg/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	m²	%
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) if T<10°C and f(T) = -0.025*(T-10) 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 µg/m³ 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) [μg/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.

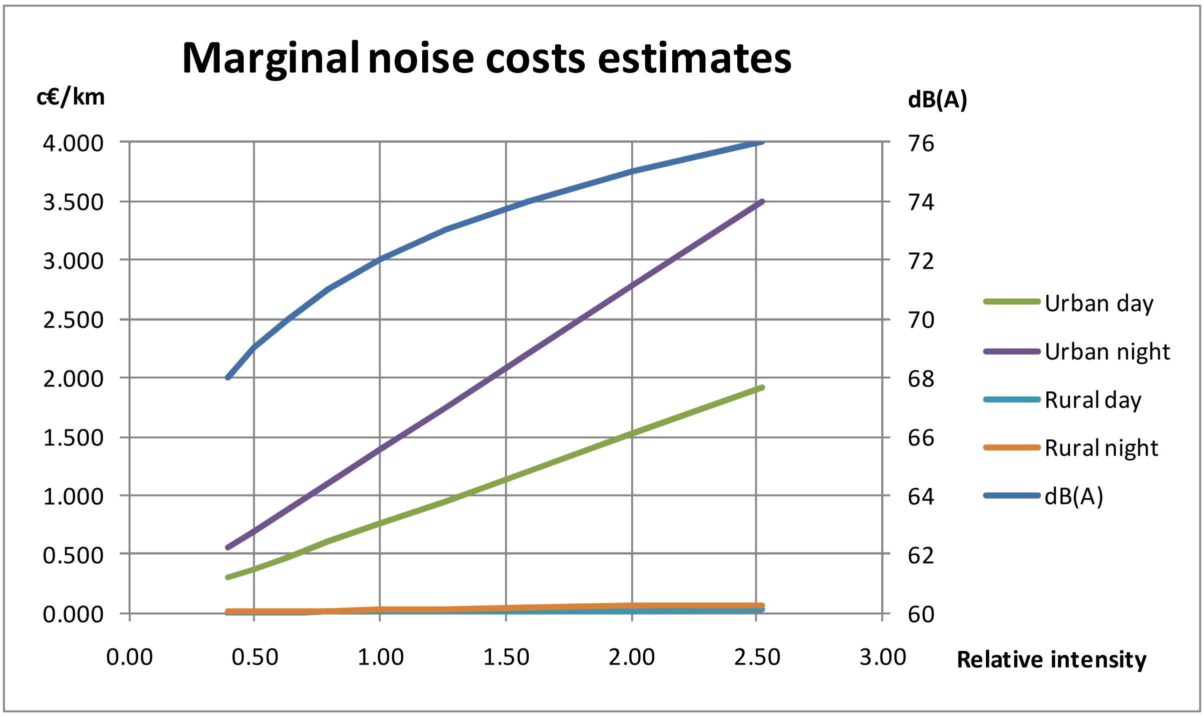
Using these costs as central values, we derived equations (Table 9) reflecting the annoyance level induced by car noise emissions. We derived noise costs proportional to a linearised perceived relative intensity scale reflecting the logarithmic nature of noise, rather than to emitted noise in decibel.

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.

[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	1.6I AMBIENTE	P
	FORD	FOCUS	1.6TDCI66 TREND	D
	FORD	FOCUS	1.6TDCI80 DURASH. CVT AMBIENTE	D PF
	FORD	FOCUS	1.6I AMBIENTE LPG	LPG
	OPEL	ZAFIRA	1.6 CNG ENJOY	CNG
Mono-volume	FORD	GALAXY	2.0I AMBIENTE	P
	FORD	GALAXY	2.0TDCI103 AMBIENTE	D
	FORD	GALAXY	2.0TDCI103 DPF AMBIENTE	D PF
	FORD	GALAXY	2.0I 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

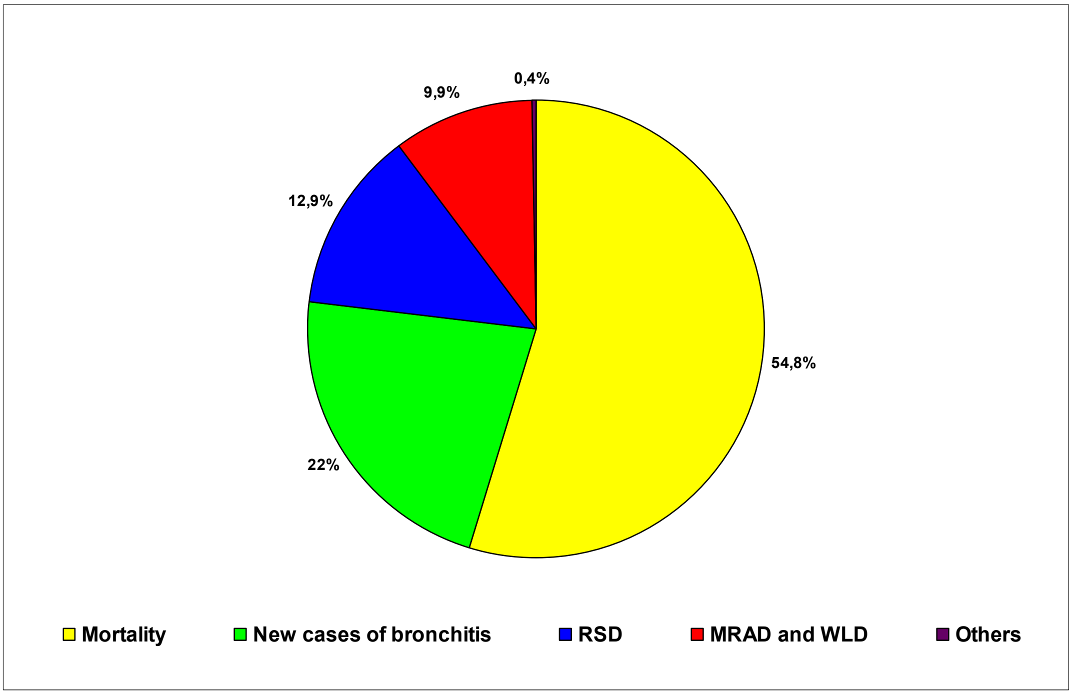
(i) AIRBORNE PARTICULATE MATTER

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 [%]

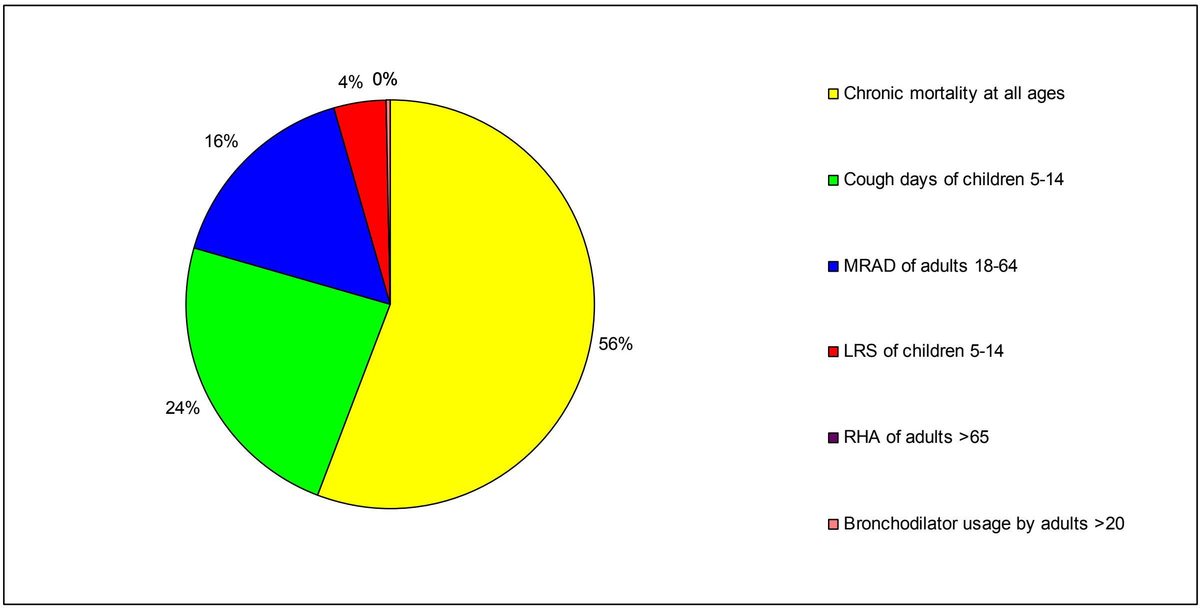
As discussed before, mechanically produced particles differ from direct emission in composition and size. Whereas exhaust particles primarily consist of very fine soot and organic compounds (partly known as carcinogenic), the fraction of particles produced mechanically is dominated by relatively coarse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

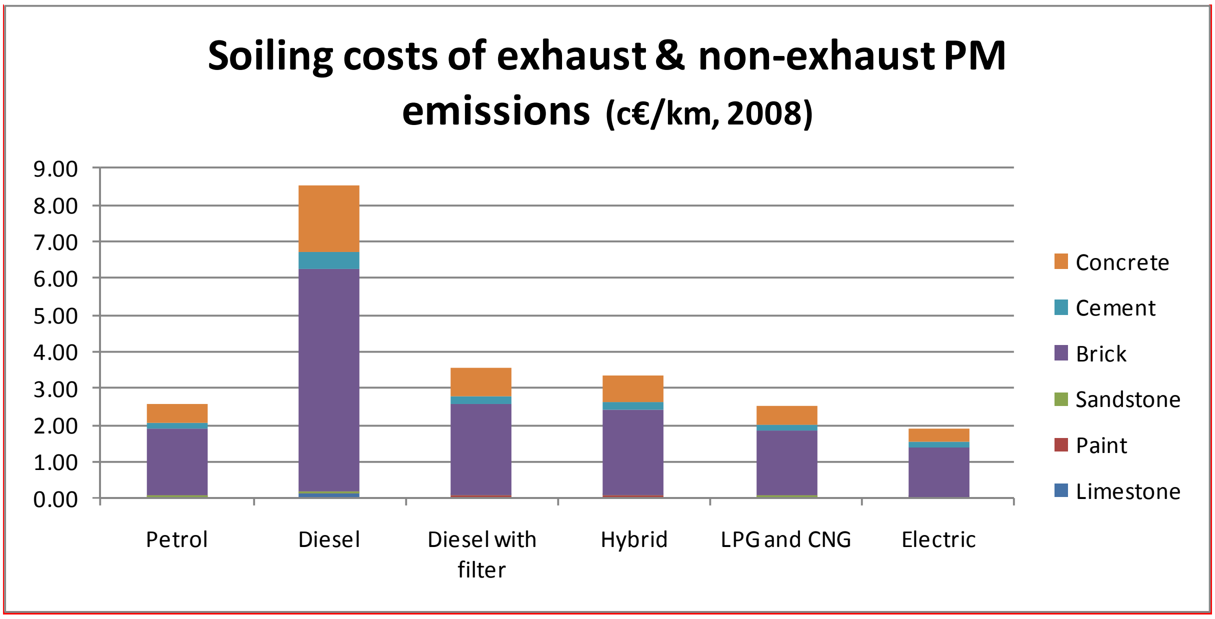
However, we should keep in mind the uncertainties surrounding ozone modelling and these conclusions would require further investigations.

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.

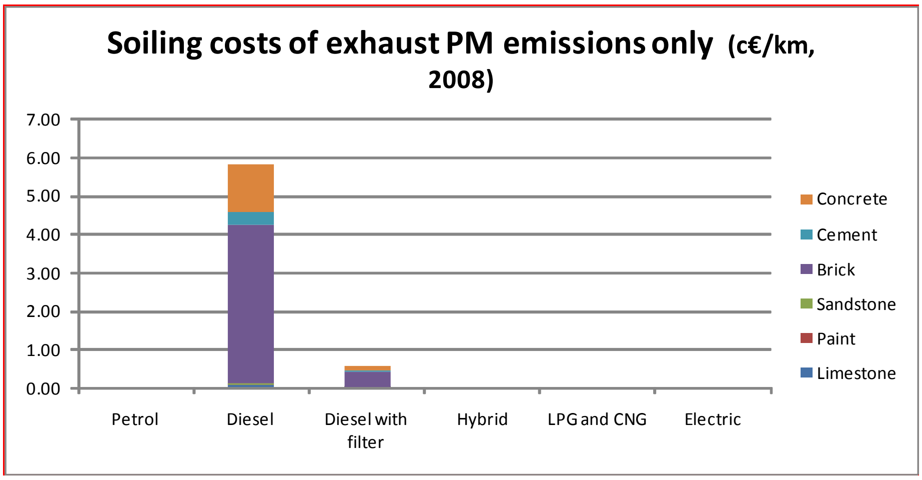


Graph 5: Soiling costs of exhaust and non-exhaust PM emissions

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.

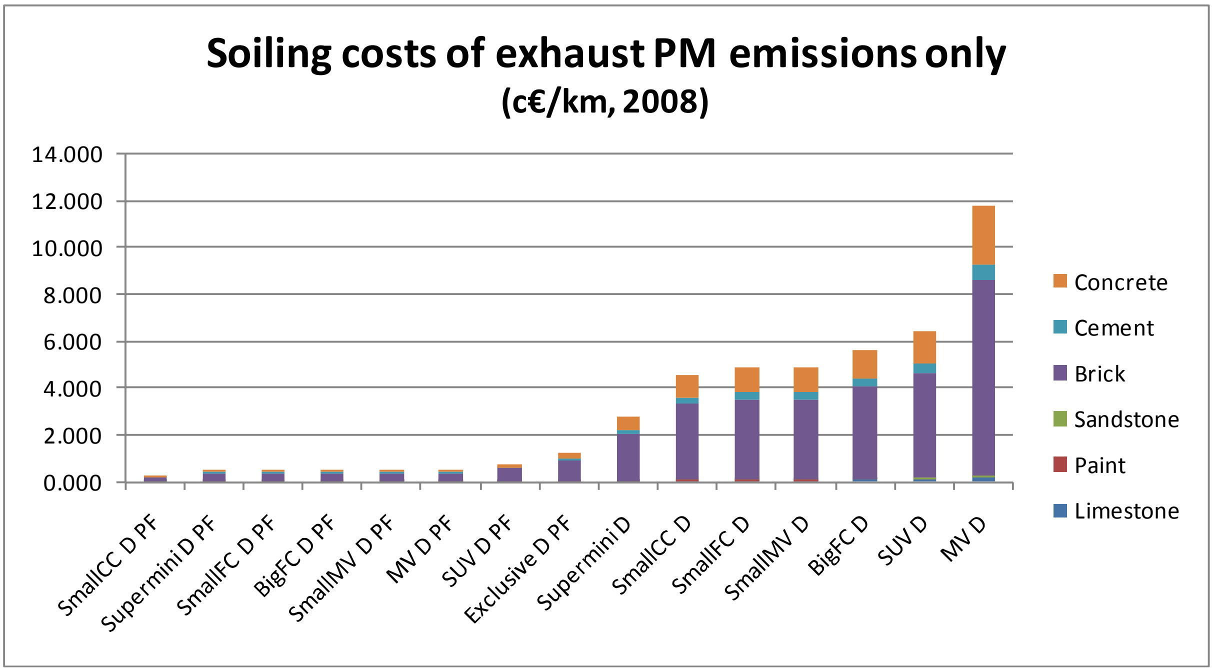
It can be argued that abrasion particles probably cause less soiling than end-pipe emissions (containing soot) and therefore should not be assessed or valued as other PMs. However, as with other health DRFs, soiling, dose-response functions were obtained under current atmospheric conditions where both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

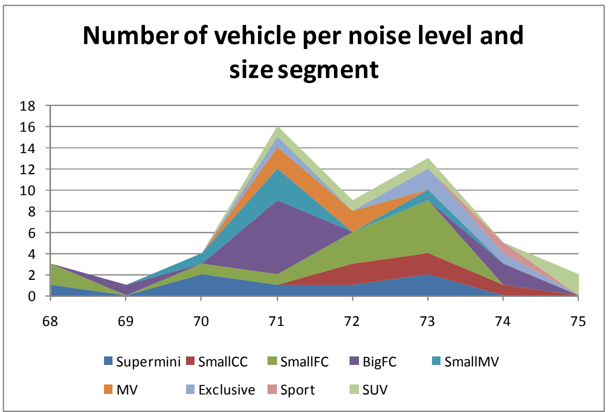
Building degradation by acid rain mainly affects limestone (95% of the total corrosion costs). Other costs gather galvanized steel, zinc, and sandstone corrosion impacts. These costs are linked with SO_2 emissions of vehicles and range from c€ 0.00032/km for a supermini LPG up to c€ 0.0031/km for a sports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

III.4 Noise

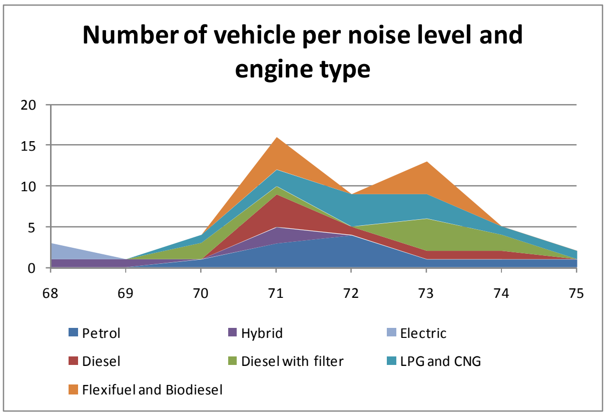
Graph 8 and Graph 9 both present the noise emission level of the set of selected cars organised by car size segment and by engine type. We notice that the emitted noise is not clearly linked either to a specific propulsion mode or to car size. This may seem natural, given the fact that noise is mainly 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.

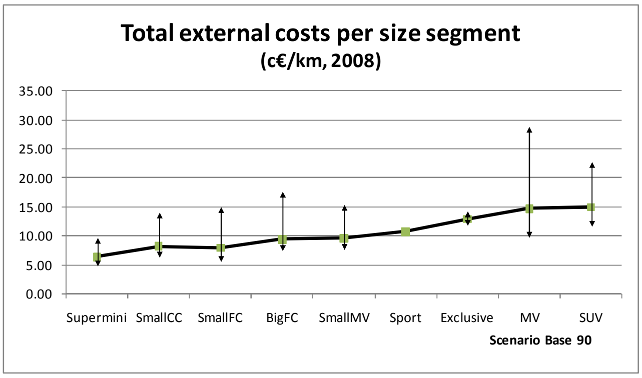
Appendix 3 and Appendix 4 provide the same information grouped by engine type and by car size segmentation for each scenario.

III.7.A. The baseline scenario

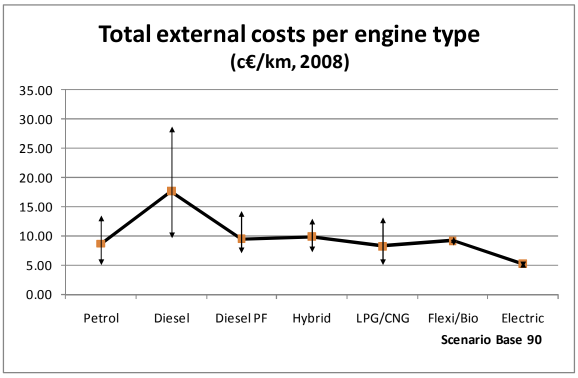
In the baseline scenario where the value of a ton $CO_{2\ eq}$ corresponds to € 90, the total environmental external costs range from c€ 4.81/km per year for a supermini electric car to c€ 28.88/km per year for a diesel monovolume (MV) without particulate filter. The average total external yearly cost 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.

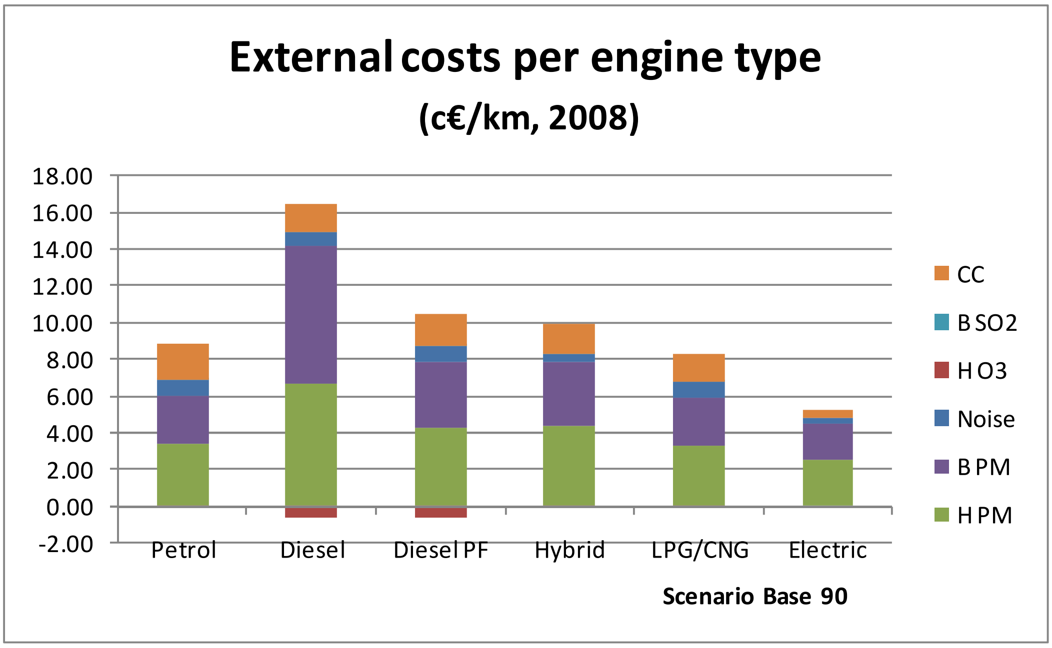
The very positive impact of particulate filters on diesel motorisation is however very obvious.

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.

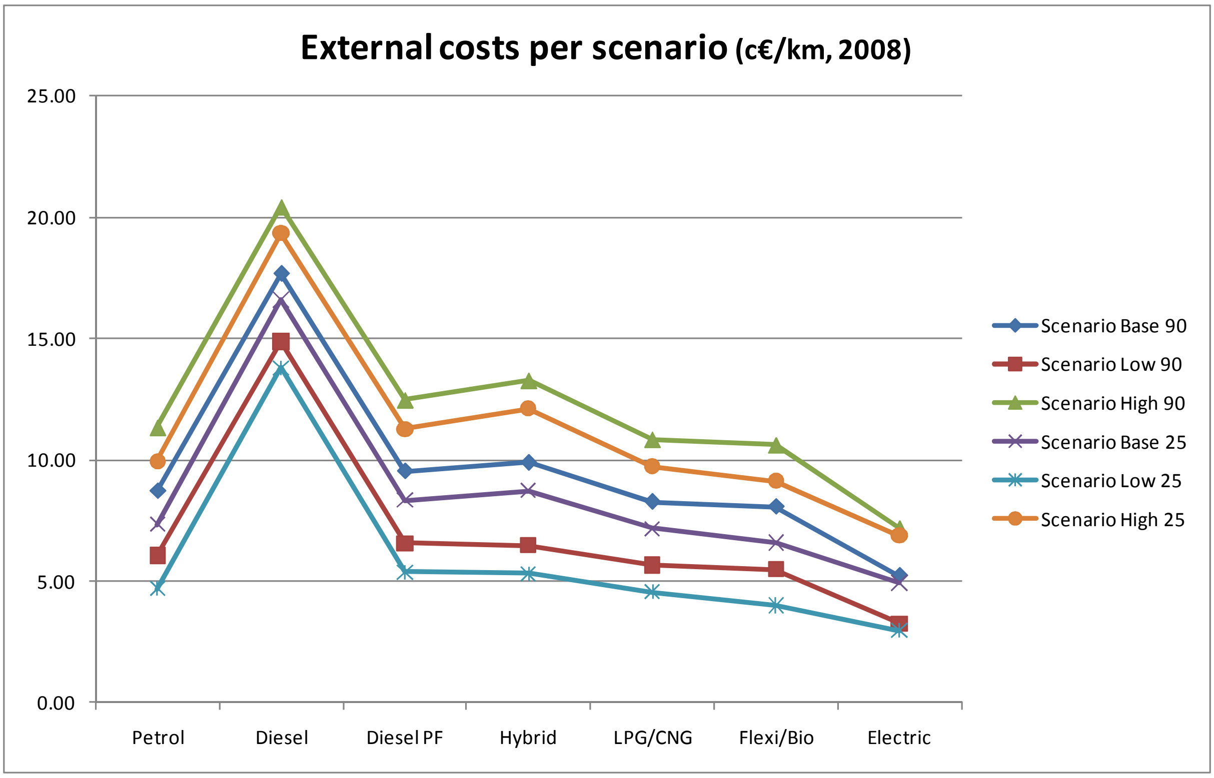
Costs related to building damage as a result of acidification produced by SO_2 emissions are nowadays completely negligible. The highest value for all cars in this survey is c€ 0.0031/km.

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.

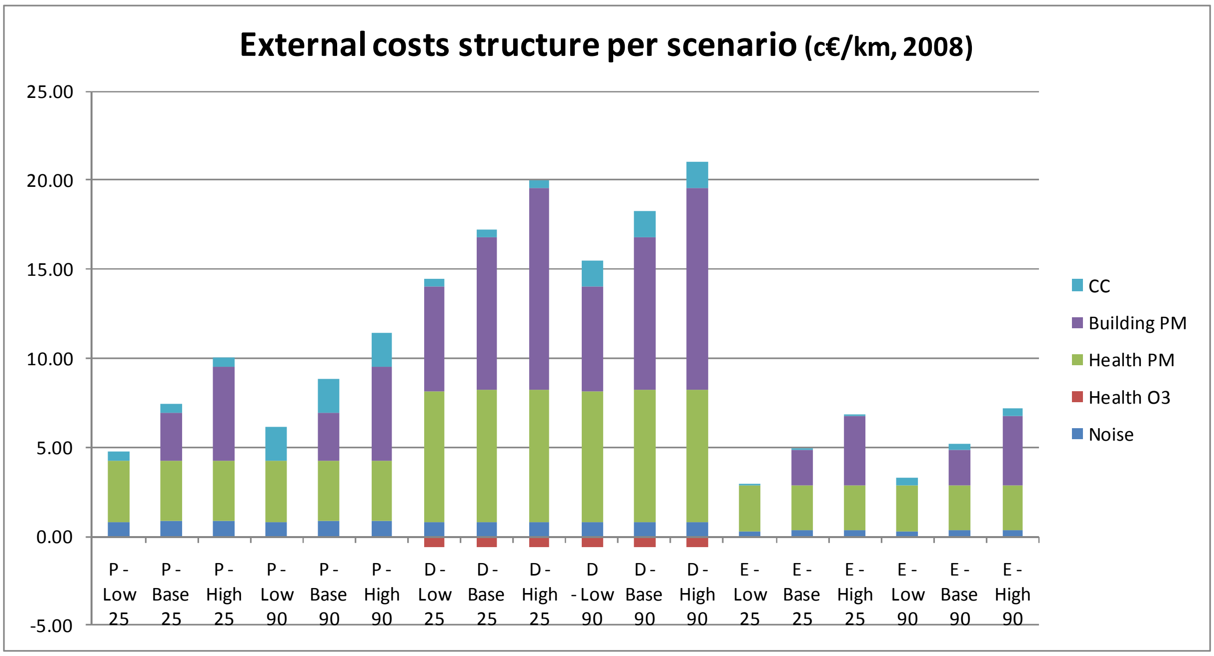
Graph 13 shows the total external costs of the different engine types for the six scenarios/sets. From this graph, we can make a number of observations:

- 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.

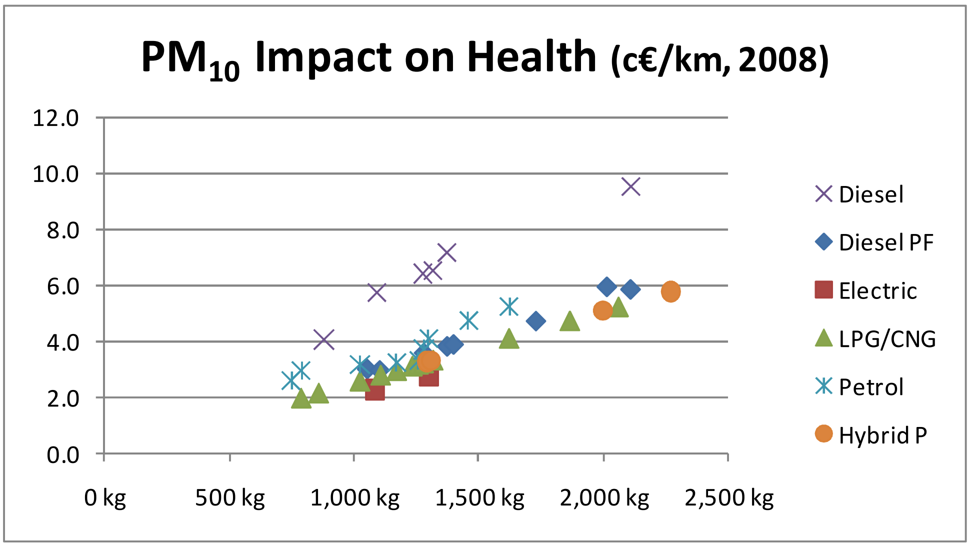
Table 14 is given for scenario 'Base 90', but remain very similar for other scenarios. The conclusions given above remain the same in all scenarios.

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.

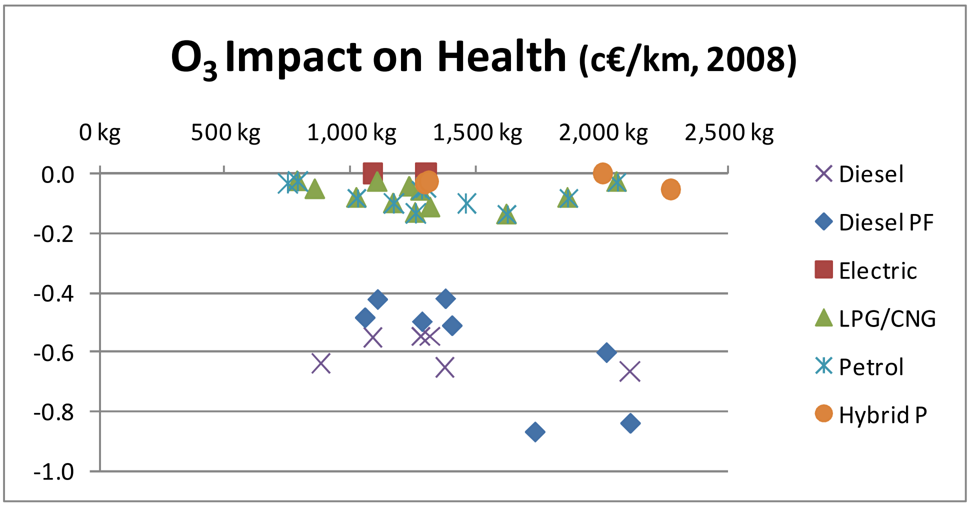
III.8.A. Impact of PM_{10} and O_3 on Health

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.

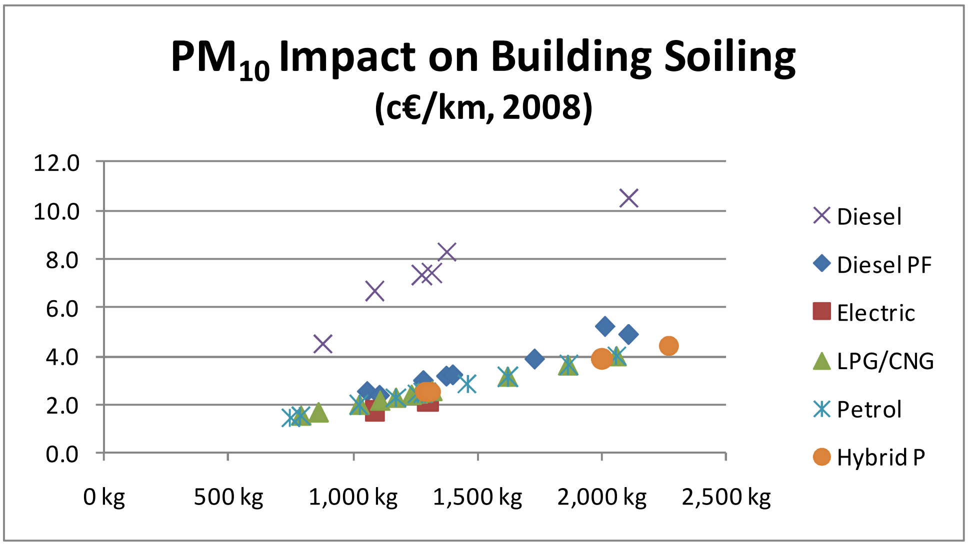


Graph 16: O_3 Impact on Health

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.

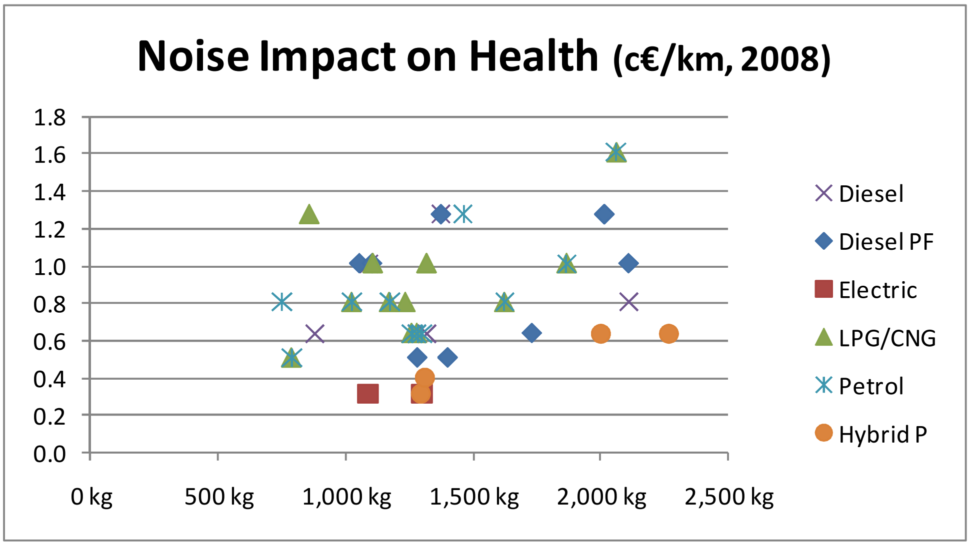
The average marginal external costs are again important for all types of cars (c€ 1.5 – 10.5 /km), and are well correlated with the weight of the cars (Graph 17). Diesel cars with their high exhaust PM emissions are roughly three times as damaging as electric cars.



Graph 17: PM_{10} Impact on Building Soiling

III.8.C. Impact of Noise on health

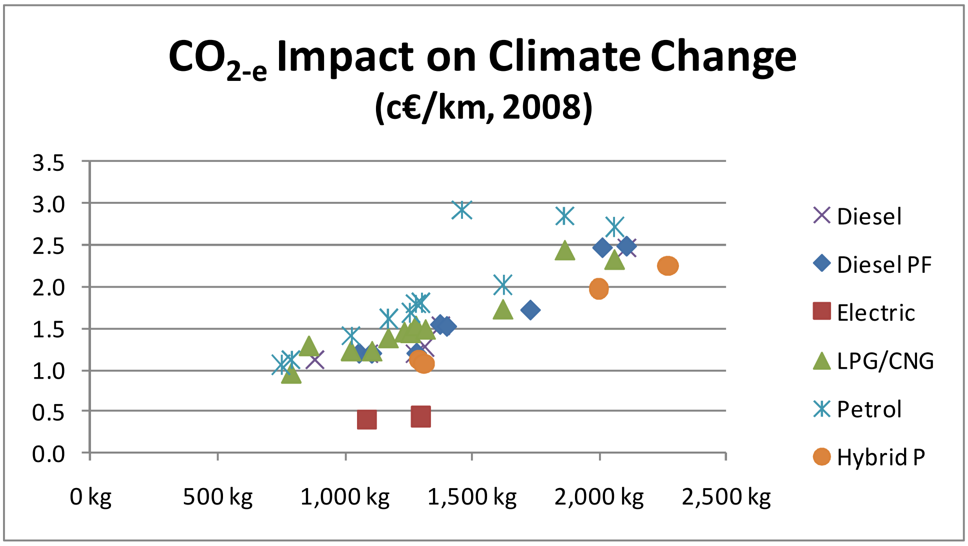
Graph 18 clearly shows that there are no clear links between noise levels from all types of cars, except for electric cars that are the most silent.



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

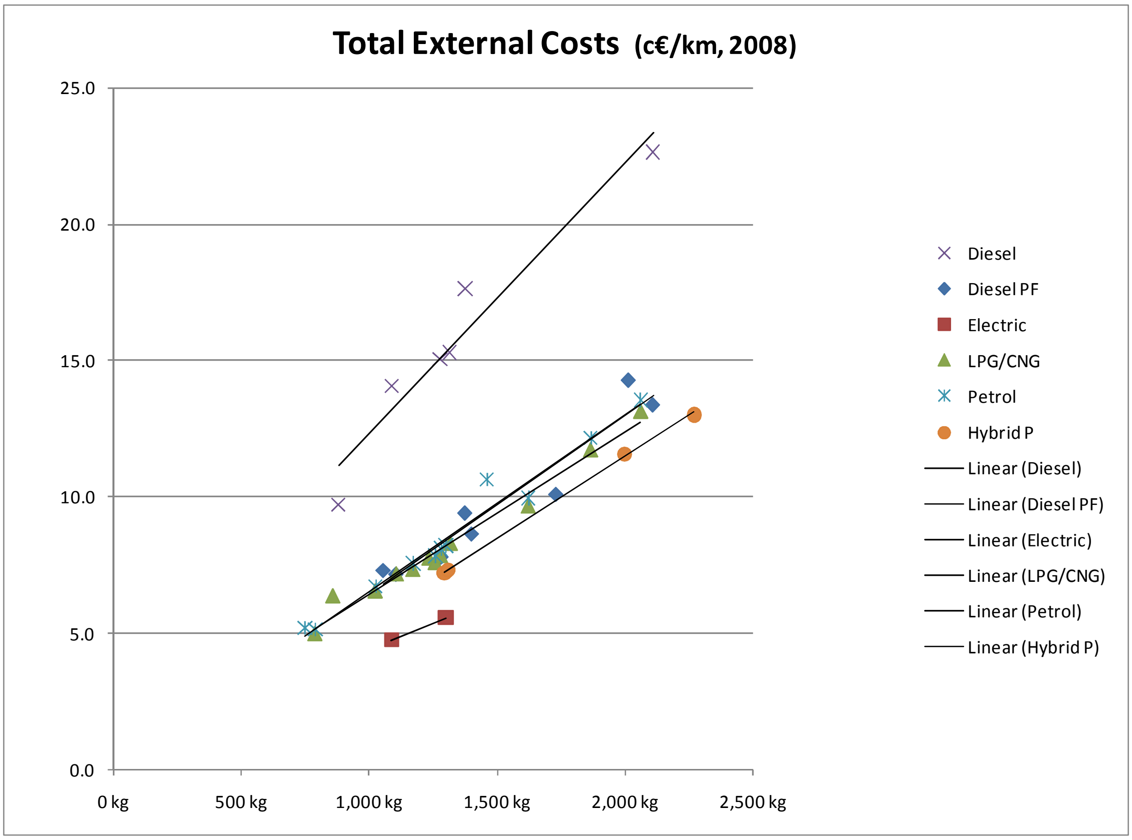
To get a better idea of the impact of the motorisation system on the total marginal external costs, the relation between external costs and vehicle weight has been analysed for the different engine types. Graph 20 represents this relation. It clearly shows that, for each engine type, a linear relationship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

REFERENCES

Abbey, David E., Bessie L. Hwang, Raoul J. Burchette, Tony Vancren, Paul K. Mills. 1995. "Estimated Long-Term Ambient Concentration of PM_{10} and Development of Respiratory Symptoms in a Nonsmoking Population." *Archives of Environmental Health*. Vol 50, N0 2, pp. 139-152.

Al-Alawi S., Abdul-Wahab S, Bakheit C. (2008). Combining principal component regression and artificial neural networks for more accurate predictions of ground-level ozone. Environmental Modelling & Software 2008, 23, pp 396-403.

Anthoff, D. (2007). "Report on marginal external damage costs inventory of greenhouse gas emissions", EC Project n°502687, 6FP, NEEDS, Delivery n°5.4 – RS 1b, 47 p.

Baum, H., Geißler, T., Schneider, J., Bühne, J-A. (2008). "External Costs in the Transport Sector – A Critical Review of the EC-Internalisation Policy", *Institute for Transport Economics,* University of Cologne, 78 p.

Beekmann, M., Vautard, R. (2009). "A modelling study of photochemical regimes over Europe: robustness and variability", in *Atmospheric Chemistry and Physics Discussion*, 9, 1521-1560.

Blok *et* al, (2001). "Economic valuation of Sectorial Emission reduction Objectives for Climate Change Comparison of "Top-down" and "bottom-up" Analysis of Emission Reduction Opportunities for CO_2 in the European Union", AEA Technology Environment and National Technical University of Athens, September 2001.

Borrell, P., (2003). "The weekend effect", RSC, in *Advancing the Chemical Sciences*, http://www.rsc.org/chemistryworld/Issues/2003/May/weekend.asp, 6 p.

Boureima, F-S., Messagie, M., Sergent, N., Matheys, J., Van Mierlo, J., De Vos, M., De Caevel, B. (2009). "Comparative LCA of Electric, Hybrid, LPG and Gasoline family cars in a Belgian context", Stavanger, Norway, in World Electric Vehicle Journal, vol.3, ISBN-ISSN: 2032-6653, 8 p.

CEC (2008). "Strategy for the internalisation of external costs", Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions 435 final, 9 p.

Clapp, L.J., Jenkin, M.E. (2001). "Analysis of the relationship between ambient levels of O3, NO2 and NO as a function of NOx in the UK", in *Atmospheric Environment*, 35, 6391-6405.

COPERT II (1998). Computer Program to Calculate Emissions from Road Transport - Users Manual- EEA, 51p.

DEFRA (2007). "The Social Cost of Carbon and the Shadow Price of Carbon: What they are and How to Use them in Economic Appraisal in the UK", Economics Group of DEFRA, http://www.defra.gov.uk.

Department of Energy (2000). Federal Register / Vol. 65, No. 113 / Monday, June 12, 2000 / Rules and Regulations 36989

Derwent, R.G. (2008). “New Directions: Prospects for regional ozone in north-west Europe“ Atmospheric Environment, 42, 1958–1960.

ECMT, (1998). Resolution No. 98/1 on the policy approach to internalising the external costs of transport. [CEMT/CM(98)5/FINAL]. Minister of Transport of the ECMT, meeting in Copehagen on 26-27 May 1998, 4 p.

EEA (1998). Tropospheric ozone: background information. Tropospheric ozone in the EU – the consolidated report. pp 1-6.

EEA (2000). Computer program to calculi emissions from road transport. COPERT III – Technical Report N° 50, 46 p.

EEA (2009). “Assessment of ground-level ozone in EEA member countries, with a focus on long-term trends“ European Environment Agency , *Technical report No 7,* 52 p.

ERPURS (1997). “Analyse des liens à court terme entre pollution atmosphérique et santé ; Résultats 1991-1995” (Analysis of short term correlations between air pollution and health : results 1991-1995). Evaluation des Risques de la Pollution Urbaine sur la Santé. Observatoire Régional de Santé d’Ile-de-France, Paris.

ExternE (1999). “Externalities of Energy. Vol 7 – Methodology Update. A report produced for the EC – DG XII”, Office of Publications for the European Communities, Luxembourg, 518 p..

ExternE (2000). “External Costs of Energy Conversion – Improvement of the Externe Methodology and Assesment Of Energy-related Transport Externalities”. Final Report for Contract JOS3-CT97-0015, published as Environmental External Costs of Transport. R. Friedrich and P. Bickel (eds.) Springer Verlag Heigelberg 2001, 260 p..

ExternE (2005). “Externalities of Energy, Methodology 2005 update”. Bickel P. & Freidrich R. (Eds). IER, Stuttgart, Germany, 270p..

Favrel, V., Hecq, W., (2001). “External costs of air pollution generated by road traffic in the Brussels urban area" in "International Journal of Vehicle Design”. 27, (1-4),129-139.

Favrel, V., Hecq, W., Pons,T., Marechal, K., Claeys, P., et Ferdinand, C. (2001). “Sustainable Mobility in Brussels - Analysis of the impacts on the environment - Evaluation of environmental externalities”. Research carried out for the Federal Office for Scientific, Technical and Cultural Affairs. Programme of scientific support for a sustainable development. 68 p. appendices 300 p.

Fierens, A., Ferdinand, C., Landrain, V., Hecq, W. (1998). “An assessment of the external costs produced by air pollution from building heating in Belgium”. Study carried out for ELECTRABEL/SPE, Vol. 2 - 99 p. + appendices. (In French).

Forster, et al., (2007). Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Gehrig *et al*, (2004). Seperate determination of PM10 emission factors of road traffic for tailpipe emissions from abrasion and resuspension processes. *In:* Int. J. Environment and Pollution, Vol. 22, No. 3, 2004. pp 312-325.

Guignard, A. *et al.*, (2005). Coûts financiersdirects et indirects engendré&s par l'installation de systèmes d'air climatisé dans les voitures particulières. CEESE and ETEC report – Brussels Environment Institut. 118 p..

Harrison, R. M., Jonesa A. M. & Barrowcliffe R. (2004). "Field study of the influence of meteorological factors and traffic volumes upon suspended particle mass at urban roadside sites of differing géométries", in *Atmospheric Environment*, 38, 6361–6369.

Harrison, R. M., Yin, J., Mark, D., Stedman, J., Appleby, R. S., Booker, J., et al. (2001). Studies of the coarse particle (2.5–10 μm) component in U.K. urban atmosphere. Atmospheric Environment, 35, 3667–3679.

Hecq, W., Borissov, Y., Debever, C. (1994). "An empirical hybrid model for the assessment of daily SO2 concentrations in an urban environment in connection with the use of fossil fuel", in *Journal of Environmental Management*, J.N. Jeffers (Ed), Academic Press Limited, vol.42, 181–198.

http://economie.fgov.be/fr/statistiques/chiffres/population/structure/index.jsp

IBGE (Bruxelles Environnement) (2003), "Plan d'amélioration structurelle de la qualité de l'air et de lutte contre le réchauffement climatique 2002-2010", *Les Cahiers de l'I.B.G.E. 20,* 109 p.

IBGE (Bruxelles Environnement) (2009). "La qualité de l'air en Région de Bruxelles Capitale. Mesures à l'immission 2006-2008, Synthèse", 31 p.

IPCC (2007). "Climate Change 2007: Synthesis Report Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change", Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) IPCC, Geneva, Switzerland. 104 p.

Kourtidis K.A. et al. (1999), Evaporative traffic hydrocarbon emissions, traffic CO and speciated HC traffic emissions from the city of Athens. Atmospheric Environment, 33, 3831-3842.

Laden, F; Neas, L.M., Dockery, D.W. and Schwartz, J. (2000). Association of fine particulate matter from different sources with daily mortality in six US cities. *In:* Environmental Health Prespectives, Vol. 108, pp. 941-947.

Maibach et al., (2008). Handbook on estimation of external cost in the transport sector, produced within the Internalisation Measures and Policies for All external Cost of Transport (IMPACT) study. Delft, 332 p. CE.

Miller, B. G., Hurley, J.F. (2009). "On transferability of concentration-response (C-R) relationships linking outdoor air pollution and health NEEDS", *Technical Paper* n°4.2b - RS 1d, 16 p.

Navrud, S. (2009). "Value Transfer Techniques and Expected Uncertainties", Deliverable n°2.1 – RS 3a, EC Project n°502687, 6FP, NEEDS, SWECO, 26 p.

NEEDS (2007). Sixth Framework Programme. New Energy Externalities Developments for Sustainability. Project no: 502687. Deliverable 3.7-RS1b/WP3. "A set of concentration-response functions". Vito, IOM and Armines (eds.).

Nellthorp, J. *et al.*, (2007). Introducing willingness-to-pay for noise changes into transport appraisal – An application of benefit-transfer. Transport reviews, 27(3), pp 327-353.

OECD (2005). OECD Environmental Data – Compendium 2004, OECD Publication, Paris, 324 p.

OECD (2008). The health costs of inaction on key environmental challenges, OECD Publication, Paris, 40 p.

Pope CA, RT Burnett, MJ Thun, EE Cale, D Krewski, K Ito, and GD Thurston (2002). "Lung cancer, cardiopulmonary mortality, and long term exposure to fine particulate air pollution". *In:* J. Amer. Med. Assoc., vol.287(9), pp 1132-1141.

Quinet et al., (2008). La valeur tutélaire du carbone. Centre d'analyse stratégique. La documentation Française. 16. 421 p.

Rabl A. (2002). Relation between Life expectancy and Probability of Dying. Report Centre d'Energétique, Ecole des Mines, Paris. http://www-cep.ensmp.fr/francais/themes/cycle/.

Rabl A. (2007). Pollution atmosphétique et bâtiments : estimation du coût des dommages. *In :* Pollution atmosphérique numéro spécial, Octobre 2007, pp 101-109. Centre énergétique, école des Mines, Paris.

Rosenberg *et al.*, 2001. Benefit transfer of outdoor recreation use values: A technical document supporting the Forest Service Strategic Plan (2000 revision). U.S. Department of Agriculture, Forest Service.

Scholz W & Rabl P, 2006. Unexpectedly low decrease of $N0_2$ air pollution – Correlation with ozone concentration and altered exhaust emissions. Published in: 2nd conf. Environment & Transport, incl. 15th conf. Transport and Air Pollution. Reims, France, 12-14 June 2006. Proceedings n°107, Vol. 2, Inrets ed., Arceuil, France, 2006, pp. 264-269

Sillman S. Overview: Tropospheric ozone, smog and ozone-NO_x-VOC sensitivity. http://www.personal.engin.umich.edu/~sillman (September 2009)

SPF Economie (2010). "Structure de la population",

Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., Crane, D., Cruickshank, S., Dietz, S., Edmonson, N., Garbett, S-L., Hamid, L., Hoffman, G., Ingram, D., Jones, B., Patmore, N., Radcliffe, H., Sathiyarajah, R., Stock, M., Taylor, C., Vernon, T., Wanjie, H., Zenghelis, D. (2006). "Stern Review: The Economics of Climate Change". HM Treasury, London, Cambridge University Press, 712 p.

Thorpe, A. J., Harrison, R. M., Boulter P.G. and McCrae, I.S. (2007). "Estimation of particle resuspension source strength on a major London Road", in *Atmospheric Environment*,**Error! Hyperlink reference not valid.**) 8007-8020.

Timmermans, J-M, Matheys, J., Van Mierlo J., Lataire P., (2006). “Environmental rating of vehicles with different fuels and drive trains: a univocal and applicable methodology”, *European Journal of Transport and Infrastructure Research (EJTIR)*, 6, n°4, pp 313-334.

Tol, R., S., (2002). Estimates of the damages costs of climate Change. Part I and II, - Environmental and Resource Economics 21 (1), (2) ; pp47-73, pp 135-160.

Tol, R.S.J. (2006). “Report on marginal external costs inventory of greenhouse gas emissions / Report on the analysis on average and marginal avoidance costs of greenhouse gas emissions”, EC Project n°502687, 6FP, NEEDS, Technical Paper n°5.4/5.5 - RS 1b, Hamburg, Vrije and Carnegie Mellon Universities, 9 p.

Torfs, R., Hurley, F., Miller, B., Rabl, A., (2007). “A set of concentration-response functions” NEEDS Deliverable 3.7-RS1b/WP3, 162 p.

Van Regemorter, R.D., Pietrapertosa, F.,Di Leo, S.,Cosmi, C., (2009). “Integration of External cost data and LCA data in TIMES and application to two policy issues”, Deliverable n° 8.5 - RS 1b, 21 p.

WHO (2004). Health aspects of air pollution – Results from the WHO project “Systematic Review of Health Aspects of Air Pollution in Europe”, WHO, Copenhagen. http://www.euro.who.int/document/e83080.pdf; accessed february 2009.

www.internationaltransportforum.org/europe/acquis/env19981e.pdf, 01/10/08.

Internet sites

http://ies.jrc.ec.europa.eu/WTW.html

http://www.ecoscore.be

http://statbel.fgov.be

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

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	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

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	0.475	-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

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	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

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	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

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	0.475	-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 AME	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

Engine type		Weight	Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Engine type		Weight	Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Engine type		Weight	Noise (c€/km)	H O3 (c€/km)	H PM (c€/km)	B PM (c€/km)	B SO2 (c€/km)	CC (c€/km)	Total (c€/km)	%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

Engine type		Weight	Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Engine type		Weight	Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Engine type		Weight	Noise c€/km	H O3 c€/km	H PM c€/km	B PM c€/km	B SO2 c€/km	CC c€/km	Total c€/km	%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

Car size segmentation			Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Car size segmentation			Noise	H O3	H PM	B PM	B SO2	CC	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						
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

Car size segmentation			Noise c€/km	H O3 c€/km	H PM c€/km	B PM c€/km	B SO2 c€/km	CC c€/km	Total c€/km	%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 AMB	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	on-CO2/CO2 e	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													

Clean **V**ehicle **R**esearch: LCA and Policy Measures
(CLEVER)

Report Task 4.2
Barriers to the development of alternative vehicles in Belgium

Université Libre de Bruxelles
Centre d'Etudes Economiques et Sociales de l'Environnement (CEESE)

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LIST OF ACRONYMS

ACEA	European Automobile Manufacturers’ Association
BIM	Brussels Instituut voor Milieubeheer
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CVO	Corporate Vehicle Observatory
DBDMH	Brusselse Hoofdstedelijke Dienst voor Brandbestrijding en Dringende Medische Hulp
E85	85 % Ethanol (15 % Petrol)
EU	European Union
FEBIAC	Fédération Belge de l'Automobile et du Cycle / Belgische Automobiel- en tweewielerfederatie
GHG	Greenhouse Gas
IBGE	Institut Bruxellois pour la Gestion de l’Environnement
LPG	Liquefied Petroleum Gas
MIVB	Maatschappij voor het Intercommunaal Vervoer te Brussel
MBHG	Ministerie van het Brussels Hoofdstedelijk Gewest
MRBC	Ministère de la Région de Bruxelles-Capitale
NGO	Non Governmental Organisation
NMVOC	Non-methane volatile organic compounds
NOx	Nitrogen oxides
R&D	Research & Development
STIB	Société des Transports Intercommunaux de Bruxelles
SIAMU	Service d'Incendie et d'Aide Médicale Urgente de la Région de Bruxelles-Capitale
TGAP	Taxe Générale sur les Activités Polluantes

INTRODUCTION

The transport sector contributes significantly to CO_2 emissions (about 28% from fossil fuel emissions in EU-25 in 2005), with the road transportation being responsible for about 20% of the CO_2 emissions in EU-25 in 2005[1]. Road transportation is also responsible for the majority of NO_X, CO, and NMVOCs[2] emissions, and is the second most important source for primary particulate matter emissions in EU-27[3]. For this reason and because of the finite nature of oil resources, important changes in the field of transport are needed.

Alternatives to conventional fossil fuel vehicles (gasoline and diesel vehicles) offer sometimes attractive environmental characteristics and can contribute to a diversification of energy sources. With this aim, the European Union has fixed the objective of substituting 10% of traditional automotive fuels by alternative fuels before the year 2020 in Europe[4]. Of course, it is important to keep in mind that every vehicle is polluting to some extent and that alternative vehicles will not allow for maintaining the current over-utilization of cars (more generally, new technologies do not allow for maintaining the current way of life in our societies). So, promoting alternative vehicles has to go together with a decrease in the current utilization of cars.

In the present study, alternative vehicles include vehicles with alternative propulsion systems (battery, hybrid and fuel cell) and vehicles using alternative fuels (LPG, CNG and biogas, biofuels and hydrogen). Although some of those alternatives could contribute to a diversification of energy sources and to the reduction of the increase of GHG and pollutants emissions, their diffusion on the Belgian market is still low (about 1 % of the Belgian park in 2006[5]).

- Objectives

The first objective of the present study is to identify the main barriers impeding the development and the diffusion of alternative vehicles in Belgium, and to evaluate their relative importance. This objective is approached through the **consultation of the different groups of stakeholders**. In this study, a distinction has been made between barriers that prevent the development of alternative vehicles in general and those that more specifically apply to particular technologies or fuels.

In many previous studies, barriers have been considered in a static and independent way, in the sense that they are all considered on the same level without analysis of causality relations and interdependences. However, strong relationships exist between the different barriers; in fact, they are integrated into an aggregation of complex causal connections. Next to the identification of barriers and evaluation of their relative importance, **the second original objective of the study is to derive a systemic scheme representing the interrelations between the barriers**. This allows for a more global view on the barriers which is essential for drawing effective policy measures. Indeed, policy measures aiming at promoting

[1] European Commission (2008)
[2] non-methane volatile organic compounds
[3] EEA (2008)
[4] http://www.euractiv.com/en/transport/industry-wants-clear-priorities-alternative-transport-fuels/article-177754
[5] Federal Public services mobility and transport (2007)

alternative vehicles development could not have the expected results if they fail to take those interrelations into account.

- Methodology

The first step of the study consisted in performing a literature review on barriers to the development of alternative vehicles. A series of barriers has been pre-identified and classified by category with a typology inspired by literature. The referred studies generally identified barriers in an independent way, without taking interrelations into account.

The literature review helped us to draw up the questionnaires for the **consultation of the stakeholders**, which is the second and main step of this study. The objective of this consultation was to identify barriers to the development of alternative vehicles. Barriers to the purchase and utilisation of alternative vehicles/fuels are different from the barriers to the supply of alternative vehicles/fuel. Also, from the demand-side point of view, it is expected that barriers perceived by individual consumers are different from barriers perceived by companies (private and public) owning a fleet of vehicles. For this reason, stakeholders have been classified into different groups: the demand-side stakeholders, divided between individual consumers and fleet managers, the supply-side stakeholders (vehicles makers, fuel distributors...) and the “experts” from various institutions (research centres, policy makers, NGO’s...) who offer a more global and analytic view on barriers. Those four groups (including the two groups of demand-side stakeholders) have been sounded out concerning barriers to the development of alternative vehicles from their point of view.

The data and information collected from the stakeholders’ consultation have been treated trough statistical and/or qualitative analysis.

In a third and last step, **a systemic diagram representing the interrelations between the barriers** expressed by the different stakeholders has been derived from a transversal analysis of the results. This analysis has been complemented by elements of the literature about the “technological lock-in” concept.

- Content

In a first introductory part, the classification of barriers by category is presented (typology of barriers).

The second part includes the results of the stakeholders’ consultation and is divided into four chapters: the first one presents the barriers to the purchase and use of alternative vehicles from the individual consumer’s point of view and the second one, from the point of view of the fleet managers from private and public companies. The third chapter presents the identified barriers to the supply of alternative vehicles from the supply-side stakeholder’s point of view. Barriers to the development of alternative vehicles according to the “experts” (which include demand-side and supply-side barriers but also barriers “upstream”, i.e. linked to the broader context in which the automobile sector operates) are presented in the fourth chapter.

The third part of the study is dedicated to a transversal and systemic analysis of the barriers identified through the stakeholders’ consultation. In the first chapter of this part, some characteristics and consequences of the “technological lock-in” process are given. On this basis and on the basis of the results of the stakeholder’s consultation, a dynamic view of the barriers is proposed and a systemic scheme representing the interrelations between barriers is presented in the second chapter. Some general elements of policy recommendation following our results are given in the third chapter of this part.

Main conclusions of the study are presented in the fourth and last part.

- Note for the reader

A first rapid reading of this report is possible by reading only the first part, the first chapter of the second part, the third part and the conclusion.

PART 1: TYPE OF BARRIERS AND CLASSIFICATION

Alternative vehicles are confronted with a wide range of barriers impeding their market introduction and their diffusion. Indeed, numbers of factors can explain the low demand and supply of those vehicles.

A first identification of barriers has been done, based on a literature review[6] and on a first consultation of a sample of experts. In most of those referred studies, barriers are considered in a static way, in the sense that they are all considered on the same level without analysis of causality and interdependence. Those pre-identified barriers are listed in the questionnaire (for experts and supply-side stakeholders) in the appendix 4. Some of those barriers impede the development of barriers in general and other (more specific) barriers applied to some category of alternative vehicles only. In the questionnaires and in the study in general, this distinction has been made.

Although those barriers are not independent and are often highly interconnected, they have been classified by group according to their nature in order to facilitate the analysis. The typology used in the study is inspired by previous works[7]. However, classification is sometimes highly debatable, and varies from one study to another. For this reason, the classification used in this study will not correspond exactly to one particular reference (although it is very much inspired by literature), but is specific to this study according to what we consider as relevant. In economics, the supply and demand are function of the price of the product (here the alternative vehicle, for example the CNG vehicle), the price of the substitutes (conventional cars -fossil fuel- and the other category of alternative vehicles, like electric vehicles etc.) and the price of complementary products (fuel price -like the CNG price-, maintenance costs...), and also other "external" (non economic) factors influencing the demand and the supply curves: quality, taste, habits, legislation etc. In this regard, typology of the barriers presented below includes these different elements.

The barriers - which can explain the low demand and supply of alternative vehicles -, have been delimited and classified according to the following categories:

- ***Economic barriers***: this category includes all the barriers related to price and cost (high purchase price of the vehicle, high cost of refuelling/recharging infrastructure, high fuel prices…).

- ***Technical barriers***: this category refers to the possible technical problems or technical disadvantages of alternatives vehicles (limited range, long refuelling time, tank heavy and cumbersome …).

- ***Psychological barriers***: this category refers to the "non-rational" behaviour of the consumers, the emotional side influencing their preference and the process of purchase decisions. Those barriers are related to habits (routine behaviour), apprehension/fear of new systems, influence of advertising, symbolic content of the car for some people (associated

[6] The literature review used for the questionnaire was mostly based on the following studies: Favrel et al. (2001), Kofoed-Wiuff and al. (2006), Murray and al. (2000), Smith (2001) and Troelstra (1999).
[7] Favrel et al. (2001) and Smith (2001)

with personality, social status …) and the representation of the concept of a car: image of freedom (so a car has to be fast, with a long range etc.),…

- ***Legislative barriers***: this category includes possible lack of legislation (e.g. lack of standard or lack of harmonised standards for alternative fuels) and possible inappropriate legislation.

- ***Political barriers****:* this category includes barriers related the lack of necessary policy measures.

- ***Institutional barriers:*** this category is referring to barriers related with institutions, conflicts of interest or lobbying of various socio-economic groups.

It has to be noted that the frontiers between legislative, political and institutional barriers are not always clear, so it happens in the report that we group those categories together when classifying a barrier.

- ***Environmental and societal barriers***: this category includes the possible lack of conviction of stakeholders about the environmental or the societal benefits of alternative vehicles (controversies about energy efficiency of biofuels or hydrogen, impact of biofuel on food sector etc.).

- ***Market barriers***: this category refers to all the other factors which have a negative influence on the supply and demand for alternative vehicles and which are not included in the previous groups. We distinguish ***demand-side market barriers*** (including the factors with a negative influence on the demand for alternative vehicles) and ***supply-side market barriers*** (including the factors with a negative influence on the supply of alternative vehicles).
Demand-side market barriers include for example the lack of information of consumers on alternative vehicles[8], the lack of development of those vehicles (implying that people prefer to wait for others to use such vehicles before adopting them themselves), lack of general competitiveness of the alternative compared to conventional cars for various reasons (as a consequence of other barriers) etc. ***Supply-side market barriers*** include for example the lack of fuel availability (lack of refuelling/recharging stations) which prevent vehicle makers from developing and commercializing alternatives (on a massive scale) and vice versa ("chicken and eggs" problem), the lack of maintenance and after-sale services etc.

Beside this, we have to consider that a short supply (quantitative and qualitative e.g. lack of available models) of alternative vehicles represents of course an important barrier to the purchase for consumers; in this case, when talking about barriers from the consumer's point of view, the "***supply barriers***" will refer to the impact of short supply on consumer purchase behaviour. Symmetrically, when considering barriers from the supply-side point of view, the "***demand barriers***" will refer to barriers perceived by vehicle makers as they expect no demand for alternative vehicles (a reason why they do not develop their supply).

[8] The barrier "lack of information" is sometimes considered separately in the study.

PART 2: IDENTIFICATION AND EVALUATION OF THE IMPORTANCE OF BARRIERS IN BELGIUM THROUGH STAKEHOLDERS' CONSULTATION

All the stakeholders are not confronted with the same barriers or will perceive differently the importance of barriers. For this reason, they have been classified in the different groups listed below:

1) Demand-side stakeholders, who are expected to react to demand side barriers; they are divided into 2 groups:

- Individual consumers
- Fleet managers (Companies/administrations with a fleet of vehicles)

2) Supply-side stakeholders: vehicle makers (and federations), fuel distributors, LPG fitters... who are expected to react to supply-side barriers

3) "Experts" (from research centre, politics, NGO's...), who offer a more global and analytic view on the question (about demand and supply-side barriers, but also about the "upstream" barriers, e.g. related to the context in which the automobile sector operates).

Those four groups (including the two groups on the demand-side) were sounded out concerning the barriers to the development of alternative vehicles from their points of view. However, the applied methods were different for each group. For the individual consumer's group, a survey was carried out at the Brussels Motor Show in January 2008. A specific questionnaire was drawn up for it, and a sample of 263 people was interviewed. For the supply-side stakeholders and the experts, a more detailed questionnaire was drawn up. In those cases, smaller samples of stakeholders (about 20 for each group, with various contributions) were met to answer the questionnaire directly and to allow for an in-depth interview-discussion. For the companies and administrations with a fleet of vehicles, a sample of 14 fleet managers (as well as 2 taxi drivers) was sounded out by phone. The majority of them were from public institutions, from Brussels in particular.

The results of the stakeholders' consultations are presented below. As the questionnaires and the answers were different for each group of stakeholders, the presentation of the results varies for each group. The first chapter of this part presents the results of the survey at the Motor Show, which are indicative of the barriers to the purchase and to the use of alternative vehicles/fuels from the point of view of the Belgian individual consumer. The second chapter presents the results of the fleet managers' consultation, giving information on the barriers to the introduction of alternative vehicles in companies/administrations owning a fleet of vehicles. The third chapter is dedicated to the results of the supply-side stakeholders' consultation, revealing barriers met by industries and actors on the supply-side. Finally, the last chapter of this part is devoted to the opinions of experts about the existing barriers to the development of alternative vehicles.

2.1. Barriers to the purchase/use of alternative vehicles from the individual consumer's point of view: survey results

Barriers to the purchase of alternative vehicles were assessed by a survey performed at the Motor Show of Brussels in January 2008.

The **general objectives** of the survey were the following:
- Identification of barriers to the purchase/use of alternative vehicles (in general and by technology/fuel) in the context of Belgium from the consumer's point of view through open questions;
- Validation (or invalidation) of "demand-side" barriers pre-identified in the literature;
- "Quantitative" evaluation of the "demand-side" barriers' relative importance;

The sample is composed of 263 individuals. However, respondents had the possibility to answer only some parts of the questionnaire (see section 2.1.1.). Although the representativeness is discussed in the first section below, it has to be underlined that this survey does not pretend to be representative of the all Belgian population and it was not the purpose. Indeed, the purpose of the survey was focused on the collect of opinions and on an in-depth analysis of the answers (many open questions in the questionnaire).

The chapter is divided in 6 sections; the first section brings out some basics of methodology about the survey and discusses the question of representativeness of the sample. The second section is dedicated to the penetration onto the market of alternative vehicles in the survey sample (current users), the reasons from buying an alternative car and the problems encountered on the one hand (sub-section 2.1.2.1), and the purchase intentions of the survey population on the other hand (sub-section 2.1.2.2.). The third section concerns the lack of information of people about alternative vehicles. As the lack of information represents a very important barrier, it has been decided to devote a particular section to this topic. Furthermore, it is a particular barrier in the sense that it can generate barriers than do not actually exist (prejudices resulting from bad information) or it may hide possible other barriers. The fourth section presents the results about the importance of barriers to the purchase/use of alternative vehicles in general. The fifth part presents the results about the importance of barriers by vehicle technology. The sixth part introduces some types of policy measures proposed by the respondents to encourage the purchase of alternative vehicles and the last part concludes and summaries the main results of the survey.

2.1.1. Methodology and representativeness of the survey in brief

- Structure of the questionnaire

In order to meet the objectives mentioned above, the structure of the questionnaire consisted in 3 main parts:
I. General questions (mainly open questions) on knowledge about the different alternative technologies, on purchase intentions, on barriers to the purchase of alternative vehicles, on policy measures…
II. Personal evaluation of the importance of barriers to the purchase/use of alternative vehicles in general (pre-identified barriers and barriers identified by the respondent).

III. Open question about barriers to the purchase/use of specific categories of alternative vehicles and personal evaluation of the importance of barriers by category of alternative vehicle (pre-identified barriers and other barriers identified by the respondent).

Respondents were given the option of not answering part III (according to their knowledge). Most respondents only filled in part I and II (general barriers), and about 25% also answered part III.

- Methodology for the data treatment

The methodology for the data treatment was the following:

- Qualitative information from open questions was first codified according to the type of response. Then, those codified answers were classified by category of barriers following the typology described in part I. Finally, those answers were treated through *frequency of occurrence* (software: excel).
- For quantitative information from closed questions where the respondents had to select an answer on a scale (e.g. between 0 and 10 for the evaluation of the importance of barriers), *the average*s of the answers were computed, as well as *the standard deviations* (software: excel).
- Associations between the different answers were tested (*bivariate analysis*), e.g.: are reasons for no intention of buying alternative vehicles linked to degree of knowledge or to respondent attributes? (Software: SAS). Three types of statistical tests (according to the nature of the variables considered) have been performed to identify possible relations between the answers:
    - *Analyses of variance (ANOVA test)* were used to test the relation between a discrete variable and a continuous variable. The objective is to test if significant differences between means of different groups exist. The homogeneity of the variances ("homoscedasticity"), which is the most important condition for using this test, has always been checked.
    - *Khi-2 tests* were used to test the relation between two discrete variables. The objective is to test the independence between the distributions.
    - *Correlation coefficients of Pearson (r^2) were used* to test the linear correlation and its direction between two continuous variables.

  Those tests have been done for all possible relations between variables; only significant results are mentioned in the following sections, and the p-value is given for each test. The acceptable error rate (significant level) for the p-value is 0.05 (5 %).

- Type of survey and representativeness

The questionnaire included many open questions and the interviewers read the questions to the respondents to ensure a right interpretation. Such **in-depth interviews** were only possible with a restricted sample of interviewees. This implies that **the purpose of the survey was not to be representative of the Belgian population but rather to collect detailed information from the public as to their reasons for not buying alternative vehicles**. **However, for information, representativeness is discussed below**.

Above all, final results will have to be interpreted with caution concerning representativeness of the Belgian population. Indeed, we can reasonably assume the presence of 2 uncontrolled biases; the first one (and the most important) is that **visitors to the Motor Show** have specific characteristics as they decided to go to the salon (for example, they are probably more interested in cars than the average population). The second bias comes from the fact that people who accepted to answer the questionnaire may also have some specific characteristics (interests on environment for example)[9]. Those biases have to be kept in mind when considering the results.

Beside this point, representativeness of the sample was evaluated by **comparing the characteristics of the sample population group with those of the Belgian population**. It was observed that the percentage of people in the different social statuses (share of municipal officers, workers, employees and independent) is roughly equal to the corresponding percentage of the Belgian population. On the other hand, we noticed a strong over-representation of men in the sample (80%), corresponding to the proportion of men visiting the Motor Show. Concerning the distribution of age in the sample, an over-representation of people between 20 and 39 years old and an under-representation of people of more than 50 (which is again a characteristic of visitors to the Motor Show) was observed. Finally, it was noticed that the level of education of the sample was above the level of the Belgian population, while average household income in the sample was below the average household income of the population.

2.1.2. Current users and purchase intentions

In this section, the current users of alternative vehicles, their reasons for buying (advantages) and the possible problems (disadvantages) they have met are presented in a first sub-section. In a second one, the purchase intentions of the respondents and the reasons for their intentions are described.

2.1.2.1 Current users, their reasons of purchase/use and the problems encountered

Among the interviewed people, 5% (13 people) had an alternative vehicle. Of course this 5 % is not representative of the proportion of alternative vehicles in the whole population (where the proportion is about 1%[10]). As a reminder, it was not the objective of the survey to know the rate of penetration of alternative vehicles on the market in Belgium but rather to discuss the reasons of buying those cars and the advantages and disadvantages of the user.

Among this 13 people using an alternative vehicle, we had:
- 9 with an LPG car
- 2 with electric vehicles (one had a small motor bike and the other had a vehicle, a scooter and an electric bike)
-1 with a Terios ethanol
-1 with a Prius LPG

Without surprise, most of the alternative vehicles used are LPG vehicles.

Generally speaking, among the total 23 advantages mentioned by the owners about their alternative vehicle, 13 are economic and only 4 are environmental (the others are quite diversified).

[9] The interviewers were moving around the different halls in order to obtain a sample which is as representative as possible of the visitors to the Motor Show (with their different interests).
[10] Federal Public services mobility and transport (2007)

It was observed that ***LPG* is mainly chosen for economic reasons rather than for environmental reasons.**

Among the disadvantages encountered for LPG[11], the LPG users have mentioned:
- Limited space (at the back of the car)
- Range limitation
- Poor performance
- High tax
- Not fully achieved (immature technology)
- Lack of refuelling stations and lack of availability to refuel at night
- Lack of access to underground parking

This implies that for LPG users, the economic advantage of LPG compensate for the range of disadvantages mentioned.

For ***electric cars***, the advantage of silence is firstly mentioned for the 2 people involved. The other advantages mentioned are: environmental, economic, less maintenance needed and easy to use for short distances. About the disadvantages, the problem of limited range is mentioned, as well as the maintenance required for the batteries and the problems with the batteries.

For the ***Terios ethanol***, the advantage mentioned is economic (price of the fuel). No disadvantage is mentioned.

For the ***Prius LPG***, the economic advantage (less cost/km) is mentioned.

So it is interesting to note that among the small sample who own an alternative vehicle (in most cases an LPG vehicle), the first motive of purchase is often **economic.**

2.1.2.2 Purchase intentions

Respondents were asked if they had the intention of buying an alternative vehicle in the future. To this question, about 40% of the sample answered "yes" and about 60% answered "no"[12].

It must be mentioned that 6% of the whole sample had answered yes, but when specifying which category of clean vehicle they meant, they mentioned a conventional car with low fuel consumption. As this is not an alternative vehicle, we considered the answer as negative (so they are included in the 60% of negative answers), and the competition with low consumption conventional cars as an obstacle (see section 2.1.4.).

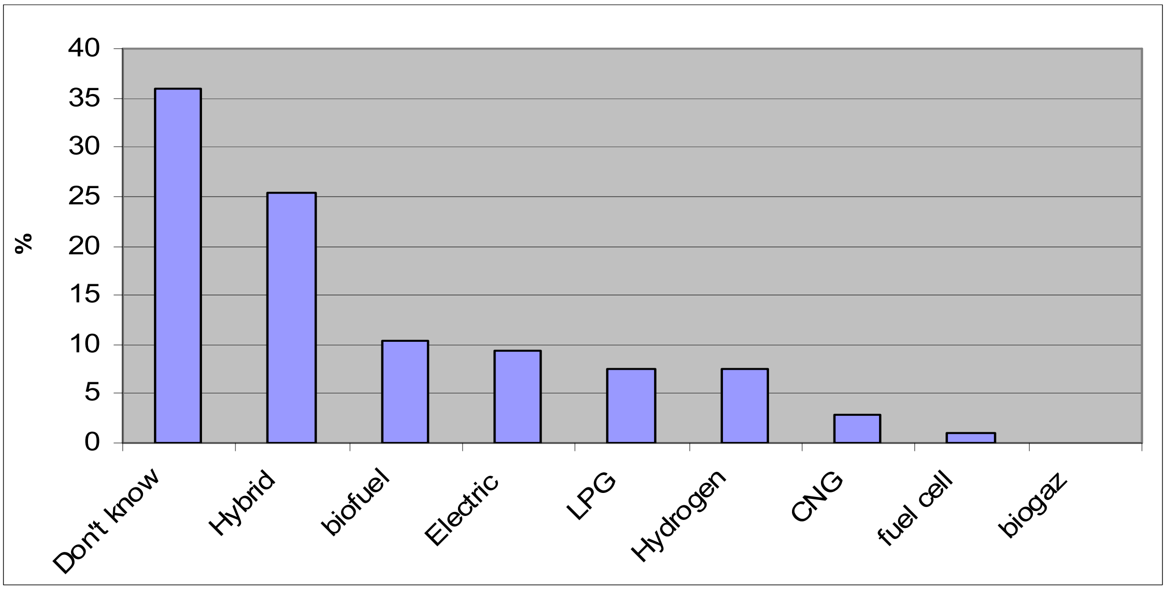
Of course we have to interpret these results (40% of people who have the intention of buying an alternative vehicle) with caution, as it seems to be over-optimistic. This raises the question of the real purchase intention of the respondents, and the difference between the theoretical idea of buying an alternative vehicle and its translation into concrete action. Indeed, the question is asked without precision in time, so respondents who answered positively should

[11] One person mentions 0 disadvantage
[12] 106 respondents have answered "yes" and 152 have answered "no" (5 respondents did not answered to this question).

be considered as the people not against the idea of alternative vehicles (rather than people with actual intentions of buying in the short run). Also, the respondents may be willing to give a positive image of themselves, even if it is not translated into actual facts ("social desirability bias"). Finally, it may also illustrate a case of "counterintentional habits"[13], in the sense that those people have the "rational" intention to buy an alternative vehicle, but their habits (routine behaviour) make them acting in another way and generate"inertia" towards a possible change of car technology. Anyway, in general, people who answered "yes" may differ from others in the sense that they are likely to be more concerned with the environment (if they want to give a green image of themselves) and so probably more open to buy a cleaner car.

The graph below (graph 1) indicates which kind of alternative vehicle the respondents want to buy, among those who have the intention to buy an alternative vehicle in the future.

Graph 1 : Purchase intentions by category of alternative vehicle (% of the population who intend buying an alternative vehicle in the future)



N (sample size) = 106

We notice that more than 35 % of the people who have answered that they had the intention to buy an alternative vehicle in the future (106 respondents) didn't know which sort of vehicle they would like to buy. This can indicate a lack of information about the different kinds of alternative. This lack of information can either come from an objective lack of documentation and advertisements about alternative vehicles, or from a lack of motivation from people to look for information. This latter possibility would confirm that those people are not against the idea of buying an alternative vehicle in theory, but they are not ready to translate it into action by collecting information etc. (mental laziness). It can also come from a biased search process of people with strong habits, i.e. that people develop expectations about their behaviour consumption pattern which lead to a kind of "tunnel vision"[14], implying routine consumption behaviour and no active search for information about alternatives.

Moreover, among the people who don't know which kind of alternative vehicle to buy, a lot of them gave certain conditions or moderated their choice (at the question: "Do you have the intention to buy an alternative vehicle, they answer for example: "yes, but in a far future",

[13] Maréchal K. (2009).
[14] Verplanken B. and Wood W. (2006).

"yes, but in the future because there is still a lot of progress to be made", "yes, but it will depend on the price", etc.)[15].

We can see in graph 1 that the first vehicle mentioned is the hybrid; bio fuels vehicles, electric vehicles, LPG and hydrogen vehicles come quite far behind. It has to be note that among the different categories of alternative vehicle, LPG and hybrid vehicles are the most available and developed ones in Belgium. With regards to this, it is interesting to compare the position of the hybrid and the LPG concerning purchase intentions: we can see that hybrid is much more successful than LPG, despite the fact that LPG is the best known alternatives (see graph 2 below), is more spread (older technology) and is also cheaper. The fact that the hybrid is much more successful than the LPG here may indicate that **non-economic factors are potentially stronger that economic ones**, even if it is the contrary which is explicitly mentioned by the respondents (see sections 2.1.3 and 2.1.5). This preference for hybrid cars may reveal the good effect of advertisement (fashion), the fact that the brand (Toyota) is famous, and also the fact that the hybrid does not imply a change in habits (same refuelling systems…); LPG is a gas, and as we will see, people are afraid of it (see section 2.1.5). Also, LPG is often considered as an old system. Moreover, LPG vehicles show some disadvantages, like the problem of access to underground car parks, as well as possible technical problems (for converted vehicles). The lack of dedicated LPG vehicles, which imply a need to convert the vehicle after purchase, may also influence purchase intentions.

Among the people who expressed an intention to buy an alternative vehicle in the future and who do not know which one to buy, most of them mentioned the environment as a reason for buying an alternative vehicle. This indicates that those people are concerned about the environment but they probably do not have enough information about alternative vehicles.

Among people expressing the reasons why they have the intention of buying a specific kind of vehicle (64 people), 36% in total of the reasons they mentioned concern environment and society and 28% are economic reasons. So, **environmental and economic reasons seem to be the main <u>expressed</u> motivations for having the intention of buying a specific kind of alternative vehicle in the future**. However, in practice, economic arguments seem to prevail for the few respondents who actually own an alternative vehicle (mainly LPG). See point 2.1.2.1. Also, the fact that hybrid is preferred to LPG indicates that other factors influence purchase intentions (see above).

Various other opinions or remarks made by the respondents are worth mentioning. The lack of development and the lack of availability of alternative vehicles are expressed by some people (one respondent mentioned that "for the moment when an alternative exists, the supply is too short and it is too expensive"). It comes out that some people would choose one type of vehicle because it is the most developed or the most famous one ("the one which is most talked about" was the argument of a respondent to choose biofuel vehicle), or because it is the only one that they know; the brand seems also to play a role for some people: it appears that if the brand is famous, it inspires confidence and reliability ("brand loyalty"); we notice also that some people use the information they have to make short cuts: "hydrogen vehicles are the most famous so they are probably the most developed alternatives (and developed by vehicle maker - brand - that I like)"; this shows that people use their limited or incomplete

[15] Some of those remarks were taken up as a barrier (section 2.1.3) since they give reasons why people do not want to buy an alternative vehicle at the current time (e.g. if a person answered "yes, but if the range is better", range is currently an obstacle).

information to conclude things that are not always correct[16]. A respondent expressed his desire to buy a biofuel vehicle because it is "cool", which may indicate that the idea or the use of the word "biofuel" may sound pleasant for some people.

For hybrid, it is also interesting to note the transitory aspect of this solution, as some people opt for hybrid because "it is the best compromise in the short run" (by waiting for a better alternative). The fact that it is like a conventional car ("like the others" as mentioned by a respondent) seems also to contribute to its success, which indicates the influence of habits in car preference.

Among the few people who plan to buy an electric car, some of their reasons are: the increase of oil price (economic reason), the fact that "it is the future" or the fact that they can charge it at home. So, what could be perceived as a disadvantage may possibly turn out to be considered as an advantage…

It is important to note that statistically, people who do not intend to buy an alternative vehicle differ from the other (those who do have this intention) in the sense that the barrier "lack of confidence in safety" is more important for them (see section 2.1.4.).

[16] Another respondent mentioned that he would choose a hydrogen vehicle "on the condition that it is always water", which indicates the lack and/or the wrong information of some people.

2.1.3. Lack of information and type of information asked by the respondents

In the first paragraph of this section, the lack of information on alternative vehicles that arises from the survey is highlighted trough different findings. In the second paragraph, the kind of information that respondents would like to obtain is given.

- Lack of information on alternative vehicles

Lack of information on alternative vehicles represents a very important barrier to their purchase. Of course, this lack of information could be a consequence of the lack of development of these vehicles that would be quickly solved in the instance of a massive development of their supply. However, in the short run, providing people with more and better information could enhance the actual demand for alternative vehicles, so encouraging vehicle makers to develop the supply. Moreover, it could reduce the perception of other barriers (see below). But we will also see that while good information is a necessary condition to the development of alternative vehicles, it is not a sufficient one. Indeed, the impact of overcoming the barrier "lack of information" on the development of alternative vehicles will depend on the other existing barriers and their importance.

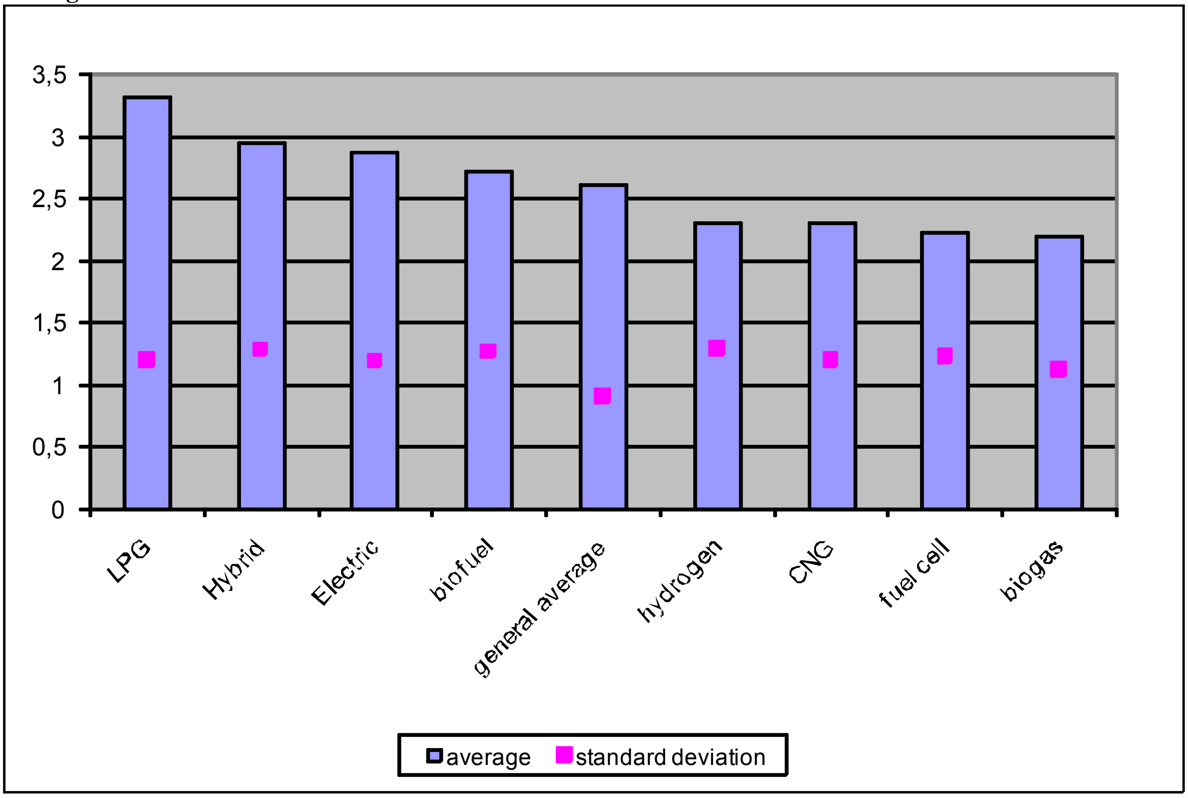
Several results of the survey indicate that there is an important lack of information about the different categories of alternative vehicles.

Firstly, only 25 % of the respondent answered the second part of the questionnaire (concerning the barriers by category of alternative vehicle. See above section 2.1.1). This means that people usually have a general idea about alternative vehicles but do not know enough about the different kinds to answer questions on specific technologies.

Secondly, as we have seen in the previous section, most people who claim to have the intention of buying an alternative vehicle do not know which category they would like to buy. This again indicates the fact that there is a lack of information (or at least that the information they have do not allow them to come to a decision).

Thirdly, all the respondents were asked to evaluate their relative knowledge about the various kinds of alternative vehicles. People had the possibility to choose between 5 degrees of knowledge (between "low" and "very high"); for average and standard deviation computation, we gave a quotation to the different propositions between 1 (= "low") and 5 (= "very high"). Results are presented in the graph (Graph 2) below.

Graph 2 : Level of knowledge of the different kinds of alternative vehicles (from 1 = low to 5 = very high): average and standard deviation



N (sample size) = 263

As we can see, the general average knowledge about alternative vehicles is not very high. Indeed, the general average knowledge is between "rather low" and "middle", with quite a small standard deviation. We notice also that even the vehicles with the relatively higher score remain not so high in absolute terms ("middle" knowledge), which indicates that knowledge about alternative vehicles is still low for most people. Moreover, we can suppose that visitors to the Motor Show are better informed about cars than other people, which could lead to even more pessimistic conclusions with respect to the knowledge of the whole population. On the other hand, we may also assume that visitors to the Motor Show are very keen on cars and may be less concerned about the environment than the majority of people, so it is difficult to say if these results are upside or downside biased.

We also observe that LPG vehicle is the best known alternative, followed by hybrid (with a standard deviation higher for hybrids than for LPG). The first position of LPG in the degree of knowledge can be explained by the fact that it is an "old" technology, and it is also the most developed alternative in the Belgian fleet[17]. Hybrid is a new technology but is very mediatised and developed by famous car brands. They are followed by electric and biofuel vehicles, which is not surprising since electric vehicles are somehow "famous" because they have been existing for a long time, and since biofuel vehicles are much "present" in the medias nowadays. Below the general average, we have first of all hydrogen, followed by CNG, fuel cells and biogas.

Results of the survey have indicated that the lack of information is perceived by respondents as an important barrier to the purchase/use of alternative vehicles (see section 2.1.4, graph 5).

[17] 0,9 % of the Belgian fleet in 2007 (source: FEBIAC)

Statistical analysis has also shown that the personal evaluation (perception) of the importance of the barrier "lack of information" is decreasing with the level of knowledge about alternative vehicles, which is a consistent result (see section 2.1.4). This confirms that more and better information would reduce the importance of this barrier. **However, while the lack of information represents an important barrier for non-informed people, it is not certain whether the fact of overcoming this barrier will obviously have a positive impact on the development of every alternative vehicle. This would depend on the other existing barriers and their importance (stacking of barriers).** Indeed, in the case of LPG, we can observe that the better degree of knowledge/information (see Graph 2) does not imply a better success of this category of alternative concerning purchase intentions (see Graph 1). **Conversely, we also noticed that a low level of knowledge has a statistical positive influence on the importance of some other barriers** (the perception of the importance of some barriers is greater if the degree of knowledge about alternative vehicles is low. See point 2.1.4).

A strong dependency between the levels of knowledge of the different kinds of alternative vehicles has been observed[18]. It means that when one person has a low level of knowledge about one type of alternative, he/she usually has a low level of knowledge about the other ones (and vice versa).

We also noticed that gender has a statistical influence on the level of knowledge: women have usually a weaker level of knowledge about the different kind of alternative vehicles[19], except for biogas (the difference between the degree of knowledge of men and women is particularly significant for LPG). This implies that our results probably overestimate the average knowledge of the Belgian population, as the proportion of women in our sample (20%) is much weaker than in Belgian population (50%).

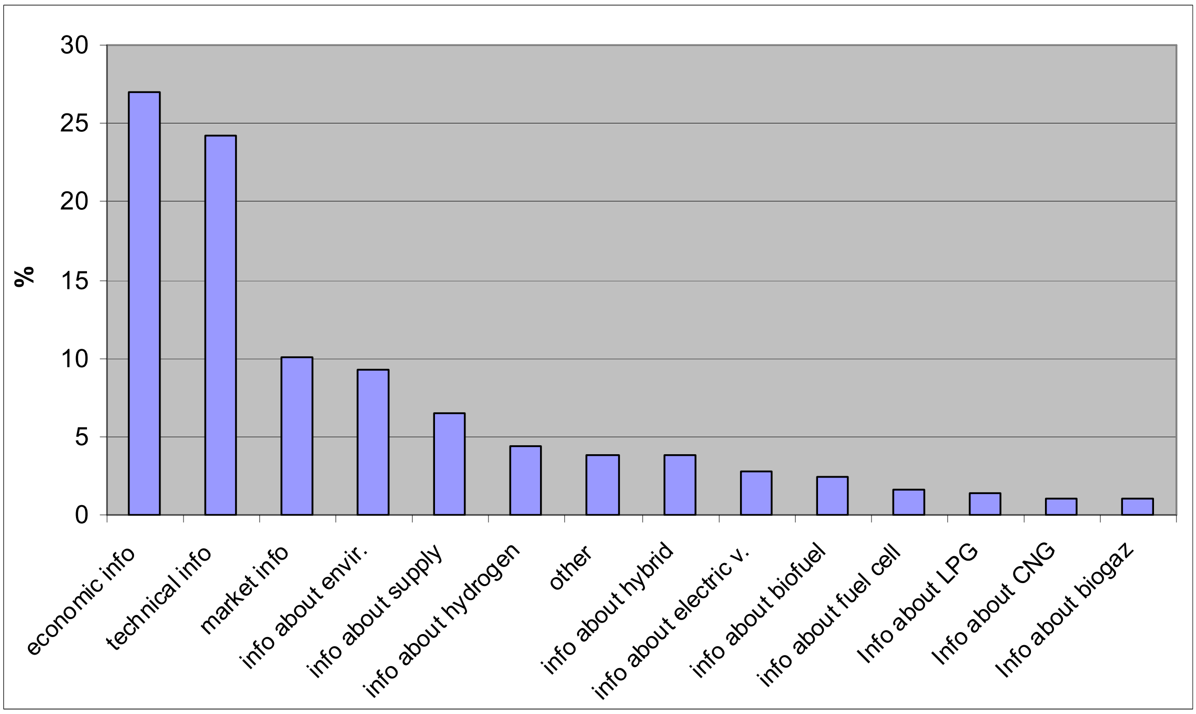
- Kind of information respondents would like to obtain

The questionnaire allowed us to obtain –through an open question- the type of information respondents do not have and which they would like to obtain in priority.

[18] The Khi-2 test (as well as the maximum likelihood test and the Khi-2 Mantel-Haenszel test) is significant (p-value always smaller than 0, 0001).

[19] Khi-2 test is significant and the p-value is smaller than 0, 01 for general knowledge, LPG, CNG and hydrogen and smaller than 0, 05 for the other.

Graph 3 : Kind of information people want to obtain (% of the total of information asked)



N (sample size) = 216 (47 abstention)

This graph informs us about the information lacking and the type of information that they consider as important about cars. So it also indicates the important factors for a car purchase, as it is what the respondents want to know in priority.

We can see that **economic information is the first kind of information people are asking for** (more than 25% of all the criteria mentioned). It is closely followed by technical information[20]. It shows that this information is often lacking and it reflects an important rational factor for the consumer in car purchase decision: the quality-price ratio. Economic and technical information are followed by "market" information (see below), information about the effect on the environment (and on society) of such cars, and information about the supply.

A general remark has to be made: **we have to keep in mind that the questionnaire was conceived to appeal mainly to rational and "conscious" factors, so the emotional and unconscious components of a car purchase decision (which are known to be important) do not appear directly.**

The kind of *economic information* asked by people concerns mainly the prices of alternative vehicles, but also the fuel consumption. The *technical information* asked is mostly general, but information about range, life time, and to a lesser extent questions concerning the ease to use these vehicles and their reliability are also frequently asked. *Market information* includes here mainly general information about the vehicles. A number of people would like to have simplified and clear information's (e.g. to have a comparative and synthetic board with a description of the different categories, and their advantages and disadvantages); they ask for public information, information to the dealer point, on TV and internet, in the press, in specialised magazines, in advertising, etc. Other asked for the best alternative and how to

[20] Including safety (only 3 occurrences)

choose between the different technologies. Sometimes people expressed doubts and lack of confidence about alternative vehicles ("why aren't these vehicles on the market?" is an example of a question from sceptical people); some of them asked about the general advantages of these technologies, or more specifically about their environmental advantage. Lack of interest is sometimes clearly expressed by a few respondents ("the information is there but I am not interested in alternative vehicles" as affirmed one respondent). A respondent asked for the difference between alternatives vehicles and "normal" cars, which may indicate a certain apprehension about changing habits.

This section has highlighted the important lack of information about alternative vehicles. So, **measures dedicated to spread clear information about the different existing alternatives, their advantages and disadvantages, their costs etc. through different channels are necessary. Moreover, as we will see, this could contribute to the reduction of the perception of the importance of other barriers (see section 2.1.4). However, while the lack of information is a very important barrier, overcoming it would not always guarantee a better development of the alternative; this will depend on the other existing barriers and their importance.** Indeed, we have seen that LPG is the best known alternative vehicle but is not very successful concerning purchase intention. **So, overcoming the barrier "lack of information" is a necessary but not sufficient condition to the development of alternative vehicles.**

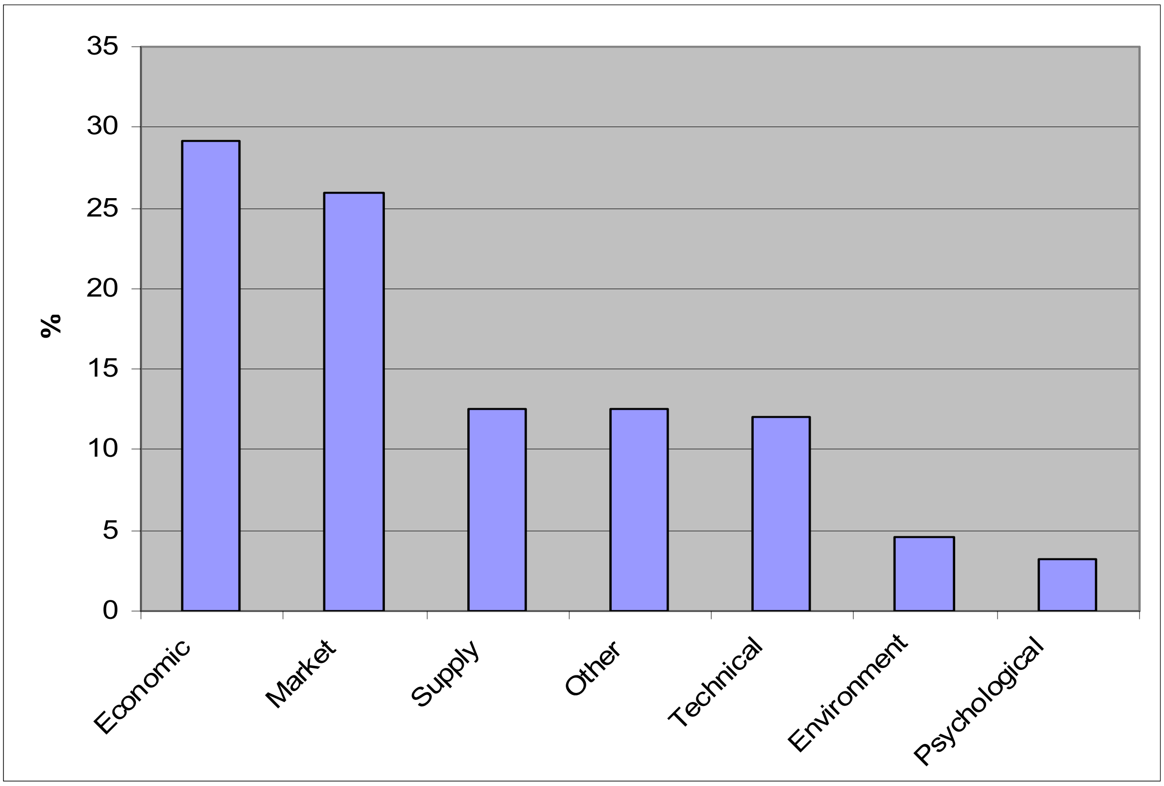
2.1.4. Identification and importance of barriers to the purchase/use of alternative vehicles in general

This section includes different information coming from different questions of the questionnaire. In the first paragraph, we present the result of an open question where the respondents were asked to give their main reasons for not having the intention to buy an alternative vehicle. This allowed us to have people's spontaneous feelings (without restrictions), to identify new barriers and to have an idea about the relative importance of barriers according to the frequency of the different obstacles mentioned. In another question which results are presented in the second paragraph, respondents were asked to give a quantitative evaluation of the importance of a list of proposed barriers. A quotation system was given to the respondents. So we obtained a quantitative evaluation of the importance of a list of different pre-identified barriers (identified beforehand through literature review). Statistical associations (correlations) between answers to this question and other answers are also analysed in the last paragraph.

- Reasons for no intention of buying an alternative vehicle: results of open question

The answers to the open question were codified and classed by group of barriers. The results of the frequency of occurrence are presented below (Graph 4) by group of barriers. A remark has to be made: as we have mentioned before, a group of people (6% of the all sample) had answered at the same time "yes" to the question relative to the intention to buy an alternative vehicle, and when specifying which category of them, they mentioned a conventional fossil fuel car with low fuel consumption. As this is not an alternative vehicle, we considered the answer as negative, and the competition with low consumption conventional cars as an obstacle. This obstacle was included in the group of "market barriers".

Graph 4: Reasons why people do not want to buy an alternative vehicle (in % of the total of the reasons mentioned)



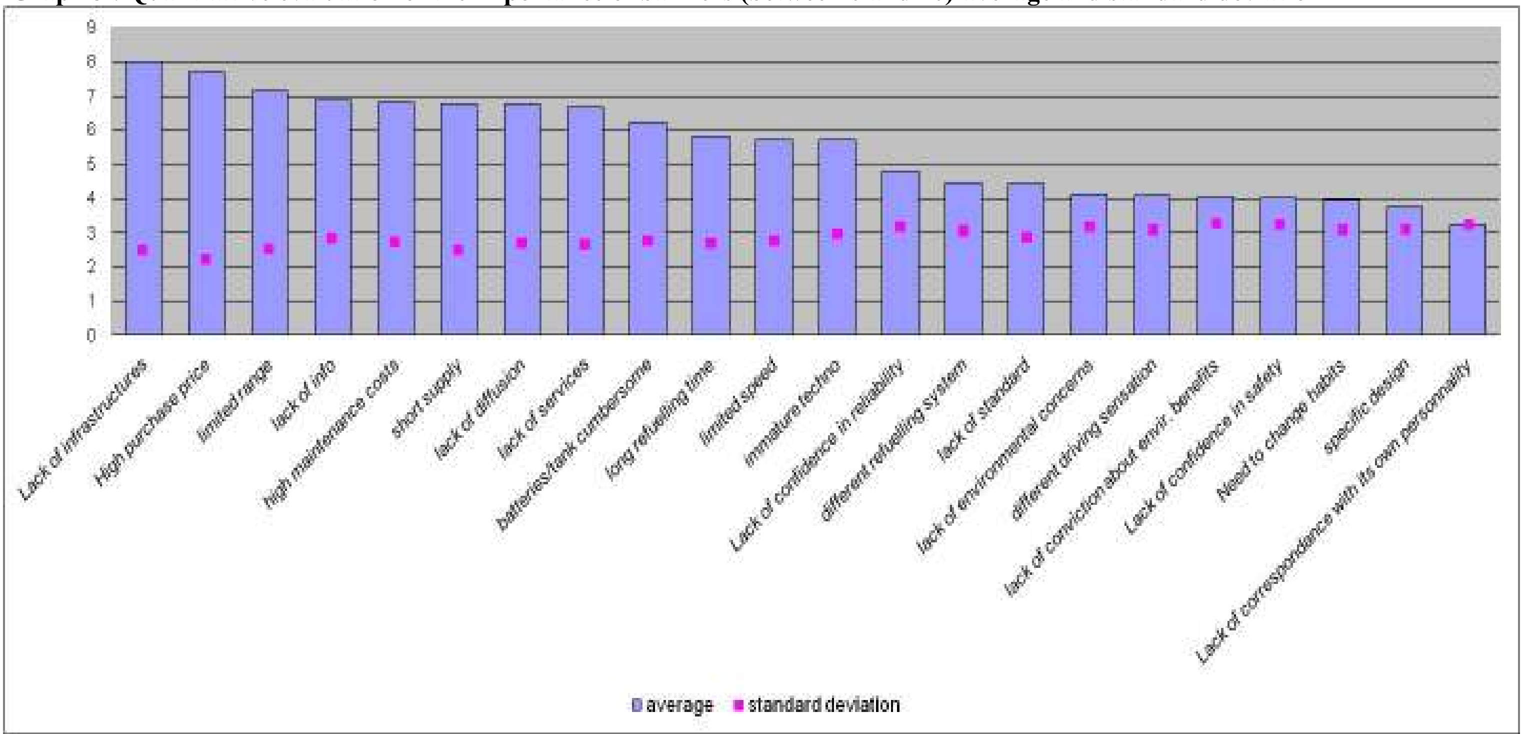
N (sample size) = 154

We can see that in the total of the reasons mentioned, **the economic ones represent the highest share (price too high)**. This implies that on the one hand people think alternative vehicles are expensive, and on the other hand that they are not ready to pay more for an alternative vehicle. Different answers reveal also the importance of the quality-price ratio (people don't want to pay more for a less performing or less reliable car). Then come the market barriers, which are mainly composed of 3 important groups: **competition with conventional vehicles considered as clean** (which have a relatively low fuel consumption and for which a grant is sometimes allocated), **lack of information** and **lack of diffusion** (fear of potential problems, and preference to wait for others to adopt the technology or to test it before adopting it themselves). After market barriers come supply barriers. In the supply barriers, the **lack of diversified models** is prominent (not enough choices, unpleasant look, no convenient models, no big vehicles etc.), then come the lack of availability of the vehicles (quantitative) and the lack of refuelling stations. The category "other" includes mainly people who have just bought a new car, and some others who have a company car (so they do not always have the choice or the possibility to use alternative vehicles). The group of technical barriers is split between a lot of different items, which implies that those barriers do not appear so significant in the open question; however, the only barriers that come up more than twice are "immaturity" (directly linked to the market barrier: "lack of development"), "limited range" and "reliability" (feeling that alternative vehicles are not reliable). Environment (environmental barriers) refers to the people's lack of conviction that alternative vehicles are beneficial to the environment or to society. We have noticed that the "true ecologists" have doubts about the environmental advantages of those vehicles and so prefer not to have a car (they would rather use bike, public transport, car-sharing…). Psychological barriers include change of habits (e.g. one respondent mentioned that he was too old to change), driving sensation (e.g. one respondent liked the sound of the engine, so do not want an electric vehicle) and lack of confidence in safety[21].

- Quantitative evaluation of different pre-identified barriers

Respondents were asked to evaluate the importance of a list of proposed barriers by giving them a quotation between 0 (not a barrier) and 10 (very important barrier). Two types of information are contained in the answers. Firstly, it informs us about the perceived barriers which are possibly prejudices as it indicates what people think to be the characteristics of alternative vehicles. Secondly, it brings the information about the importance of the various items for the car purchaser. It has to be noted that the respondents to this question include the ones who had the intention of buying an alternative vehicle as well as the ones who did not.

Graph 5 : Quantitative evaluation of the importance of barriers (between 0 and 10)-average and standard deviation



N (sample size) = 251[22]

We notice that the highly quoted barriers are usually the ones which show the smallest standard deviation. This implies that the differences between the answers (variation from the average) were not very important, at the contrary of the lowest quoted barriers, which show relatively larger standard deviations. This means that measures that could be taken to overcome the most important barriers (the highly quoted barriers) are likely to be even more efficient since they represent very important barriers for most people.

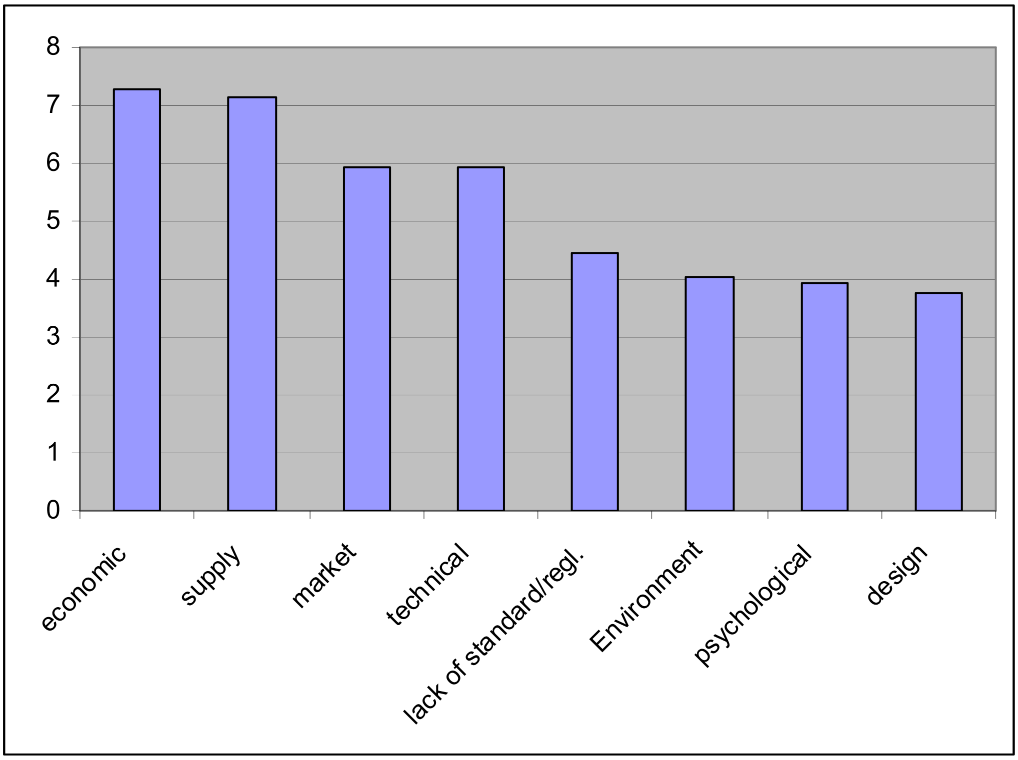
We can see in Graph 5 that the two most important barriers are the lack of refuelling/recharging infrastructures (supply barrier) and the high purchase price (economic barrier), with a smaller standard deviation for the second barrier. The limited range (technical

[21] Psychological barriers may be underestimated, as the questionnaire was conceived to appeal mainly to rational and "conscious" factors (see general remark page 17 and the conclusion).
[22] 3 abstentions and 9 respondents answered only to the part of the questionnaire by technology.

barrier) is also perceived as an important barrier. We notice that psychological barriers ("need to change habits", "lack of correspondence with my personality", "lack of confidence in safety") and "too specific design"[23] are not highly quoted; again, we have to interpret this result with caution, because psychological barriers are typically unconscious and emotion-related; however, this question is asked to appeal to the rational behaviour and the conscious thinking of the consumers, so the emotional factors may be underestimated.

In the graph below (Graph 6) we have grouped the barriers from Graph 5 by category, to have a clearer view of the most important categories of barriers[24].

Graph 6 : Quantitative evaluation of barriers by category of barrier



N (sample size) = 251 (see graph 5)

We observe from graph 6 that the **most important categories of barriers are economic and supply barriers (i.e. barriers linked to short supply: lack of availability of vehicles, lack of refuelling/recharging infrastructures and of after-sale and maintenance services), then come market and technical barriers.**

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[23] The barrier "too specific design" could be considered as a psychological barrier or as a supply barrier. Here and in graph 6 we decided not to classify this barrier in one specific category.

[24] We calculate the average value of barriers by group. The different categories includes: economic barriers (purchase price and maintenance costs), technical barriers (limited range, limited speed, batteries and tank heavy and cumbersome, long refuelling/recharging time, immature technology, lack of confidence in technical reliability), supply-side barriers (lack of refuelling/recharging stations, lack of after-sale and maintenance services, short quantitative and qualitative vehicle supply), market barriers (lack of information, lack of development/diffusion of the vehicles, lack of environmental concerns), psychological barriers (different driving sensation, need to change habits, lack of confidence in safety, lack of correspondence with one's own personality, different tank system). "Lack of regulation and standard", "too specific design" and "lack of personal conviction of the environmental benefit of alternative vehicles" (= environment) have been kept separate.

It has to be mentioned that **this graph (Graph 6) cannot be directly compared to Graph 4 for different reasons**; firstly, the group of barriers does not include exactly the same barriers: indeed, in Graph 6 the groups include the pre-identified barriers from Graph 5 (see footnote 24 for the details) and in Graph 4 the groups include all what has been mentioned in the open question. It has to be noted that the legislative barrier "lack of standard and regulation", was not mentioned in the open question (so it is absent in the Graph 4), and the barrier "too specific design" has been separated from the "supply barriers" (which was not the case in Graph 4) because the average value was too different (much lower) from the other "supply barrier". Secondly, Graph 4 indicates the frequency of the different reasons for not having the intention to buy an alternative vehicle, while Graph 6 is the average of a quantitative evaluation of the importance of the pre-identified barriers. Thirdly, the respondents (and so the sample size) are different in the two graphs: in Graph 4, the respondents are only those who do not have the intention to buy an alternative in the future, and in Graph 6 every respondent had to evaluate quantitatively the importance of the list of pre-identified barriers (the ones who had the intention of buying an alternative vehicle as well as the ones who did not). So in some way, barriers are better represented in Graph 4 than in Graph 6, as the latter also includes people who consider that barriers are surmountable (as they had the intention to buy an alternative vehicle). Moreover, barriers presented in Graph 4 correspond to the spontaneous feeling of respondents without any restrictions (open question).

- Statistical associations between the different answers

Some interesting statistical links have been observed between results presented in Graph 5 (quantitative evaluation of the importance of barriers) and other answers. Firstly, we noticed that the importance of the barrier « lack of information » is strongly linked with the average level of knowledge about alternative vehicles. Indeed, the weaker the average knowledge about alternative vehicles is, the more the barrier "lack of information" is important (consistency)[25]. Secondly and importantly, interactions between different barriers have been observed; indeed, **statistical tests have shown that the better the average level of knowledge is the less the barrier "different refuelling system" is important[26]. There is also a positive correlation between the importance of the barrier "high purchase price" and the barrier "lack of information"[27].** So (as we have already mentioned in section 2.1.3), **this implies that those perceived barriers could be reduced if people were better informed.**

Importantly, we also observed that **for the people who intend to buy an alternative vehicle in the future, the barrier "lack of confidence in safety" (psychological barrier)[28] is less important than for the others**[29]. This was the only statistically significant difference between people who had the intentions to buy an alternative vehicle and the ones who did not. So we can conclude that, even if this barrier is not highly quoted (see graph 5), the lack of confidence in safety seems to play an important role in people's purchase intention.

[25] Anova test significant (p-value < 0,0001) and the assumption of homogeneity of variance is accepted
[26] Anova test significant (p-value < 0,028) and the assumption of homogeneity of variance is accepted
[27] $R^2 = 0, 22$ and p-value < 0, 0004
[28] As alternative vehicles are in general not less safe than conventional ones (Favrel et al (2001b)), this lack of confidence in safety is considered as a psychological barrier (as it probably comes from the fear of the unknown).
[29] Anova test significant (p-value < 0,0189) and the assumption of homogeneity of variance is accepted

- Conclusions from the four last sections

We can conclude from those results that **economic, market and supply barriers appear to be the most important categories of barriers to the purchase/use of alternative vehicles in general when considering people's <u>conscious</u> (expressed) motivations. However, while the barrier "lack of confidence in safety" (psychological barrier) is not highly quoted, it appears that it influences the people's purchase intentions.** Indeed, people who do not have the intention to buy an alternative vehicle differ from the others in the sense that the barrier "lack of confidence in safety" is more important for them. We also noticed the **presence of an interaction between barriers,** in this case between the barrier "lack of information" and "high purchase price" (economic barrier). Also, we found a negative relation between the level of knowledge about alternative vehicles and the importance of the barrier "different refuelling system" (psychological barrier). **This implies that measures aiming at overcoming the barrier "lack of information" will have a positive effect on the reduction of other barriers. However, overcoming the barrier "lack of information" is a necessary but not sufficient condition to foster the development of alternative vehicles**. This will depend on the other existing barriers and their importance (see the example of LPG above).

2.1.5. Identification and importance of barriers to the purchase/use of alternative vehicles by technology

Respondents could choose to answer to the question about barriers by category of vehicles, rather than to answer to the question about the evaluation of the importance of barriers to alternative vehicles in general. So, only the respondents who had a relatively good knowledge about the different categories of alternative vehicle have answered this part. Unsurprisingly, the response rate was much lower for this part (about 25 % of the whole sample, but the exact sample size differ for every technology). However, the main results presented here bring some interesting elements about barriers to the purchase/use of specific alternative vehicles. **The response rate for the questions about each category of vehicle and the graphs with the frequency of the different obstacles mentioned are presented in appendix 2.** In this section only the main conclusions and some interesting elements are given.

<u>*2.1.5.1. Hybrid*</u>

The high purchase price (**economic barrier**) appears to be the most frequent barrier. It is directly followed by supply barriers, which include in majority the lack of available diversified models and the inconvenience of the models currently available, as well as their too specific design (unpleasant look). Two people mentioned the lack of after-sale services, and one of them made the following deductive reasoning: "lack of diffusion <u>so</u> lack of after-sale services". So this person uses his/her partial information to make short cuts and draw conclusions that prevent him/her from buying the vehicle. One person mentioned that hybrid vehicle is not beneficial in his/her case since he/she drives mainly on motorway.

<u>*2.1.5.2. Electric*</u>

The group of technical barriers[30] is clearly the most important group of barriers for electrical vehicles. In this group, **limited range** is by far the most important technical barrier, and then but far below, come the long recharging time and the limited space of the car.

2.1.5.3. Fuel cell

Here the difference in the frequency between the various groups of barrier is narrower than for electric and hybrid vehicles (barriers mentioned are more disparate). By decreasing number of frequency, we have the group of **technical barriers**, then not very far below the group of market barriers and finally the economic and supply barriers. In the technical barriers, various items are mentioned, but the question of space, immaturity and range come up more often. In market barriers we have mostly the **lack of information**, and also but far below, the lack of diffusion. A few people mentioned the question of safety (**psychological barriers**). About the environment, the question of recycling is mentioned. One person also stated that it is better to use directly electricity (electric vehicles).

2.1.5.4. LPG

Technical barriers are the first kind of barriers mentioned. It is followed by **psychological barriers** and then by economic barriers. In technical barriers, there are various items; the most frequent are the problems of access to underground car parks and the reduced space in the car. Psychological barriers are mainly the **fear associated with gas**; one person mentioned also that it is an "old system" (which means that he/she has a bad image of LPG). In economic barriers, mainly the price of installation and the tax system are mentioned.

2.1.5.5. CNG

The group of supply related barriers is the most important one (mainly the **lack of refuelling stations**). It is followed by **psychological barriers** (**lack of confidence in safety and fear of gas**), and then by technical barriers (various). After these come economic barriers and market barriers (which include mainly the lack of information).

2.1.5.5. Biogas

The response rate for biogas is lower than for CNG. Similarly to CNG, the supply barriers come first (**lack of refuelling stations**). Then we have in decreasing order: technical, market and psychological barriers (lack of confidence in safety). It is interesting to note that psychological barriers (lack of confidence in safety) seem to be less important for biogas than for CNG.

2.1.5.6. Biofuel

Supply related barriers (mainly **lack of refuelling stations**) are the most frequently mentioned barriers. Then come **environmental and social ("ethical") barriers** (impact on food supply and price, deforestation…). Quite far below we have economic, technical and market barriers (lack of information/ diffusion).

[30] Here the safety was included in technical barriers because the fear was about the light weight of the electric vehicles (can be dangerous in case of accident).

2.1.5.7. Hydrogen

The ranking of barriers for hydrogen is quite similar to that of CNG. Supply barriers (**lack of availability of the fuel** and of refuelling stations) come first, and just after come **psychological barriers (lack of confidence in safety)**. Then (in decreasing order) come technical (various), market (lack of information and diffusion) and economic barriers. Two people also mentioned environmental barriers (too much energy required to produce hydrogen).

2.1.5.8. Summary

Interestingly, **we noticed that economic barriers are much less important when considering barriers by technology than when considering barriers in general, except for hybrid**. This observation may indicate different things: firstly, it may imply that high price is a barrier corresponding to a prejudice for people who do not really know existing alternatives, and so it is linked to the **lack of information**. Indeed, people who answered only the first part of the questionnaire (about alternative vehicles in general) are probably less informed about alternative vehicles than the ones who answered to the second part (questions detailed by technology of vehicle). Moreover, the link between the importance of economic barrier and the barrier "lack of information" (positive correlation) has been confirmed by a statistical test (see section 2.1.4). Secondly and along the same line, it is likely that when uninformed people think about alternative vehicles, they associate them with the hybrid vehicle, as this is a quite famous and developed alternative. Yet, hybrids are more expensive so that implies a greater economic barrier. Finally and more importantly, **it reveals the importance of a range of non economic barriers, which implies that overcoming the economic barriers would not be sufficient to foster the purchase/use of alternative vehicles.** For all the alternative fuels except LPG, the **lack of fuel distribution is the first barrier (supply barrier)**. For electric vehicles, the problem of **limited range** appears to be the first barrier (technical barrier). This section has also revealed **the fear of gas and the lack of confidence in safety concerning gas fuel (psychological barriers),** which are often the second most important barriers mentioned for most alternative fuels. So making alternative vehicles at the same price than conventional ones is not expected to give impressive results. Only an economic incentive sufficiently high to compensate for the other problems mentioned (in such a manner that alternative vehicles would be financially attractive compared to conventional cars) could have a possible effect but still, it would probably not be sufficient.

2.1.6. Type of policy measures to implement (according to the respondents)

All respondents were asked about the **measures that would encourage them to buy an alternative vehicle**. It comes out that economic measures are the most frequent type of measures people are thinking of (about 65% of the suggested measures)[31]. This includes reduction of purchase price (through grants for example) and fiscal incentives; they mainly ask for fiscal advantages (reduction of TVA for example) related to cleaner cars, and sometimes, but much less often, to a "punishing" tax for more polluting cars (someone suggested more excises on diesel for example). Of course, we have to temperate this result as it is clear that economic incentives are not sufficient to motivate alternative cars purchase for example in a case of non-availability of cars and/or refuelling stations (supply barriers). Also,

[31] See graph in the appendix

as we have already seen, non-economic barriers prevail in most cases when considering barriers by technology. Finally, many studies have shown that economic incentives are not sufficient to change consumer behaviour. For example, a study carried out by Bartiaux et al (2006) about socio-technical factors influencing residential energy consumption has demonstrated that a mix of different kinds of policy instruments (combination of instruments) will have more impact that a smaller number of instrument. Indeed, interviews lead in the context of this study has shown that economic incentives won't be enough as they fail to address social and psychological barriers[32].

Some interesting propositions related to the supply (about 10 % of the suggested measures), can be mentioned: some people asked for more beautiful cars with one of them suggesting "a modern but not futuristic design". Other people suggested that measures should concern the vehicle makers (they would buy the cars "when the vehicle makers only focus on alternative vehicles"). A significant part of the respondent asked for more refuelling stations, and one person asked for "finding the alternative fuel every where in Europe". In the technical measures (about 7% of the suggested measures), solving the problem of limited range is the one which is mentioned the most (technological improvement), but also the improvement of performance and the facility to use. Concerning the suggested "market measures" (about 5%), people ask mainly for informational measures. Finally, measures linked to the environment (about 5 %) are related to the assurance that there is a real environmental benefit from alternatives (e.g. "to find ecological ways of producing the fuel").

2.1.7. Conclusion of the survey at the Motor Show

A range of barriers, with their importance and nuances came out from the survey. In this section, findings of the survey are summarised and presented by category of identified barriers.

- **<u>Economic barriers</u>**: the survey has revealed the **importance of economic barriers and the importance of "quality-price" ratio** (people do not seem to be willing to pay more[33] for a less performing or less reliable car). Indeed, economic barrier is very often mentioned as a reason for not having the intention to buy an alternative vehicle and is also very highly quoted barrier in the ranking of importance. So, it seems that people are really not keen on paying more for a cleaner car. Indeed, in the case of cars, the individual costs of purchasing an alternative car is upper the individual benefits, as the benefits are social. Conversely, the environmental cost of the polluting cars is not borne by the car user. As a result, cleaner cars are a typical example of goods that should be financially encouraged by the society (through policy measures), in order to internalise external costs. Moreover, respondents have clearly expressed that the measure that would encourage them to buy an alternative vehicle are economic incentives, in particular fiscal incentives. **However, while economic barriers seem very important when talking about alternative vehicles in general, it appears to be much less important (relative to other barriers) when considering the expressed barrier by category of alternative vehicles, except for hybrid**. **This reveals the importance of a range of non-economic barriers, and implies that overcoming economic barriers won't be sufficient to foster alternative vehicles purchase/use**. The fact that hybrid is preferred to LPG concerning purchase intention also indicates that non-economic barriers are potentially

[32] See also Maréchal K. (2007, 2009).

[33] For more detailed analysis about willingness to pay for alternative vehicles, see the task 3.2 of the Clever project about price elasticity: Turcksin L. and Macharis C. (2009)

stronger than economic ones[34]. So it is likely that only an economic incentive sufficiently high to compensate for the other problems mentioned (in such a manner that alternative vehicles would be financially attractive relative to conventional cars) could have a possible effect on purchase behaviour (but still, it would probably not be sufficient). Results indicate also that the perception of the importance of economic barriers seems to be linked with the level of information of people, as the lack of information may possibly create an overestimation of the price of alternative vehicles. **The link between the perception of the importance of economic barrier and the lack of information has been confirmed by a statistical test.**

- **Market barrier**:

- **Lack of information**. The survey has revealed the important lack of information about alternative vehicles which represent a significant barrier to their purchase. We have observed that the lack of information has an influence (statistical correlation) on some other barriers, indicating the existence of an **interaction between barriers**. **As a result, the importance of the barrier "high purchase price" (an economic barrier) and "different refuelling system" (a psychological barrier) could decrease if people were better informed.** However, **more and better information (to overcome the barrier "lack of information") is a necessary but not a sufficient condition to foster the purchase/use of alternative vehicles.** Indeed, we have seen that LPG is the best known alternative vehicle but is not very successful concerning purchase intention.
- **Lack of development** of alternative vehicles represent a barrier for consumer's as they fear to have problems, and people wait for other people to adopt the technology to test it before adopting it themselves.
- **Competition with conventional vehicles that have a low fuel consumption** and are subsidised (granting of a premium) represents a barrier to the purchase of alternative vehicles. Indeed, a large range of conventional cars, financially encouraged and presented as environmentally friendly is proposed to the consumer. So, it seems that as long as there will be a supply of conventional vehicle (which imply no change in habits), with low consumption, relatively cheap and encouraged by policy measures, there is little chance that the consumer would choose an alternative vehicle.

- **Supply barriers: the short supply of cars and refuelling stations** appear to be unsurprisingly a very important barrier to the purchase of alternative vehicles from the consumer's point of view. So measures aiming at developing the supply is thus of first importance.

- Technical barriers: technical immaturity of alternatives seems to be perceived and to constitute an important barrier. **The limited range** seems also to be an important barrier**,** in particular for electric vehicles[35].

- **Psychological barriers**: the **lack of confidence in safety[36]**, even if the importance of this barrier is not clearly expressed by respondents, seems to play a role in the purchase intention. Indeed, **statistical test has shown that the barrier "lack of confidence in safety" is more**

[34] Read explanations below in "psychological barriers".
[35] We have to note that this barrier (limited range) can, to some extent, be also considered as a psychological barrier, as it implies to organise differently and to change habits.
[36] As a reminder, the barrier "lack of confidence in safety" has been classified in psychological barrier because most alternative vehicles are not less safe than the conventional ones (Favrel et al. (2001b)). So this barrier comes from the feeling of people about new technologies (which they don't know well).

important for people who do not have any purchase intention than for people who plan to buy an alternative vehicle. This is the only statistical difference between people with the intention of purchasing an alternative vehicle and the others. Also, the **fear of gas**, as people are **not used to** it, appear to be important when considering barriers to the purchase/use of gas fuel. The lack of confidence in safety and in particular the fear of gas indicates that people apprehend the "new". This would imply again that **economic measures would probably not be sufficient if there aren't combined with other policy measures that act on psychological barriers (such as educational measures for example), as well as on other non-economic barriers.** The fact that hybrid is preferred to LPG when considering purchase intention may also be a consequence of psychological effect. Indeed, as LPG is less expensive than hybrid, it is likely that the fact that hybrid has the same characteristics of an ordinary car, with the same comfort and which doesn't imply to change habits, has an influence on purchase intention. This conclusion (influence of habits on purchase consumption behaviour) is in line with other studies about consumer purchase/consumption behaviour. For example, in a recent article, Maréchal K. (2009) highlights the importance of taking into account the role of habits in energy consumption patterns when designing policies. He also touches on one specific feature of habits, which is their low level of consciousness. This makes that people underestimate the role of habits in their consumption behaviour, which seems to be confirmed in our survey. Indeed, respondents do not think "consciously" that psychological barriers are important (see graph 4 and 5 section 2.1.4). However, as we have mentioned, elements of the survey results clearly indicate the presence and the influence of psychological barriers (habits and apprehension of new system) in car purchase behaviour and purchase intentions.

- **Environmental barriers**: the questionnaire has revealed the presence of **doubts and scepticism about environmental advantages** of alternative vehicles from a few people; in particular, **the "true ecologists" prefer not to have a car and would rather use other way of transportation** than private car (bike, public transport, car-sharing…). So, if even the public of "green people" are not buying alternative cleaner cars, it is difficult to find a market segment for this category of cars…

- **Barriers by technology**: results have also revealed important differences between barriers for each technology. Indeed, it appears that **the hybrid is the only technology for which the economic barrier (the high price) is the most important one**. For electric vehicles, the problem of **limited range** appears to be by far the first barrier (technical barrier). For the LPG, The first category is the technical barriers. For all the alternative fuels except LPG, the **lack of fuel distribution is the first barrier (supply barrier). The fear of gas and the lack of confidence in safety concerning gas fuel (psychological barriers)** come generally in second position in the occurrence of frequency for nearly all gas fuel. For biofuel, the environmental and societal barriers ("ethical barriers") come in second position in the frequency of barriers mentioned. It is important to note that the number of barriers from different natures vary greatly according to the technology. It appears that for some vehicles, there are only a small number of barriers but which are very important. For other, there are many barriers but which are less important. The reader interested by these considerations should refer to the appendix 2.

We have to note that many of these barriers are linked to the supply-side of the market. Indeed, the short supply and lack of development may induce a lack of information and a lack of confidence about alternative vehicles. Also, the competition with conventional low emission cars is a market barrier also linked to the supply. Finally, economic and technical barriers may partly decrease with an increase in production (economies of scale, learning effect...). So policy measures aiming at encouraging the supply-side of the market (availability of alternative fuels and alternative vehicles) would help to reduce a significant part of demand-side barriers. Of course, in the short run, those barriers slow down the introduction of new technology and prevent the supply itself from developing.

The survey has revealed that economic incentive is needed for encouraging people to use alternative vehicles. However, we have seen that it wouldn't be sufficient as non-economic barriers appear to be also an important brake to the purchase/use of alternative vehicles. This conclusion indicates the need for a mix of policy instruments (combination of policy instruments) that would act on the different categories of barriers.

2.2. Barriers to the introduction of alternative vehicles in private and public companies fleet: interviews results

Fleets of vehicle represent an attractive market for alternative vehicles. Indeed, private and public company vehicles account for a significant part of the Belgian fleet (about 20% of the Belgian fleet and 49% of the matriculation of new vehicles in 2007)[37]. Moreover, fleets of vehicle are usually much more used in terms of kilometer per vehicle than private vehicles (about twice)[38]. Concerning public companies, they are also likely to make some extra effort in this field to set an example. Finally, in the case vehicles are fuelled at one or some fix points of location (e.g. bus), the company can install the alternative fuel infrastructure for its vehicles before the development of public infrastructures[39].

While fleets of vehicle represent an interesting market for alternative vehicles, the position of Belgium concerning the percentage of clean vehicles (including conventional low-emission cars) in private company fleets is not exemplary. Indeed, according to the Corporate Vehicle Observatory Barometer (2008), the percentage of company using at least one alternative vehicle is the smallest in Belgium compared to the other countries of the survey[40].

Barriers to the introduction of alternative vehicles in company fleets are expected not to be exactly the same as barriers for individual users; firstly, fleet managers have to deal with administrative and regulatory framework which may constitute barriers that do not exist for individual users. Secondly, fleet managers have the responsibility to satisfy a group of employees on the one hand and possible specific needs of the company on the other hand, which is not the case for private users.

However, fleet managers' behaviors are not homogenous and will depend on the type of company, its function and specific needs[41]. That’s a reason why only a few studies are performed on this subject[42].

This chapter is divided into 4 different sections. Firstly, a brief description of the sample and methodology for our interviews are given (section 2.2.1). In a second section (2.2.2), identified barriers to the introduction of alternative vehicles in fleets of vehicle in general (main trends of the interviews) are presented. This section contains barriers that have been mentioned by several fleet managers and can be considered as a summary of the third section. So, the third section present barriers by company or type of companies in more detailed (rough results). Finally, some elements of policy measures suggested by fleet managers to encourage the purchase of alternative vehicles for fleets of vehicle are given in the fourth and last section of the chapter. It has to be noted that some sections of the chapter are complemented by the results of the CVO Barometer survey (2008).

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[37] Personal calculation based on FEBIAC statistics; www.febiac.be

[38] National Survey of MOBEL (« La mobilité quotidienne des Belges »), 1998 in Conseil Central de l’Economie (CCE), 2007

[39] Nesbitt K. and Sperling D. (2000).

[40] The other considered countries are : Italy, Germany, Switzerland, France, Poland, Portugal, Czech Republic and Spain.

[41] Nesbitt K. and Sperling D. (2000).

[42] Idem

2.2.1. Sample and methodology

A sample of fleet managers from different companies and public administrations as well as taxi drivers has been interviewed. The sample includes fleet managers from a private company, 3 communes of Brussels, 2 police services from Brussels, the 5 public administrations concerned with "ordonnance air - ordonnantie lucht"[43] (STIB-MIVB, SIAMU-DBDMH, Bruxelles propreté-Net Brussel, IBGE-BIM, MRBC-MBHG), a federal public service, the Walloon region, the Flemish region and 2 taxi drivers. Of course, the purpose of these interviews was not to be representative of Belgian company's fleet management concerning alternative vehicles, but to have an idea about main barriers trough deep interview-discussions for various types of company.

All the interviews were done by phone during the second semester 2008, and took the form of a discussion about barriers to the introduction of alternative vehicles in the company fleet, future purchase intention and policy recommendations.

2.2.2. Barriers to the introduction of alternative vehicles in company fleets in general

This section resumes first the main barriers mentioned by most (or at least several) fleet managers interviewed (sub-section 2.2.2.1). It is complemented by results of the survey of the Corporate Vehicles Barometer, 2008 (sub-section 2.2.2.2).

2.2.2.1. Main barriers to the introduction of alternative vehicles in company fleets in general: our interviews' results

This sub-section presents the interesting elements that came out from the interviews and which seem to reflect common barriers for fleet managers in general (main trends of the ideas coming out from the interviews). It can be considered as a summary of the next section (2.2.3).

- *Combination of economic, technical and supply barriers*

Every fleet manager and the taxis interviewed mentioned at first the **economic** barriers, combined with **technical problems or disadvantages (profitability and performance-price ratio)**. Moreover, they mentioned that the **supply of alternative vehicles (not enough models) is too short and/or the fuel distribution is lacking (all the infrastructures are dedicated to gasoline/diesel)**. **So, fleet managers clearly expressed that it is the combination of those different barriers that make alternative vehicles unattractive**.

- *No best option*

[43] The "ordonnance air"-"ordonnantie lucht", applied in the context of the evaluation and improvement of air quality in Brussels, constrained (through a decree) public administrations/companies with a fleet of more than 50 vehicles to reach 20% of vehicles considered as clean in 2008. Source: IBGE-BIM (2007). The decree is being modified concerning among other, re-definition of a clean vehicle according to new threshold of ecoscore (progressive threshold every year). Communes will probably be concerned from 2010. Source: IBGE-BIM (2007).

They also generally argue that there is no one alternative that comes out and which is satisfying (no best option). Only for some fleet managers, hybrid is mentioned as the only alternative which is technically mature, but which is too expensive.

- *Lack of information and too much uncertainties*

Some fleet managers mention that they are still too many uncertainties about the total cost, some technical questions and the viability of the different options. Some of them underlined also a lack of information and the contradictory nature of information about alternative vehicles (many controversies).

- *Fear of technical problems because of bad past experience*

Some administrations had **bad experiences** with electric cars some years ago (problems with batteries), but also with CNG and LPG that were not properly installed (technical problems). It generates a lack of confidence and discourages them to try again.

- *Various problems linked to short supply of alternative vehicles*

- Some fleet managers mentioned a practical and legislative barrier linked to the lack of supply: the problem with **public market legislation**. Every new purchase of vehicle is made according to the public market procedure. However, if a company whishes to buy a hybrid for example, it won't be legal if there is only one supplier, as competition is required for a public market procedure[44]. So here, the problem of short supply (supply barrier) is combined with a legislative barrier which may prevent the purchase of alternative vehicles.

- A lot of company **cars are in leasing. This implies that fleet managers have to deal with the vehicles available in leasing companies**. Those generally propose only hybrid vehicles (Toyota Prius) as alternative vehicle, which is again very expensive.

- For intervention vehicles (polices or SIAMU-DBDMH), **no convenient alternatives** exist up to now. Indeed, as the vehicle has to be powerful (fast and with a good range), there is no satisfying alternatives (even the hybrid is too heavy and not enough powerful).

- *Market barrier: diesel as major competitor*

Diesel appears again as a major competitor to alternative vehicles for several reasons: economic (in particular for private companies and taxi's), reason of supply (for example, vans exist only in diesel for some car brands), and because it is often considered as the best environmental option considering the current supply and the "environment-price ratio" (best compromise combining environment and economy). So, most administrations are planning to focus on low-emissions diesel car with particle filters to satisfy future environmental legislation. One stakeholder also mentioned that diesel engine is still improving. **More generally, the interviewed stakeholders are planning to buy conventional low-emission cars rather than alternative ones.** This is in line with the results of the Corporate Vehicle Observatory survey (2008) concerning private company fleets. Indeed, today clean vehicles used by private companies are mainly conventional low-consumption vehicles (15% of the

[44] It has to be noted however that public administrations are often taking into account the environment in their public markets, and the criteria used is often the ecoscore.

interviewed companies affirm to have at least one clean vehicle and among those 15%, 10% affirm having at least one alternative vehicle). According to the companies surveyed by the CVO (2008), this proportion of alternative vehicles among vehicles considered as clean (1/3) is expected to be about the same in the short run.

- *Barriers are "upstream"*

It is important to note that most of the fleet managers interviewed consider that the problem don't come from them but is "upstream": they consider that the supply has to develop first, with means of policy measures. Only when the supply of alternative vehicles and fuels will be developed, technically mature and at a reasonable price, fleet managers wouldn't hesitate to introduce them in their fleet.

2.2.2.2. Barriers to the introduction of alternative vehicles in company fleets in general: results of Corporate Vehicle Observatory survey (2008)

Next to our interviews results, it is interesting to give also the results of the Corporate Vehicle Observatory survey about barriers. This survey was concerning only private companies, but is probably also indicative of barriers faced by all companies with a fleet of vehicles. The survey sample counted 418 fleet managers. There were asked to evaluate the importance of a list of mentioned barriers presented on table 1.

Tab. 1 : Discouraging motives to use clean vehicles: percentage of fleet managers of private company that consider the mentioned barriers as "definitely" discouraging (result of the CVO Barometer 2008)

Restricted number of refueling points	39%
Models not adapted to the activity of the company	38%
Restricted number of garages able to maintain and repair those vehicles	27%
Higher purchase price	27%
Limited number of available models	22%
Lack of adapted supply of leasing companies	20%
The brakes (reserves) from drivers of the company to use those vehicles	9%

Source: Corporate Vehicle Observatory Barometer (2008)

So, we can see that pre-identified barriers proposed by the interviewers to fleet managers can be grouped in 3 categories: supply barriers, economic barriers and a barrier specific to fleet managers: the brakes (reserves) from drivers of the company to use those vehicles (for whatever reasons). Interestingly, we can observe that among those barriers, the most important ones appear to be in the category of supply barriers (barriers resulting from the short supply). Lack of refueling infrastructures seems to be the first barrier, follows by the lack of models adapted to the company and finally, the lack of services (maintenance and reparation). They are followed by economic barriers. Those results corroborate roughly our results.

2.2.3. Barriers to the introduction of alternative vehicles in company fleets by type of company/administration

In this section, barriers are presented by companies (or types of companies) in more detail than in the previous section. They are rather “gross” results of our interviews. In some cases, it includes also information about barriers by category of alternative vehicles. Such detailed information may be interesting for public authorities if they decide to draw up specific programs to remove barriers adapted to each stakeholder.

- *Private companies*

- The ***fleet manager from the private company*** interviewed had a 100% **diesel** fleet, and it seems to be (according to him) the general trend for private companies. Reasons are of course **economic**, as diesel is particularly attractive for long distance driven.

The **lack of information and the contradictory information** (there is no consensus) is an important barrier as well, as **uncertainties** about the environmental sustainability of alternatives, about technical questions (ex.: compatibility with conventional engine for some fuel), about life cycle costs etc. It is “**too risky and too soon for fleet managers to take such an initiative”,** and such an investment has to be justify and will be accepted only if it is financially profitable on the long run. More generally, “**fleet managers can not experiment "hazardous" alternatives and can’t be considered as first actors”**. He insists that measures have to be taken “upstream”: fleet managers are waiting for development and diffusion (no one wants to be the initiator for testing the technologies). Nevertheless, they are really interested on this question and **wait for a reliable and financially attractive alternative** (they speak a lot about “green fleet”).

- *Taxis*

Taxis usually use **diesel** for **economic reasons**. They mention also the need of perfect reliability (must be resistant) and good performance (need to drive fast). About LPG, there is too many practical disadvantages (lack of refueling stations, problem of access to underground parking’s...) and customers are also afraid of gas.

- *Polices*

The main problem is that there is **no convenient alternative for interventions vehicles** (see above). Other barriers are mainly **economic (short of budget)**. There is also a **lack of information** (one fleet manager mentioned that he was a policeman not specialized in environmental alternatives, but he was open to alternative vehicles and was planning to work with a consultant centre for analyzing the best options). However, for the "police of proximity", electric vehicles could be a good option for the future.

- *Communes*

The main barrier is **economic (short of budget)**.

Political and administrative barriers have been also mentioned, as the purchase decision must be approved by the college, the financial services etc. Communication between the different services is quite important. Also, it seems –according to some respondents- that the presence of alternative vehicles in the fleet of communes depends on the political color of the political representatives in the commune.

The lack of availability of alternative vehicles in the supply of important distributors (brands) is also a barrier.

It has to be noted that one commune has bought 14 LPG vehicles and one hybrid in 2006 with the help of subsides[45] offered by IBGE-BIM at that time (they answered to a call for project). They wanted also LPG vans, but it was not possibly as there are only diesel vans (supply barrier). The only problem mentioned with **LPG** from this commune is the **restricted number of refueling stations**.

Another commune had a **CNG** transformed van and the recharging infrastructure but they had a **lot of problems**:
- Technical barriers:
    - Long recharging time (12 h)
    - Recharging at night but it is noisy (and because they didn't know it, the infrastructure is installed next to houses)
    - The range is very limited (30 to 50 km)
- Economic barrier:
    - High maintenance expenditures because of technical problems (it was badly installed).

They have also an **LPG** transformed vehicle because they evaluated that it was profitable from a certain number of km driven. The only problem is that there is **no refueling station in their commune (supply barrier)**.

They own also one **electric vehicle** for small distance for the "green image"; however, it was not economically interesting because they had to change the batteries after 4 years and it would have been more profitable to buy a diesel. So they decided **to keep it for the "green image"** and also for some advantages of the vehicle: silent, easy to use, no local pollution… so in this case, the economic barrier was overcome by other advantages.

- *Federal public services*[46]

The Federal Public Services have the possibility to command an LPG vehicle, but it is hardly ever used.

Up to now there haven't been public markets for alternative vehicles. But even if there was a demand, **the supply is currently insufficient for a public market** (supply and legislative barrier).

- *Administrations concerned with "Ordonnance Air-Ordonnantie Lucht"*

[45] 2000 EUR for an LPG transformation and 10.000 EUR for the Prius
[46] It has to be noted that a circular is in project that would impose more points given for environment in public market, based on the ecoscore (with derogation when needed).

Most barriers have been mentioned above (see general barriers).

Those administrations have tested some alternatives but usually it was not very successful:

- **Electric vehicles**:
- Economic barrier: too expensive (the vehicle and the cost of battery replacement)
- Technical barriers:
  - Limited range (some employees didn't like it and they were worry to break down)
  - Too much maintenance needed
  - Dead batteries (very soon)

Finally some administrations replaced their electric vehicles by small conventional vehicles. However, some have electric scooters.

- **CNG used by the STIB-MIVB (first generation of CNG buses):**
- Technical barriers: various technical problems
- Supply barriers: There is also the problem of infrastructure as it needs a lot of space, it has to respect strict safety rules, it is very expensive and for the moment there is only one at Haren which is insufficient.

However, the STIB-MIVB is planning to buy about 70 new CNG buses and the extra cost would be born by regional authorities.

Another administration mentions that they don't want to try **CNG** because of bad experiences of several cities (like in Anvers, according to one administration):
- Technical barriers:
  - Various technical problems
  - Need to regulate finely the engine according to the gas quality
  - Tank heavy and cumbersome
- Psychological barrier:
  - Fear of gas
- Economic barrier
  - High cost

- **LPG**: some administrations have LPG transformed vehicles but they usually ride with gasoline because of technical problems.
- Technical barriers:
  - Some of the vehicles where actually not adapted for LPG (the cylinder head was not reinforced), which implies various problems; for example, drivers had to fill in the tank with lubricant but they usually forgot it.
- Psychological barrier:
  - They consider that it is also more difficult and dangerous to refuel with LPG: the personnel are not used to it and are afraid of gas.

Others mentioned also about LPG:
- Supply barrier:
  - The problem of lack of LPG refueling stations
- Technical barriers:
  - The lack of power

- Problem of access in underground parking (they even can not go in their own parking)

- Environmental barrier:
  - The benefit in terms of CO_2 is not so good

- **Hybrid:** No specific problem is mentioned except the price which is too high (economic barrier).

Those administrations are thinking not to buy again gas (LPG and CNG) because of these bad experiences and they have generally decided to orient their fleet towards low-emissions diesel vehicles with particle filters (rather than alternative vehicles) to respond to environmental legislation. Fleet managers from some administrations mentioned also that they will or do rather choose leasing vehicles instead of buying them (it seems to be the trend).

It has to be noted that the MRBC-MBHG had to respect a circular in which a certain percentage of gas vehicles was required. Now it has been modified to allow for diesel vehicles.

- *The Walloon region*

It follows the same trend that Brussels public companies. The main barriers mentioned are: the price and the uncertainties about life cycle cost, as well as the short supply.

They had experience with **electric vehicles** but they find them extremely expensive relative to their small size (economic barrier). The **Prius** is also too expensive (economic barrier). About **LPG**, they consider that there are too many disadvantages: less station and need for pump assistant (supply barrier); limited space (technical barrier); problem of access to underground parking's (technical barrier) etc.

- *The Flemish region*

They have some **Prius** and there are satisfied but the price is too high (economic barrier). They don't have gas (they haven't thought about it). The barrier mentioned is mainly the lack of choice.

The current "ordonnantie" for the Flemish region doesn't include environmental criteria (even if it is taken into account in public market), but the new one will fix a minimum ecoscore for every vehicle.

2.2.4. Measures suggested by fleet managers

In this section, the types of measure mentioned by the fleet managers that would encourage them to introduce alternative vehicles in their fleet are given in the first sub-section 2.2.4.1 (results of our interviews). It is complemented by results from the survey of the Corporate Vehicles Barometer, 2008 (sub-section 2.2.4.2).

2.2.4.1. Type of measure to encourage the introduction of alternative vehicles in fleets of vehicle: results from our interviews

- **Economic measures**: most of the fleet managers interviewed mentioned that subsidies would encourage them to buy alternative vehicles.

- **Measures aiming at increasing the supply** are also often mentioned, like for example:
  - Developing the supply of alternative vehicles in leasing companies (with tax incentives for example)
  - Developing recharging/refueling stations. For example, public authorities could invest in public recharging and refueling stations (to encourage the private and show the example).
  - Various incentives to develop the supply of alternative vehicles in general, and in particular of electric vehicle (as other categories of alternative vehicles are according to one fleet manager, not sustainable).

- **Technical improvement**: Some of the fleet managers mentioned that technical problems should be first solved (R&D…).

- The possibility to **make an essay** with different alternatives to see how it works and evaluate the total cost is also a suggestion mentioned by some fleet managers.

2.2.4.2. Type of measures to encourage introduction of alternative vehicles in fleets of vehicle: results from Corporate Vehicle Observatory survey (2008)

Next to the examples of measures mentioned by fleet managers during our interviews, it is interesting to complement them with the results of the Corporate Vehicle Observatory survey (see sub-section 2.2.2.2 for information about the sample of this survey). Fleet managers interviewed by the CVO were asked to evaluate the importance of a list of mentioned measures that would encourage them to introduce alternative vehicles in their fleet. The proposed drivers are presented on table 2.

Tab. 2 : Measures that would encourage the purchase/use of alternative vehicles in fleets of vehicle: percentage of fleet managers of private company that consider the mentioned measures as "definitely" encouraging (result of the CVO Barometer 2008)

A fiscal incentive for company to use those vehicles	54%
A guarantee from the vehicle makers longer for alternative vehicles than for conventional vehicles	37%
Higher taxes on polluting vehicles	34%
Better information on the global utilization cost of those vehicles	30%
A better technical information on those vehicles	25%
The support of a leasing society in case of technical problems	14%

Source: Corporate Vehicle Observatory Barometer (2008)

We can observe that the fiscal incentive (economic measure) is the most successful policy for respondents of this survey. A longer guarantee for those vehicles seems also to be an interesting measures, which can indicate the lack of confidence in reliability and the apprehension of new systems from fleet managers (similarly to individual users). Fiscal incentives for cleaner vehicles could be combined with higher taxes on more polluting vehicles (as it appears to be also a possible driver).

2.2.5. Conclusion of the fleet managers' interviews

A lot of barriers to the introduction of alternative vehicles in fleets of vehicle are the same as for the individual consumers. Main barriers are supply-side barriers (lack of supply of vehicles and lack of refueling stations), economic barriers, technical and market barriers.

However, some new elements and some particular barriers came out from the interviews. *Firstly*, interviews have revealed clearly that it is the **combination of several barriers** (supply, economic, technical and market) that make alternative vehicles particularly unattractive (except the hybrid, for which the main barrier is economic). *Secondly*, bad experiences (technical problems) with some types of vehicles (like electric, CNG and LPG vehicles) imply a **lack of confidence** in those vehicles. Policy measures should aim at restoring confidence in those vehicles, and maybe could encourage R&D to ensure vehicles **technical reliability**. Also, the existence of many **uncertainties** (about total cost, technical reliability, viability of the different options, etc.) implies that **more and better information is needed**, together with other measures like for example the possibility to make an essay. *Thirdly and importantly*, **the short supply creates sometimes the impossibility for companies to buy or to lease alternative vehicles.** Indeed, **public market legislation** prevents the purchase of a vehicle if there is no competition between several vehicle makers. Also, the **lack of supply of alternative vehicles in leasing companies** and the **inexistence of alternative for intervention vehicles or vans limit greatly the development of alternative vehicles in vehicles fleet. In this case, barriers come not from the companies but from the supply-side of the market.**

We also notice that **the trend is to use diesel low-emission vehicles with particle filter and more generally conventional low-emission vehicles rather than alternative vehicles**.

Fleet managers have an important responsibility and often mentioned that it is difficult to justify an extra-investment for vehicles that are less reliable, with less refueling stations etc. this implies a need either for an economic incentives possibly combined with a constraining legislation (to oblige company to have a certain percentage of alternative vehicles in fleets of vehicle) either to focus on policy measures aiming at developing (qualitatively and quantitatively) the supply (of vehicles and of the fuel). A mix of these different policies would probably give the best results.

2.3. Barriers to the supply of alternative vehicles from the supply-side stakeholders point of view: interviews results

As we have seen in the first two chapters, the short supply of alternative vehicles and fuels appear to be an important barrier for demand-side stakeholders. The purpose of this chapter is to understand barriers faced by the supply-side of the market through results from the consultation of supply-side stakeholders.

This chapter is divided into 6 sections. The first section gives some methodological elements concerning the interviews and describes the sample. The second section summarizes the results of the interviews concerning barriers to the supply of alternative vehicles in general (without distinction between the different categories of alternative vehicles). Some policy measures recommended by the stakeholders to overcome those barriers are addressed in the third section. Barriers to the supply by category of alternative vehicles as well as possible policy measures to overcome them are treated in a fourth section. In a fifth section, the types of alternative vehicle that would be most easily introduced in the Belgian market according to the supply-side stakeholders are discussed. The sixth and last section concludes the chapter.

Note that supply-side stakeholders provided us with a lot and detailed information about barriers and policy recommendations. In particular, the fourth section 2.3.4 (about barriers and policy recommendations by category of alternative vehicles) goes in much detail as concerned supply-side stakeholders are facing a lot of precise barriers. We decided that it was important to keep this detailed information as it is interesting for possible policy measures aiming at promoting one specific category of alternative vehicle. However, for a quick reading, we recommend the reader to rather focus on the other sections of this chapter, and to read the section 2.3.4 only in case of a special interest about barriers to specific categories of alternative vehicles.

2.3.1. Sample and methodology

- *Structure of the questionnaire*

A detailed questionnaire (see in annexe) has been drawn for the supply side stakeholders (which is the same for the experts). The questionnaire was composed of 3 main parts. The thematic and structure of the different parts of the questionnaire were the following:
I. General questions (mainly open questions) about:
- Barriers to the supply of alternative vehicles/fuels (in general and by technology)
- Measures suggested for stimulating alternative vehicles diffusion
- Type of clean vehicles better adapted to the Belgian market

II. Evaluation of the importance of barriers to the development of alternative vehicles in general (pre-identified barriers and "new" barriers identified by the respondent)
III. Evaluation of the importance of barriers specific to the development of the different categories of alternative vehicle (pre-identified barriers and "new" barriers identified by the respondent)

The "supply-side" stakeholders could answer only to the parts relative to one specific category of alternative vehicles according to their special field. They could choose also to answer only one (or some) of the 3 parts of the questionnaire. In a few cases, the respondents only answered to the general open question about barriers.

- ***<u>Sample and way of consultation</u>***

A sample of 20 stakeholders from the supply-side of the market has been interviewed. This has allowed for **in-dept interview-discussions**. Most interviews were face-to-face, but also sometimes by phone or by e-mail or post-mail (according to the respondent preference and availability). The consultation took place through the year 2008.

The sample includes 2 stakeholders' group: the first one is concerned with alternative vehicles in general and the second one is concerned only with a specific category of alternative.

a) The first group includes: the ACEA and FEBIAC which are federations of vehicle makers, Federauto (which is a confederation of cars trade and reparation sectors and other related sectors), three vehicle dealers (Citroën, Volvo trucks and D'Ieteren) and a salesman of second-hand vehicles.
b) The second group includes: Toyota (hybrid vehicles), Saab (E85 vehicles), a biofuel producer, Biowanze (bio-ethanol factory), the Belgian Petroleum Federation (concerned with biofuels), Octa + (fuel distributor concerned with E85), the Reva importer and mechanic (electric vehicles), an LPG fitter, Drive systems (LPG-CNG), Primagaz (LPG), Totalgaz (LPG) and BMW (hydrogen).

Although the results from the consultation of the second group of stakeholders are mainly presented in the point 2.3.3 (barriers by category of alternative vehicles), some of them had sometimes opinions on barriers in general that have been included in the point 2.3.2 (barriers in general).

- ***<u>Treatment of the information</u>***

All the information coming from the interviews (or filled-in questionnaires) were treated in a qualitative way, as quantitative analysis had no sense with such a small sample. Results presented in the next sections summarize the main ideas that come out from the interview, as well as new and interesting ideas that emerge. This means that **every barrier mentioned in this chapter were not necessarily mentioned by all the stakeholders.**

Barriers have been classified and presented by category according to their nature (see first part of the report).

It has also to be noted that all what is written in this part **<u>do not reflect personal opinion of the authors</u>, but resume all the ideas that were mentioned by one or several supply-side stakeholders**.

2.3.2. Barriers to the supply of alternative vehicles in general

This section summarized what has been mentioned by supply-side stakeholders concerning barriers to the development of alternative vehicles in general.

It comes out from the interviews that vehicle makers meet several important brakes that prevent them to develop massively and commercialize alternative vehicles in general. Those barriers are mentioned and explained in this section. As we will see, many of the barriers are related to the demand, as vehicle makers expect no or little demand for alternative vehicles for several reasons. Many of those reasons (mentioned here below) correspond to the results mentioned by demand-side stakeholders.

1. **Economic barriers:** the **higher cost** of alternative vehicles implies a non-acceptable price for consumers. At this price, the demand would be too weak and would not compensate investments. It was also mentioned that fossil fuel costs were not high enough to encourage consumers (and thus vehicle makers) to look for alternatives. So it is not yet financially interesting enough to develop them massively (and public helps are not yet enough). One stakeholder mentioned also that financial resource for investment is limited because of current economic context (increase of steel price, of oil and of the Euro) and also more recently because of the economic crisis.

2. **Technical barriers:** some alternatives are not yet mature or/and have too many **disadvantages** compared to fossil fuel cars.

It has to be noted that in general stakeholders agreed that economic and technical barriers will decrease with development (thanks to economies of scale, learning effects...).

3. **Market barriers:** for these two reasons (1 and 2), alternative vehicles are at the moment **not competitive** relative to conventional cars, it is thus unlikely that the demand for those vehicles will compensate the important investments needed. Moreover, some vehicle makers mentioned the other following **demand-side barriers**: firstly, the consumer's have habits, and have apprehension concerning new systems (psychological barriers). Secondly, there is a lack of information among the consumers about alternative vehicles. Finally, one vehicle distributor mentioned that the current demand trend goes at the opposite side of the alternative vehicles characteristics: consumers are asking for more and more comfort and options, with the possibility to drive long distances etc. and at acceptable costs. Such requirements are not compatible with the characteristics of most alternative vehicles.

Importantly, today strategy of most vehicle makers is to **focus on improvement of conventional fossil fuel cars - diesel car in particular -** in terms of efficiency and reduction of emissions. Indeed, supply-side stakeholders mentioned that it allows for reduction of emissions while maintaining a reasonable price (technology has been developed for years), offers the same comfort, implies the same habits for consumers, etc.

4. **Supply-side market barriers**: the **fuel availability** is a big problem for vehicle makers to develop alternative vehicles. Indeed, if there would be alternative fuels distribution, it would be an impulse for the car industry to develop and commercialise alternative vehicles ("chicken and eggs" problem).

5. **Environmental and societal barrier (linked to market and political barriers)**: supply-side stakeholders mentioned that there are too **many possible alternatives and too many uncertainties about the future of each technology**. It is too risky to invest a lot in a complex and costly technology, to train workers etc. if they have to abandon it some years later (in case we realise that it is not such a good environmental option). For example, biofuel was presented as a very good solution some years ago, and now it is highly debated. Also, there are a lot of controversies about the environmental benefits of hydrogen, hybrid, and electric cars since electricity is not produced with renewable energy. Some vehicle makers consider

that there are pushed to go too fast, as there is still a need for more R&D and for a clearer message about good and bad environmental options.

6. **Political and legislative barriers**: the barriers mentioned above could be reduced with policy measures. However, stakeholders mentioned very often a lack of appropriate policy measures.

Firstly, as alternatives are not yet competitive, there is a **need to create incentives for consumers**. However, **today tax system is inappropriate** as it is not linked to environmental criteria.

Secondly and more generally, there is a **lack of clear, well-defined and harmonised policy** to encourage development of cleaner cars. Heterogeneity of legislation (between countries and inside Belgium) is a major problem for vehicle makers. For example, there is a difference in Flanders where the criteria used for policy measures is based on the Ecoscore and in Wallonia where it is based on CO_2 emissions. Policies should be harmonised at Belgian but also at European level (and ideally at global level). In the same line, there are too many **uncertainties about long-term policies and legislation**. For those reasons, **vehicle makers are unable to define a strategy**.

Thirdly and in the same line, there is a **lack of clear policy for the introduction and the promotion of alternative fuel**, which would overcome the barrier of fuel availability and give a positive signal to the industry to bring corresponding alternative vehicles on the market.

Finally, there is a **need for supporting R&D,** which would allow for a clear and long-term message from policy makers about the alternatives that have to be promoted.

It has to be noted however that some stakeholders have insisted on the fact that financial supports in general should be technologically neutral (based on environmental criteria rather than technology-based).

Uncertainties about public support and promotion are thus an important brake for vehicle makers. Note that those uncertainties are reinforced by a lack of confidence because of past lack of political support and because of changing message through time. Indeed, for example, one interviewed evoke a kind of "**frustration" from the automobile sector** resulting from the evolution of policies: in the 80^{th}, vehicle makers were solicited to reduce harmful gas like CO. Thus they developed systems where the CO was combined with O_2 to emit only CO_2 (at this time we didn't speak much about CO_2 and GHG emissions). That was the first phase of the "ecological move". Now we are in the second phase in which the focus is on CO_2 reduction. Moreover, at the time, environmental initiatives proposed by the industry were not well received (lack of interest from politics, public and media). So they abandoned them and have developed other models. And now, they are pushed to take measures very quickly...

7. **Institutional barriers**

Some stakeholders mentioned the presence of a **lobby** against the development of alternative fuels from **oil companies** on the one hand, but also from some **environmental NGO's and associations on the other hand against some category of alternative vehicles because the environmental benefits are contested** (cf. Biofuel for example). It seems to exist also a lobbying in favour of diesel development from the diesel automobile industry, particularly at European level, which can have an indirect impact on alternative vehicles development. Some stakeholders admit that **there is a lobbying from some vehicle makers against constraining measures or environmental objectives** (that could indirectly enhance the development of alternative vehicles)**, in particular if the objectives are too ambitious for the time horizon proposed**[47]**. However, there is no lobbying against alternative vehicles in general and in the long-run as it represents an opportunity for the automobile industry**.

Some observations about the interviews can still be mentioned:

- **The interviewed stakeholders have often various opinions about the different alternatives. Every car brand seems to develop its own strategy**, following what they think to be the option of the future. **The strategies they will generally choose seem also to depend on what is easier for them to develop, according to their current supply. Symmetrically, they often criticized other options.** For example, some car brands that are mainly focusing on diesel are very critical about LPG.

- One interviewed expressed a **feeling of unfairness related to the eagerness on the automobile sector** about environment while the residential sector is even more responsible for GHG emissions.

- Another interviewed argued that there is a lack of coherence in policy, and that it makes no sense to start with alternative vehicles development while some other policies are missing; for example, we should first focus on rearranging the infrastructure (fewer traffic lights), encouraging teleworking, developing tramways, etc.

2.3.3. Measures suggested by the supply-side stakeholders to overcome barriers in general

This section summarises policy measures suggested by the supply-side stakeholders for overcoming barriers to the development of alternative vehicles in general.

In general

- Need for **harmonisation (inside regions of Belgium and between European countries) and clear and long-term policies**. Those points are imperative for allowing vehicle makers to define a strategy, to reduce costs, uncertainties and make sustainable decisions.

- Some vehicle makers suggested that incentives for the industry should be "technologically neutral". However, it has been mentioned by one vehicle maker that policy encouragement that would be applied to too many models would discourage R&D. This can indicate that the opinion inside the automobile industry may sometimes differ (and seem to depend on the type of supply of the vehicle maker, i.e. if they propose already an alternative vehicle or not).

- It was suggested from some vehicle makers that measures in general should concern the whole park and not only new vehicles.

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[47] See the European objectives on CO_2 reduction for the automobile industry and the pressure from German vehicle makers to reduce those objectives (EURACTIV 22/01/07)

Legislative measure: a new fiscal system

- Most vehicle makers (and federations) suggested **an automobile tax system based on simple environmental criteria, combined with an incentive to change old polluting cars to new less polluting cars. At European level, the automobile industry proposes a tax system based on CO_2 emissions for vehicles and fuel.** In their opinion, this taxation must be linear and not progressive, and of course harmonised between countries. However, a vehicle maker was rather in favour of a premium at the purchase rather than “delay incentive” like tax incentives. This difference indicates again **that the position may differ inside the automobile industry.**

Economic (and supportive) measures

- To support **R&D** with subsides.

- Some vehicle makers suggest a **clearer support to alternative fuels for which the technology already exist, like biofuel (high blend) and CNG**[48]. The government has to **ensure the supply of fuel** along with making the vehicle fiscally attractive.

Diverse non-economic measures

- **The introduction of alternative vehicles in public fleets** would be a first step: it would encourage the industry as it offers to vehicle makers the guarantee of a market on the one hand, and is a good way to educate society by setting an example on the other hand.

- To educate the public about alternative vehicles (training, school, academics…).

- Creation of **environmental zones, etc.**

Remark: some stakeholders insisted on encouraging eco-driving, and suggest often to take other measures to reduce pollution rather than focusing on alternative vehicles. It may for example consist in modifying the structure of the city (less traffic lights…) etc.

2.3.4. Barriers to the supply of alternative vehicles by category of alternative

In this section the results of the supply-side stakeholder’s consultation concerning barriers to the development of specific category of alternative vehicles are presented. This may be of high interest at the moment to design policy programs adapted to each category of alternative. The content mainly comes from stakeholders that are concerned only with a specific category of alternative. However, the barriers mentioned are often complemented by the opinion of general supply-side stakeholders (which are not concerned with one specific alternative) about barriers to specific category of alternative vehicles (reasons why they don’t develop each alternative).

[48] No mention is made about LPG among vehicle makers we interviewed.

For every category of alternative vehicle, barriers are firstly mentioned and are sometimes followed by specific policy measures suggested by the stakeholders concerned with the specific category of alternative (however it is not always the case because for some categories of vehicles, the suggested measures are more general - cf. above - or because stakeholders of a specific technology haven't been interviewed – cf. fuel cells and hydrogen).

As a reminder, barriers (and suggested policy measures) are those mentioned by the concerned supply-side stakeholders, without any modification so as to have really the perceived barriers from the supply-side stakeholders' point of view.

2.3.4.1. Hybrid vehicle

2.3.4.1.1. Barrier to the development of hybrid vehicles

1. **Economic barrier**: the **extra-cost** (because of the battery), not acceptable for a large public, is the first barrier. Also, it is difficult for the consumer to evaluate the saving on fuel consumption when using a hybrid (compared with a classic car).

2. **Technical barriers**: some technical barriers exist, like the question of reliability and performance of the batteries, their weight, the space taken by the batteries, or some technical difficulties to develop hybrid-diesel vehicles. Most of these barriers can be solved but it will take time.

3. **Market barrier**: **diesel** is a major competitor for alternative vehicles because it is fiscally encouraged, it is seen as better than gasoline because of less CO_2 emissions, and it is now widely spread in Belgium and in Europe. According to the interviewed stakeholder, gasoline hybrids are well developed in the US because they don't have Diesel.

4. **Supply-related market barrier**: **lack of available models**: there are not a lot of different models of hybrid vehicles in Europe up to now. There are only a few very luxurious cars and the Prius since 1997. The problem is the **space needed for the batteries, which implies that small vehicles are very loaded** (but this can evolve with new generation of batteries). Also, the **design** of the Prius is rather special and is not appreciated by every one.

5. **Demand side market barrier:** there is a **lack of information** of the consumer about hybrid vehicles. Something which contributes to the diffusion of bad information is "ethic pollution" or "greenwashing" from some "non ethical" vehicle makers using the term "hybrid" even when it is not a "true" hybrid. For example, the stakeholder interviewed argued that some so called "micro-hybrids" were not "true" hybrid vehicles but vehicles with a system similar to the system start & stop; in this case the word "hybrid" has only been used for marketing and can generate wrong information or scepticism from the consumer about "true" hybrids.

6. **Legislative barrier**: there is a refund (premium) of 15 % on vehicles which emit less than 105 g of CO_2/km (the Honda Civic has a reduction of 3 % on the purchase price because the emissions are more than 105 g of CO_2/km and less than 115 g of CO_2/km). An important barrier is that **this advantage do not apply for company cars** (so it is still too expensive for companies) **and in the second-hand cars market**.

7. **Environmental and societal barrier (linked to market and political barrier)**: more generally, some vehicles makers decided not to develop hybrid because of the **fear to invest in such a complex and costly technology if it is only temporary** (**uncertainties** about the future). Some also underlined that **environmental benefits of hybrids are sometimes not so important** and depend on the type of hybrid and the type of use (cf. No or little benefits on motorway). They sometimes underlined that small diesel can be better that currently developed hybrid vehicles.

2.3.4.1.2. Suggested measures to overcome barriers to the development of hybrids

Economic measures

- **Coherent policy about purchase incentives**: the **purchase incentive** (for cleaner vehicles in general) must be (a) financially **significant** (minimum 15% of the purchase price) and (b) **immediate**: reduction obtained directly on the invoice at the moment of purchase. Policies based on postpone or **delay incentives (like future tax reduction) must be avoided**. Also, **policy encouragement that would be applied to too many models would discourage R&D**.

- **Incentive policy applied to the whole life cycle of the vehicle**: incentives must be applied also in the **second-hand market** (following the example of the "Eco-Bonus" of the Wallonia region which applies to new and second-hand vehicles).

- **Incentive policy applied to the different segments of sale, like the fleet vehicles**. Indeed, it is still to expensive for companies to lease or to buy hybrids. Purchase incentives related to cleaner company cars are not yet sufficient. The current refund allowed to the individual user (when purchasing a clean car) should be applied also to companies.

- **A policy linked to the family situation should exist**: families with a lot of children need to purchase a mono volume. However, those would always emit more than a small car. As a consequence, it doesn't exist in Belgium incentives to choice the less polluting mono volume as there are all considered as pollutant. This problem doesn't encourage vehicle makers to develop a supply of hybrid mono volumes on Belgian market. But a policy linked only to the size or the weight is also to proscribe because it would not encourage people to continue to buy lighter vehicles.

Non economic measures

- **Protection of the hybrid concept**. Public authorities should protect the "hybrid" appellation (read above).

- Beside economic incentives, other policies are needed (like environmental zones for cleaner cars etc.).

2.3.4.2. Electric vehicles

2.3.4.2.1. Barriers to the development of electric vehicles

1. **Demand-side barrier: psychological barrier**: A very important barrier to electric vehicles development is related with **mentalities.** Indeed, the car is charged with emotions: for many, it is a symbol (of freedom…), it represents social status etc; people have also a precise idea of what is a car and how it should be (it has to be spacious, fast, etc.). The Reva (which is at the time of the study, the only electrical car proposed in Belgium) represent the "anti-car" as it small, not aggressive, silent, with a limited range etc.

2. **Some technical disadvantages can be mentioned, but are considered by the stakeholder interviewed as psychological barriers:**
- The **limited range** is an important barrier. However, for some consumers, the fear of limited range can be psychological and can correspond to a non-rational behaviour. Indeed, families have often two cars with one used mainly inside the city to drive small distances (which do not require an important range).

- The maintenance of the batteries (which are fragile) requires some new habits, like filling a tank with distilled water (more or less every 10 days) and to avoid driving with empty batteries because it can get broken.

- The long recharging time can also be perceived as a problem.

3. **Technical barrier**: a garage is needed or a place to recharge the batteries.

4. **Supply-related market barrier: lack of supply of electric vehicles** (quantitative and qualitative). This short supply implies a short number of after-sales and maintenance services. The lack of public recharging stations is also mentioned.

5. **Economic barrier**: **high purchase price** for a small car as well as the short life cycle of current batteries (replacement every 3, 4 years) and their high price.

6. **Political and institutional barriers**:
- **Lack of coherent and voluntary support from public authorities**. Example: the reduction offered by the federal government on low-emission vehicles does not apply to electric vehicles because those are considered as "quadricycles" and not as vehicles. Electric vehicle has currently a "double" competitive disadvantage as it is more expensive and it does not receive the reduction.

- **Conflicts of interest and various lobbies (from socio-economic groups)**, as the passage to electric cars implies a **change of socio-economic "paradigm"**. It has also to be noted that the electric vehicle need much less maintenance than conventional cars. That can be a problem for maintenance services benefits.

7. **Market barriers**: more generally, vehicle makers do not develop electric vehicles because of the batteries limited capacities which make electric vehicle **not competitive with conventional cars (in terms of space, range, speed and cost)**. They are **waiting** for the new generation of batteries.

8. **Environmental barrier**: some vehicle makers mentioned also that it makes no sense to develop electric cars since most of the electricity is not (yet) produced with renewable energy in Belgium **(uncertainties about the viability of this option**).

2.3.4.2.2. Suggested measures to overcome barriers to the development of electric vehicles

There is a need for a **coherent and voluntary support from public authorities:**
- Tax system: need to tax more polluting vehicles and make electric vehicles free of tax
→ Need for a significant financial advantage in terms of cost/km.
- Apply the federal premium (refund) to electric vehicles also.
- Take the example of Norway:
  - Tax exemption (no registration tax and no VAT on electric cars)
  - Electric cars can ride on bus zones (environmental zone)
  - Free parking, public recharging stations etc.

- Need to give more and better information to the consumers about the advantages (less maintenance needed etc.)

2.3.4.3. Barriers to the development of fuel cell vehicles

Remark: the number of mentioned barriers to fuel cells and hydrogen vehicles is small (i.e. often the same barriers are mentioned) but each of them is particularly important. This is because the technology is still in its infancy and it is still in process of development. Other more "practical" barriers will emerge at the moment of possible commercialisation. Most of the interviewed planned their market introduction for about 2020. No stakeholder specifically linked with this technology has been interviewed.

1. **Economic barrier**: cost still too high to be commercialised at large scale.

2. **Technical barrier**: not yet technically mature (problem of space, weight…).

3. **Supply-related market barrier:** importantly, the availability of hydrogen is too uncertain on the short run and there are numerous challenges linked to hydrogen production and distribution (see below).

2.3.4.4. Barriers to the development of hydrogen vehicles

1. **Supply-related market barrier:** the uncertainties about the sustainability and the availability of the fuel impede the introduction of hydrogen cars on the market.

2. **Environmental barrier**: those uncertainties concerning the fuel are related to the important controversies about its environmental benefits. There are many debates about the source of energy that must be used to produce hydrogen (need for renewable energy...), and about the way of producing it.

3. **Economic barrier:** Important production cost and high cost of infrastructures (need for supporting measures).

4. **Demand side barrier (psychological barrier)**: fear of explosion.

2.3.4.5. LPG vehicles

2.3.4.5.1. Barriers to the development of LPG vehicles[49]

1. **Legislative barriers: Diesel is the most important competitor of LPG because it has a fiscal advantage (less excises).** This generates other barriers mentioned below (point 2). **Moreover, there is an added circulation tax for LPG vehicles**, which, even if it's quite low in itself, represents a psychological barrier for people. So, tax systems on fuel and circulation tax are **inappropriate** to encourage LPG vehicles development.

2**. The important development of diesel vehicles in Belgium (and in Europe) appears to generate important market and institutional barriers to LPG development:**

- Market barriers: more than half of the Belgian park is composed of **Diesel** cars (54,5% in 2007)[50]. This can be considered as a barrier to LPG vehicles development as an LPG system makes sense on gasoline car but not on diesel car, which reduces the number of possible transformations.

- **Institutional barrier**: as a consequence, some vehicle makers are not interested in LPG because of the spread of diesel cars. Therefore, some vehicle makers do not support LPG. According to LPG stakeholders, there is an important **lobbying** in favour of diesel and indirectly against LPG from some vehicle makers on the European market.

3. **Political barrier**: there is **not enough promotion from the government** in favour of LPG, so there is **no message about the societal/environmental benefits of LPG to the consumers**. Also, there is **no financial incentive** for LPG installation; indeed, the premium (refund) that existed before (in 2001-2002) has been cancelled. However, this incentive, combined with a public advertisement about the LPG benefits, was very effective: at the time, the utilisation of LPG vehicles increased, but then decreased as soon as the premium was suppressed.

4. **Market barriers**:

- As a consequence of lack of promotion, there is an important **lack of awareness/information of the consumers about the LPG and its advantages**.

- **Leasing companies don't propose LPG**, which reduce significantly their development in fleets of vehicles.

5. **Psychological barriers**: in addition to the lack of information, there is a **bad perception** (bad image) of LPG, which is often perceived as an old system, with an impression of "dirtiness", and sometimes considered as the "fuel of the poor". Additionally, the **fear of gas,** associated with explosion, increase the psychological barriers. Finally, as all the LPG fitters are not reliable, bad adjustment can happen implying that some people experienced technical problems (which reinforce bad image).

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[49] It has to be note that in some countries like Italy or Poland, the LPG is quite well-developed.
[50] Source : FEBIAC statistics

To summarize those points and according to the stakeholders, the causality relations between barriers are the following: inappropriate tax system → diesel development → lobbying → lack of political motivation/support for LPG → lack of information and prejudice of the population about LPG.

6. **Supply-related market barrier:**
- The **reduced number of refuelling stations** is also a barrier. The interdiction to refuel in station without a pump assistant is a problem (according to some stakeholders, there is no such interdiction in other countries) as it reduces much the availability of refuelling points. Also, there is no station in the city centre for safety reasons.

- **The lack of dedicated LPG vehicles**, implying an additional step for consumers to make the transformation is of course a barrier. Moreover, people **usually lost the guarantee of the vehicle makers when the vehicle is transformed.**

7. **Technical/legislative barrier**: **the lack of access to most underground parking** is of course also an important technical/legislative barrier.

8. **Environmental barrier**: some vehicle makers mentioned that it is not a good option because it is still a fossil energy (limited resource) on the one hand, and because it doesn't have such good environmental performance on the other hand.

2.3.4.5.2. Suggested measures to overcome barriers to the development of LPG vehicles

- **To reform the tax system** on fuel and on the vehicle use (circulation tax) on the base of the Ecoscore, and to define long-term sustainable tax system (like in Germany for CNG. Read below).

- **To Promote and to create incentives to the purchase/installation** (like the premium introduced in 2001-2002). But the message should be stable trough time. Indeed, the quick suppression of the premium at the time was a problem for the investment made from the LPG fitters (trainings of workers etc.), and create uncertainties and lack of confidence among the different market segments.

- To organise **roundtables with all the LPG stakeholders to agree on a common view and a coherent discourse** towards public authorities and consumers.

- Suppression of the interdiction of access to underground parking and of refuelling without a pump assistant (according to one stakeholder).

2.3.4.6. CNG and biogas

2.3.4.6.1. Barriers to the development of CNG and biogas vehicles

1. **Supply-related market barrier:**

- The lack of refuelling stations for CNG (and biogas) is the main barrier.

- There is a lack of trained people to install a CNG system (as well as people trained for maintenance and reparation).

2. **Legislative barrier**: there is no legislative framework for CNG; indeed, the tax system (excises) for CNG is not defined. Also, safety standards for the installation of the system and refuelling stations do not exist.

3. **Technical barrier**:
- CNG/biogas vehicles are less powerful and have limited range (better for city use).

- The long refuelling time is also an inconvenient (those two barriers can be considered as psychological).

- The space needed for the tank can also be a problem.

4. **Market barrier**: there is a lack of information and knowledge of the population about CNG/biogas.

5. **Psychological barrier**: fear of gas (explosion).

6. **Environmental barrier**: for CNG, it is also mentioned that it is a limited resource.

7. **Market barrier**: for biogas, the production capacity is quite limited and has to be close to the place of utilisation (local utilisation).

Remark:
- **From the car industry point of view, the technology (CNG vehicles) is mature but the uncertainties about the availability of the fuel and the unclearness about future legislation in Belgium prevent their market introduction.** This alternative is already quite well developed in Germany and Italy.

2.3.4.6.2. Suggested measures to overcome barriers to the development of CNG/biogas vehicles

- Initiatives to develop a network of refuelling infrastructures (by private and public stakeholders working together and by way of subsidies).

- **To define a sustainable tax system framework for CNG**: for example in Germany the government has committed itself to fix the excises and guarantee a low price of CNG until 2020; by this way there is no uncertainty for the industries and they can plan a strategy and invest on this technology. Policy measures to support CNG in Germany were very successful.

2.3.4.7. Biofuel

2.3.4.7.1. Barrier to the development of biofuel[51]

[51] For a more detailed analysis on barriers to the development of biofuel see BIOSES project, supported by the Belgian Science Policy.

Various stakeholders linked to the industry of biofuel have been consulted, from biofuel producer, to distributors and biofuel vehicle makers. As a lot of information has been obtained, this sub-section has been organized as follow: in a first point, barriers to the production of biofuels are presented. Barriers to the distribution of biofuels are presented in a second point. In the third point, a barrier to the supply of biofuel's vehicles (adapted for a high blend) is mentioned. The fourth point includes barriers to the demand of biofuel vehicles (according to supply-side stakeholders' point of view). Finally, the last point is dedicated to more general barriers to the diffusion of biofuels, with some elements of causality relations between barriers.

a) <u>Barriers to the production of biofuel</u>

1. Legislative barriers*:*

- **Limited volume of production** (quota) for the internal Belgian market that can be tax exempted: for biodiesel, the quota is 380 000 m^3/year and for bioethanol it is 250 000 m^3/year (distributed by the government between different approved selected producers). However, 380 000 m^3/year of biodiesel 250 000 m^3/year of ethanol won't be sufficient to meet the objective of 5,75% of biofuel in fuel consumption in 2010 (as the quantity has been calculated in 2004 and the fuel consumption is increasing). Also, we are for the moment far from using those quantities of biofuels in Belgium.

- The **lack of constraining measures in Belgium that would oblige oil companies to buy a certain amount of biofuel** generates an insufficient demand for biofuel, and so limits the production even below the quantities that can be tax exempted (tax exemption not sufficient)[52].

- **Need to legalize E85** which is currently forbidden to sell (cf. Octa + has a E85 pump which is embedded) and there is no specific tax exemption.

2. Economic barriers:

- Biofuel price is **not competitive with current fossil fuel price. Also and importantly, even with the tax exemption, it is still more expensive for oil companies to buy biofuel (rather than to use their own fossil fuel) because of some logistic or administrative costs** (e.g. checking the quality, the percent of incorporation etc.). This implies again a lack of demand for biofuel.

- Problem of **international competition**: European production of biofuel is more expensive than in developing countries (not so good if we want energetic independency and strict rules of sustainable production). Also, some biofuel are sometimes subsidized, like for example the American biodiesel, which is currently creating important pressure on Belgian biofuel producers (unfair competition).

→ The lack of constraining measures in Belgium to oblige oil companies to buy a certain amount of biofuel, combined with the international competition of foreign biofuel (which is sometimes subsidized like for example the American biodiesel) generate important pressures on biofuel factories which face an **insufficient demand**.

[52] Indeed, in Belgium, the tax exemption on biofuel was not sufficient to reach the objectives, and the question of the obligation of incorporation for oil companies is currently in discussion in the government.

b) Barriers to the distribution of biofuel

1. Legislative barriers:

- **European standards about fuel quality limit the incorporation to biodiesel in diesel and to ethanol in gasoline**, which is a technical limiting factor of development. For biodiesel, the maximum incorporation in diesel is 5% in volume (CEN diesel standard EN 590). For the bioethanol, the maximum incorporation of ethanol in gasoline in volume (CEN gasoline standard EN228) is about 5% and about 15% for ETBE which is equivalent to 7% of ethanol.

- **For bioethanol: there is a contradiction between the Belgian and the European legislation** from a technical point of view. Indeed, in Belgium, if an oil company buys bioethanol to an approved operator, it will obtain a tax exemption on it only if he proved that the incorporation of bioethanol in gasoline is minimum 7 %. However, at the same time, the European standard fixes the maximum incorporation of ethanol in gasoline to an equivalent of 7%. This implies that 7% is just the technical limit to respect the Belgian and the European legislation. The problem is that it is very difficult to obtain such a precise incorporation (and it implies a very heavy administrative procedure), and it quickly goes out of the standard.

- **Oil companies mention that it is imperative for them to respect strictly European standards and to respect the limit of incorporation**. Oil companies are not for a "proliferation" of specific standards for different fuel (with specific incorporation of biofuel). The reasons are that they consider as essential to maintain a good "interchangeability" of fuel at European level (flexibility of exchange, common standards in every member state etc.).

- The **diversity of legislative and administrative framework concerning biofuel in every member state and in particular in neighbour countries is a problem for oil industry** (difference in fiscal incentives, in the percentage of incorporation, etc.).

2. Economic and political barrier

- **Oil companies are not financially interested in buying biofuel** (tax exemption is an insufficient incentive). There is a lack of appropriate policy measures to ensure a demand of biofuel from oil companies:

→ Inappropriate tax system and lack of financial encouragement: **current fiscal advantage is not sufficient**. Also, there is no tax exemption for high blend like E85.

→ **Lack of constraining measures that would oblige oil companies to incorporate a certain percentage of biofuel in their fossil fuel**.

A general remark was that **in Belgium, the supply of biofuel has been organised** (fixation of quotas and selection of approved producers) **but not the demand** (there is very little demand for biofuel from oil companies).

3. Technical barrier: according to oil companies, the quality needed for biodiesel is not always met, which has consequences on the quality of the diesel mix (biodiesel producers seem to have difficulties to meet the level of quality needed).

4. Market barrier: there are delays and uncertainties concerning the start of production factories of biofuel, implying problems of organisation for oil companies.

c) Barrier to the supply of biofuel vehicles (high blend)

The technology is mature but **the uncertainties about the distribution of biofuel and the unclearness of legislation** in Belgium prevent the market introduction of biofuel vehicles.

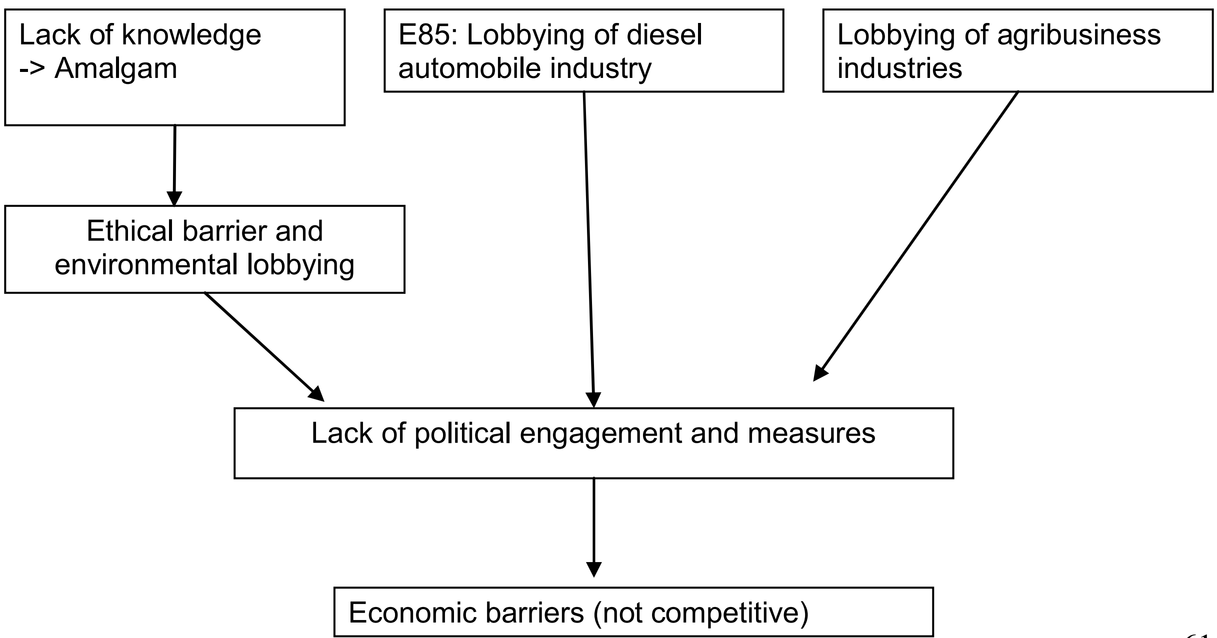
d) Barrier to the demand of biofuel (for the consumer)

The main barrier mentioned by supply-side stakeholders is related to "**ethical barriers**", linked to the **controversies about the environmental and societal effect of biofuels** because of an **amalgam** between the different kinds of biofuels (the environmental effects vary greatly according to the raw material and the way of producing the biofuel).

e) General barriers: interaction between political, institutional, market and economic barriers

According to some stakeholders, there is a **strong environmental lobbying (from environmental NGO's and associations) against biofuels because of an amalgam between the different kinds of biofuel and the different type of production** (public opinion is mixing bioethanol, biodiesel, the different raw materials used, location of production etc). More generally, **public opinion is also sceptical** (because of this amalguam) and **a bad image is conveyed to the consumers trough the medias (over-mediatisation)**. There is also a **lobbying against E85 from some vehicle makers because of the spread of diesel cars** (the important share of diesel cars is a barrier in itself for bioethanol). Finally, it exists also a **lobbying against biofuels from agribusiness** (like Monsanto or Nestlé) because of the fear of the increase of some product price. All **this prevents politicians to take position and measures** to promote biofuels because they make themselves the amalgam on the one hand and they are confronted with various lobbying on the other hand. As an important barrier is economic, there is a need for financial support (tax exemption etc.); if no measure, there is no demand.

Figure 1: Barriers to the development of biofuel according to supply-side stakeholders and relations between barriers



2.3.4.7.2. Suggested measures to overcome barriers to the development of biofuel

- To legalize E85

- Policy measures to encourage/to oblige oil companies to buy biofuel:
  - Financial encouragement and tax exemption on E85
  - Obligation for oil companies to incorporate biofuels[53]
  - French model ("TGAP"[54]): environmental tax, avoidable if incorporation (if not environmental punitive tax).
  - Increasing excises on gasoline and particularly on diesel.

- Need for more and information for the civil society and need for European standards, as well as directives with environmental and social criteria for the production of biofuel.

2.3.5. Category of alternative vehicles that would be more easily introduced in the market according to vehicle makers

Supply-side stakeholders were asked to mention which kind of alternative vehicles could be more easily introduced in Belgium and why.

While their answers are influenced by their own supply strategy, the answers that come out the most often are: **hybrid and biofuel vehicles** (for the short term) **because there are no differences of utilisation compared with conventional cars (no change of habits) and they can be used with current infrastructures**. **CNG** is then sometimes mentioned, as well as electric vehicles (but at medium term) while hydrogen vehicle is planned at very long term. However, some vehicle maker's remark that new models of **diesel** (with particle filter) have to be promoted first, as it implies no change of habits, of infrastructure, and of vehicle makers' strategies.

2.3.6. Conclusions of the supply-side stakeholders interviews

Different kind of barriers to the development of the supply of alternative vehicles came out from the supply-side stakeholders' consultation.

Demand barriers: economic, technical and psychological barriers

An important barrier for vehicle makers which prevent them to develop alternative vehicles in their supply is related to the fact that they expect no (or not enough) demand for those vehicle because there **consider them as not competitive with conventional vehicles for several reasons: economic (higher price), technical (alternatives have often some disadvantages), psychological (habits of the consumers) and also the actual trend of the characteristics of**

[53] Currently in discussion in Belgium.
[54]«Taxe générale sur l'activité polluante »

the demand (more and more requirements of the consumers for more comforts, options, at an acceptable costs).

This is exactly the reverse situation than demand-side stakeholders (individual users and fleet managers), for whom one important barrier was linked to the short supply. However economic and technical barriers are expected to decrease with mass production and development. But for the moment, **the market is "stuck" because supply-side stakeholders expect no demand and demand-side stakeholders wait for supply development. This implies a need for policy intervention to release this "locked" situation.**

Supply-side barrier: lack of distribution of alternative fuel ("chicken and eggs" problem)

Next to the higher price and the possible technical disadvantages, the lack of alternative fuel availability is a **major brake for vehicle makers to develop and commercialise alternative vehicles,** even when the technology is mature (e.g. CNG or biofuel)**.**

Market barrier: competition of conventional low emission cars, diesel cars in particular

Also and importantly, while vehicle makers are developing slowly alternatives, their current strategy is rather to **focus on the improvement of conventional fossil fuel cars-diesel car in particular-** in terms of efficiency and reduction of emissions. Indeed, it allows for reduction of emissions while maintaining a reasonable price (technology has being developed since years), offers the same comfort, implies the same habits for the consumers, etc. We can deduce from our interviews that diesel is often considered as major competitor for alternatives, also because it is fiscally encouraged.

Environmental and societal barrier

There are too **many possible alternatives and too many uncertainties about the "sustainability" of the different alternatives**. It is too risky to invest a lot in a complex and costly technology, to train workers etc. if they have to abandon it some years later because it appears to be not such a good environmental option.

Political barrier

Given the current context, **alternative vehicles would not spontaneously emerge from the market but need an impulse trough policy intervention**. **The lack of coherent and global policy measures to promote alternative vehicles and fuel is a major barrier to their introduction. Moreover, there are a lot of uncertainties about the evolution of future legislation**. Policy should be **clear** (legislation based on clear criteria), **harmonised** (between countries and inside Belgium), **and defined on the long run**, **to enable the industry to define a strategy**.

There is a **lack of clear policy for the introduction and the promotion of alternative fuel:** policy measures should ensure alternative fuel distribution. More generally, policy makers have to promote alternative vehicles/fuel and take a clear position. In order to play this role, policy makers have to ensure about the "sustainability" of the different options (trough R&D etc.).

Today tax system is inappropriate as it is not linked to environmental criteria: there is a need to create incentive for the consumers. Also, educational and informational measures have to be taken in order to bring a clear message to change mentalities, habits, prejudices and fear of the public.

2.4. Barriers to the development of alternative vehicles according to the experts: interviews results

The “experts” include different groups of stakeholders from the society: universities and research centers, NGO’s and associations, and politicians. This group is supposed to be “neutral” is the sense that they are not consulted as demand-side stakeholders or supply-side stakeholders. The “experts” have a more global view on the question, about demand and supply-side barriers, but also about the barriers “upstream”, e.g. related to the context in which the automobile sector operates.

This part is divided into 3 chapters: the first one is about the sample and the methodology for the interviews (same as the previous chapter), the second one is about barriers in general from the expert’s point of view and the third one is about the policy measures suggested by the experts to overcome barriers. **Opinions of experts about barriers by category of alternative vehicles are given in the appendix[55].**

As we will see and without surprises, a significant number of barriers mentioned by the “experts” have already been mentioned by the previous groups of stakeholders, which reinforce and confirm their existence and their importance. However, some new ideas are also emerging.

2.4.1. Sample and methodology

The questionnaire and the methodology was the same as for supply-side stakeholders (see point 2.3.1). A sample of 18 “experts” has been interviewed. This has allowed, as previously, for in-dept interview-discussions. As for stakeholders of the supply-side, most interviews were face-to-face, but also sometimes by phone or in writing (according to the preference and the availability of the interviewed). This consultation took place through the year 2008.

The sample includes people from the European Commission (Energy and Transport DG), the European Council, the IBGE-BIM, Minaraad[56], 2 ministerial cabinets (Smet and Huytebroek), 2 Federal Public Service (transport & mobility, and public health and environment[57]), Transport & Environment (T&E), Inter-environment Bruxelles, le Centre Interuniversitaire d’Etudes de la Mobilité (CIEM), Green Propulsion, le Centre de recherches routières (CRR), the European Commission joint Research Centre, an automobile journalist, a consultant and a centre of automobile training (Autoform).

As a reminder, all the information coming from the interviews (or filled-in questionnaires) were treated in a qualitative way, as quantitative analysis had no sense with such a small sample. The results presented in the next sections resume the main ideas that come out from

[55] In appendix, we give a summary of what have been said by the experts about barriers by category of alternative vehicles. To facilitate presentation, barriers have been classified and are presented in a synthetic way in a box for each category of alternative. The results correspond roughly to the barriers mentioned by the previous group of stakeholders, but some new ideas of barriers often related to more environmental or social criteria (but also other kinds) have been added by the experts.
[56] Het natuur- en milieuadviesorgaan van de Vlaamse Regering en het Vlaams Parlement
[57] Service Public Fédéral santé publique, sécurité chaine alimentaire et environnement.

the interviews, as well as new and interesting ideas that emerge. This means that every barrier mentioned in this chapter is of course not necessarily mentioned by all the stakeholders.

Barriers have been classified and presented by category according to their nature (see first part of the report).

It has also to be noted that all what is written in this part **do not reflect personal opinion of the authors**, but resumes all the ideas that were mentioned by one or several "experts".

2.4.2. Opinion of "experts" about barriers to the development of alternative vehicles in general

This section resumes what has been said by the experts about barriers to alternative vehicles in general. We will see that many barriers have already been mentioned by the other groups of stakeholders, which confirm their existence and reinforce their importance. But consultations with "experts" have also allowed us to highlight some new barriers to the development of alternative vehicles, in particular institutional, political and legislative barriers.

1. **Institutional barrier**

One expert highlighted an important barrier referring to history: the fact that society has made the technological "choice" of fossil fuel vehicles in the past. So, societies have invested so much and since such a long time on fossil fuel engine and on related infrastructures that the costs of using fossil fuel vehicles are lower and the general performance (except about the environment) is "better" compared to the other technologies. Also, the performance of gasoline and diesel engines are still improving, implying that the gap between the technologies is maintaining. This implies a lack of competitiveness of alternatives from an economic and technological point of view. This expert mentioned that the other barriers could come from this technological past choice and proposed some causality relations between barriers. This has been used and more developed in the next part of the report (part 3).

2. **Economic barriers**

The economic barriers (higher prices), making alternative vehicles not economically competitive, are mentioned by most experts and considered as very important.

3. **Technical barriers**

Experts often mentioned the problem of technical disadvantages (compared with conventional cars), and in particular the combination of economic and technical disadvantages (making the vehicle particularly unattractive).

Some expert's mentioned that those obstacles (economic and technical) are more important in the short-run, as they will decease with diffusion and mass production (thanks to economies of scale, R&D...).

4. **Market barriers**

Experts mentioned that the **large range of alternatives**, **each one with advantages and disadvantages, is also a significant barrier.** Indeed, vehicle makers (and consumers) don't know what to choose, as there is not really one solution which imposes itself and comes out. Also, the (long run) credibility of the technology is important for vehicle makers, as they don't want to invest a lot in a "transitional" technology. However, vehicle makers face uncertainties about the viability of the different options and so about the future of each alternative vehicle market.

5. **Supply barriers**

Because of those previously mentioned barriers, there is a **lack of supply of vehicles (quantitative and qualitative)**, which can be considered as a barrier for the consumers, as often mentioned by the experts (the fact that there is not yet diesel-hybrid in Europe is also mentioned). Also, the consumer faces an **uncompleted product (lack of refuelling/recharging infrastructures and lack of maintenance services etc.)**. Indeed, the **lack of distribution** of the fuel is of course a very important barrier, often mentioned by the expert. About this subject, one expert noted the advantage of "liquid fuel" which is easy to transport (as all the infrastructures exist), and the fact that it is not easy to switch to gas, notably because there is not always enough space in station to add a new product (logistic barrier).

6. **Psychological barriers**

Some experts mentioned the **"use effect" and the attachment of people to conventional vehicles**, as well as the force of the **symbol**, the image of the traditional vehicles with good range and high speed (image of freedom…). **Unconsciously, people are stuck in their habits and there is a kind of "mental laziness", causing resistance to change and maintaining the same purchase behaviour.** The way the alternative vehicles are perceived by consumers is thus a barrier.

This is reinforced by a **lack of general confidence in alternative vehicles**, in particular concerning **safety** (risks) associated with new technologies, which is related to the **fear of the unknown.**

7**. Demand side market barriers**

Psychological barriers are enhanced by a **lack of information or bad information about alternative vehicles**, which is considered as an important barrier according to the experts. Indeed, some experts underlined that **the information is complicated and full of contradictions, which discourage the consumer.** This is true at a precise point in time (e.g. hydrogen is sometimes presented as the ultimate solution, sometimes as a non-sense) or through time (biofuel was considered as a good alternative some years ago, and now it is much debated). This implies **no clear message** for the consumer who loose confidence and don't know what to choose. In this case, economic incentives will not be useful if the information and the message is unclear and if people are not confident about the alternatives (economic barriers can be supplanted by other barriers). Some experts also mentioned a need for a **more important environmental awakening of the population**, for more "environmental advertising" and for a clearer view about the environmental impact of every category of alternative vehicle.

8. **Political and institutional barriers**:

Several experts mentioned that there is a **lack of policy measures and political encouragement (financial and informational) at national and European level (lack of "political view" and of voluntary policies)** to encourage the development of alternative cleaner vehicles (which is considered as an important barrier for the expert). Some of them mentioned the lack of legislation and of binding measures (applied to both supply-side and demand-side of the market). For example, some experts mentioned a need to oblige vehicle makers -by way of legislation- to respect more ambitious limited emissions value for all the vehicles, as well as to fix even more ambitious objectives on the long-run.

The lack of (sufficient) policy measures in general have been explained by the experts by various factors:

- At national level, one expert underlined the fact that in Belgium it is more difficult to take national measure (for national competences like tax system) as the 3 regions must agree (**institutional barrier**).
- Psychological barriers (and other demand-side barriers) reduce the political willingness of policy makers (they don't want to take unpopular measures), who prefer to wait for a change of mentalities.
- The fact that the car market is a globalised market can also reduce the room of action for national politicians.
- The **wide range of alternatives** -mentioned by the experts- with no perfect solution and with every one being much debated, can constitute a problem for politicians and prevent them to promote one alternative. Also, it comes out from the expert's consultation that there are no agreement about which alternative is good or bad for the environment (the opinions are very diverse) what makes difficult possible agreements.
- **Lobbying**: there seem to exist some kind of lobbying indirectly or directly against alternative vehicles development, which could prevent politicians to take ambitious policy measures: on the one hand, and according to some NGO's and politicians, there exist various **economic lobbying** from various industries and socio-economic groups that could directly or indirectly have an impact of alternative vehicles development. On the other hand, we noticed trough the interviews a kind of **lobbying from some environmental NGO's or associations against some alternatives.**

  According to some NGO's and politicians, **economic lobbying** (from oil industries, some vehicle makers and other various socio-economic group), in particular at European level, is an important institutional barrier to significant policy measures. For example, some vehicles makers are lobbying against ambitious objectives in terms of CO_2. Also, Diesel-related stakeholders would lobby to keep the fiscal advantages, which have also an indirect impact on alternatives (as it places diesel as a major competitor for alternative vehicles). Europe is roughly the only important market for diesel, which can explain that it is important for this industry to keep their market part. Lobbying has an influence on technological choice and on maintaining one technology. Note that some NGOs consider at current time that the alternatives developed by vehicle makers are generally shown rather for the image ("marketing") than for real purpose of commercialisation in the short run.

  As mentioned, it seems also to exist a kind of lobbying against alternative vehicles from some environmental NGO's and associations. Indeed, as **alternative vehicles are still bad for the environment** (even if they are less pollutant), those stakeholders consider that “collateral effects” are sometimes even worst (see for example the debate about biofuels…). Also, alternative vehicles encourage the current trend to the “overuse” of the car and contribute to the (wrong) idea that it is possible to maintain our current ways of consumption. It is related to the idea that “salvation” will come from new technologies, which is a mistake. Many environmental NGO’s and associations would rather lobby for a reduction of the number of cars (in order to improve quality of life, the proofing of the grounds etc.); according to this view, the federal premium for low-emission cars is not good because it encourages the purchase of cars.

- In the same line, it also came out from the interviews is that alternative or clean vehicles by themselves **do not constitute a political priority** for green politicians (it is secondary). As some environmental NGO’s and associations, green politicians would act rather for a more global and structural change: reduction of the use and the number of cars, reorganisation of public space (which is currently dedicated to cars), etc. Also, like some NGO’s, they remind that **alternative vehicles are still bad for the environment** (no one is satisfying) even if there are less pollutant, and they are often highly debated from an environmental point of view **(environmental barriers)**. Also, one politician mentioned that even if alternatives are cleaner, it is likely that the technological improvement will not compensate for the current trend towards the vehicle park increase. Moreover, cleaner vehicles could contribute to the trend towards a structure of urbanization and “peri-urbanization” cars-oriented by encouraging the trend to the “overuse” of cars. One stakeholder mentioned also that alternatives technologies and energies come in third position in the hierarchy of their priority: public transport and soft mobility (bike, car sharing…) come first, and then come the efficiency improvement of vehicles in general (cf. European legislation about emissions). Alternative vehicles are considered as a “last recourse” solution (we first have to avoid a maximum to use individual cars). Also, according to one NGO, all the vehicles should decrease emissions and it is technically possible to reduce significantly the consumption of conventional vehicles; alternative vehicles may be a way to reach CO_2 objectives (in particular for bigger cars) but should not be an objective in itself.

As we will see in the next point, the lack of appropriate policy measures implies some inadequate policies that results in legislative barriers which are described in the next point.

9. Legislative barriers

It is interesting to note that some of the inappropriate policies mentioned by the experts are the same than those mentioned by the supply-side stakeholders. However, they have also highlighted some new barriers.

- Most of experts agree that current **tax system is inappropriate**. There is a lack of adequacy between the final cost for the user and the cost (direct and indirect) for the society (the fact that environmental costs -damages- are not taken into account in vehicle prices are considered as an important barrier); tax system should be based on environmental criteria. If we do so, the possible problem of higher initial cost could be overcome. If we don’t change anything the alternatives will be more expensive, and the consumer is not ready to pay more as his individual benefit is smaller than the social benefits (need for intervention). There is a need for a tax that would decrease the use of car and encourage clean vehicles purchase. Moreover, there is a need for fiscal incentives because of the risk associated with a new product (need for an extra-advantage to compensate).

- According to most experts, the **price of Diesel** is really **too low** and shouldn't be supported by the state. Indeed, diesel price is encouraged as if it was a clean fuel so it gives a wrong message to consumers (contradiction). It places diesel as a major competitor for alternatives. Not only diesel is not enough taxed, but it is encouraged by legislation based on CO_2 (like "bonus-malus" in Wallonia, or the European objectives on CO_2…). So, according to most experts, diesel should be more taxed; this would also allow the less polluting fuel to be free of tax (or less taxed); of course, it's not politically easy… A remark was that diesel is an appropriate fuel for road transport (not in city), so it would be necessary to "delink" fuel price for professionals' users and for private users: tax for private user should be higher than for professional users. As this is difficult to implement in practice, it may constitute a barrier. Moreover, Europe is more or less the only diesel market in the world (diesel is not much spread in Japan and United-States) which implies a lobbying from diesel related industry.

- Some experts mentioned also that **the circulation and registration taxes** are based on criteria which have nothing to do with the environment (and even can encourage more polluting older cars). Green politicians are working to change that (tax based on the ecoscore) but they are political oppositions from other parties as the measures could overtax poor households who have older cars.

- **Uncertainties about environmental legislation** are also considered as important for most experts (one expert noted that at the end of the 70ies, a lot of researches and projects have started and have been stopped in the 80ies when petrol prices have gone down). This implies that vehicles makers are facing **uncertainties about the viability of the possible projects** (due to uncertainties about future policies). In order to create a market for alternative technologies there is a need for a stable, coherent and harmonised legal context with clear policies defined at long-run that has to come from the different level of authorities (supranational, national and local); inclusion of social cost of emissions trough national or European tax system and local policies like special zones should be part of a coherent and voluntary program.

- Legislation for **company cars** (which are much more used than private vehicles) **is inappropriate**, as incentives for using low-emissions cars are not sufficient and alternatives are hardly ever used.

- The existing legislation to encourage clean vehicles in public administrations fleet in Brussels ("**ordonnance air"/"ordonnantie lucht**") was a "fiasco" according to some experts: only 5 administrations -which have more than 50 vehicles-, are concerned (with not all the vehicles concerned) and the definition of clean vehicles was not so clear. But now some changes are in process implying among other that every new vehicle will need a minimum ecoscore (except for vehicles with specific functions).

2.4.3. Measures suggested by the experts to overcome barriers

In this chapter we summarised what have been mentioned by the experts about measures to implement to overcome barriers.

In general, according to the experts, public authorities should set up a favorable context to create a supply and a demand for alternative vehicles. This has to be done trough coherent, clear, harmonized and stable (long-run) policies. Those policies have to guarantee to vehicle makers and fuel distributors that they will be able to develop and maintain their business (alternative vehicles/fuel production and distribution) in the long run in a clear and stable context, and that they will be able to get a return in their investment.

Measures suggested by the experts have been classified in 6 different categories: development of niche markets, general financial instruments, encouragement to R&D and infrastructures development, regulatory instruments, information and education and other complementary measures.

1. Development of niche market

Initially, it would be interesting to focus on niche markets: captive fleets, vehicles fleets of public administrations etc. this could be done through compulsory measures. Example: to reorient the replacement of the fleet by imposing that every new vehicle bought has to be alternative or clean, or at least a certain percentage of the fleet (cf. "ordonnance air"- "ordonnantie lucht"). It is important to create the necessary conditions to allow the acquisition of alternative vehicles for public administrations: environmental clauses in public market for vehicle acquisition or specific public market for the acquisition of such vehicles…

2. General financial instruments

Those instruments should allow **compensating the price differential between alternative and conventional vehicles, and giving an incentive for consumers to buy alternative/clean vehicles.**

The instrument that is suggested by most experts' concerns **green car taxation**. As mentioned by one expert, people are very "receptive" to tax incentives. Tax system should be based on the external cost of the vehicles, in such a way to create the adequation between private and social cost. So tax system should be based on environmental performance, for the purchase and the use of the car (circulation and registration taxes as well as excises on the fuel). Some experts suggested that the environmental criteria could be the ecoscore or even better the LCA but it's more complicated (for example for electricity the sources have to be known) and need to be more developed. They often mentioned that the criteria shouldn't be CO_2-based as it would encourage diesel vehicles. So, the new tax system would imply to tax more diesel (more excises), which is not politically easy. One expert mentioned that tax increase on diesel must concern only the individuals, and not the commercial vehicles (see above). Some experts mentioned also the need for tax exemption on some fuel and for the suppression of discouraging tax (like the complementary tax on LPG). It has been highlighted that green taxation should also be applied to company cars; also, some particular measures could be done at this level, because it would allow for a more rapid introduction of alternative vehicles, as those cars are quickly replaced (important turnover)[58].

A system of tax exemption for green vehicle makers could also be an option.

[58] It has been remarked that company have a fiscal advantage to offer a car to their employees with current legislation, which is a non-sense from an environmental point of view.

Premiums and subsidies are other instruments that could encourage consumers to buy alternative vehicles. Indeed, the premium for the LPG in 2001-2002 had a significant effect on LPG use. Indeed, premium allowance encourages people financially but also gives a certain confidence in the product.

Some experts mentioned a need for a **public-private partnership**, in which stakeholders would look at what is needed to have a "complete product" (enough supply of the alternative vehicle, availability of the fuel, after sales and maintenance services, etc.) and public stakeholders could lend to private stakeholders at a low or with no interest rate (in such a way that the extra cost at the beginning is born by the public), with refunding when it's commercially sustainable (so when the market is well set). Before the public-private partnership, some experts consider that the different private stakeholders of the industry should first make a "brainstorming" together in order to determine every need and problem relative to each alternative (good organisation between actors for every technology) and make then part of their need to public authorities.

3. Encouragement to R&D and infrastructures development

There is a need **to encourage (financially) R&D to improve the technologies and to evaluate the sustainability of the different options**.

Public authorities must ensure and set up the necessary conditions to the development of fuel distribution infrastructures. Public sector can invest directly on infrastructure or lend to the private sector at the beginning (see above). If infrastructures need a very important investment, it may be preferable to start with captive fleets.

4. Regulatory instruments

Environmental standards of production of vehicles must be designed (regulatory framework for vehicle makers). At European level, a restrictive limited value of emission (more ambitious than today) for every vehicle should be imposed.

5. Information and education

Public authorities have to play a role to overcome psychological barriers, by making campaign of information and "advertising" (to insist on environmental benefits and other positive attributes of alternative vehicles -like the silence for electric car for example-). It will allow reducing the lack of confidence of the public about new technologies. More generally, the environmental consciousness of people has to be developed.

Another interesting educational measure is to introduce alternative vehicles in drive school so that driving licence would include the use of alternative vehicles.

6. Other complementary measures

Diverse advantages for users of alternative/clean vehicles: low-emission zones, free parking's etc.

2.4.4. Conclusion of consultation with experts

An important range of barriers identified by the experts are from the same nature than those expressed by demand-side and supply-side stakeholders, which confirm their existence and reinforce their importance. However, some new barriers (institutional, political and legislative) have been underlined by the experts.

Among barriers that had already been expressed by the other group of stakeholders, we have **economic barriers**, of which the importance have been confirmed by the experts, and **technical barriers** (technical disadvantages). As mentioned by the experts, those barriers (economic and technical) are more important at short run and will decrease with development (thanks to economies of scale, learning economies, R&D...). **Psychological barriers** have been underlined, including the problem of habits, the lack of confidence in safety and the apprehension of new systems. Other **demand-side barriers** have been mentioned, like the **lack of bad information** and the **lack of clear message** to the consumer about the advantages of the different alternatives. Also a **lack of sufficient environmental consciousness** of the population has been mentioned. **Supply barriers** (lack of availability of alternative vehicles and fuel...) have also been confirmed by the experts (as a barrier for demand-side stakeholders). **Market barriers**, in particular the **existence of many alternatives with no "perfect" solution** has been mentioned has a barrier for vehicle makers, consumers and policy makers. Also, the **uncertainties about the viability** of each option are a barrier for vehicle makers to invest massively and commercialise new technologies (too risky).

The inappropriate tax system (legislative barrier), already mentioned by the supply-side stakeholders, has been underlined by most experts: current tax system should be replaced by green car taxation. Tax system should be based on the external costs of the vehicle. Experts specified that **diesel price is too low** (which gives a wrong message to consumers) and it creates competition with cleaner fuel. **Like supply-side stakeholders, lack of coherent and clear policies as well as uncertainties about environmental legislation are considered by experts as an important barrier** (as it causes uncertainties about the viability of possible projects and prevents supply-side stakeholders to plan a strategy). About legislative barrier, the inappropriate legislation for company cars (not enough incentives to use clean/alternative vehicles) and the weak impact of the "ordonnance air"/"ordonnantie lucht" have also been mentioned.

Experts particularly insisted on the **lack of policy measures and political encouragement to promote alternative vehicles**, which is an important barrier to their development (political barrier). Lack of policy measures has been explained by **various reasons**; firstly, at national level, one expert underlined that it is **difficult to take national measures as the 3 regions must agree** for some field like taxation (institutional barrier). Another mentioned that the **globalized level of vehicle's market** can also reduce the room of action of national government. Also, **psychological barriers** (kind of "reluctance" of people towards alternative vehicles) impede politicians for taking measures as they don't want to take unpopular measures. The **wide range of alternatives** with no perfect solution is also a barrier for politicians to take measures (as each solution is somehow open to criticism). Secondly, there seem to exist lobbying that brake the implementation of important policy measures: on the one hand, according to some NGO's and politicians, **there would be an economic lobbying from some industries and socio-economic groups, notably for example from the automobile industry and oil companies** against ambitious environmental measures (that would indirectly encourage the development of alternative vehicles); on the other hand, we noticed trough the interviews a kind of **lobbying from some environmental NGO's and associations against some alternative vehicles** (or against the idea that alternative vehicles are a good solution). Also, it appears from the interviews that **alternative and clean vehicles do not constitute a political priority for green politicians. Like environmental NGO's, green politicians would rather act for a more structural change of the society**: reduction of the use of the car, use of bikes and public transport etc., because alternative technologies are still bad for the environment (environmental barrier) and because it can make people think (wrongly) that we don't have to change our current way of consumption (use of cars). The fact that alternative vehicles do not represent a political priority for green politicians and the fact they would more orientate their policies for a reduction of car is in line with the result from the survey at the Motor show, where it has been noticed that "true" ecologist prefer not to have a car than buying a vehicle, even cleaner.

Last but not least, one expert highlighted an important barrier referring to history: the fact that society has made the technological choice of fossil fuel in the past, implying a development which have reduce costs and improve performance of fossil fuel vehicles. This would explain the wide range of barriers to the development of alternative technologies that societies are facing. This idea will be developed in the next chapter.

About policy measures, **an array of policies from different natures was suggested by the experts**: development of niche markets, general financial instruments, encouragement to R&D and infrastructures development, regulatory instruments, information and education as well as other complementary measures. So, according to the interviews of experts, this would imply that a mix of instruments would be necessary to overcome the different categories of barriers.

PART 3: TRANSVERSAL ANALYSIS OF THE INTERVIEWS: TECHNOLOGICAL LOCK-IN AND SYSTEMIC SCHEME OF THE INTERRELATIONS BETWEEN BARRIERS

The results of the consultation of the different groups of stakeholder typically illustrate a situation of technological locked-in. Because of past choices, we are “stuck” in what has been named a “socio-technical complex system”. As a result, the different pans of our society are designed in accordance with the generalised use of fossil fuel cars, with very strong links and interdependences between the different elements.

Thinking in terms of system when apprehending the barriers appear to make more sense than considering them separately and in a static way. It implies to have a holistic view of the different elements of the network that characterise an energy system. This allows for apprehending the interrelations between barriers. Understanding the framework and the dynamic of the system will help to find the possible driving forces to overcome barriers and to create the necessary environment for alternative vehicles to develop. This is essential for drawing up effective and ambitious policy measures based on an integrated approach. Indeed, policy measures aiming at promoting alternative vehicles development could not have the expected results if they fail to take into account the interrelations between barriers.

Evolutionary economists have studied and developed a theory describing the characteristics of the technological lock-in process. This description fits particularly to the barriers to alternative vehicles mentioned by the stakeholders, and brings a theoretical framework to our conclusions. Indeed, the issue of the barriers to the development of alternative vehicles can be replaced in a more global question referring to a change of “technological paradigm”.

In this chapter we will describe in a first section the characteristics of a technological locked-in situation, as it summarizes particularly well the barriers (to the development of alternative technologies) met and perceived at the different levels of the society. Moreover, it shows the complex and strong interrelations as well as the interdependences between the different kinds of barriers. So, this wide array of interrelated barriers explains what has been qualified as the “lock-out” of alternative technologies. In a second chapter we have used the information coming from the stakeholders' consultation by including it in an analytical framework inspired by the “lock-in” process. A systemic scheme representing the interrelations between barriers will be proposed together with possible levers (type of policy measures) for overcoming this lock-in situation.

3.1. Fossil fuel cars: technological lock-in

In this chapter, some elements on the characteristics of the lock-in situation based on literature are presented.

It is necessary to better depict the context wherein alternative vehicles have to develop in order to identify the potential triggers that could help to overcome the barriers preventing their wider diffusion ("lock-out" situation). **Alternative vehicles do not come up and operate in a "virgin" environment. Indeed, conventional cars with internal combustion engine working with fossil fuel have been used for decades. This implies that alternative vehicles must compete with this old and well-developed pre-existing technology for which the linked technologies, economic sectors, institutions, infrastructures etc. are well established.**

The automobile market belongs to the "**fossil fuel energy system**", which can be considered as a "Techno-Institutional Complex" (TIC)[59]. A TIC corresponds to a specific organisation of the different facets of society. It consists in a wide range of interrelated and complementary elements (components of the society) including specific infrastructures (physical organisation), institutions, social organisations and mentalities. **In the case of the automobile system, it is composed of the following interconnected elements[60]: cars, refuelling infrastructures, garages, firms, lobbies, culture (e.g. automobile sport), shaped mentalities (symbolic of the car and representation of what should be a car), etc. So, all these components of the system are related to fossil fuel vehicles;** we speak about a "locked-in" situation (inertia) when the technological system follow a trajectory which is diffficult and costly to change (path-dependent process)[61].

Technological lock-in emerges from a path-dependent process with increasing returns to scale, improving efficiency, and narrowing relationships between the different stakeholders that become interdependent[62]. In this context and due to increasing returns to adoption, the technology which has gained an initial lead will gradually exclude other competitors[63] (as its advantages intensify with development). Four types of increasing returns identified by the lock-in literature can be mentioned[64]: "scale economies", "learning economies", "adaptive expectations" and "network externalities". Scale economies occur as firms invest in an initial technology and the increase of production implies a decrease of the price per unit. It goes often together with "learning economies", as the competencies and skills are developed and actors learn from experiences which reduces also the cost of production. "Adaptive expectations" refers to a behaviour in which people based their future expectations on what happened in the past. It occurs when actors from the demand and the supply-side of the market are more and more confident in the quality of the technologies (weak level of uncertainties). Finally, and this is a very important characteristics of the lock-in process, "network externalities" appear when the diffusion (growing number of users) of the technology increases its value for each individual user. The network starts with the development of firms and infrastructures resulting from the production, the distribution

[59] P. del Rio, G. Unruh (2005)
[60] Maréchal K. (2007)
[61] Maréchal K. (2007)
[62] P. del Rio, G. Unruh (2005)
[63] Maréchal K. (2007)
[64] Arthur (1994) in Maréchal K. (2007)

and the services linked to the technology/fuel (roads, refuelling infrastructures, garages…). Then, other relations between firms or industries are created (for example, the plastic industry uses by-product from oil refineries). So, strong relations and interdependencies between firms and industries emerge. Development of the network goes together with development of various lobbies[65].

The development of the industries network implies a parallel development of the civil society by the way of advertising, medias etc. which modulates the demand according to the supply. Also, **beside the decreasing costs mentioned, the building of the system also implies a decrease of "social cost" because of a "use effect" (habits) to the technology. Indeed, agents adopt "routine" behaviour in their purchase decision to avoid mental effort and to ensure satisfaction (no uncertainties).** So, it results that **agents are "locked-in" in routine consumption patterns, which have often been observed in the energy field (and can explain non-rational behaviour and non-efficient decision). Routine behaviour can also expand to firms and institutions.**

The lock-in process goes together with **harmonised standards and legislation**, which can reach an international level, increasing again network externalities etc.

Public institutions and governments play also a major role in fostering (or inversely discouraging) the development of one technology trough policy measures like specific tax system, subsidies, legislation etc.

A **decrease of transaction costs** result also from those various processes.

The lock-in is also strengthened by a lock-in of ideas, in the sense that R&D focuses more on the improvement of the current technology rather than on radical changes.

So, the lock-in process implies that **society at large is "stuck" in a specific technology because of past choice, as it has reached a point where economic and social costs are low enough because of network externalities**[66]. As we have seen, **the entire society is designed in accordance with the general use of this specific technology, with strong links between the different components of the society and reinforcing lock-in effects.** This framework offers a background helped us to draw a scheme with the interrelations and relations of causality between barriers to the development of alternative vehicles.

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[65] Flink (1970,1988) in Maréchal K. (2007)

[66] It has to be mentioned that those externalities can eventually lead to a lock-in in a non-efficient technology. However, the consideration whether internal combustion engine working with fossil fuel was (at the beginning of its development) the most-efficient choice is beyond the scope of this study.

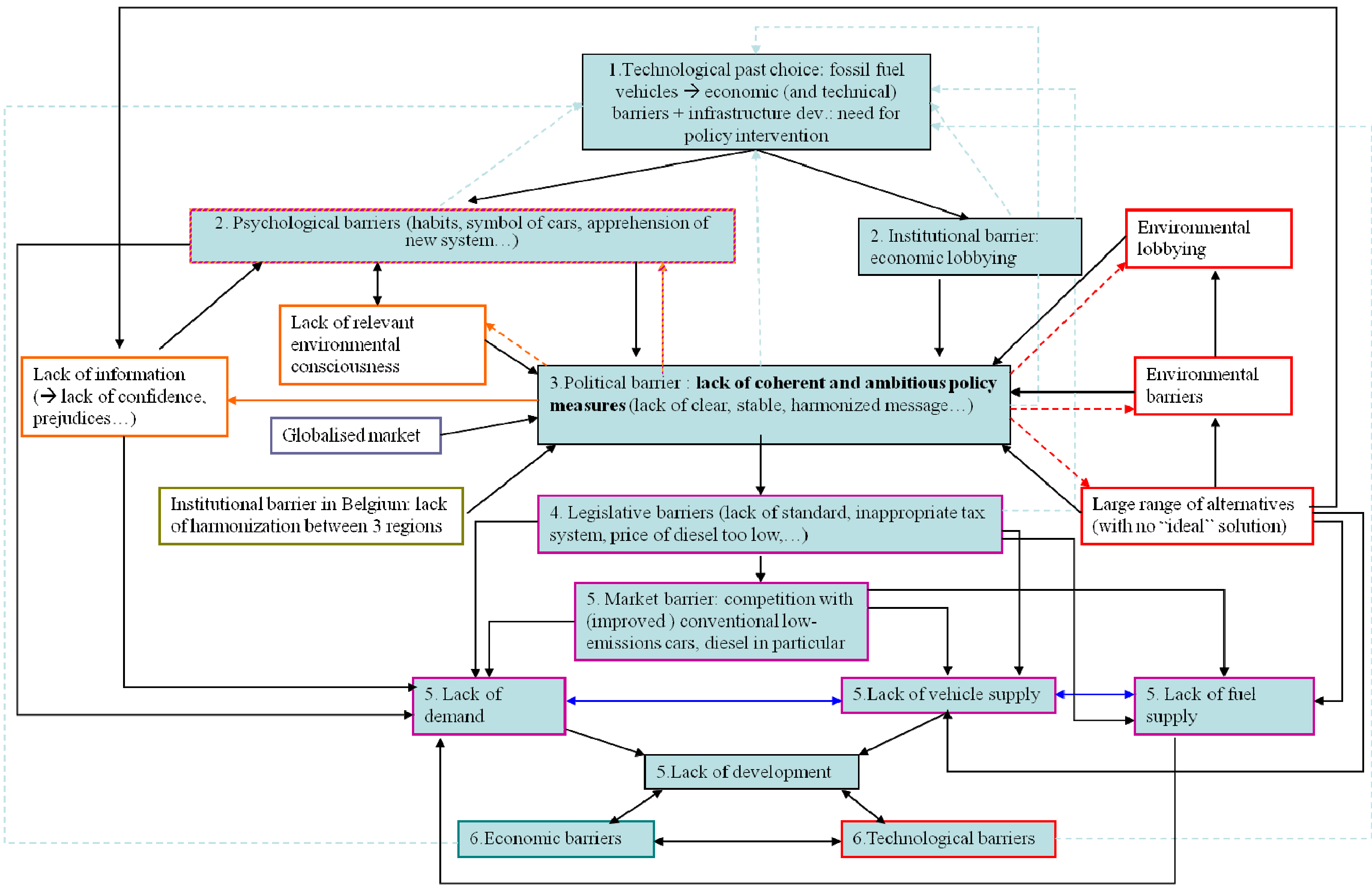
3.2. Systemic diagram of the interrelations between barriers

In this chapter, the information about barriers coming from the stakeholders' consultation has been included in an analytical framework inspired by the literature on the “technological locked-in” process. A systemic diagram representing the interrelations between barriers is proposed. This diagram is inspired by the opinion of some experts, by a transversal reading of the results from the stakeholders' consultation and by the elements of the lock-in process.

The diagram below summarizes the different kinds of barriers and represents the interrelations between them. Interrelations and their causality directions are represented by arrows. The blue boxes correspond to the element of the lock-in process described in the previous section, and the blue arrows in dotted line indicate the “buckle” of the lock-in created by the different barriers and maintaining fossil fuel technology domination. Colored border boxes and arrows represent (according to the color) barriers that could be released trough one specific example of policy measures (see legend below the diagram)[67]. It has to be mentioned that, as we can see, there are many barriers implying a lack (or an insufficiency) of policy measures. However, it is also strong policy measures which can eventually overcome those barriers.

[67] For more in-dept analysis of policy measures see task 1.3 or task 5 of the clever project.

Figure 2 : Interrelation between barriers, lock-in process and examples of policy measures to implement to overcome barriers



Lock-in process

Type of policy measure to implement : support to R&D

Type of policy measure to implement: educational and information measures

Type of policy measure to implement: tax system based on environmental criteria + regulatory measures

Type of policy measure to implement: subsides

Need for supra national measures

Need for harmonised measures

Need for stimulation of the market through coordination/cooperation between consumer's, vehicle makers and fuel distributors (meeting organisation…)

a) Interrelation between barriers and lock-in process

1. We are **"stuck" in fossil fuel technology**, as a result of past choices: as mentioned, there have been **decades of investments in fossil fuel vehicles and related infrastructures**, implying increasing return to scale (thanks to economies of scale, learning economies, adaptive expectations and network externalities. See chapter 3.1.) and efficiency improvement. This implies a **lack of competitiveness of alternative vehicles from an economic and technological point of view**. Also, as a consequence of network development, the entire current **infrastructure is designed for the fossil fuel technology**. Moreover, actors of the automobile sector are trained and offer services for fossil fuel cars (workers qualified in this technology), and the relations between firms and industries are well established. This makes difficult the impulse to introduce alternative vehicles. For all these reasons and as number of experts underlined, **it is not economically interesting or possible for the industry to invest and develop massively alternative vehicles. In parallel, it is not interesting for the consumer to buy the possible alternatives** for economic reasons but also technical (disadvantages) or because they face an "uncompleted product" (lack of refuelling stations or after sales services...). For overcoming this "technological domination" of fossil fuel vehicle, there is a **need for strong policy measures,** as the current characteristics of the market will not bring alternative vehicles "spontaneously". However, we can observe that **such strong measures are not taken** (and as we will see, current policies are inappropriate). Why?

2. The lack of policy measures can be explained (among others) by **two important reasons (which are barriers in itself)**:
Firstly, the decades of fossil fuel vehicles have shaped **mentalities** and imply that the **population is used to the characteristics of conventional cars: consumers have a precise idea of what a car should be (with a long range and high speed, a certain comfort and way of refuelling etc.) and are lock-in in their habits (routine behaviour)**. While consumers are very confident in fossil fuel cars (no uncertainties), there are afraid of new systems and are not confident in alternatives (e.g. Fear of gas). Those are **psychological barriers**. They are reinforced on the one hand by the **lack of "relevant" environmental consciousness of the population** (individuals are more and more conscious about environment but it often doesn't translate into concrete actions), and by the **lack of information** about alternatives on the other hand. This lack of information (or bad

information) exacerbates the apprehension about new systems and generates some prejudices. Indeed, we have seen that the perception of the importance of some barriers is greater with a lack of information (see section 2.1.4). Those factors have a direct and negative impact on the consumer's behaviour towards the purchase of alternative vehicles (lack of demand).
Secondly, there is an **important economic lobbying from different groups preventing alternative vehicles development** directly or indirectly linked to the automobile market. This is also the result of the expansion of the network, which characterise the lock-in process. This kind of lobbying, preventing alternative vehicles/fuel development is sometimes "direct" and often "indirect" (when lobbyists are against environmental measures that would indirectly foster cleaner and alternative vehicles development). This latter kind of lobbying include for example pressure against ambitious environmental measures that are not always financially "feasible" for the concerned sectors; another example is the Europe's media corporations, which lobby against the European proposition to write environmental performance of the car in advertising; this is because the free press, which is quasi totally financed by car advertising, fear that it may result in a decrease of car advertising (as the advertising would be less attractive) which would have important consequences on their business[68]. Diesel industry and related sectors would lobby to keep its fiscal advantages, which have also an indirect impact on alternatives (as it places diesel as a major competitor for alternative vehicles). Lobbying has an influence on technological choice and on maintaining one technology.

These two important barriers contribute to reduce the room for manoeuvre and the willingness to act of policy makers. However, at the same time and reversely, it is also by way of ambitious policy measures that the breakdown of these barriers would be possible.

Another lobbying against alternative vehicles (or some categories of alternative vehicles), from a completely different nature, is exerted by some environmental NGO's and associations, as a result of **environmental problems associated with alternative vehicles (environmental barriers).** Indeed, environmental benefits of most alternatives are often disputed. Moreover, interviews have highlighted that **alternative vehicles do not represent a political priority for green politicians**. Indeed, for many "green people", the environmental solution is to reduce the number and the use of cars rather than to develop less polluting cars (than could possibly generate other kinds of environmental problems).

The large range of alternatives each with advantages and disadvantages impede also policy measures, as no perfect solution is coming out.

The problem of globalisation of automobile market reduce the possibility for national government to take effective measures, and implies that measures should be taken at a supra-national level (internationalisation of the lock-in). Indeed, as mentioned by vehicles makers, the measures should be harmonized between countries (at least at European level).

Finally, the lack of harmonization of environmental measures about cars and the need for an agreement between the different regions of Belgium represents also an institutional barrier.

3. So, those reasons would contribute to prevent politicians to take the necessary measures. **The lack of policy measures and more precisely the lack of clear, stable (long-term), harmonized and coherent policy scheme generate too many uncertainties for supply-side**

[68] EURACTIV, 25/10/2007

stakeholders (making the investments too risky and preventing them to plan a strategy). Also, it goes together with a lack of clear message for the demand-side stakeholders.

4. **Some current policies result in legislation which is preventing the development of alternative vehicles.** Indeed, the lack of appropriate policy measures creates or maintains **legislative barriers**; it includes for example **the lack of standards** for some alternative fuels or vehicles (at the contrary of fossil fuel for which the standards are well-developed and harmonised between countries). Also and importantly, the **inappropriate tax system** (which should be based on environmental criteria) and in particular the **price of diesel which is too low** are important barriers to alternative vehicles development. So, it contributes to maintain fossil fuel vehicles domination.

5. - **Another characteristic of the lock-in is that actors of the society focus more on the improvement of current technologies than on new ones. Indeed, as we have seen trough the interviews, supply-side and demand-side stakeholders are more oriented to conventional low consumption cars and sometimes on hybrid models, rather than on completely new concepts (like electric cars).** Indeed, the context of technological lock-in implies that hybrid vehicles are more convenient than complete alternative ones such as electric vehicles: hybrid vehicles (up to a certain degree of hybridisation) exploit the fossil fuel technology and infrastructures, do not disrupt to much the economic balance (role of the firms and relations between firms) and correspond to the socially accepted standard of cars (about the same comfort, performance etc.). However, it comes out from the interviews that the **focus is mainly on diesel cars**, as they are conventional cars (no psychological and social barriers, no problem of infrastructure...) which are encouraged through fiscal incentives. Success of diesel cars is explained by different factors: firstly, tax policies have had major effect on buying patterns and as a result, on the supply of vehicles makers (wide range of models and equipments). This has generated a lobbying from these actors. Also, a wide range of environmental legislation at country and at European level are CO_2-based (which can be linked to the importance of the diesel sector in Europe and to lobbying), which tend to encourage diesel even more. This has allowed for an improvement of the efficiency of the technology...and a "sub-lock-in process" has emerged inside the "fossil fuel technological lock-in". In this case, policy measures have strongly influence the process. However, the important effect resulting from it was unsurprising as there was no technological revolution (fossil fuel cars with same characteristics than gasoline cars).

- Inappropriate tax system (and other legislative barriers), competition with low-emission diesel cars, and the co-existence of a wide range of alternatives (with no "ideal" solution) imply a lack of demand and supply of alternative vehicles and fuel. Lack of demand is enhanced by psychological barriers and lack of information of the public. At this level, **strong interactions between the lack of demand and the lack of supply, as well as between the lack of supply of vehicles and the lack of fuel distribution exist. Indeed, consumers face a short supply of vehicles and fuel and an uncompleted product, which represent an important barrier to the purchase/use of alternative vehicles. At the same time and reversely, vehicle makers and fuel distributors do not develop the supply because there is (or they expect) no demand from the consumers. Also, vehicle makers do not develop their supply of alternatives because there is a lack of fuel distribution and vice versa ("chicken and eggs" problem).**

6. This causes (and maintains) **economic and technical barriers** resulting from the lack of development of alternatives, **which reinforce the lack of demand and supply and maintain fossil fuel vehicles domination.**

It results in **a cycle where society is stuck and every barrier reinforces the others.** As we have mentioned, we face a complex system with many interrelations between barriers. A large part of the barrier mentioned corresponds to the characteristics of the lock-in situation.

b) Some policy measures

Colored border boxes and arrows represent (according to the color) example of type of policy measures that can have an impact on reducing barriers (see legend below the diagram). For example, environmental barriers (and linked barriers) could be partly reduced with a *stimulation of R&D* which can help to determine which are the "best" and sustainable alternatives that would make sense to encourage. Also, R&D can contribute to reduce technical barriers. Barriers contributing to the lack of demand (from the consumer's point of view), like psychological barriers and lack of information, could be reduce with *educational and informational measures*. About legislative barriers, an interesting policy to implement would be a *tax system based on environmental criteria*, along with *regulatory measures* (e.g. standard of production fixing limited value of emissions for every car). *Stimulation of the market through coordination/cooperation between consumer's, vehicle makers and fuel distributors* (meeting organisation…) could also contribute to reduce "chicken and eggs" problem. Finally, economic barriers could be reduced trough various kind of *subsidies*. It has to be note that those policy measures are only general examples (list non exhaustive). Also, **policy measures mentioned would not have an effect only on the barriers in colour border boxes; indeed, because of strong interrelations between barriers, there would be indirect effects on other barriers as well. The colours in the schema are indicative of the direct effect of the measures. In the same line, some policy measures could fail if they don't consider interrelations between barriers. For example, trying to overcome the economic barrier only by way of subsidies is expected not to give very good results, as economic barriers are resulting from a wide range of other barriers and mechanisms that have also to be overcome.**

It is also important for policy makers not to create a new technological lock-in with a technology that is not the most efficient or which is not sustainable. To this regards, development of "niche" market would be an interesting solution to test the technology. Also, "hybridization" is also an interesting way to overcome barriers resulting from the technological lock-in. Both "niche" market and "hybridization" development are possible ways to overcome gradually the technological lock-in situation[69].

[69] Maréchal K. (2007).

PART 4: CONCLUSION

This study has allowed us to identify barriers to the development of alternative vehicles in Belgium through the consultation of different groups of stakeholders, and to draw a systemic diagram with the interrelations between barriers and possible levers to overcome those barriers. In this study, a distinction has been made between pre-identified barriers that temper the development of alternative vehicles in general and those that more specifically apply to certain technologies or fuels[70]. It has to be noted that our results about barriers differ according to the category of alternative vehicles. However, in this conclusion, only barriers in general are presented[71]. Stakeholders have been identified and classified into different groups: the demand-side stakeholders, divided between individual consumers and fleet managers, the supply-side stakeholders (vehicles makers, fuel distributors...) and the "experts" from various institutions (research centres, policy makers, NGO's...) which offer a more global and analytic view on barriers. Those four groups (including the two groups of demand-side stakeholders) have been sounded out about barriers to the development of alternative vehicles from their point of view. Survey and interviews have revealed the existence of a wide array of barriers from various types, with strong interrelations between barriers.

It is important to note that although the list of barriers identified in this study is as much exhaustive as possible, it is of course always possible to find new or other ones according to the focus considered criteria (according to the type of vehicle, the stage of development of the vehicle, the level of detail considered etc.).

Barriers to the purchase and use of alternative vehicles from the individual users point of view

A survey at the Brussels Motor Show has highlighted several types of barriers to the purchase and use of alternative vehicles from the individual users' point of view: economic (high price…), supply (short supply of vehicles and fuel…), market (lack of development…), technical (technical immaturity and limited range…), etc. **While economic barriers appear to be very important[72], results have shown that other aspects have also a significant impact on consumer behaviour about alternative cars, sometimes even more important than economic aspects.** Indeed, it appeared that economic barriers are much less important when considering barriers by technology than when considering barriers in general (revealing the importance of other non economic barriers), except for hybrid. Also, it came out that hybrid vehicle is preferred to LPG vehicle when considering purchase intention, despite the fact that LPG vehicle is cheaper (and better-known). This may indicate that **non-economic factors are potentially stronger that economic ones. More specifically, results have shown that psychological barriers have a significant impact on consumer behaviour**

[70] It has to be noted that our results about barriers differ according to the category of alternative vehicles. However, in this conclusion, only barriers in general are presented.

[71] The reader interested by the results about barriers by category of alternative vehicles must refer to the section 2.1.5. for barriers from the individual consumers point of view and to the section 2.3.4 for barriers from the supply-side stakeholders point of view.

[72] This is in line with the results from the survey of the task 3.2 of the CLEVER project (Turcksin L. and Macharis C. (2008)) which show that the first selection criteria of a new car are based on rational factors, economic factors in particular (most important car attributes according to the "spontaneous" answers of the respondents).

about cars: some elements of the survey indicated the role of **habits** (preference for conventional vehicles or vehicles that are rather similar to conventional cars), and a clear apprehension of new systems (e.g. lack of confidence in safety and fear of gas). Survey has also illustrated the low level of consciousness of habits, in the sense that people do not think consciously about the influence of habits in their purchase behaviour (so do not expressed it directly), but analysis of their answers have revealed that they do play a role. Indeed, **economic, market and supply barriers appear to be the most important categories of barriers to the purchase/use of alternative vehicles in general when considering "conscious" motivations of people. However, while the barrier "lack of confidence in safety" (psychological barrier) is not highly quoted when asking people to evaluate the importance of barriers, it appears that it does influence their purchase intentions.** Indeed, our survey results shown that people who don't have the intention to buy an alternative vehicle statistically differ from the others in that the barrier "lack of confidence in safety" is more important for them[73] (this is the only statistical difference between the 2 groups). The fact that hybrid vehicle is preferred to LPG vehicle when considering purchase intention (despite the fact that LPG vehicle is cheaper and better-known) may also indicate people preference for a car that do not imply to change habits (same refuelling system[74], same comfort, etc.). Finally, the fear of gas is the second most frequent expressed barrier for all gas fuel (the first is the lack of refueling stations, except for LPG). This clearly indicates an apprehension of "the new".
About the importance of barriers expressed by the respondents**, problems related to the short supply (of vehicles and fuel) are of course major barriers to the purchase/use of alternative vehicles**. Often, the consumer faces an "uncompleted product" (lack of refuelling stations, or lack of after-sale services...). Market barriers appear also to be important; this group includes the lack of development of the market (people prefer to wait that the other use a new technology before adopting it themselves), the **competition with low emission conventional cars** (a sample of people prefer to choose a conventional low-emission cars rather than an alternative one) and the lack of information. Indeed, the survey has highlighted the **important lack of information about alternative vehicles** among people, which represent an important obstacle to the purchase (statistical analysis has shown that the personal evaluation of the importance of the barrier "lack of information" is decreasing with the level of knowledge about alternative vehicles[75]). Moreover, statistical analyses have revealed the **presence of an interaction between barriers:** we noticed that the better the average level of knowledge is the less the barrier "different refuelling system" is important[76]. Also, there is a positive correlation between the importance of the barrier "high purchase price" and the barrier "lack of information". **This implies that measures aiming at overcoming the barrier "lack of information" will have a positive effect on the reduction of the perception of other barriers. However, while the lack of information is a very important barrier, overcoming it would not always guarantee a better development of the alternative.** Indeed, we have seen that LPG is the best known alternative vehicle but is not very successful concerning purchase intention. It implies that **more and better information (to overcome the barrier "lack of information") is a necessary but non-sufficient condition to foster the purchase/use of alternative vehicles.** Finally, the survey has also revealed the presence of **doubts and scepticism about the environmental**

[73] Anova test significant (p-value < 0,0189).
[74] For the currently sold hybrid like the Prius (non plug-in).
[75] Indeed, the weaker the average knowledge of alternative vehicles is the more this barrier is important (consistency): anova test significant (p-value < 0,0001) and the assumption of homogeneity of variance is accepted
[76] Anova test significant (p-value < 0,028) and the hypothesis of homogeneity is accepted

advantages of those vehicles; in particular, **the "true ecologists" prefer not to have their own car and would rather use other way of transportation** (bike, public transport, car-sharing…). So, if even the "green people" are not supporting alternative cleaner cars, it is difficult to find a market segment for alternative vehicles.

Barriers to the introduction of alternative vehicles in fleets of vehicle

Interviews of fleet managers have highlighted that it is the **combination of several barriers** (supply, economic, technical and market) that make alternative vehicles particularly unattractive for introducing them in fleets of vehicle (except hybrid, for which the main barrier is economic). Also, previous bad experiences (technical problems) with some types of vehicle (like electric, CNG and LPG vehicles) imply a **lack of confidence** in those vehicles. Fleet managers expressed as well the inaccurate nature of the information and the presence of many **uncertainties** (about the total cost, the technical reliability, the viability of the different options, etc.) implying that **more and better information is needed**. Finally and importantly, **the short supply (and the short number of suppliers) creates sometimes the impossibility for companies to buy or to lease alternative vehicles.** Indeed, **public market legislation** prevents the purchase of a vehicle if there is no competition between several vehicle makers. Also, the **lack of supply of alternative vehicles in leasing companies** and also the **inexistence of alternative for intervention vehicles or vans limit greatly the development of alternative vehicles in some fleets of vehicle. In this last case, barriers come not from the companies but from the supply-side of the market** (fleet managers often expressed that measures have to be taken "upstream").

We also noticed that **the current trend is to use diesel low-emission vehicles with particle filter and more generally conventional low-emission vehicles rather than alternative vehicles**.

Barriers to the supply of alternative vehicles

An important barrier which prevent vehicle makers to develop alternative vehicles in their supply is related to the fact that **they expect no (or not enough) demand for those vehicles, as there are not be competitive with conventional vehicles** for several reasons: economic, technical and psychological (people are used to conventional fossil fuel cars), and because of the actual trend of the characteristics of the demand (more and more requirements of the consumers for more comforts and options at an acceptable cost). Also, the lack of fuel availability (e.g. CNG or biofuel) is a **major brake for vehicle makers to develop and commercialise alternative vehicles.**

Some vehicles makers mentioned also that there are too **many possible alternatives and too many uncertainties about the sustainability of the different options**. It is too risky to invest a lot in a complex and costly technology, to train workers etc. if they have to abandon it some years later because in case it would appear to be not such a good environmental solution. Also and importantly, while vehicle makers are slowly developing alternatives, their current strategy is rather to **focus on the improvement of conventional fossil fuel cars-diesel in particular-** in terms of efficiency and reduction of emissions. This is in line with the trend of the demand (see results of the demand-side stakeholders' consultation).

Given the current context, alternative vehicles would not spontaneously emerge from the market but need an impulse trough policy intervention. **The lack of coherent, clear** (based on a clear criterion) **and harmonised** (between country and inside Belgium) **policy measures to promote alternative vehicles is thus a major barrier to their introduction. Moreover, there are a lot of uncertainties about the evolution of future legislation**. The lack of clear, global and **long** run defined policy scheme **prevent the industry from defining a strategy**[77]. In the same line, there is a **lack of clear policy for the introduction and the promotion of alternative fuel:** policy measures should ensure alternative fuel distribution. More generally, policy makers have to promote alternative vehicles/fuel and take a clear position. In order to play this role, policy makers should first make sure about the sustainability of the different options (trough subsidies to R&D etc.). Importantly**, current car tax system is inappropriate** to create a favourable context to alternative vehicles, as it is not linked to environmental criteria. There is a lack of adequacy between the final cost for the user and the cost (direct and indirect) for the society (the fact that environmental costs –damages - are not taken into account in vehicle prices is considered as an important barrier). More specifically, we also deduced from our interviews that **diesel is often considered as a major competitor for alternatives, as it is fiscally encouraged (price of diesel is too low) and is widely spread in Europe.**

Barriers at society level

Currently, the market is "stuck" because supply-side stakeholders expect no demand and demand-side stakeholders wait for supply development. This implies a need for policy intervention to release this locking mechanism. However, there is a lack of policy measures to promote alternative vehicles. Interviews of "experts" have brought several type of barriers "upstream", and gave also some reasons why there is a lack of policy and supportive measures for alternative vehicles. On the one hand, according to some NGO's and politicians, **there would be a lobbying from the automobile industry and oil companies** against some environmental measures (that would indirectly encourage the development of alternative vehicles) because those are not always feasible or realistic from an economic point of view. On the other hand, we noticed trough the interviews a kind of **lobbying from environmental NGO's against many alternative vehicles**. Also and importantly, it appears from the interviews that **alternative and clean vehicles do not constitute a political priority for green politicians. Like environmental NGO's, green politicians would rather act for a more structural change of the society**: reduction of the use of cars, promotion of the use of bikes etc., because alternative technologies are still bad for the environment (environmental barrier) and make people think (wrongly) that we don't have to change our habits of consumption. This lack of social support for alternative vehicles from green activists and green politicians (that would rather orientate their policies for a reduction of car) is in line with the result from the survey at the Motor show, where it has been noticed that "true ecologist" prefer not to have a car than buying a vehicle, even cleaner.

Technological lock-in and interrelation between barriers

It has appeared that the results of the consultation of the different groups of stakeholder illustrate typically a technological locked-in situation. Some evolutionary economists have studied and described the characteristics and the consequences of the technological lock-in process. This description appears to correspond to the barriers to alternative vehicles mentioned by the stakeholders, which brings a theoretical framework to our conclusions.

[77] The need for a stable framework for the car industry has also come out from the stakeholders consultations lead by VITO in the context of the task 5 of the Clever project (Vanderschaeghe M., 2008).

Because of past choices, we are "stuck" in what has been named a "socio-technical complex system"; as a result, the different pans of our society are designed for fossil fuel cars (infrastructure, legislation, institutions, mentalities etc.), with very strong links and interdependences between the different elements. Indeed, **decades of investments in fossil fuel vehicles and infrastructures** have implied a decrease of economic costs (thanks to economies of scale, learning effects, etc.) and social costs (routine behavior…). This implies that **alternatives are not competitive from an economic, technical, social etc. point of view. Interrelations and causality relations between barriers have been presented in a systemic diagram in the third part of the study (chapter 3.2).**

Thinking in terms of system when apprehending the barriers appear to make more sense than considering them separately and in a static way. It implies to have a holistic view of the different elements and help to find the possible driving force to overcome barriers and to create the necessary environment for alternative vehicles to develop. This is essential for drawing up effective and ambitious policy measures based on an integrated approach. Indeed, policy measures aiming at promoting alternative vehicles development could not have the expected results if they fail to take into account those interrelations.

***General policy recommendations*[78]**

Spurring the barriers implies **creating a new system that will allow for a significant development of alternative vehicles**[79]. As we have seen in the previous chapter, the different barriers are highly interconnected. As a result, **policy measures to implement will be effective only if they are combined or if they have an effect on the different elements that constitute a system**. Moreover, **different policies can have mutual reinforcing effects** as a result of interrelations. As a result, **a mix of policy measures acting on the supply and the demand side of the market as well as on the broader environment in which the automobile market operate would give the better results**. The need for a mix of policies had already been recommended by the report of the task 1.3 of the Clever project ("Overview of policy measures")[80], in which a "combination of carrots (incentives), sticks (disincentives) and regulations" including "a mix of target audiences" (industries, public and private consumers) is presented as working best. The importance of diversification of policy instrument has also been highlighted in other studies concerning energy consumption[81].

As mentioned by the different groups of stakeholders, financial incentives and encouragements appear to be an important condition to foster the development of alternative vehicles. However, **while financial incentives are important, they are far from sufficient as they don't operate on a wide range of non economic barriers, like psychological barriers (routine behavior…) etc.** Campaign of good and clear information as well as educational measures is also essential for public acceptance. Also those measures should go together with regulatory measures (standards of production…).

Public authorities can play a major role in fostering the development of alternatives. Indeed, a "**highly supportive institutional framework**"[82] including important financial support but also stable, clear and certain promotion scheme through accurate legislation is a

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[78] For more detailed analysis of policy instruments and policy recommendations, see task 5 of the Clever project.
[79]Del Rio P., Unruh G. (2005), for the all paragraph.
[80] Tobias D., Govaerts L. (2007)
[81] Example: Bartiaux et al. (2006)
[82] Del Rio P., Unruh G. (2005)

necessary condition to encourage the development of alternative vehicles. However, this can occur when R&D has demonstrated that the alternative shows clearly environmental benefits also on the long run (to make sure about the viability of the alternative)[83]. Indeed, public authorities have to be careful not to develop a new "lock-in" of an unsustainable technology (which can happen if decisions are taken in emergency)[84]. To this respect, it can be better to define policy based on environmental criteria rather than focus on a specific technology. Also, development of "niche" market would be an interesting measure to test the technology and to overcome gradually the current technological lock-in[85].

[83] Del Rio P., Unruh G. (2005)
[84] Maréchal K. (2007)
[85] Idem

BIBLIOGRAPHY

Bartiaux F., Vekemans G., Gram-Hanssen K, Maes D., Cantaert M., Spies B, Desmedt J. (2006), "Socio-technical factors influencing residential energy consumption (SEREC)". Belgian Science Policy, Université Catholique de Louvain, Vlaamse Instelling voor Technologisch Onderzoek, Statens Byggeforskningsinstitut (Danish Building Research Institute), 222 p. Disponible sur http://www.belspo.be/belspo/home/publ/rappCPen_fr.stm

Corporate Vehicle Observatory (2008), "CVO Baromètre European 2008". Disponible sur http://www.cvo-belgium.be/

Del Rio P., Unruh G. (2005), "Overcoming the lock-out of renewable energy technologies in Spain: The cases of wind and solar energy", Renewable and Sustainable Energy Reviews 11, p. 1498-1513.

EEA (2008), "Annual European Community LRTAP Convention emission inventory report 1990-2006, technical report n°7, 78 pp.

European Commission (2008), "EU energy and transport in figures", statistical pocketbook 2007/2008, DG for energy and transport, 212 pp.

Favrel V., Meyer S., Vereecken L., Gallet V., Van Mierlo J., Hecq W., Maggetto G. (2001a), Véhicule propres, Rapport WP5: « Perspectives bruxelloises à court terme », Region de Bruxelles-Capitale, IBGE-BIM, 79 p.

Favrel V., Meyer S., Vereecken L., Gallet V., Van Mierlo J., Hecq W., Maggetto G. (2001b), Véhicule propres, résumés des W.P., Region de Bruxelles-Capitale, IBGE-BIM, 49 p.

Federal Public services mobility and transport (2007), "Relevé des kilomètrages annuels parcourus en 2006", N°38, 92 pp.

IBGE-BIM (2007), « Plan d'action en matière d'efficacité énergétique de la Région de Bruxelles-Capitale », 56 p.

Kofoed-Wiuff, Anders, Sandholt, Kaare & Marcus-Moller, Catarina. (2006). "Renewable Energy Technology Deployment: Barriers, Challenges and Opportunities". Energianalyse (RSEV), 106p.

Maréchal K. (2007), "The economics of climate change and the change of climate in economics", Energy Policy 35, p.5181-5194

Maréchal K. (2009), "An Evolutionary Perspective on the Economics of Energy Consumption: the Crucial Role of Habits", forthcoming in Journal of Economics Issues, vol. XLIII n°1, 20 p.

MOBEL (La mobilité quotidienne des Belges), 1998 in Conseil Central de l'Economie, Lettre mensuelle socio-économique n°128, août 2007, 44 p.

Murray, J; Lane, B.; Lillie, K.; McCallum, J.: "The Report of the Alternative Fuels Group of the Cleaner Vehicles *Task Force.* An Assessment of the Emissions Performance of Alternative and Conventional Fuels*"*. DTI Automotive Directorate, London, UK, January 2000

Nesbitt K. and Sperling D. (2000), "Fleet purchase behavior: decision processes and implication for new vehicle technologies and fuels", Institute of Transportation Studies, University of California, Transportation Research part C, p. 297-318

Smith, A. (2001a) "Promoting Cleaner Vehicles: Policies and Programs in the EU", UTOPIA project deliverable 17. European Commission, DG-TREN, Brussels

Tobias D. and Govaerts L. (2007), "Overview of policy measures", report of the task 1.3 of the CLEVER project, Vlaamse Instelling voor Technologisch onderzoek (VITO)

Troelstra W.P., Smith A., Bol M. (1999), "Implementation Barriers of alternative transport fuels", Innas, 90 p., *publicly available through Innas.*

Turcksin L. and Macharis C. (2009), "Price Elasticity", report of the task 3.2. of the CLEVER project, Vrije Universiteit Brussel (VUB), Department of Transport and Logistics (MOSI-T), Mobility and automotive technology research group (MOBI)

Vanderschaeghe M. (2008), "Draft report: stakeholder meeting 1 December 2008" in the framework of the task 5.2 of the Clever project, Vlaamse Instelling voor Technologisch onderzoek (VITO)

Verplanken B. and Wood W. (2006), "Interventions to break and create consumer habits", Journal of Public Policy and Marketing, Vol. 25 (1), pp. 90-103

APPENDIX

Appendix 1: Questionnaire for the Motor Show of Brussels[86]

A. Questionnaire for the Motor Show of Brussels: French version

[86] In this questionnaire alternative vehicles are named as « clean vehicles » ; this can be considered as a semantic experimental error but it has been corrected by the interviewers (which precise that we were considering only alternative vehicles).

Centre d'Etudes Economiques et Sociales de l'Environnement (Université Libre de Bruxelles)

Politique scientifique fédérale

Enquête sur les obstacles au développement des véhicules propres

Madame, Monsieur,

Plusieurs centres de recherche du pays[87] collaborent activement en vue de proposer aux autorités des mesures qui pourraient encourager la diffusion des véhicules plus respectueux de l'environnement[88], dits « véhicules propres »[89]. En tant que consommateur intéressé par la nouveauté dans le domaine de l'automobile, vous pouvez nous aider à découvrir les obstacles les plus importants à la diffusion des véhicules propres[90].

Nous vous proposons, pour ce faire, de consacrer environ 15 minutes de votre temps à répondre au questionnaire ci-joint. Le formulaire de réponse est bien évidemment anonyme et sera traité en respectant une totale confidentialité[91].

Merci d'avance pour votre collaboration

[87] Le Centre d'Etudes Economiques et Sociales de l'Environnement de l'Université Libre de Bruxelles (CEESE-ULB), le département Transport et Logistique de la VUB (MOSI), l'unité de recherche sur les technologies de transport ETEC de la VUB, l'Institut pout la recherche technologique VITO et RDC environnement

[88] CLEVER "Clean Vehicle Research: LCA and Policy Measures" financé par le Service Public Fédéral de Programmation Politique Scientifique.

[89] Les « véhicules propres » désignent ici des véhicules contribuant relativement peu à l'effet de serre (réchauffement climatique) et à la détérioration de la qualité de l'air et à la nuisance sonore. La qualité écologique d'une voiture peut être mesurée par son « Ecoscore ». Il s'agit d'un indicateur dont la valeur varie entre 0 et 100 et qui intègre les différents impacts de cette voiture sur l'environnement. Un indicateur élevé correspond à une voiture moins polluante et vice versa. Par définition, pour un véhicule propre, l'Ecoscore atteint une valeur de 70 et plus.

[90] Le CEESE (ULB) est chargé du volet du projet « CLEVER » qui concerne l'identification des obstacles à la diffusion des véhicules propres

[91] Les réponses resteront en la seule possession du Service Public Fédéral de Programmation Politique Scientifique.

Questions préliminaires

1. Comment estimez-vous votre niveau de connaissances générales sur les véhicules (réputés) propres suivants ? Entourez votre réponse.

a. Hybrides	très bon	bon	moyen	plutôt faible	faible
b. Electriques (à batteries)	très bon	bon	moyen	plutôt faible	faible
c. A pile à combustible	très bon	bon	moyen	plutôt faible	faible
d. Fonctionnant au LPG	très bon	bon	moyen	plutôt faible	faible
e. Fonctionnant au gaz naturel (CNG)	très bon	bon	moyen	plutôt faible	faible
f. Fonctionnant au biogaz	très bon	bon	moyen	plutôt faible	faible
g. Fonctionnant au biocarburant (biodiesel, bioethanol,…)[92]	très bon	bon	moyen	plutôt faible	faible
h. Fonctionnant à l'hydrogène[93]	très bon	bon	moyen	plutôt faible	faible

2. Lorsque vous estimez votre niveau de connaissance insuffisant, quelle sorte d'information souhaiteriez-vous obtenir en priorité?

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………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

[92] Nous considérons ici les véhicules qui nécessitent une transformation pour fonctionner au biocarburant (biocarburant pure ou mélange à haute concentration)
[93] Avec un moteur à combustion interne

3. Possédez-vous un véhicule propre/Utilisez-vous un carburant alternatif?

- ○ **Oui**
- ○ **Non**

Si oui, lequel ?...

Citez les avantages de ce type de véhicule/de carburant

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………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
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………………………………………………………………………………………………

Citez les inconvénients/problèmes éventuellement rencontrés

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4. Avez-vous l'intention d'acheter un véhicule propre/d'utiliser un carburant alternatif?

- ○ **Oui**
- ○ **Non**

Si oui, lequel ?..

Pourquoi ?

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………………………………………………………………………………………………
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………………………………………………………………………………………………
………………………………………………………………………………………………

Si non (vous n’avez ni l’intention d’acheter un véhicule propre ni l’intention d’utiliser un carburant alternatif), pourquoi ?

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5. Quels types de mesures vous encourageraient à acheter un véhicule propre/à utiliser un carburant alternatif?

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La partie I du questionnaire a trait aux obstacles à la diffusion des véhicules propres en général (questions 6 et 7).

La partie II du questionnaire a trait aux obstacles à la diffusion de certaines catégories de véhicules propres (questions 8 à 16).

Si vous le souhaitez, vous pouvez ne répondre qu'à l'une des deux parties.

Merci de répondre en tout cas à la partie III (données personnelles).

Partie I : Obstacles à la diffusion des véhicules propres en général

6. Evaluer l'importance que vous attribuez aux différents obstacles suivant en leur attribuant une cotation de 1 (pas important) à 10 (très important). Entourez le 0 dans le cas où cet obstacle vous paraît inexistant.

- Prix du véhicule à l'achat élevé	0	1	2	3	4	5	6	7	8	9	10
- Autonomie limitée	0	1	2	3	4	5	6	7	8	9	10
- Vitesse limitée	0	1	2	3	4	5	6	7	8	9	10
- Batteries ou réservoirs lourds et encombrants (espace utile réduit)	0	1	2	3	4	5	6	7	8	9	10
- Temps de ravitaillement/de recharge plus long	0	1	2	3	4	5	6	7	8	9	10
- Peu d'infrastructures de recharge et de ravitaillement	0	1	2	3	4	5	6	7	8	9	10
- Services après-vente et de maintenance insuffisants	0	1	2	3	4	5	6	7	8	9	10
- Offre restreinte (quantitativement) et peu variée	0	1	2	3	4	5	6	7	8	9	10
- Manque d'informations	0	1	2	3	4	5	6	7	8	9	10
- Préoccupation environnementale personnelle insuffisante	0	1	2	3	4	5	6	7	8	9	10
- Manque de conviction personnelle par rapport à l'utilité environnementale de ces véhicules	0	1	2	3	4	5	6	7	8	9	10
- Sensation de conduite différente	0	1	2	3	4	5	6	7	8	9	10
- Nécessité de modifier ses habitudes	0	1	2	3	4	5	6	7	8	9	10
- Diffusion de ces véhicules encore trop restreinte	0	1	2	3	4	5	6	7	8	9	10
- Manque de confiance concernant la sécurité	0	1	2	3	4	5	6	7	8	9	10
- Manque de confiance concernant la fiabilité technique	0	1	2	3	4	5	6	7	8	9	10

- Design trop spécifique	0	1	2	3	4	5	6	7	8	9	10
- Manque de correspondance avec ma personnalité	0	1	2	3	4	5	6	7	8	9	10
- Manque de réglementation et de normes	0	1	2	3	4	5	6	7	8	9	10
- Système de ravitaillement différent	0	1	2	3	4	5	6	7	8	9	10
- Technologie immature	0	1	2	3	4	5	6	7	8	9	10
- Coût de l'entretien élevé	0	1	2	3	4	5	6	7	8	9	10
- Autre ?	0	1	2	3	4	5	6	7	8	9	10
- Autre ?...	0	1	2	3	4	5	6	7	8	9	10

7. Lors de l'achat d'un véhicule, accordez-vous surtout de l'importance au prix d'achat ou accordez-vous surtout de l'importance au coût du véhicule sur l'ensemble du cycle de vie (prix du carburant, de l'entretien etc.), au point d'effectuer les démarches nécessaires pour obtenir ces informations? Cocher si possible l'une des deux alternatives :

○ **Prix d'achat**

○ **Coût sur l'ensemble du cycle de vie du véhicule**

Partie II : obstacles à la diffusion de certaines catégories de véhicules propres

8. Quels sont les principaux obstacles qui vous empêcheraient d'acheter un <u>véhicule hybride</u> ?

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9. Quels sont les principaux obstacles qui vous empêcheraient d'acheter un <u>véhicule électrique</u> ?

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10. Quels sont les principaux obstacles qui vous empêcheraient d'acheter un <u>véhicule à pile à combustible</u>?

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11. Quelles sont les principaux obstacles qui vous empêcheraient d'utiliser du <u>LPG</u> ?

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12. Quelles sont les principaux obstacles qui vous empêcheraient d'utiliser du <u>gaz naturel</u> ?

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13. Quelles sont les principaux obstacles qui vous empêcheraient d'utiliser du <u>biogaz</u> ?

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14. Quelles sont les principaux obstacles qui vous empêcheraient d'utiliser du <u>biocarburant</u> ?

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15. Quelles sont les principaux obstacles qui vous empêcheraient d'utiliser de <u>l'hydrogène</u> ?

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16. Evaluez pour chacune des catégories de véhicules, l'importance que vous attribuez aux différents obstacles mentionnés en leur attribuant une cotation de 1 (pas important) à 10 (très important) dans la case correspondante. Indiquez 0 dans le cas où cet obstacle vous paraît inexistant.

	Hybride	**Electrique**	**A pile à combustible**	**LPG**[94]	**CNG**[95]	**Biocarburant**	**Hydrogène**
Prix du véhicule à l'achat élevé							
Autonomie limitée							
Vitesse limitée							
Batteries ou réservoirs lourds et encombrants (réduit l'espace utile)							
Temps de recharge/de ravitaillement plus long							
Peu d'infrastructures de recharge et de ravitaillement							
Services après-vente et de maintenance insuffisants							

[94] Liquid petroleum gas
[95] Compressed natural gas

	Hybride	**Electrique**	**A pile à combustible**	**LPG[96]**	**CNG[97]**	**Biocarburant**	**Hydrogène**
Offre de véhicules restreinte (quantitativement) et peu variée							
Manque d'informations							
Manque de conviction personnelle par rapport à l'utilité environnementale de ces véhicules							
Sensation de conduite différente							
Nécessité de modifier ses habitudes							
Diffusion de ces véhicules encore trop restreinte							
Manque de confiance concernant la sécurité							
Manque de confiance concernant la fiabilité technique							
Design spécifique							
Manque de réglementation et de normes							

[96] Liquid petroleum gas
[97] Compressed natural gas

	Hybride	Electrique	A pile à combustible	LPG[98]	CNG[99]	Biocarburant	Hydrogène
Système de ravitaillement différent							
Technologie immature							
Coût de l'entretien élevé							
Prix des batteries élevé							
Problème d'accès aux parkings souterrains							
Surcoût pour l'adaptation du véhicule au LPG							
Taxe annuelle supplémentaire							
Autre ?							
Autre ?							

[98] Liquid petroleum gas
[99] Compressed natural gas

Partie III : Données personnelles

17. Quel est votre sexe?

- ○ Masculin
- ○ Féminin

18. Quelle est votre date de naissance?

...

19. Combien de personnes compte votre ménage?

- ○ Nombre d'adultes: …
- ○ Nombre d'enfants: …

20. Quelle est votre plus haut niveau de formation ?

- ○ Enseignement primaire
- ○ Enseignement secondaire (inférieur)
- ○ Enseignement secondaire (supérieur)
- ○ Enseignement supérieur
- ○ Universitaire
- ○ Post-universitaire

21. Quelle est votre statut professionnel?

- ○ Fonctionnaire
- ○ Ouvrier
- ○ Employé
- ○ Pensionné
- ○ Etudiant
- ○ Indépendant
- ○ Autre (spécifiez): …

22. Dans quelle tranche de revenus nets se situe votre ménage (allocations sociales, familiales et pensions comprises)?

- ○ Moins de 900 € net/mois
- ○ Entre 901 et 1300 € net/mois
- ○ Entre 1301 et 1700 € net/mois
- ○ Entre 1701 et 2100 € net/mois
- ○ Entre 2101 et 2900 € net/mois
- ○ Entre 2901 et 3300 € net/mois
- ○ Entre 3301 et 3700 € net/mois
- ○ Entre 3701 et 4100 € net/mois
- ○ Plus de 4100 € net/mois

23. Souhaitez-vous participer à une enquête supplémentaire via internet concernant votre comportement en matière d'achat de voiture ?

- ○ Oui, mon adresse e-mail est la suivante

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- ○ Non

Nous vous remercions pour votre collaboration

B. Questionnaire for the Motor Show of Brussels: Dutch version

Centrum voor Economische en Sociale Milieustudies van de Université Libre de Bruxelles (CEESE-ULB)

Federale Overheidsdienst voor Wetenschapsbeleid

Enquête over de hinderpalen voor een brede verspreiding van milieuvriendelijke voertuigen

Geachte Mevrouw, Geachte Heer,

Verschillende Belgische onderzoekscentra[100] werken actief samen met de bedoeling om maatregelen uit te werken ter verspreiding van meer milieuvriendelijke voertuigen[101] en om deze aan de overheid voor te leggen[102]. Als consument met interesse voor nieuwe ontwikkelingen in de automobielsector, kan u ons helpen om de voornaamste hinderpalen voor een brede verspreiding van schone voertuigen te identificeren[103].

In deze context stellen we u voor om 15 minuten van uw tijd te besteden aan het invullen aan volgende vragenlijst. Het antwoordformulier is uiteraard anoniem en zal volledig confidentieel behandeld worden[104].

Alvast hartelijk dank bij voorbaat voor uw medewerking

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[100] Het Centrum voor Economische en Sociale Milieustudies van de Université Libre de Bruxelles (CEESE-ULB), het departement Transport en Logistiek van de Vrije Universiteit Brussel VUB (MOSI-T), de onderzoekseenheid transporttechnologie van de vakgroep ETEC van de VUB, de Vlaamse Instelling voor Technologisch Onderzoek (VITO) en RDC environment

[101] We definiëren een milieuvriendelijk voertuig als een voertuig dat zowel een beperkte bijdrage levert aan de opwarming van de aarde (CO_2 emissies), als aan de verslechtering van de luchtkwaliteit (stofdeeltjes, NO_x emissies,…) en weinig lawaaihinder veroorzaakt. De milieuvriendelijkheid van een wagen kan gemeten worden aan de hand van zijn Ecoscore. In deze Ecoscore worden verschillende schade-effecten in rekening gebracht zoals het broeikaseffect, gezondheidseffecten en effecten op ecosystemen en geluidshinder. De Ecoscore geeft een score tussen 0 (oneindig vervuilend) en 100 (emissievrij en stil). Een Ecoscore van 70 is hierbij de referentiewaarde voor een milieuvriendelijk voertuig.

[102] CLEVER "Clean Vehicle Research: LCA and Policy Measures" gefinancierd door de Federale Overheidsdienst voor Wetenschapsbeleid.

[103] Het CEESE (ULB) heeft binnen het « CLEVER » project de opdracht om de hinderpalen voor de verspreiding van milieuvriendelijke voertuigen te identificeren

[104] De antwoordformulieren blijven in het uitsluitend bezit van de Federale Overheidsdienst Wetenschapsbeleid.

Voorafgaande vragen

1. Wat is volgens uzelf het niveau van uw algemene kennis van volgende voertuigen die doorgaans als milieuvriendelijk bestempeld worden ?

a. Hybride Voertuigen	zeer goed	goed	matig	eerder zwak	zwak
b. (Batterij) Elektrische Voertuigen	zeer goed	goed	matig	eerder zwak	zwak
c. Brandstofcelvoertuigen	zeer goed	goed	matig	eerder zwak	zwak
d. LPG-voertuigen	zeer goed	goed	matig	eerder zwak	zwak
e. Aardgasvoertuigen (CNG)	zeer goed	goed	matig	eerder zwak	zwak
f. Biogasvoertuigen	zeer goed	goed	matig	eerder zwak	zwak
g. Voertuigen op vloeibare biobrandstoffen (biodiesel/bio-ethanol,…)[105]	zeer goed	goed	matig	eerder zwak	zwak
h. Voertuigen op waterstof[106]	zeer goed	goed	matig	eerder zwak	zwak

2. Over welke bijkomende informatie zou u prioritair wensen te beschikken voor de voertuigen waarvan u het niveau van uw kennis als ontoereikend bestempeld heeft?

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[105] Men beschouwt hier enkel de voertuigen die een aanpassing vereisen voor het gebruik van de biobrandstoffen
[106] Met verbrandingsmotoren

3. Bent u eigenaar van een milieuvriendelijk voertuig of rijdt uw voertuig op een alternatieve brandstof?

- ○ **Ja**
- ○ **Neen**

Zo ja, verklaar nader over welk type voertuig of brandstof het gaat?
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Noem de voordelen van dit type voertuig of brandstof op

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Noem de nadelen of ervaren problemen er van op

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4. Wenst u een milieuvriendelijk voertuig aan te schaffen of wenst u een alternatieve brandstof te gebruiken?

- ○ **Ja**
- ○ **Neen**

Zo ja, verklaar om welk type voertuig of brandstof het gaat...

Waarom ?

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Zo neen, wat verklaart uw beslissing?

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5. Welke soort maatregelen zou u kunnen aanzetten om een milieuvriendelijk voertuig aan te schaffen of om alternatieve brandstoffen te gebruiken?

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Deel I van de vragenlijst betreft de hinderpalen voor de verspreiding van milieuvriendelijke voertuigen in het algemeen (vragen 6 en 7).

Deel II van de vragenlijst betreft de hinderpalen voor de verspreiding van bepaalde categorieën milieuvriendelijke voertuigen in het bijzonder (vragen 8 tot 16).

<u>Indien u het wenst, kan u ervoor kiezen om slechts 1 van beide delen te beantwoorden</u>.

Wel vragen we u om in ieder geval deel III van de vragenlijst (persoonlijke gegevens) te willen beantwoorden.

Deel I : Hinderpalen voor de verspreiding van milieuvriendelijke voertuigen in het algemeen

6. Gelieve, naar uw mening, het belang van volgende hinderpalen in het algemeen aan te duiden. Ken hiervoor een score toe gaande van 1 (niet belangrijk) tot 10 (zeer belangrijk). Duid 0 aan indien dit u geen hinderpaal lijkt te zijn.

- Hoge aankoopprijs van het voertuig	0	1	2	3	4	5	6	7	8	9	10
- Beperkt rijbereik	0	1	2	3	4	5	6	7	8	9	10
- Beperkte snelheid	0	1	2	3	4	5	6	7	8	9	10
- Zware en hinderlijke batterijen of brandstoftank (verminderen de nuttige laadruimte)	0	1	2	3	4	5	6	7	8	9	10
- Langere tank- of laadtijden	0	1	2	3	4	5	6	7	8	9	10
- Ontoereikende infrastructuur voor tanken, en landen	0	1	2	3	4	5	6	7	8	9	10
- Ontoereikende dienst na verkoop en onderhoudsdienst	0	1	2	3	4	5	6	7	8	9	10
- Kwantitatief beperkt en weinig gevarieerd aanbod	0	1	2	3	4	5	6	7	8	9	10
- Gebrek aan informatie	0	1	2	3	4	5	6	7	8	9	10
- Gebrek aan milieubewustheid	0	1	2	3	4	5	6	7	8	9	10
- Gebrek aan persoonlijke overtuiging omtrent de milieumeerwaarde van deze voertuigen	0	1	2	3	4	5	6	7	8	9	10
- Verschillende rijervaring	0	1	2	3	4	5	6	7	8	9	10
- Vereiste om gewoonten te veranderen	0	1	2	3	4	5	6	7	8	9	10
- Verspreiding van deze voertuigen is nog te beperkt	0	1	2	3	4	5	6	7	8	9	10
- Wantrouwen betreffende de veiligheid	0	1	2	3	4	5	6	7	8	9	10
- Wantrouwen betreffende de technische betrouwbaarheid	0	1	2	3	4	5	6	7	8	9	10

- Design is te kenmerkend	0	1	2	3	4	5	6	7	8	9	10
- Gebrek aan regelgeving en normen	0	1	2	3	4	5	6	7	8	9	10
- Verschillend tanksysteem	0	1	2	3	4	5	6	7	8	9	10
- Technologie is nog niet rijp	0	1	2	3	4	5	6	7	8	9	10
- Hoge onderhoudskosten	0	1	2	3	4	5	6	7	8	9	10
- Komt niet overeen met mijn persoonlijkheid	0	1	2	3	4	5	6	7	8	9	10
- Andere ?..	0	1	2	3	4	5	6	7	8	9	10
- Andere ?..	0	1	2	3	4	5	6	7	8	9	10

7. Wanneer u een voertuig aanschaft hecht u voornamelijk belang aan (vink het gepaste antwoord aan) de aankoopprijs of voornamelijk aan de kost van het voertuig over de hele levenscyclus (prijs van de brandstof, onderhoud, ...) waarover u dan ook bereid bent om moeite te doen om informatie te verzamelen

○ **De aankoopprijs**

○ **De kost van het voertuig over de hele levenscyclus**

Deel II : hinderpalen voor de verspreiding van sommige soorten milieuvriendelijke voertuigen in het bijzonder

8. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>hybride voertuig</u> zou kopen?

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9. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>elektrisch voertuig</u> zou kopen?

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10. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>brandstofcelvoertuig</u> zou kopen?

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11. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>LPG</u> zou gebruiken?

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12. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>aardgas</u> zou gebruiken?

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13. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>biogas</u> zou gebruiken?

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14. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>biobrandstof</u> zou gebruiken?

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15. Wat zijn de voornaamste hinderpalen die ervoor zorgen dat u geen <u>waterstofgas</u> zou gebruiken?

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16. Gelieve, voor elk type voertuig, het belang van volgende hinderpalen aan te duiden. Ken hiervoor een score toe gaande van 1 (niet belangrijk) tot 10 (zeer belangrijk). Duid 0 aan indien dit u geen hinderpaal lijkt te zijn.

	Hybride	**Electrisch**	**Brandstofcel**	**LPG**[107]	**CNG**[108]	**Biobrandstoffen**	**Waterstof**
Hoge aankoopprijs van het voertuig							
Beperkt rijbereik							
Beperkte snelheid							
Zware en hinderlijke batterijen of brandstoftank (verminderen nuttige laadruimte)							
Langere tank- of laadtijden							
Ontoereikende infrastructuur voor tanken en landen							
Ontoereikende dienst na verkoop en onderhoudsdienst							

[107] Liquid petroleum gas
[108] Compressed natural gas

	Hybride	**Electrische**	**Brandstofcel**	**LPG**[109]	**CNG**[110]	**Biobrandstoffen**	**Waterstof**
Kwantitatief beperkt en weinig gevarieerd aanbod							
Gebrek aan informatie							
Gebrek aan persoonlijke overtuiging omtrent de milieumeerwaarde van deze voertuigen							
Verschillende rijervaring							
Vereiste om gewoonten te veranderen							
Verspreiding van deze voertuigen is nog te beperkt							
Wantrouwen betreffende de veiligheid							
Wantrouwen betreffende de technische betrouwbaarheid							
Design kenmerkend							
Gebrek aan regelgeving en normen							

[109] Liquid petroleum gas
[110] Compressed natural gas

	Hybride	Electrische	Brandstofcel	LPG[111]	CNG[112]	Biobrandstoffen	Waterstof
Verschillend tanksysteem							
Technische is nog niet rijp							
Hoge onderhoudskosten							
Hoge kost van de batterijen							
Problemen van toegang tot ondergrondse parkeerruimten							
Extra kost om het voertuig tot LPG voertuig om te bouwen							
Bijkomende jaarlijkse belasting voor LPG							
Andere ?							
Andere ?							

[111] Liquid petroleum gas
[112] Compressed natural gas

Deel III : Persoonlijke gegevens

17. Wat is uw geslacht?

- Mannelijk
- Vrouwelijk

18. Wat is uw geboortedatum?

……………………………………………………………………………………………………

19. Uit hoeveel personen bestaat uw gezin?

- Aantal volwassenen: …
- Aantal kinderen: …

20. Wat is uw hoogste voltooide opleiding ?

- Lager onderwijs
- (Lager) middelbaar onderwijs
- (Hoger) middelbaar onderwijs
- Hoger onderwijs
- Universitair onderwijs
- Post-universitair onderwijs

21. Wat is uw beroepssituatie?

- Ambtenaar
- Arbeider
- Bediende
- Gepensioneerd
- Student
- Zelfstandige
- Andere (specifieer): …

22. In welke inkomensklasse bevindt uw gezin zich (inclusief sociale uitkeringen, kinderbijslag en pensioenen)?

- ○ Minder dan 900 € netto/maand
- ○ Tussen 901 en 1300 € netto/maand
- ○ Tussen 1301 en 1700 € netto/maand
- ○ Tussen 1701 en 2100 € netto/maand
- ○ Tussen 2101 en 2900 € netto/maand
- ○ Tussen 2901 en 3300 € netto/maand
- ○ Tussen 3301 en 3700 € netto/maand
- ○ Tussen 3701 en 4100 € netto/maand
- ○ Meer dan 4100 € netto/maand

23. Zou u geïnteresseerd zijn om eventueel deel te nemen aan een computer gestuurde enquête met betrekking tot uw aankoopgedrag van wagens?

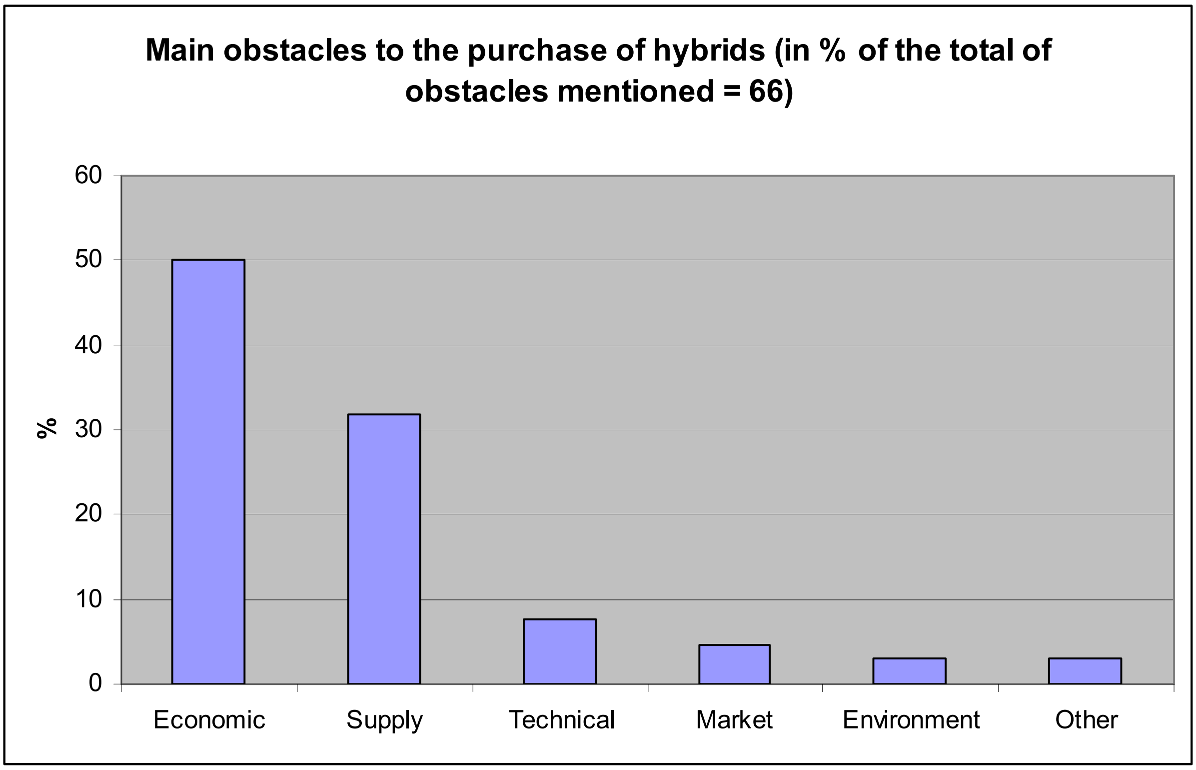
- ○ Ja, mijn e-mailadres is: …………………………………………………………….
- ○ Neen

***Wij danken u voor uw medewerking*.**

Appendix 2: Barriers to the purchase/use of alternative vehicles by technology (results of open questions)

a. Hybrid

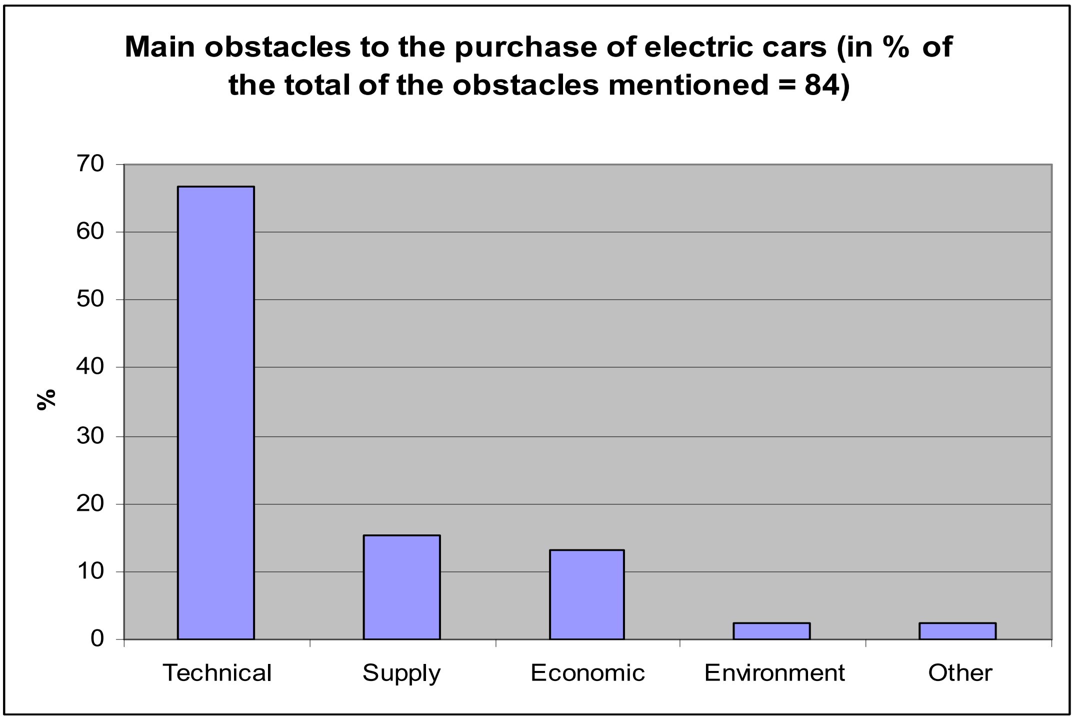
Response rate = 48



- Supply barriers: non convenience of the models, the design and the lack of models are the main groups of barrier. 2 people mentioned the lack of after-sale services, whose one used its information as: "lack of diffusion so lack of after-sale services" (short cut).
- Other barrier: one person mentioned that hybrid is not profitable in his case as he drives mainly on motorway.

b. Electric vehicles

Response rate = 51

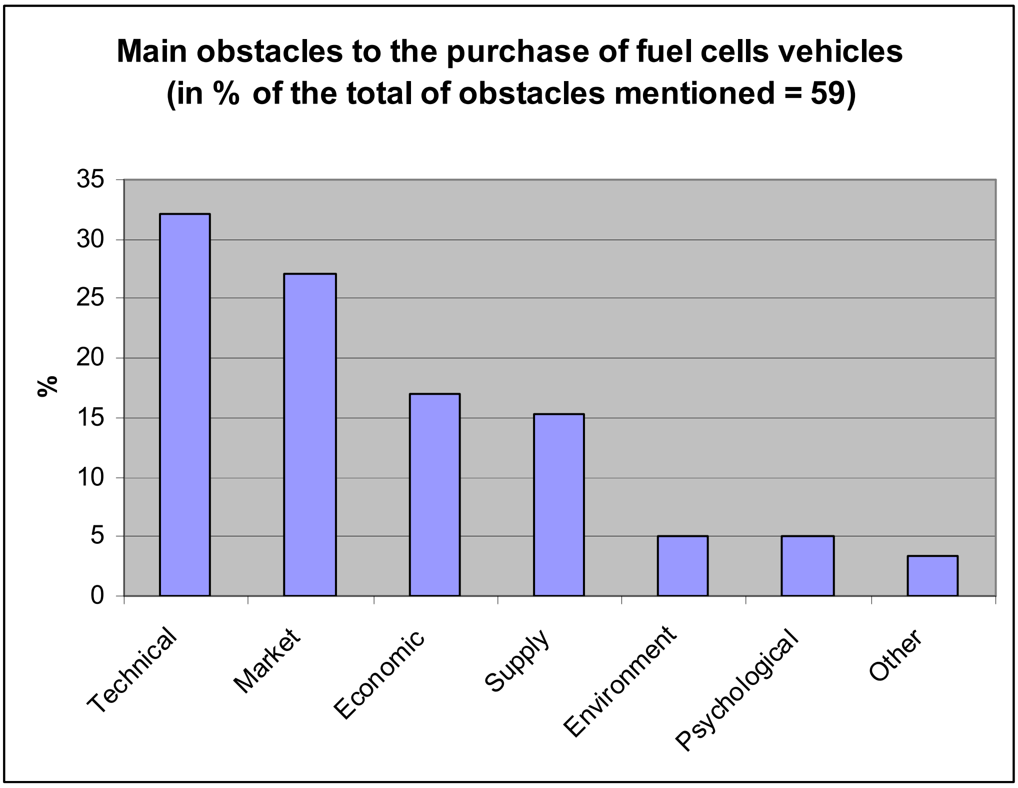


- Technical barrier: limited range is by far the most important technical barrier, then but far below, we have the long recharging time and the space of the car[113].

[113] Here the safety was put in the technical barriers (only 2, whose one was related to "safety with other vehicles")

c. Fuel cells

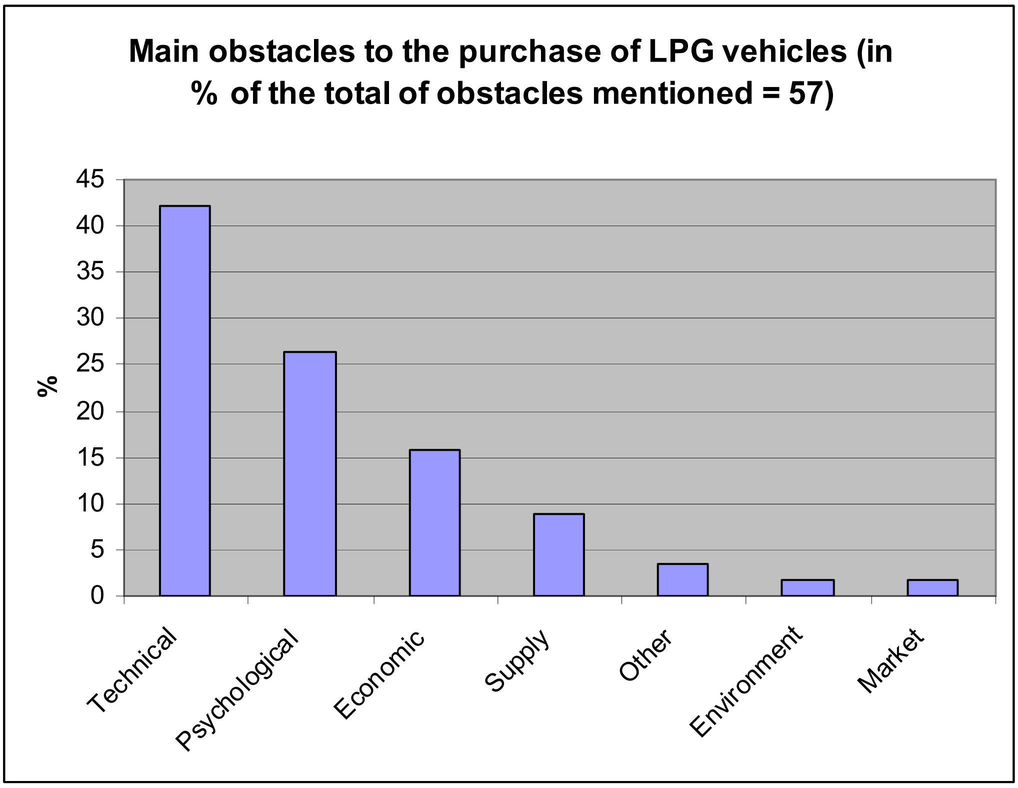
Response rate = 43



- Technical barriers: various items are mentioned, but the question of space, immaturity and range are coming more often. In market barriers we have mostly the lack of information, and also but far below the lack of diffusion.
- Environmental barriers: question of recycling is mentioned. One person mentioned that it is better to use directly electricity (category "other").
- Psychological: lack of confidence in safety.

d. LPG

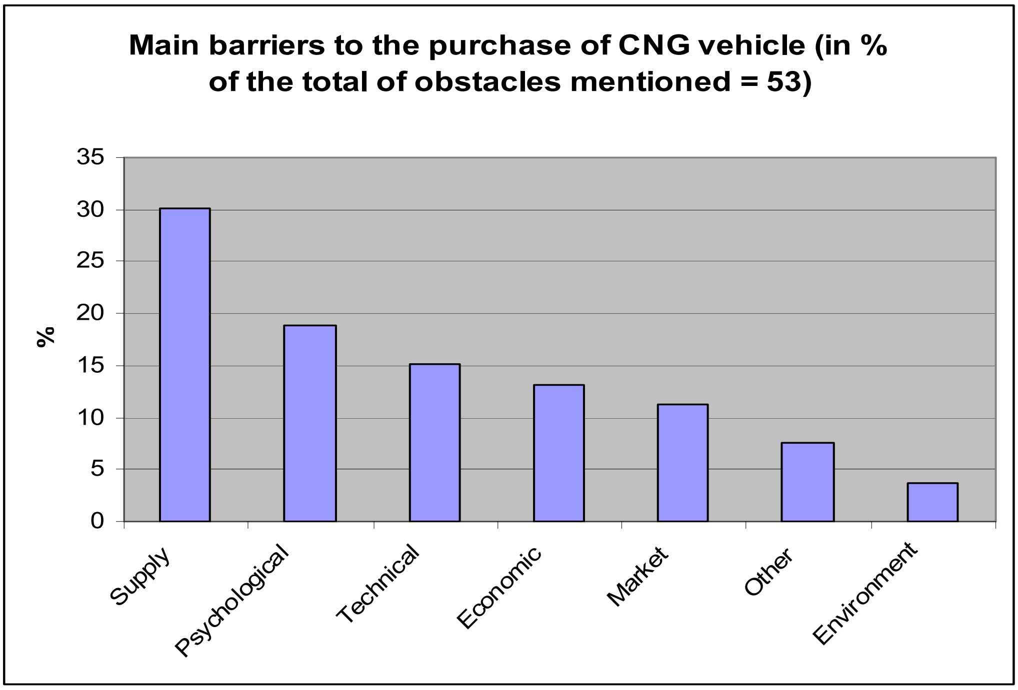
Response rate = 37



- Technical barriers: various items; the more frequent ones are the problems of access to underground parking and the space in the car.
- Psychological barriers: mainly the fear associated with gas; one person mentioned also that it is an "old system" (bad image).
- Economic barriers, we have mainly the price of the installations and the additional tax.

e. CNG

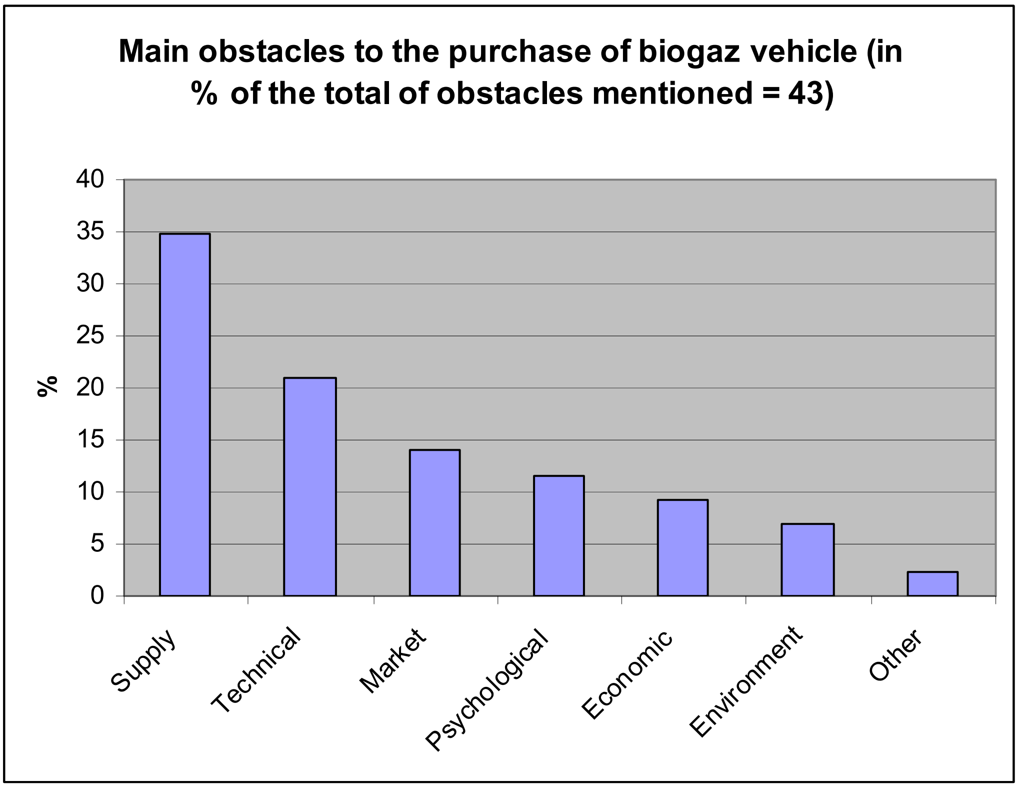
Response rate = 36



- Supply barriers: mainly lack of refuelling stations (and far below lack of vehicles).
- Psychological barriers: lack of confidence in safety (fear of gas).
- Market barriers: lack of information (one person asked the difference between LPG and CNG).

f. Biogaz.

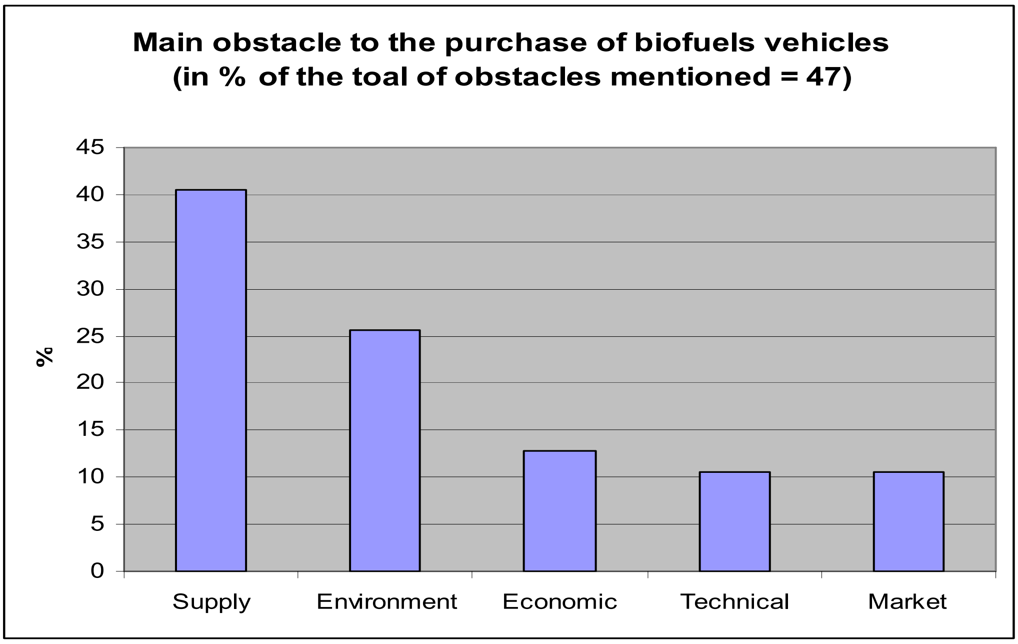
Response rate = 32



- Supply barriers: mainly lack of refuelling stations
- Psychological barriers: lack of confidence in safety

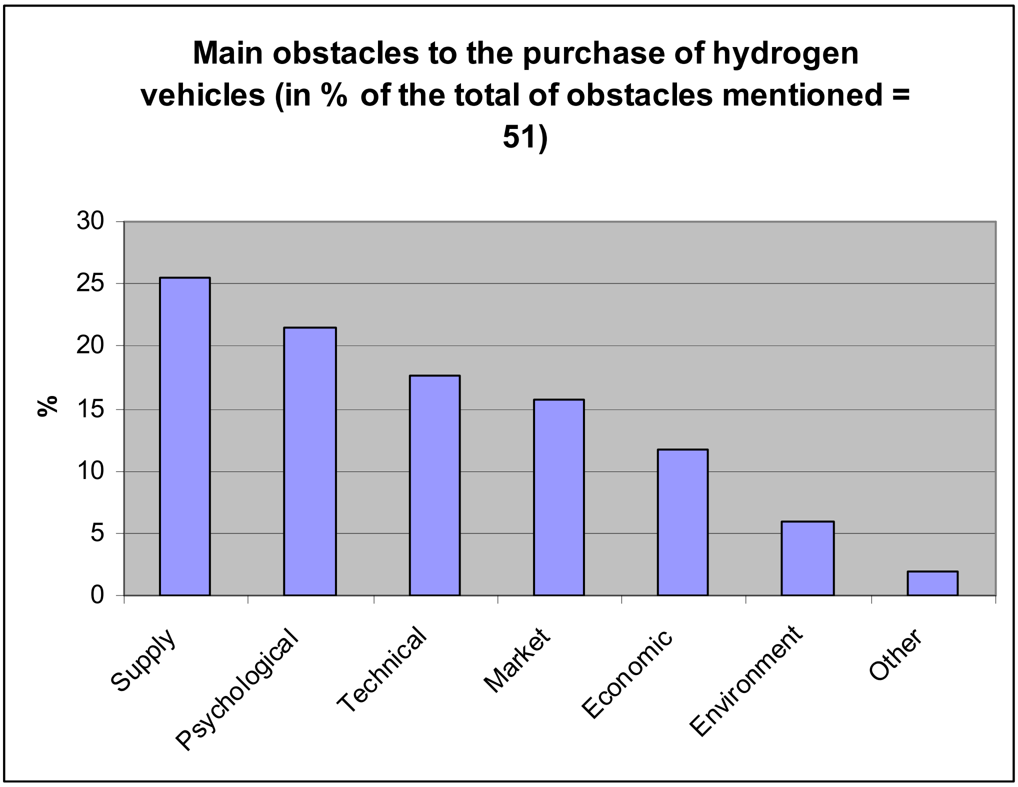
g. Biofuel

Response rate = 38

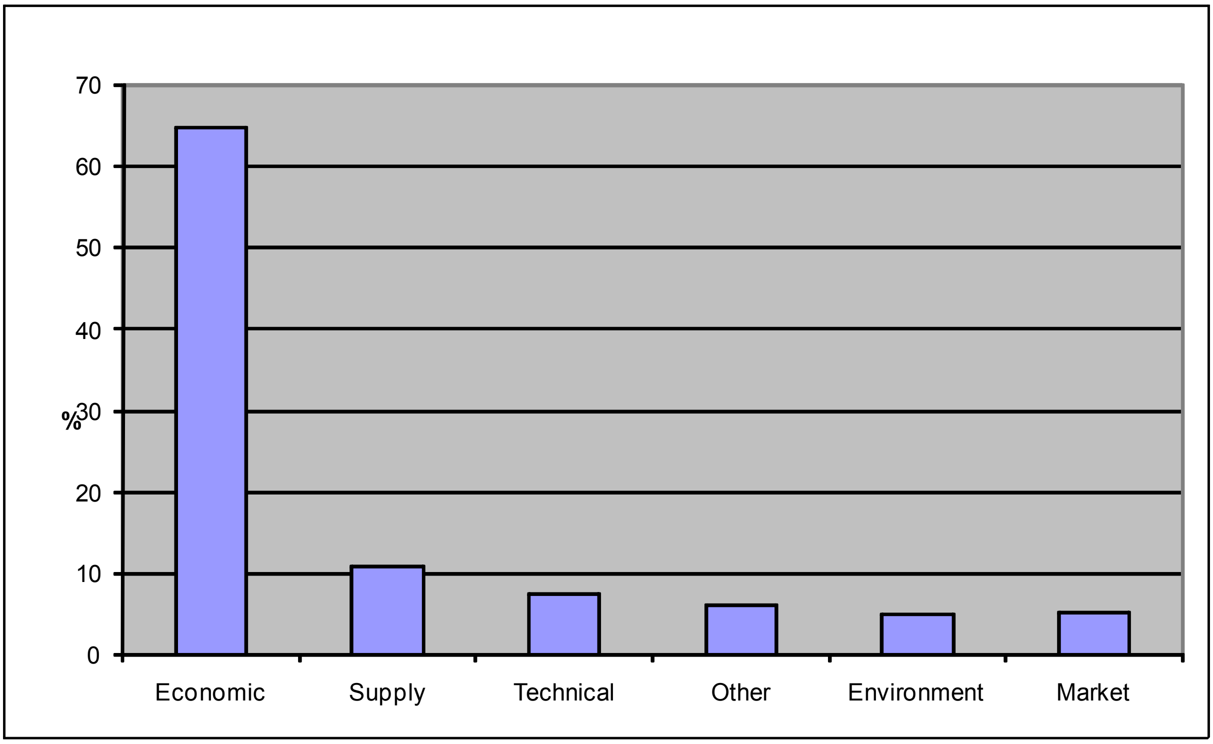


- Supply barriers: lack of refuelling stations
- Environmental barriers: in this category we have the “ethical barriers” and the environment barriers (non conviction about the environmental benefits)

h. Response rate = 37



Appendix 3: Type of policy measures to implement according to the respondents of the Motor Show (% of the total of suggested measures)



N (sample size) = 218

Appendix 4: Questionnaire for supply-side stakeholders and "experts"[114]

A. <u>Questionnaire for supply-side stakeholders and experts: French version</u>

Chère Madame, cher Monsieur,

Ce questionnaire, développé par Marion Englert, du Centre d'Etudes Economiques et Sociales de l'Environnement de l'Université Libre de Bruxelles (CEESE-ULB), s'inscrit dans le cadre d'une étude sur les véhicules propres (« projet CLEVER ») impliquant plusieurs partenaires universitaires belges[115] et commandité par la politique scientifique fédérale (Belspo).

Les objectifs de ce questionnaire sont de déterminer les barrières au développement des véhicules propres en Belgique, et d'évaluer l'importance relative de ces différentes barrières.

Par véhicule propre, nous entendons un véhicule qui utilise des technologies alternatives et/ou des carburants alternatifs aux véhicules à moteur à combustion fonctionnant uniquement aux carburants fossiles (essence et diesel), et en principe caractérisé par un impact environnemental global plus favorable. En l'occurrence il s'agit :

1) des véhicules à mode de propulsion alternatif :

- Hybrides
- Electriques (batteries)
- A pile à combustible

2) des véhicules utilisant des carburants alternatifs :

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[114] Note that in the questionnaire the categories of barriers may slightly differ from the list used in the study and presented in part I. This is because it appears (during the data treatment and treatment of the information) that it was sometimes more relevant to split one pre-identified category into different ones, or to add new categories. For example, the category of "environmental and societal barriers" (mentioned in part I) do not appear directly in the categories mentioned in the questionnaire, and was added during data treatment as it was considered as an important and quite specific barrier.

[115] Le Centre d'Etudes Economiques et Sociales de l'Environnement de l'Université Libre de Bruxelles (CEESE-ULB), le département Transport et Logistique de la « Vrije Universiteit Brussel » VUB (MOSI), l'unité de recherche sur les technologies de transport ETEC de la VUB, l'Institut pout la recherche technologique VITO (« Vlaamse instelling voor technologisch onderzoek ») et RDC environnement

- LPG (liquid petroleum gas)
- Gaz naturel compressé (CNG)
- Biocarburant (bioéthanol, méthanol, biodiesel, huile de colza)
- Biogaz
- Hydrogène

Une série de barrières (actuelles) ont été pré-identifiées sur base d'un travail de recherche et d'une revue de la littérature. Celles-ci peuvent être classées par groupe selon leur nature :

a) Barrières techniques (inconvénients techniques constituant des désavantages par rapport aux véhicules conventionnels. Ex. : autonomie limitée,…)
b) Barrières économiques (ex. : surcoûts, prix,…)
c) Barrières de marché (autres facteurs influençant négativement l'offre et la demande de véhicules propres. Ex. : manque de concessionnaires, d'infrastructures de ravitaillement,…)
d) Barrières législatives et règlementaires (ex. : manque de normes harmonisées pour les nouveaux carburants,…)
e) Barrières sociales et psychologiques (relatives aux comportements « non-rationnels » des consommateurs. Ex. : effet d'habitude,…)
f) Barrières institutionnelles et politiques (lobbying, insuffisance de dispositions contraignantes,…)

Bien évidemment, il existe de fortes interrelations entre ces différentes barrières. En effet, celles-ci s'intègrent dans un ensemble de relations causales complexes. Un objectif secondaire de la présente étude est de dégager un éventuel schéma représentant ces interrelations.

Certaines des barrières pré-identifiées freinent le développement des véhicules propres en général et d'autres (plus spécifiques) ne s'appliquent qu'à certain(e)s technologies/carburants.

Nous vous avons contacté en tant qu'expert afin de compléter la liste des barrières pré-identifiées, et d'évaluer l'importance relative de ces différentes barrières.

Le questionnaire comprend différentes parties ; si vous le souhaitez, vous avez la possibilité – en fonction de votre temps et/ou de vos connaissances – de ne répondre qu'à certaines parties du questionnaire (cf. page 4). Au total, le temps de réponse est d'environ 1 heure.

Nous vous remercions vivement d'avance pour l'accueil que vous voudrez bien réserver à ce questionnaire et pour votre précieuse collaboration. Nous vous prions de croire, Madame, Monsieur, à l'expression de nos meilleurs sentiments.

<u>Plan du questionnaire</u>

La partie II du questionnaire a trait aux obstacles à la diffusion des véhicules propres en général.

La partie III du questionnaire a trait aux obstacles à la diffusion des différentes catégories de véhicules propres.

Si vous le souhaitez, vous pouvez en fonction de vos connaissances et de votre temps disponible, ne répondre qu'à l'une de ces deux parties. De même, au sein de la partie III, vous pouvez également ne compléter que les questions relatives aux catégories de véhicules propres pour lesquelles vous estimez vos connaissances suffisantes.

Merci de répondre en tout cas à la partie I (questions générales, principalement ouvertes) et à la partie V (données personnelles).

I. <u>Questions générales</u>

1) Comment estimez-vous votre niveau de connaissance relative aux véhicules suivants ?

a. Hybrides

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

b. Electriques (batteries)

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

c. A pile à combustible

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

d. Fonctionnant au LPG

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

e. Fonctionnant au gaz naturel (CNG)

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

f. Fonctionnant au biogaz

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

g. Fonctionnant au biocarburant

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

h. Fonctionnant à l'hydrogène

☐ très bonnes ☐ bonnes ☐ moyennes ☐ plutôt faibles ☐ faibles

2) Selon vous, quels sont les principaux obstacles au développement des véhicules propres à l'heure actuelle

a. En général?

b. Par type de véhicule ?

- Type de propulsion alternatif :
  - <u>Hybrides</u>
  - <u>Electriques (batteries)</u>
  - <u>A pile à combustible</u>
- Type de carburant alternatif :
  - <u>LPG</u>
  - <u>Gaz naturel compressé (CNG)</u>
  - <u>Biocarburant</u>
  - <u>Biogaz</u>
  - <u>Hydrogène</u>

3) Selon vous, les barrières (actuelles) se situent-elles plutôt du côté de l'offre ou plutôt de la demande ? Pourquoi ?

4) Selon vous, quelles sont les mesures à prendre pour stimuler le développement des véhicules propres ?

5) Selon vous, quels types de véhicules propres pourraient le plus facilement être introduits dans le marché belge à court et à long terme? Pourquoi ?

6) Utilisez-vous des véhicules propres dans votre institution ? Si oui, de quels types sont-ils? Quels sont les éventuels problèmes rencontrés ?

II. Evaluation de l’importance des barrières pré-identifiées au développement des véhicules propres en général

1) Certaines barrières au développement des véhicules propres en général (qui s’appliquent à toutes les technologies) ont été pré-identifiées et listées ci-dessous.

Veuillez évaluer l’importance de chacune des barrières en leur attribuant, de façon indépendante, une cotation entre 0/10 (barrière non existante) et 10/10 (barrière très importante).

Vous pouvez ne pas répondre aux questions pour lesquelles vous estimez qu’une approche générale n’est pas adaptée.

Barrières techniques

[] Les technologies alternatives montrent en général certains désavantages techniques par rapport aux véhicules conventionnels (voir point III pour plus de précisions car ces barrières sont spécifiques à chaque type de véhicules)

Barrières économiques

[] Prix d’achat généralement plus élevé pour la plupart des technologies alternatives (par rapport aux véhicules conventionnels)

[] Coûts du cycle de vie total du véhicule (de la production à la mise au rebut) souvent plus élevé (pour le consommateur)

[] Absence de marché de seconde main (difficulté de revente pour le consommateur)

[] Risques de « coûts cachés » (ex. : coûts d’apprentissage etc.) des nouvelles technologies (incertitudes pour le consommateur et le producteur)

[] Coûts de production trop élevés pour le producteur

[] Non prise en compte des coûts environnementaux (externalités) dans les prix des véhicules conventionnels

[] Autres?

Barrières liées au marché côté demande

[] Peu d'infrastructures (de ravitaillement, de recharge, de services de maintenance…), ce qui décourage le consommateur

[] Offre peu variée et quantitativement insuffisante

[] Manque d'informations (→ manque de confiance des utilisateurs potentiels quant à la fiabilité et aux performances des véhicules)

[] Manque de conscience environnementale au sein de la population

[] Manque de conviction quant à l'utilité environnementale des véhicules propres (en tenant compte des effets environnementaux du cycle de vie total)

[] Autres?

Barrières liées au marché côté offre

[] Manque de confiance des producteurs quant à la taille, la rentabilité et la viabilité des marchés

[] Incertitudes des producteurs quant à la tendance à la hausse des prix du pétrole

[] Incertitudes des producteurs par rapport à l'évolution des prix des carburants alternatifs

[] Incertitudes sur les politiques futures (sur la législation par rapport aux émissions, les régulations de sécurité et les régimes de taxation), qui ont tendance à varier dans le temps (causant également des incertitudes quant à la taille du marché)

[] Peu d'infrastructures (de ravitaillement, de recharge, de services de maintenance…), ce qui décourage la production de véhicules (problème de « l'œuf et la poule »)

[] Problème de financement des investissements étant donné les incertitudes, la petite taille des marchés et les temps longs de remboursement (→ les prêts sont perçus comme risqués par les organismes de financement)

[] Free-riding (les producteurs attendent que d'autres producteurs développent la technologie et que le marché se développe avant d'adopter eux-mêmes la nouvelle technologie)

[] Autres?

Barrières législatives et règlementaires

[] Existence de barrières administratives décourageant la production d'un « nouveau » type de véhicule ou d'un « nouveau » carburant

[] Les politiques visant à développer les véhicules propres ne sont pas harmonisées entre les pays (par exemple les primes ou avantages fiscaux ne sont pas accordés en fonction d'une règle commune)

[] Manque de réglementation et de standards communs internationaux sur les systèmes de ravitaillement et la qualité des carburants

[] Autres?

Barrières sociales et psychologiques (comportement non rationnel)

[] Influence de la publicité, modes, importance du « look », de la signification symbolique du véhicule traditionnel (image de liberté individuelle et sentiment de puissance associé au véhicule traditionnel) et des pratiques socioculturelles reliées (ex. : sport automobile)

[] Effet d'habitude : appréhension due à une sensation ou façon de conduite éventuellement différente, à la nécessité d'adapter son comportement (ex. : précautions à prendre différentes), au fait de changer le mode et/ou les lieux de ravitaillement etc.

[] Sentiment d'insécurité (crainte d'explosion etc.)

[] Autres?

Barrières institutionnelles et politiques

[] Importance du réseau d'infrastructure et d'institution existant (ex. : existence de filières académiques comme l'ingénierie mécanique) lié à la filière des combustibles fossiles

[] Lobbying des industries automobiles

[] Lobbying des acteurs de la filière du pétrole

[] Lobbying d'autres acteurs/groupes ? Si oui, lesquels ?

[] Manque de « lobbyistes » en faveur des véhicules propres (peu de groupes de pression qui bénéficient financièrement de l'introduction des nouvelles technologies)

[] Manque de politiques d’encouragement financier

[] Manque de politiques d’encouragement au niveau de la diffusion de l’information et de la promotion des véhicules/carburants alternatifs

[] Manque de mesures contraignantes vis-à-vis des véhicules plus polluants

[] Autres ?

Autres? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules propres en général en leur attribuant une cotation)

2) Parmi les groupes de barrières susmentionnées, pouvez-vous mentionner les éventuelles relations de causalité existantes (par exemple sous forme de schéma)?

III. Evaluation de l'importance des barrières pré-identifiées spécifiques aux différents types de véhicules propres

Des barrières spécifiques à chaque type de véhicules ont également été pré-identifiées

Veuillez compléter cette question comme à la question précédente, pour chaque type de véhicule.

1) Véhicule électrique

Evaluez l'importance des barrières au développement des véhicules électriques à batteries en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières techniques

[] Autonomie particulièrement limitée

[] Vitesse maximale limitée

[] Batteries lourdes et encombrantes (réduit l'espace utile)

[] Temps long de recharge sur prise standard pour la plupart des batteries

[] Autres ?

Barrières économiques

[] Coût élevé à l'achat

[] Prix élevé des batteries lors de leur remplacement

[] Autres ?

Barrières de marché

[] Manque d'infrastructures de recharge publiques (risque de panne à cause de batteries plates)

[] Offre de véhicule très limitée

[] Manque de services après-vente

[] Problème des services de maintenance (les garagistes ne sont pas toujours formés pour réparer les véhicules électriques)

[] Autres ?

Barrières psychologiques

[] Appréhension concernant la sécurité associée au système électrique (décharge,…)

[] Sensation et façon de conduire différentes

[] Crainte de tomber en panne et de ne pas pouvoir recharger sur place

[] Autres ?

Autres? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules électriques à batteries en leur attribuant une cotation)

2) Véhicule hybride

Evaluez l'importance des barrières au développement des véhicules hybrides en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières économiques

[] Prix d'achat élevé

[] Coût élevé des batteries lors de leur remplacement

[] Autres ?

Barrières de marché

[] Peu de modèles disponibles (offre peu variée)

[] Problème des services de maintenance (les garagistes et mécaniciens ne sont pas toujours formés pour réparer les hybrides)

[] Manque de conviction quant à l'importance de l'avantage environnemental des véhicules hybrides (cf. gain faible au niveau de la conduite autoroutière,…)

[] Autres ?

Barrières psychologiques

[] Façon de conduire différente (pour garantir une économie significative de carburant)

[] Autres ?

Autres? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules hybrides en leur attribuant une cotation)

3) LPG (liquid petroleum gas)

Evaluez l'importance des barrières au développement des véhicules LPG en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières techniques

[] Autonomie relativement faible

[] Réservoirs importants et lourds pouvant réduire l'espace utile (ou prendre la place de la roue de secours)

[] Système de ravitaillement en LPG un peu plus compliqué (précautions à prendre)

[] Autres ?

Barrières économiques

[] Coût additionnel de transformation du véhicule (si véhicule non dédié)

[] Les propriétaires de voitures équipées au LPG doivent payer une taxe de circulation complémentaire

[] Autres ?

Barrières de marché

[] Manque d'infrastructure de ravitaillement LPG

[] La plupart des véhicules LPG sont des véhicules conventionnels transformés, ce qui demande au consommateur une démarche supplémentaire (offre de véhicules dédiés très limitée)

[] La transformation en véhicule LPG ne s'applique qu'aux moteurs à essence (pas diesel)

[] Problème des services de maintenance (les garagistes et mécaniciens ne sont pas toujours formés pour réparer les véhicules au LPG)

[] Problème de disponibilité à long-terme du carburant (sous-produit du raffinage du pétrole→ source d'énergie limitée)

[] Autres ?

Barrières législatives

[] L'absence de norme internationale de qualité du carburant entraîne la nécessité d'un réglage du moteur des véhicules pour chaque composition du carburant (varie quelque peu d'un pays à l'autre)

[] L'absence de norme internationale implique que les méthodes de ravitaillement en LPG peuvent varier dans les différents pays (ex. : certains pays nécessitent des connecteurs spéciaux)

[] Accès aux parkings souterrains interdit (excepté pour les parkings respectant certaines conditions)

[] Autres ?

Barrières psychologiques

[] Crainte d'explosion associée au LPG (gaz comprimé inflammable)

[] Autres ?

Autres *?* (Veuillez indiquer les éventuelles autres barrières au développement des véhicules LPG en leur attribuant une cotation)

4) Gaz Naturel

Evaluez l'importance des barrières au développement des véhicules au gaz naturel en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières techniques

[] Faible autonomie

[] Temps long de ravitaillement pour les systèmes normaux (existence d'un système rapide mais plus cher)

[] Méthode de ravitaillement pouvant varier dans les différents pays (certains pays nécessitent des connecteurs spéciaux)

[] La proportion en méthane est variable ce qui peut poser problème, le moteur n'étant pas conçu pour cette variabilité

[] Réservoirs importants (pressurisés) pouvant réduire l'espace utile

[] Autres ?

Barrières économiques

[] Coût à l'achat élevé

[] Coût élevé des stations de ravitaillement en gaz naturel (en particulier pour les systèmes de ravitaillement rapides)

[] Coût élevé de l'installation domestique de ravitaillement en gaz naturel

[] Autres ?

Barrières de marché

[] Manque d'infrastructures publiques de ravitaillement en gaz naturel

[] Problème des services de maintenance (les garagistes et mécaniciens ne sont pas toujours formés pour réparer les véhicules au gaz naturel)

[] Incertitudes sur l'évolution des prix

[] Incertitude quant à l'offre de gaz à long-terme (source d'énergie limitée)

[] Autres ?

Barrières législatives

[] Manque de législation spécifique et de certification de sécurité harmonisée pour le gaz naturel destiné aux véhicules (composition variable)

[] Autres ?

Autres ? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules au gaz naturel en leur attribuant une cotation)

5) Biocarburants

Evaluez l'importance des barrières au développement des véhicules au biocarburant en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières techniques

[] Rendement énergétique inférieur au carburant fossile (pour un même volume de carburant on parcourt moins de km)

[] Caractère corrosif du bioéthanol et du biodiesel + toxicité de méthanol → doivent être manipulé avec précaution

[] Si trop grande proportion de biocarburant dans le carburant classique, pose problème de compatibilité avec les moteurs ou les infrastructures → nécessite adaptation

[] Variation de la production pendant l'année, en fonction des cultures

[] Formation de dépôt dans le réservoir de la voiture si longue période de stockage (biodiesel)

[] Le filtre doit être remplacé plus souvent

[] Autres ?

Barrières économiques

[] Coûts de production du biocarburant plus élevé que carburant classique (donc prix du carburant plus élevé)

[] Coûts des matières premières

[] Autres ?

Barrières de marché

[] Problème de disponibilité (surfaces agricoles limitées et compétition pour l'utilisation des terres)

[] Incertitudes par rapport à la demande et au prix (rentabilité) → manque de confiance des producteurs

[] Certaines matières premières servant à produire du biocarburant sont plus rentables si on les utilise pour d'autres applications (bois, nourriture)

[] Manque de conviction car bilan environnemental contesté (effets environnementaux néfastes de la production agricole intensive → pesticides, consommation et pollution des ressources en eau, appauvrissement des paysages et des sols etc.), et effets collatéraux (déforestation, augmentation des prix des matières premières, problèmes de monocultures etc.)

[] Autres ?

Barrières législatives

[] Les permis pour la production/l'utilisation de biocarburant sont difficiles à obtenir (les procédures d'approbation sont lentes et coûteuses)

[] Au niveau européen, les normes de qualité définies pour les carburants fossiles limite l'incorporation de biodiesel au diesel et de bioéthanol à l'essence à 5% (norme E590 pour le diesel et la norme EN228 pour l'essence)

[] Manque de norme pour les mélanges à haute concentration et pour l'huile de colza (problèmes pour les fabricants de moteurs et le public)

[] Pas d'avantages fiscaux particuliers pour les mélanges à haute concentration en biocarburant.

[] Autres ?

Barrières politiques

[] Manque de mesures contraignantes (ex. : obligation pour les pétroliers d'acheter un certain pourcentage de biocarburants)

[] Autres ?

Autres *?* (Veuillez indiquer les éventuelles autres barrières au développement des véhicules au biocarburant en leur attribuant une cotation)

6) Piles à combustible (PAC)

Evaluez l'importance des barrières au développement des véhicules à PAC en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante). Remarque : les barrières spécifiques à l'hydrogène sont à évaluer dans le point suivant.

Barrières techniques

[] Technologie immature: pas encore assez fiable, efficacité et capacité de stockage limités, durée de vie limitée

[] Diversité des technologies en matière de PAC (utilisation de différents carburants) -> empêche la standardisation des PAC nécessaire à la baisse des coûts de production

[] Problèmes liés à l'hydrogène (pour les PAC à l'hydrogène)

[] PAC lourdes et encombrantes

[] Autres ?

Barrières économiques

[] Coût de production de la pile élevé ce qui implique un prix du véhicule très élevé

[] Autres ?

Autres ? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules à PAC en leur attribuant une cotation)

7) Hydrogène

-> Il s'agit ici des véhicules alimentés directement à l'hydrogène (sans réformeur)

Evaluez l'importance des barrières au développement des véhicules à hydrogène en leur attribuant, de façon indépendante, une cotation de 0/10 (barrière inexistante) à 10/10 (barrière très importante)

Barrières techniques

[] Grande dimension et poids du réservoir (diminue l'espace utile)

[] Problèmes de sécurité et complexités liés au stockage, au transport et à l'infrastructure de ravitaillement

[] Débat sur la matière première à utiliser et les techniques de production d'hydrogène

[] Autres ?

Barrières économiques

[] Coût de l'infrastructure de ravitaillement en hydrogène élevé

[] Coût de compression et de stockage au niveau de la distribution

[] Coût de production élevé

[] Coût d'entretien élevé

Barrières de marché

[] Pratiquement pas d'infrastructure de ravitaillement en hydrogène

[] Problème des services de maintenance (manque de formation des garagistes et mécaniciens)

[] Manque de conviction car bilan environnemental contesté (dépend de la matière première utilisée pour la production d'hydrogène)

[] Autres ?

Barrières législatives

[] Absence de réglementation et de normes pour la production, la distribution et l'utilisation d'hydrogène

Barrières psychologiques

[] Danger associé à l'hydrogène (demande certaines précautions)

[] Autres ?

Autres ? (Veuillez indiquer les éventuelles autres barrières au développement des véhicules à l'hydrogène en leur attribuant une cotation)

IV. Avez-vous des commentaires à ajouter (remarques sur le questionnaire ou autres…)?

V. <u>Données personnelles</u>

Institution :

Fonction:

Formation professionnelle:

B. Questionnaire for supply-side stakeholders and experts: Dutch version

Geachte Mevrouw, Geachte Heer,

Deze vragenlijst, die uitgewerkt werd door Marion Englert, van het Centrum voor Economische en Sociale Milieustudies van de Université Libre de Bruxelles (CEESE-ULB), kadert in een studie omtrent schone voertuigen (het «CLEVER project») in opdracht van het Belgische Federale Wetenschapsbeleid (Belspo) waaraan verschillende Belgische universiteiten als partners[116] deelnemen.

De opzet van deze vragenlijst is om de hinderpalen voor de verspreiding van milieuvriendelijke voertuigen in België te identificeren, alsook om het relatieve belang van deze hinderpalen te bepalen.

Met "milieuvriendelijk voertuig", wordt hier verwezen naar voertuigen die uitgerust zijn met een alternatieve aandrijving of die rijden op alternatieve brandstoffen (en dus niet volledig afhankelijk zijn van benzine of diesel). In principe worden deze voertuigen globaal gekenmerkt door een lagere milieu-impact. In dit geval gaat het om:

1) Voertuigen met alternatieve aandrijving :

- Hybride voertuigen
- (batterij-) Elektrische voertuigen
- Brandstofcelvoertuigen

2) Voertuigen die gebruik maken van alternatieve brandstoffen:

- LPG (liquid petroleum gas)
- Samengeperst aardgas (CNG)
- Biobrandstof (bio-ethanol, methanol, biodiesel, koolzaadolie)
- Biogas
- Waterstof

[116] Het Centrum voor Economische en Sociale Milieustudies van de Université Libre de Bruxelles (CEESE-ULB), het departement Transport en Logistiek van de Vrije Universiteit Brussel VUB (MOSI-T), de onderzoekseenheid transporttechnologie van de vakgroep ETEC van de VUB, de Vlaamse Instelling voor Technologisch Onderzoek (VITO) en RDC environment

Een reeks (huidige) hinderpalen werden op voorhand geïdentificeerd aan de hand van onderzoekswerk en van een literatuurstudie. Deze hinderpalen kunnen naargelang hun kenmerken per categorie ingedeeld worden:

a) Technische barrières (technische nadelen ten opzichte van conventionele voertuigen. B.v.: beperkt rijbereik,…)
b) Economische barrières (b.v.: meerkost, prijs,…)
c) Marktbarrières (andere factoren die het aanbod aan en/of de vraag naar milieuvriendelijke voertuigen negatief beïnvloeden. B.v.: een gebrek aan verdelers, aan bevoorradingsinfrastructuur,…)
d) Wetgevingsgerelateerde barrières (b.v. : gebrek aan geharmoniseerde normen voor nieuwe brandstoffen,…)
e) Sociale en psychologische barrières (met betrekking tot « irrationeel » gedrag van de verbruikers. B.v.: Gewoontepatronen,…)
f) Institutionele en politieke barrières (lobbywerk, gebrek aan dwingende maatregelen,…)

Uiteraard bestaan er sterke verbanden tussen deze verschillende hinderpalen. Inderdaad, deze passen in een complex geheel aan causale verbanden. Een bijkomende doelstelling van deze studie bestaat erin om een overzichtelijk schema van deze verbanden te kunnen opstellen.

Sommige op voorhand geïdentificeerde barrières belemmeren de ontwikkeling van milieuvriendelijke voertuigen in het algemeen en andere, meer specifieke barrières betreffen slechts bepaalde technologieën/brandstoffen.

Men heeft u gecontacteerd omdat u, als expert, de lijst met op voorhand geïdentificeerde barrières verder zou kunnen vervolledigen alsook omdat u het relatieve belang van de verschillende barrières zou kunnen inschatten.

De vragenlijst bestaat uit verschillende delen: indien u het wenst, kan u – naargelang uw tijd en/of kennis - ervoor kiezen om slechts sommige delen van de vragenlijst te beantwoorden (cf. Pagina 4) . In totaal neemt het beantwoorden van de vragenlijst ongeveer één uur in beslag.

Wij danken u alvast hartelijk bij voorbaat voor uw behulpzaamheid en voor het beantwoorden van deze vragenlijst.

Overzicht van de vragenlijst

Deel II van de vragenlijst betreft de hinderpalen voor de verspreiding van milieuvriendelijke voertuigen in het algemeen.

Deel III van de vragenlijst betreft de hinderpalen voor de verspreiding van bepaalde categorieën milieuvriendelijke voertuigen in het bijzonder.

Indien u het wenst, kan u– naargelang uw tijd en/of kennis - ervoor kiezen om slechts 1 van beide delen te beantwoorden. In deel III kan u er eveneens voor kiezen om enkel die vragen te beantwoorden omtrent de schone voertuigtechnologieën waarvoor u over voldoende kennis beschikt.

Wel vragen we u om in ieder geval deel I (algemene, doorgaans open, vragen) en deel V (persoonlijke gegevens) van de vragenlijst te willen beantwoorden.

I. <u>Algemene vragen</u>

1) Wat is het niveau van uw algemene kennis van volgende <u>milieuvriendelijke voertuigen</u>?

a. Hybride Voertuigen

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

b. (Batterij) Elektrische Voertuigen

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

c. Brandstofcelvoertuigen

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

d. LPG-voertuigen

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

e. Aardgasvoertuigen (CNG)

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

f. Biogasvoertuigen

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

g. Voertuigen op biobrandstoffen (biodiesel/bio-ethanol)

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

h. Voertuigen op waterstof (met verbrandingsmotoren)

☐ Zeer goed ☐ Goed ☐ Matig ☐ Eerder zwak ☐ Zwak

2) Wat zijn volgens u, op dit moment, de voornaamste hinderpalen voor de ontwikkeling van milieuvriendelijke voertuigen

a. In het algemeen?

b. Voor de specifieke voertuigtypes?

- Alternatieve aandrijvingen:
  - Hybride
  - (Batterij) Elektrisch
  - Brandstofcel
- Alternatieve brandstoffen :
  - LPG
  - Samengeperst aardgas (CNG)
  - Biobrandstoffen
  - Biogas
  - Waterstof

3) Bevinden de (huidige) hinderpalen zich volgens u eerder aan de aanbodzijde of eerder aan de vraagzijde? Waarom?

4) Wat zijn de maatregelen die volgens u getroffen zouden moeten worden om de ontwikkeling en verspreiding van milieuvriendelijke voertuigen aan te moedigen?

5) Welke soort milieuvriendelijke voertuigen vertonen volgens u de grootste kans op succes (op korte termijn en op middellange termijn) op de Belgische markt? Waarom?

6) Wordt er binnen uw instelling gebruik gemaakt van milieuvriendelijke voertuigen? Zo ja, om welke type voertuig gaat het dan? Welke eventuele problemen worden hierbij ondervonden?

II. Evaluatie van het belang van de op voorhand geïdentificeerde hinderpalen voor de verspreiding van milieuvriendelijke voertuigen in het algemeen

1) Sommige hinderpalen voor de ontwikkeling van milieuvriendelijke voertuigen in het algemeen (die van toepassing zijn voor alle technologieën) werden op voorhand geïdentificeerd en worden hieronder opgesomd.

Gelieve het belang van de volgende hinderpalen individueel weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

U kan ervoor kiezen om bepaalde vragen niet te beantwoorden wanneer u van mening bent dat een algemene benadering niet aangepast is.

Technische barrières

[] Alternatieve technologieën vertonen meestal technische nadelen (hinderpalen) ten opzichte van conventionele voertuigen (zie punt III voor verduidelijking aangezien deze hinderpalen voor elk type voertuig verschillend zijn)

Economische barrières

[] Aankoopprijs van de alternatieve technologieën is doorgaans hoger (ten opzichte van conventionele voertuigen)

[] De kosten over de volledige levenscyclus van het voertuig (van de productie tot de ontmanteling) zijn vaak hoger (voor de gebruiker)

[] Ontoereikende tweedehandsmarkt (moeilijkheden bij doorverkopen van het voertuig)

[] Nieuwe technologieën houden een risico op « verborgen kosten » in, bv.: kosten die gepaard gaan met "kinderziektes" van de technologieën (er bestaat een onzekerheid doordat verbruiker en constructeur nog ervaring moeten opdoen met de technologie)

[] Te hoge productiekost (voor de constructeur)

[] De milieukost (externe kosten) wordt niet opgenomen in de prijs van de conventionele voertuigen

[] Andere?

Marktgerelateerde barrières (gebonden aan de vraag)

[] Beperkte infrastructuur (voor bevoorrading, opladen, onderhoud,…), werkt ontmoedigend voor de gebruiker

[] Weinig gevarieerd en beperkt aanbod

[] Gebrek aan informatie (→ gebrek aan vertrouwen van potentiële gebruikers betreffende de betrouwbaarheid en prestaties van de voertuigen)

[] Gebrek aan milieubewustheid van de bevolking

[] Gebrek aan overtuiging van de werkelijke meerwaarde van milieuvriendelijke voertuigen op het milieuvlak (rekening houdend met de milieu-effecten gedurende de volledige levenscyclus van het voertuig)

[] Andere?

Marktgerelateerde barrières (gebonden aan het aanbod)

[] Gebrek aan vertrouwen van de constructeurs ten aanzien van de omvang, de rentabiliteit en de leefbaarheid van de markt

[] Onzekerheid van de constructeurs ten aanzien van de stijgende olieprijzen

[] Onzekerheid van de constructeurs ten aanzien van de evolutie van de prijzen van alternatieve brandstoffen

[] Onzekerheid ten aanzien van het toekomstig beleid (omtrent de emissiewetgeving, de veiligheidsbepalingen en het fiscaal stelsel), dat de neiging vertoont om met de tijd te variëren (wat eveneens onzekerheden veroorzaakt omtrent de omvang van de markt)

[] Gebrekkige infrastructuur (voor bevoorrading, opladen, onderhoudsdiensten…), ontmoedigt de productie van deze voertuigen (het probleem van « de kip en het ei »)

[] Financieringsprobleem van de investeringen omwille van de onzekerheden omtrent de omvang van de markt en de lange terugbetalingstermijnen (-> de leningen worden als risicovol ervaren door de financiële instellingen)

[] Free-riding (sommige constructeurs wachten tot wanneer anderen de technologie ontwikkelen en dat de markt zich ontwikkelt vooraleer ze zelf de nieuwe technologie aanwenden)

[] Andere?

Wetgevingsgerelateerde barrières

[] Het bestaan van administratieve barrières die ontmoedigend werken voor de productie van een “nieuw” type voertuig of van een “nieuwe” brandstof

[] Het beleid omtrent de ontwikkeling van milieuvriendelijke voertuigen is niet geharmoniseerd in de verschillende landen (de premies of fiscale voordelen worden bijvoorbeeld niet toegekend op basis van gemeenschappelijke regels)

[] Gebrek aan reglementering en gemeenschappelijke internationale standaarden voor de bevoorradingssystemen en voor de kwaliteit van de brandstoffen

[] Andere?

Sociale en psychologische barrières (“irrationeel” gedrag)

[] Invloed van reclame, mode, belang van de « looks », van de symboliek die verbonden is met de conventionele voertuigen (individuele vrijheid en machtsgevoel worden vaak geassocieerd met de conventionele voertuigen) en met de socioculturele praktijken die eraan verbonden zijn (b.v.: autosport)

[] Doorbreken van gewoontepatroon : bezorgdheid te wijten aan een potentieel verschillende rijervaring, te wijten aan de noodzaak om zijn gedrag te wijzigen (b.v. : verschillende voorzorgsmaatregelen), te wijten aan de verandering van de plaats en manier van bevoorrading,…

[] Onveiligheidsgevoel (vrees voor ontploffing enz.)

[] Andere?

Beleidsgerelateerde barrières

[] Het belang de bestaande infrastructuur en instellingen (b.v. de bestaande academische opleidingen als mechanische ingenieurstechnieken...) en van het bestaande bevoorradingsnetwerk voor fossiele brandstoffen

[] Lobbywerk van de automobiel industrie

[] Lobbywerk van de olie industrie

[] Lobbywerk van andere actoren/groepen? Zo ja, welke?

[] Gebrek aan « lobbyisten » in het voordeel van milieuvriendelijke voertuigen (weinig belangengroepen die financieel baat hebben aan de invoering van nieuwe technologieën)

[] Gebrek aan financiële aanmoedigingsmaatregelen vanuit het beleid

[] Gebrek aan toelichting en aan promotie van alternatieve voertuigen/brandstoffen

[] Gebrek aan dwingende maatregelen omtrent de meest vervuilende voertuigen

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van milieuvriendelijke voertuigen in het algemeen aan te geven met een weergave van hun belang)

2) Kunt u (bijvoorbeeld met behulp van een schema) de causale verbanden tussen de bovenvermelde hinderpalen beschrijven?

III. Evaluatie van het belang van de specifieke, op voorhand geïdentificeerde, hinderpalen voor de verspreiding van milieuvriendelijke voertuigen

Specifieke hinderpalen voor de verschillende soorten milieuvriendelijke voertuigen werden op voorhand geïdentificeerd.

Gelieve deze vraag evenals de vorige te beantwoorden voor elke soort voertuig die in de vragenlijst vermeld wordt.

1) Elektrisch voertuig

Gelieve het belang van de volgende hinderpalen voor de verspreiding van (batterij) elektrische voertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

Technische barrières

[] Bijzonder beperkt rijbereik

[] Beperkte maximumsnelheid

[] Zware en omslachtige batterijen (beperken nuttige ruimte)

[] Lange oplaadtijd van de meeste batterijen op standaard stopcontact

[] Andere?

Economische barrières

[] Hoge aankoopprijs

[] Hoge kostprijs van de batterijen (bij vervanging)

[] Andere?

Marktgerelateerde barrières

[] Gebrek aan openbare laadinfrastructuur (risico op stilstand bij ontladen batterijen)

[] Zeer beperkt aanbod aan voertuigen

[] Ontoereikende dienst na verkoop

[] Problemen gepaard met de onderhoudsdiensten (de garagisten en mechaniekers zijn niet altijd opgeleid om elektrische voertuigen te herstellen)

[] Andere?

Psychologische barrières

[] Vrees voor risico's die gepaard gaan met het elektrisch systeem (elektrische schokken,…)

[] Verschillende rijervaring en rijstijl

[] Vrees om in panne te vallen en niet ter plekke te kunnen herladen

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van batterij elektrische voertuigen aan te geven met een weergave van hun respectievelijk belang)

2) Hybride voertuig

Gelieve het belang van de volgende hinderpalen voor de verspreiding van hybride voertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

Economische barrières

[] Hoge aankoopprijs

[] Hoge kost van de batterijen bij vervanging

[] Andere?

Marktgerelateerde barrières

[] Weinig modellen beschikbaar (weinig gevarieerd aanbod)

[] Problemen gepaard met de onderhoudsdiensten (de garagisten en mechaniekers zijn niet altijd opgeleid om hybride voertuigen te herstellen)

[] Gebrek aan overtuiging omtrent de meerwaarde van hybride voertuigen op het vlak van milieuvriendelijkheid (cf. beperkte vermindering van het verbruik op de autosnelweg,…)

[] Andere?

Psychologische barrières

[] Rijstijl dient aangepast te worden (om een signifante brandstofbesparing te verkrijgen)

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van hybride voertuigen aan te geven met een weergave van hun respectievelijk belang)

3) LPG-voertuigen (liquid petroleum gas)

Gelieve het belang van de volgende hinderpalen voor de verspreiding van LPG voertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

Technische barrières

[] Behoorlijk beperkt rijbereik

[] Omvangrijke en zware brandstoftank kan de nuttige ruimte beperken (of de plaats van het vervangwiel innemen)

[] LPG-bevoorradingsprocedure is een beetje complexer (er dienen bijkomende voorzorgsmaatregelen getroffen te worden)

[] Andere?

Economische barrières

[] Bijkomende kost voor het ombouwen van het voertuig (indien het geen "dedicated" voertuig is)

[] De eigenaars van LPG-voertuigen dienen een bijkomende verkeersbelasting te betalen

[] Andere?

Marktbarrières

[] Gebrek aan bevoorradingsinfrastructuur aan LPG

[] Het merendeel van de LPG-voertuigen zijn omgebouwde conventionele voertuigen die dus inhouden dat de gebruiker een bijkomende stap en dus inspanning moet leveren (het aanbod aan "dedicated" voertuigen is zeer beperkt)

[] Het ombouwen van een voertuig naar een LPG-voertuig is enkel van toepassing op benzinevoertuigen (niet op dieselvoertuigen)

[] Problemen gepaard met de onderhoudsdiensten (de garagisten en mechaniekers zijn niet altijd opgeleid om LPG-voertuigen te herstellen)

[] Problemen van de beschikbaarheid van de brandstof op lange termijn (nevenproduct van olie de olieraffinage → eindige energiebron)

[] Andere?

Wetgevingsgerelateerde barrières

[] Het gebrek aan internationale kwaliteitsnormen vereist de instelling van de voertuigmotoren opdat ze compatibel zouden zijn met de verschillende samenstellingen van de brandstof (die variëren naargelang het land)

[] Het gebrek aan een internationale norm omtrent de bevoorrading leidt ertoe dat de bevoorradingsmethode voor LPG naargelang het land kan verschillen (in sommige landen is er b.v. een speciale connector nodig om te tanken)

[] Toegang tot ondergrondse parkeergarages verboden voor deze voertuigen (uitgezonderd voor parkeergarages die voldoen aan bepaalde voorwaarden)

[] Andere?

Psychologische barrières

[] Vrees voor ontploffingsgevaar die geassocieerd wordt met LPG

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van LPG-voertuigen aan te geven met een weergave van hun respectievelijk belang)

4) Aardgas

Gelieve het belang van de volgende hinderpalen voor de verspreiding van aardgasvoertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

Technische barrières

[] Beperkt rijbereik

[] Lange bevoorradingstijden bij gebruik van de normale systemen

[] Bevoorradingsmethode kan verschillend zijn in verschillende landen (in sommige landen zijn speciale connectoren vereist)

[] Het methaangehalte is variabel, wat problemen kan stellen aangezien motoren niet ontworpen zijn om deze variabiliteit aan te kunnen

[] Omvangrijke brandstoftank (onder hoge druk) die de nuttige ruimte kan beperken

[] Andere?

Economische barrières

[] Hoge aankoopprijs

[] Hoge kost van de bevoorradingsstations (in het bijzonder voor de sneltanksystemen)

[] Hoge kost van de huishoudelijke gasbevoorradingsinstallatie

[] Andere?

Marktgerelateerde barrières

[] Gebrek aan openbare bevoorradingsinfrastructuur voor aardgas

[] Problemen gepaard met de onderhoudsdiensten (de garagisten en mechaniekers zijn niet altijd opgeleid om aardgasvoertuigen te herstellen)

[] Onzekerheid omtrent de evolutie van de prijzen

[] Onzekerheid omtrent aanbod van aardgas op lange termijn (eindige energiebron)

[] Andere?

Wetgevingsgerelateerde barrières

[] Gebrek aan specifieke wetgeving en veiligheidscertificatie voor aardgas voor voertuigtoepassingen (variabele samenstelling)

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van aardgasvoertuigen aan te geven met een weergave van hun respectievelijk belang)

5) Biobrandstoffen

Gelieve het belang van de volgende hinderpalen voor de verspreiding van biobrandstofvoertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal).

Technische barrières

[] Energetisch rendement is lager dan voor fossiele brandstof (met eenzelfde hoeveelheid brandstof legt men een kleinere afstand af)

[] Bio-ethanol en biodiesel vertonen bijtende eigenschappen + methanol is toxisch -> er dienen voorzorgsmaatregelen getroffen te worden

[] Indien de brandstof een te groot aandeel aan biobrandstof bevat, kan dit tot compatibiliteitsproblemen leiden met de motoren of met de infrastructuur -> aanpassingen vereist

[] Variatie van de productie in de loop van het jaar, in functie van de teelt

[] Afzettingen in de brandstoftank bij een lange stilstand van het voertuig (biodiesel)

[] De vervanging van de filters dient vaker te gebeuren

[] Andere?

Economische barrières

[] Hogere kost voor de productie van biobrandstoffen ten opzichte van de kost van de productie van conventionele brandstoffen (leidt tot een hogere brandstofprijs)

[] Kostprijs van de grondstoffen

[] Andere?

Marktgerelateerde barrières

[] Probleem van beschikbaarheid (aangezien de oppervlakte van de landbouwgrond beperkt is ontstaat er competitie voor het gebruik van de gronden)

[] Onzekerheid op het vlak van de vraag en van de prijs (rentabiliteit) -> gebrek aan vertrouwen van de producenten

[] Sommige grondstoffen die gebruikt worden voor biobrandstoffen vertonen een hogere rentabiliteit wanneer men ze gebruikt voor andere toepassingen (hout, voedsel)

[] Gebrek aan overtuiging omdat de milieubalans in twijfel getrokken wordt: negatieve gevolgen op het milieu door intensieve landbouw (bestrijdingsmiddelen, gebruik en vervuiling van de waterreserves, verlies aan landschapsdiversiteit, vermindering van de bodemvruchtbaarheid enz.) en door de schadelijke neveneffecten ervan (ontbossing, stijgende kosten van de grondstoffen, problematiek van monocultuur enz.)

[] Andere?

Wetgevingsgerelateerde barrières

[] De vergunningen voor de productie/het gebruik van biobrandstoffen zijn moeilijk te verkrijgen (de goedkeuringsprocedures zijn traag en duur)

[] De kwaliteitsnormen die op Europees niveau vastgelegd werden voor fossiele brandstoffen beperkt de toevoeging van biodiesel aan diesel en van bio-ethanol aan benzine tot 5% (E590-norm voor diesel en EN228-norm voor benzine)

[] Gebrek aan een norm voor de mengsels met hoge concentratie en voor koolzaadolie (probleem voor motorproducenten voor de consument)

[] Er bestaan geen specifieke fiscale voordelen voor mengsels met een hoge concentratie aan biobrandstof

[] Andere?

Politieke barrières

[] Gebrek aan dwingende maatregelen (b.v. : de verplichting voor de olieproducenten om een bepaald aandeel aan biobrandstoffen aan te bieden)

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van biobrandstofvoertuigen aan te geven met een weergave van hun respectievelijk belang)

6) Brandstofcelvoertuigen

Gelieve het belang van de volgende hinderpalen voor de verspreiding van brandstofcelvoertuigen weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal). Opmerking : de barrières die specifiek waterstof betreffen worden in het volgende punt van de vragenlijst besproken.

Technische barrières

[] Technologie is nog niet rijp: nog niet voldoende betrouwbaar, opslagcapaciteit nog te beperkt en nog niet voldoende efficiënt, levensduur is nog te beperkt

[] Verschillende brandstofceltechnologieën (gebruik van verschillende brandstoffen) -> verhindert standardisatie van de brandstofcellen die nodig is om de productiekosten te beperken

[] Beperkingen omtrent waterstof (geldt voor brandstofcel- en waterstofvoertuigen)

[] Zware en omslachtige brandstofcellen

[] Andere?

Economische barrières

[] Hoge productiekost van de brandstofcel leidt tot zeer hoge kostprijs van het voertuig

[] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van brandstofcelvoertuigen aan te geven met een weergave van hun respectievelijk belang)

7) Waterstof (verbrandingsmotor)

-> Het betreft hier de voertuigen die rechtstreeks voorzien worden van waterstof (zonder reformer)

Gelieve het belang van de volgende hinderpalen voor de verspreiding van voertuigen op waterstof weer te geven aan de hand van een score gaande van 0/10 (onbestaande hinderpaal) tot 10/10 (zeer belangrijke hinderpaal)

Technische barrières

[] Groot gewicht en grote afmetingen van het reservoir (vermindert de nuttige ruimte)

[] Specifieke veiligheidsproblematiek en complexiteit van opslag, transport en bevoorrading

[] Er bestaat nog discussie omtrent de te gebruiken grondstof alsook omtrent de productietechniek voor waterstof

[] Andere?

Economische barrières

[] Hoge infrastructuurkost voor waterstofbevoorrading

[] Hoge compressie- en stockagekost gedurende de distributie

[] Hoge productiekost

[] Hoge onderhoudskost

Marktgerelateerde barrières

[] Ontoereikende infrastructuur voor bevoorrading aan waterstof

[] Gebrekkige onderhoudsdiensten (gebrek aan opleiding van de garagisten en mechaniekers)

[] Gebrek aan overtuiging doordat de milieubalans in twijfel getrokken wordt (afhankelijk van de grondstof die gebruikt wordt om waterstof te produceren)

[] Andere?

Wetgevingsgerelateerde barrières

- [] Gebrek aan reglementering en normen voor de productie, verdeling en gebruik van waterstof

Psychologische barrières

- [] Gevaar geassocieerd met waterstof (vraagt bepaalde voorzorgsmaatregelen)

- [] Andere?

Andere? (Gelieve de eventuele andere barrières voor de ontwikkeling van waterstofvoertuigen aan te geven met een weergave van hun belang)

IV. Wenst u bepaalde opmerkingen toe te voegen (opmerkingen omtrent de vragenlijst e.d.m.…)?

V. <u>Persoonlijke gegevens</u>

Instelling:

Functie:

Opleiding:

Appendix 5: Opinions of experts about barriers by category of alternative vehicle

In this part we summarized what have been said by the experts about barriers by category of alternative vehicles. To facilitate presentation, barriers have been classified and are presented in a synthetic way in a box for each category of alternative. The results correspond roughly to the barriers mentioned by the previous group of stakeholders, but some new ideas of barriers often related to more environmental or social criteria (but also other kinds) have been added by the experts.

1. Hybrid vehicles

Economic barrier:
- High price but a sample of experts insists on the *cost-benefit* relation. Indeed, they mentioned that the financial cost is upper the environmental benefits. They mentioned that some conventional diesel vehicles have better cost-benefit relations. It has to be noted that the cleaner the hybrid is (high degree of hybridization) the more expensive it is.

→ **Environmental barrier:**
- Need to drive in a specific way to have significant environmental benefit (environmental benefits for city use but not on motorway).
- Need for clarification of the word “hybrid” (sometimes it’s just marketing sometimes it’s ecological) which have to be classify in function of the degree of hybridization. According to one expert, in the case of Prius the electrical range is rather weak.
- One expert mentioned that the production of the batteries has environmental impacts which balance the advantages of the emissions reduction at the use phase.

Technical barrier:
- Batteries are heavy and cumbersome (the vehicle is heavier).
→ More consumption on motorway (environmental barrier).

Psychological barriers:
- Fear of problems of the consumer because of 2 engines (idea that it’s twice more risky) and fear of the unknown.

Supply problems:
- Limited choices of vehicles.
- Big car only.
- No diesel hybrid in Europe.

Information:
- Contradictory information about the environmental benefit of hybrid vehicles.

Legislative barrier:
- No homologation cycle adapted for plug-in hybrid (to determine the fiscal category).

2. Electric vehicles

Economic barrier:
- High price of the vehicle and of the batteries (which have to be replaced).

Technical/psychological barriers:
- Limited range (considered as a very important barrier for all the experts) and limited speed (considered as less important by most experts). However performances are expected to evolve with the new generations of batteries.
- Long recharging time

→ Economic and technical barriers may decrease with development.

Psychological barrier:
- Too special design (cf. Reva)

Supply barrier:
- Only small vehicles and very short supply: only the Reva (which is not a famous car brand).
- Lack of after-sale services…

Environmental/political barrier:
- Green people and politicians are not always supporting electric vehicles because of nuclear power. More generally, the question of the source of energy used for electricity production is directly linked to the debate about developing electric vehicles for environmental reasons; and use of renewable energy for electric production is a very sensitive question for politicians... Also, we don't know exactly the environmental assessment of electric vehicles as it depends on the source of production of electricity (moreover, a part of the electricity is imported). It represents also an important problem in case of possible implementation of a green tax system and excises based on environmental criteria linked to the LCA (→ **legislative barrier**).

***Other remarks*:**
- It has been mentioned that electric vehicle is an interesting solution for captive fleets, as distances driven are short (limited range is not a problem) and they recharge at a fix point (no problem of access to recharging points).
- One expert was wondering about the reasons why commercialisation of electric vehicles does not come as we speak about it since a long time. He was questioning about possible lobbies of oil industries against electric vehicles development, which would pressurize politicians and prevent electric vehicles promotion.
- Electric vehicles development can be associated to a change of energetic "paradigm" and come up against fossil fuel locked-in, implying a wide range of barriers (see part 3 of the report).

3. Fuel cell vehicles

Most barriers to the development of fuel cell vehicles mentioned by the experts **are related to hydrogen.**

Economic barrier:
- High cost

Technical barrier:
- Immature technology

***Remarks*:**
- There seem to be a lack of knowledge about fuel cell vehicles among the experts.

4. LPG vehicles

Economic barriers:
- Installation costs
- Additional annual tax

Environmental/societal barriers:
- Poor efficiency has been mentioned as well as no significant CO_2 improvement at least for transformed engine (but we don't know so well the emissions of transformed vehicles)
- LPG production is linked to oil (so it is still a limited resource)

Technical barriers:
- LPG vehicles have some technical disadvantages (e.g. LPG system take place in the car) which make them not attractive.
- All the engines aren't adapted for an LPG transformation and we don't know it always in advance (when it is the case, many technical problems occur).
- In general people loose their guarantee when they transform their vehicles.
- Diesel engine is not adapted for LPG.

Technical/legislative barriers:
- Problem of access to underground parking's.

Psychological barrier:
- Fear of gas (explosion)

Political barrier:
- LPG is not supported/promoted enough by public authorities: additional tax[117], suppression of the premium which was allowed in 2001-2002…

→ No (or not enough) incentives.

However, one expert mentioned that there shouldn't be too many incentives to develop LPG use because its availability is limited.

Supply barriers:
- Nearly no dedicated vehicles
- Lack of refuelling stations (not everywhere, not at night…)
- Need to go to an LPG specialist for maintenance and reparations

Remarks:
- There are many barriers but they are usually not considered as very important.
- As mentioned by one expert, the advantage of LPG is that it is a waste (so it is produced anyway). The question is if automobile use is the best utilisation (can be also used for heating appliances).

[117] It has to be note that the additional circulation tax is used to compensate the tax exemption on the fuel, which is used to prevent the risk of defraud with domestic gas.

5. CNG vehicles

Economic barriers:
- Installation of refuelling infrastructure cost (need for subsidies)

Legislative barrier:
- Absence of legislative framework, in particular, uncertainties about excise and so about the price of the fuel (should be tax exempted to avoid defrauds and with a complementary tax as for LPG).

Psychological barrier:
- Fear of gas (explosion).

Supply barrier:
- No refuelling infrastructures (which is complex and expensive).

Technical barriers:
- Limited range.
- Long refuelling time.
- Tank heavy and cumbersome (take space in the car).

Environmental barriers:
- One expert mentioned that there is a lot of uncertainties about the energetic efficiency and about the environmental benefits

→ Need for a complete analysis from well-to-wheel (he notes that if gas comes from Russia it uses a lot of energy for the transport).
- Compression of natural gas increases energy consumption

***Remarks*:**
- Some experts are quite positive about CNG vehicles: they often consider that it is an interesting and realistic alternative (as it is already quite developed in Italy and Germany).
- One expert was wondering if automobile use is the best application.
- It is still fossil energy (limited resource)

Specific remarks have been made for biogas:

- Feasibility only near the production zone of biogas.
- Good solution for captive fleet.
- Application for vehicles is, according to one expert, not the most efficient one. It's better from an environmental and a logistical point of view to recover methane to produce heat or electricity on the spot.

6. Biofuel vehicles

Economic barriers:

- Too expensive for oil industry
- There will be imports of biofuel because Europe won't be competitive
→ this can create new geopolitical dependencies and imply environmental costs of transport
- Price of raw materials may increase.

Environmental barriers:
→ Environmental and social impacts depend on the type of biofuel (very various according to the raw material use, the localisation etc.)
- Problems related to intensive agriculture (use pesticides and water, soil depletion
- Difficulties to check the environmental and the social conditions of imported biofuel (e.g. forest destruction in Brazil…).

Ethical barrier:
- Possible competition with food sector: increase of price, use of ground…
→ Problem in particular for developing countries

Psychological barrier and bad information:
- Contradictory information: message conveyed by the medias is different from some years ago. Indeed, some years ago it was presented as a very good solution and now it is the opposite. Also, opinions differ from one expert to another. People often are confused because they make the amalgam between the different kinds of biofuel.
- Emotional debate because of the ethical and environmental questions related to biofuel. The emotional nature of the debate implies that it is difficult for policy makers to take position.

Legislative barrier:
- Lack of legislation for high blends (E85 not allowed and no existing standard for this fuel in Belgium).

***Remarks*:**
- Biofuel will always remain a partial solution (limited volume of production)
- Need for a control of environmental and social criteria
- Need to focus on second generation of biofuel, which imply much less ethical and environmental barriers.

7. Hydrogen vehicles

Economic barrier:
- High cost of production and storage of hydrogen.

Technical barrier:
- There are still a lot of technical questions that have to be solved.

Environment/technical barriers:
- Question and debate about the way of producing H_2 and the raw material that should be used.
- Problem of bad yield of hydrogen production (need a lot of energy).

Supply barriers:
- No supply of vehicles for the large public.
- No fuel distribution (no infrastructures).

Psychological barrier:
- Fear of explosion.

***Important remarks*:**
- Some experts mentioned that it is a non sense to use hydrogen in vehicles because it is competed with all the energy it comes from (electricity, natural gas,…) because of bad yield; so it is better to use directly electricity or natural gas as a fuel.
- Opinions of experts are very diverse and it seems that there is a lack of knowledge about hydrogen vehicles among the experts.
- One expert mentioned that the success of hydrogen may be explained by the fact that it is a proposition for a car very closed to conventional vehicle, with same performance (and with no emission at the use phase).

BELGIAN SCIENCE POLICY

Clean Vehicle Research: LCA and Policy Measures
(CLEVER)

Preparatory Document for Stakeholder Meetings (Task 5.2)

Vlaamse Instelling voor Technologisch onderzoek (VITO)

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1. Introduction

CLEVER (Clean Vehicle Research) is a research project sponsored by the Belgian Science Policy which aims at promoting the purchase and use of clean vehicles in a Belgian context. In this project, an overall assessment will be carried out on the basis of the results of several assessments:

- A life cycle assessment will allow quantifying the environmental impacts of different vehicles types from cradle-to-grave.
- A life cycle cost assessment will determine the cost per kilometre for the life cycle of the car and will include the purchase price, estimated salvage value, fuel costs, insurance costs, costs of technical control, maintenance costs, battery costs and taxes.
- The social barriers and the fleet analysis will reveal the obstacles confronting new vehicle technologies and limiting the purchase and/or use of clean vehicles.
- The influence of fiscal and other policy measures will be assessed in order to investigate possible policies towards a more sustainable car choice.

In order to assess possible policy measures to promote a more sustainable car choice it is important to gain insight in possible measures and their impact. The report of WP1.3 'Overview of policy measures', gives an overview of relevant policy measures implemented in different countries. Important in the analysis of the different policy measures or instruments were which definition of 'cleaner vehicles' is used and what the impact of the instrument is on the purchase or use of cleaner vehicles. The analysis was based on reviewing literature and other resources, a first start was the literature review on policy measures undertaken in the ecoscore-project on behalf of the Flemish Government (Govaerts et al., 2005).

The analysis was used for the development of policy pathways in Belgium for the promotion of cleaner vehicles. **This report gives an overview of policy measures that were withheld to form these policy pathways. In following tasks, these strategies will be discussed by different stakeholders and will lead to policy recommendations.** Several stakeholder meetings will be organized, with stakeholders from the supply side, with consumers, experts, environmental groups, motorist clubs and policy makers.

2. Specific objectives of the stakeholder meetings

- Discuss the definition of clean vehicles
- Discuss feasibility and effectiveness of policy pathways in Belgium
- Prioritize policy measures and pathways in Belgium

3. Barriers to the introduction of clean vehicles

In task 4.2 of the CLEVER-project, **barriers to the introduction of clean vehicles are to be identified and evaluated** by inquiring of private users, public and private fleet owners, suppliers and experts. **Policy measures should be able to lower this barriers** in order to ease the distribution and the use of clean vehicles. Therefore these measures should be very clear, purposeful and consistent.
In the following paragraphs, only preliminary results are shown. Further research will provide more insight.

3.1. Private users

The reasons given by private users as to not buying cleaner cars, are:

- higher purchase price and lack of financial incentives;
- problems with the supply side and competition with fuel-efficient conventional cars and the low diesel price;
- a lack of information and knowledge (which causes also fear for new technologies and fuels like LPG, CNG, hydrogen…);
- a lack of conviction about environmental advantages for the "true" ecologist.

3.2. Public and private fleet owners

Barriers mentioned by these stakeholders are:

- short supply (not legal if too restricted on the public market) or no appropriate vehicles available (police cars, ambulance…);
- some bad experiences with electric or LPG-vehicles;
- a lack of information;
- small budget.

3.3. Supply side

The main reasons why suppliers are hesitating to introduce environmentally friendly cars are:

- no will to invest in future technology because of uncertainty about demand, future technological developments and future political measures;
- no fuel distribution ("chicken and egg"-problem);
- lack of political measures.

3.4. Experts

The reasons identified by experts for the slow distribution of alternatively fuelled cars are:

- the "lock-in" of fossil fuels (no incentives for alternative fuels);
- the lack of political measures for encouraging clean vehicles;
- the inappropriate tax system (with prices of diesel that are too low);
- a lack of coordination between private and public stakeholders that lead to "uncompleted" products.

4. Definition of clean vehicles

An important part of the analysis of the different policy measures in the Report 'Overview of policy measures', was the definition that was used to define a clean vehicle. **Deciding on the definition is deciding which type of vehicles are to be stimulated by means of the implemented measure.** The different definitions that are listed in the Report, are:

- technology based (e.g. vehicles designed to use alternative fuels, equipped with a particulate filter, etc.);
- CO_2-emission based (e.g. vehicles with a CO_2-emission of less than 105 g/km)
- emission standard based (e.g. euro 4-vehicles);
- ecoscore of the vehicle (e.g. ecoscore > 65);
- a combination of the above.

This is **the first topic that will be discussed during the stakeholder meetings**, and can possibly be of importance when discussing certain policy measures.

5. Policy pathways

One of the conclusions of the Report 'Overview of policy measures', was that **a mix of policies which integrates carrots (incentives), sticks (disincentives) and regulations, has the largest effec**t. This includes a mix of target audiences: steer industry and final consumers, both public and private. Therefore, different policy measures that have proven to be effective will be proposed to the different stakeholders, resulting in policy pathways that consist of a mix of measures. The following measures were withheld to form these policy pathways, and will be presented and discussed during the stakeholder meetings.

- Green car taxation
- Road pricing: kilometre charge and congestion charge
- Subsidies
- Green public fleets
- Availability of clean vehicles and fuels
- User (dis)advantages (parking and restricted zones)

These measures will be discussed briefly in the following paragraphs.

5.1. Green car taxation

Car taxation can be divided into 3 types: acquisition taxes paid with the purchase or registration of a car; ownership taxes which are paid annually like circulation taxes and taxes related to the use of a car, namely fuel taxes (excise duties), and road taxes. This paragraph only deals with the first two types of taxes, which can be critical instruments to achieve the EC's target of 120/130 g CO_2/km by 2012/2015.

5.1.1. Registration tax

Since the registration tax is due at the very beginning of procurement/ownership of a car, this can be considered a good instrument **to steer the purchase decision towards a clean vehicle**.

Issues to be discussed:
- lowest rate (Belgium, 2008: € 61,5)
- highest rate (Belgium, 2008: € 4.957)
- reduction for older vehicles
- …

Examples:
- The Netherlands: reduction or increase depending on relative fuel efficiency and additional "slurp-tax" for vehicles with high CO_2-emission (extra of 110 €/g CO_2 above a certain threshold)
- France: bonus for vehicle with CO_2-emission less than 130 g/km, malus if more than 160 g/km.

5.1.2. Circulation tax

Since the circulation tax is a yearly tax, this can be considered to be a good instrument **to stimulate the replacement of existing vehicles**.

Issues to be discussed:
- lowest rate (Belgium, 2008: € 66,53)
- highest rate (Belgium, 2008: € 3.557,93)
- …

Examples:
- Germany: circulation tax based on cylinder capacity, emission standard and the presence/absence of a particulate filter.
- UK: tax based on CO_2-emissions (differentiation is too small to have an impact on purchase behaviour, min – max: £ 0 - £ 400)

5.2. Road pricing

This section covers a type of pricing mechanism **to encourage reductions in vehicle travel and shifts to other modes of travel**: road pricing. Distance and/or time based pricing and cordon based charges are the most common types of road pricing. These measures change the variable cost of driving either per kilometer, per time of day or per trip. The variable cost is in this case expressed as roadway usage fees that amount to a toll for either each unit of distance travelled, or entry into a specific area.
The purchase cost of a vehicle, which is a fixed cost, represents a high percentage of the costs associated with owning and operating a vehicle. Such fixed costs are not likely to enter into the decision about whether to take a particular trip. By shifting some of these fixed costs to variable, paid each time the car is used, a signal could be sent to drivers regarding the real costs of each trip. This in turn may encourage reductions in vehicle use and shifts to car pools, and to other modes of transportation. If pricing is implemented for travel on specific routes, at specific times, it may reduce vehicle travel in a very targeted manner, with some drivers choosing simply to switch the route or time of particular trips. Such a targeted approach may be very useful for reducing congestion and eliminating traffic bottlenecks. Moreover, when benefits are given to drivers of clean vehicles, e.g. lower tolls, a higher share of clean vehicles using the route or entering the city may be expected.

5.2.1. Kilometer charge

In a typical 'kilometer charge' scheme, a driver pays per driven kilometer. **The price per kilometer can be differentiated on the type of road (e.g. city roads, highways…), the time of the trip (e.g. during peak hours or not) and the environmental performance of the vehicle.** A tracker is installed on every vehicle in order to monitor the position of the vehicle to define the type of road, and the time of the trip. This information is then sent to the back-office by means of e.g. GPRS. The back-office then calculates the charge that has to be paid, according to the environmental performance of the vehicle.

Issues to be discussed:

- differentiation parameters (time of day, type of road, environmental performance…)
- lowest rate
- highest rate
- inclusion/exclusion/decrease of excise duties on fuel
- reduction for older vehicles
- …

Calculation example:

Passenger car, 120.000 km over 8 years. Current total taxes (exclusion of excise duties):

- lowest rate: € 61,50 + 8 * € 66,53 = € 593,74 → average of 0,005 €/km
- highest rate: € 4.957 + 8 * € 3.557,93 = € 33.420 → average of 0,280 €/km

Examples:

- German Motorway Toll (for heavy duty vehicles): based on emission standard, number of axles and kilometers driven. Registered with On-Board-Unit and GPS/GSM-technology. Applicable only on highway and some secondary roads.
- Switzerland: kilometer charge for heavy duty vehicles replaces annual road taxes. Based on distance travelled, maximum weight and emission standard. Applicable on every road.

5.2.2. Congestion charge

This is a road pricing scheme that is limited to a geographical area, typically a city centre. The price could be differentiated on the time entering the area (e.g. peak hours vs. off peak) and the environmental performance of the vehicle.

In the London and Stockholm Congestion Charge, the system is enforced by means of license plate recognition systems. The license plates of vehicles entering the area is being monitored by means of camera's, and this information is sent to the back-office. The back-office then calculates the charge that has to be paid, according to the environmental performance of the vehicle.

Issues to be discussed:

- differentiation parameters (time of day, environmental performance…)
- lowest rate
- highest rate
- reduction for older vehicles
- …

Examples:

- London Congestion Charging Zone: a daily charge of £ 8 to be paid when entering the Central or Western Extension Zone, from 7 am to 6 pm. Reduction of 90% for residents and exemption for taxis, motorcycles, clean vehicles (electric, hybrid, LPG, CNG…). Proposal to increase the daily charge for vehicles with CO_2-emission > 225 g/km (£ 25) and exemption for vehicles emitting less than 120 g CO_2/km.
- Stockholm: charge per passage depending on period (from € 0 to € 2,20, with a maximum of € 6,60 per day). Buses, taxis, motorcycles, clean vehicles (electric, fuel with alcohol-mix)… are exempt.

5.3. Subsidies

Subsidies are all kind of direct financial incentives given at the moment of purchase of a car or retrofitting the car which can not be qualified as fiscal incentives. European subsidy regulations are quite complicated and there is a clear shift from subsidies towards fiscal incentives for cleaner vehicles.

Subsidies can be a good instrument to compensate the social consequences of measures targeting polluting vehicles. Older and thus more polluting vehicles tend to belong to socially weaker classes, which would be targeted disproportionately. Subsidies for achieving less polluting vehicles, eventually coupled with the income, can form (part of) the solution.

5.4. Green public fleets

Mandatory or voluntary fleet quota for public fleets are expected to result over the long term in a general improvement in the environmental performance of the whole fleet through economies of scale, lower costs and wider deployment of enhanced environmentally friendly vehicle technologies. In other words, **fleet quota for clean vehicles create an ensured market for clean vehicles**, from which other (private) consumers can benefit on a later stage: price of clean vehicles decrease through economies of scale, fuelling infrastructure is developed, etc.

Examples:

- The European Commission published a proposal for a mandatory quota of 25 % of “Enhanced Environmentally Friendly Vehicles” (EEV) in public fleets (EC, 2005c), in a first stage limited to vehicles above 3,5 ton weight. This would represent a 10 % share of the total heavy duty market. Later on, this could be extended to light duty vehicles also. This proposal is now being finalised, and would be based on life time costs, including external costs of polluting emissions.
- Flanders: voluntary agreements with local authorities (cities, municipalities and provinces) to introduce cleaner vehicles in their fleet for which they can receive a subsidy, based on the ecoscore. In addition there is a proposal for mandatory criteria

for the environmental performance of new passenger cars purchased by Flemish government and linked institutes, also based on the ecoscore.

5.5. Availability of clean vehicles and fuels

5.5.1. Clean vehicles

An important measure to promote the introduction of cleaner vehicles is **to stimulate the car industry to bring the cleanest vehicles on the market**, which can happen voluntary or mandatory. Important examples of this measure are the voluntary agreements or standards that exist world wide on fuel economy and CO_2-emmissions of light duty vehicles. In such a system, credits are sometimes given for the production of vehicles running on alternative fuels.

5.5.2. Clean fuels

Some car manufacturers offer certain environmentally friendly vehicles running on alternative fuels within their product range. However, these **alternative fuels are not always readily available on the market**, which severely limits the sale of these vehicles. This can have several reasons:

- fuelling infrastructure for these fuels is not available in regular fuelling facilities;
- the price of the fuel at the pump is too high;
- no regulatory framework is available for the fuel (official standard, legal requirements for refuelling infrastructure, etc).

These issues can be resolved by some policy measures:

- regulating the availability of the fuel by creating incentives for the fuel distribution sector;
- regulating the availability of the fuel by mandating the fuel distribution sector to offer a certain amount of alternative fuels at their refuelling stations (e.g. Sweden);
- creating incentives to the users of these fuels, often exemption from excise duty (e.g. bio-ethanol in France, Germany, etc.);
- standardizing the fuel, e.g. by adopting an international agreement (e.g. bio-ethanol);
- facilitating the expansion of the refuelling infrastructure (eg. CNG)

Also to be discussed is the difference in excise duty on petrol and diesel fuel, in favour of the latter, which is less environmentally friendly (more CO_2 per liter than petrol, causes emission of NOx and particulate matter)

5.6. User (dis)advantages

Local authorities can put into action a set of initiatives with the aim of promoting clean means of transport and a more sustainable environment. These initiatives are, due to their local applicability, often defined as user (dis)advantages. **User advantages can aim at offering benefits to consumers who drive environmentally friendly vehicles.** In general, the benefits are of financial nature. A common example of this type of measure is reduced parking fees for clean vehicles. On the other hand, user disadvantages have the purpose to discourage the use of environmentally unfriendly vehicles. This can be obtained by e.g. prohibiting the entrance to a certain area and/or at a certain time, generally city centres, of vehicles not corresponding to a minimum emission standard.

5.6.1. Parking fees

Parking policies can be designed to target certain groups or types of vehicles. An approach that is starting to become more and more prevalent, is differentiating parking fees on the basis of the environmental performance of vehicles. By doing so, cities and municipalities can contribute to improving the local air quality and the environment in general.

5.6.2. Environmental zones

An environmental zone, also called a restricted area, can be considered as an area where a selective admittance policy for vehicles is imposed in order to increase liveability. Restricted areas are often implemented to increase air quality, reduce noise and decrease congestion. The environmental zones that are implemented in Europe are measures to ensure that cities will comply with the future air quality standards set by the European Union. Access can be limited based on the environmental performance of the vehicles. This kind of measure is focused rather on reducing pollutant emissions (particulate matter, NOx, …) and not so much on reducing CO_2-emissions, since this does not affect air quality.

Example:

- Germany: limited access to certain urban areas depending on the particulate matter emissions (recognizable through the colour of a sticker).

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REPORT

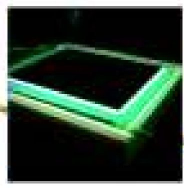
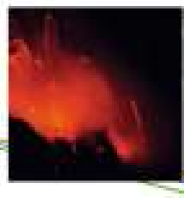
CLEVER (Task 5, Deliverable 5.2):

Stakeholder support for proposed policy measures

Michiel Vanderschaeghe, Tobias Denys, Leen Govaerts, Olivier Mairesse

Study accomplished under the authority of Belgian Science Policy
20../Unit/R/

April 2009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SUMMARY

This report is the result of the stakeholder meetings organized in November and December 2008. Several stakeholders (industry, users, policy makers…) met to discuss possible policy measures that could ease the introduction of cleaner vehicles and – as a result – green the whole fleet.
In a first part an overview is given of the discussions themselves. In the following chapter the evaluation forms that were handed out at the end of each sessions are analysed and in the last chapter some policy scenario's are initiated. These are to be elaborated in a next report, where also the consequences of those policy sets on the whole fleet will be calculated.
Almost all stakeholders agree on the fact that an environmental basis for car taxes is needed and that a well-to-wheel-approach is necessary to compare all kinds of vehicles and fuels. Modulating on the running costs, which is possible with a kilometre charge, may be a very effective solution, but will be hard to implement in the near future.
In each case all partners feel the urgent need for a coherent mobility policy. Stakeholders from the industry ask for a stable market and clear views for the future to be able to develop their products.

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LIST OF ABBREVIATIONS

CV Euro	Definition clean vehicle based on Euro emission standard
CV CO2	Definition clean vehicle based on CO_2-emission
CV combi	Definition clean vehicle based on combination of CO_2–emission and Euro emission standard
CV techn	Definition clean vehicle based on drive technology
CV ecoscore	Definition clean vehicle base don the Ecoscore
RT abolish	Abolition of the registration tax
RT env perf	Registration tax dependent on environmental performance of the car
ACT abolish	Abolition the annual circulation tax
ACT env perf	Annual circulation tax dependent on environmental performance
RP km	Road pricing: kilometre charge
RP congestion	Road pricing: congestion charge
CM incentive	Incentives for car manufacturers to make and sell clean cars
CM mandating	Mandate car manufacturers to make and sell clean cars
Adv. EURO5/6	Advantages for Euro 5/6 cars
CF low excise	Lower excise duties for clean fuels
CF stdz	Standardization of clean fuels
CF incentive	Incentives to supply clean fuels
CF mandating	Mandatory quota for clean fuels
parking fee	Variable parking fees (lower for clean vehicles)
limited access	Environmental city zones with limited access
SUBS retrofitting	Subsidies for retrofitting older cars with (diesel) filters or cleaner fuel systems (LPG, CNG…)
SUBS replace fleet	Subsidies to replace older cars by new ones in order to speed up the fleet renewal
GPF voluntary	Voluntary green public fleet quota
GPF mandatory	Mandatory green public fleet quota
GPF private	Also quota for private fleets?

CHAPTER 1 INTRODUCTION AND ORGANIZATION

1.1 Introduction

Sustainable mobility is a very important issue for the future. On the one hand mobility demand most probably will keep rising, due to several social and economical factors, but on the other hand fossil fuel resources are limited, space and road capacity is limited and there is a ever growing – and appropriate – awareness for the quality of the environment. Besides mobility management and modal shift (towards more public transport, bicycles…), there is also a need for cleaner vehicles. The CLEVER-study (CLEan VEhicle Research) focuses on conventional and alternative passenger cars. After a state-of-the-art on (clean) vehicles has been made up, Life Cycle Environmental Assessments and Life Cycle Costs Assessments will be worked out within the CLEVER-study and barriers that exist towards the introduction of those vehicles will be listed up in a first stage.

From a user perspective, life cycle cost is often an important factor to choose a new vehicle. Insight in the real cost for the complete life cycle of the car is important, as well for the consumer as for the policy makers in order to influence the purchase and car use behaviour. That's why task 5 of the CLEVER-study focuses on policy measures that may ease the introduction of cleaner vehicles for companies, individuals and public authorities, by modulating those costs.
The CLEVER work package 5 has the inventory of existing measures (work package 1.3) as a starting point. This overview was presented and discussed in a series of stakeholder meetings, in order to see which measures are supported by which stakeholders. This document is the report of the stakeholder meetings: the different opinions are described and support for and agreement on the proposed measures (according to the concerned stakeholders) are statistically analyzed.

The analysis of the support of this policy measures by the different stakeholders will lead to the elaboration of different policy scenarios (from rather conservative to frankly progressive), of which the impact on the fleet composition and environmental burden will be investigated in a further stage. Of course, the purpose of this all will be that total emissions decrease.

1.2 Organization of the stakeholder meetings

1.2.1 Sessions and participants

The stakeholder meetings were held at the end of 2008 in the buildings of Belgian Science Policy, in Brussels. Several (Belgian) stakeholders from different concerned groups (industry, users, non-governmental organisations, policy makers) were contacted by e-mail or by telephone a few weeks before and received a discussion paper resuming the measures in advance. For each meeting 10 to 15 participants would be present, which was a good number to have varied but still manageable discussions.

Eventually, four stakeholder meetings have been organized:

- 27 November 2008: stakeholders from the industry (car manufacturers, fuel suppliers…)
- 28 November 2008: users and non-governmental organisations (environmental, automotive, lease companies…)
- 1 December 2008: French spoken session with mixed stakeholder groups (industry, users, ngo's and policy)
- 3 December 2008: policy makers

Table 1: List of participants on the 4 stakeholder meetings

Stakeholder meeting 1 (27 November 2008): INDUSTRY	
Name	**Company / organisation**
Erwin Vandenbergh	Hydrotane
Hendrik Lemahieu	Alco Bio Fuel
Alfons Maes	Belgian Biodiesel Board
Jo Declercq & Hugo Clysters	Ford
Jean Wibaut	General Motors
Erik Vandenheuvel & Wim Rommel	Mercedes-Benz
René Aerts jr. & Peter Van Leuven	Volvo Cars
Ewoud Van Der Heyden	BMW
Joeri De Ridder	AVERE (ASBE)
Pol Michiels	FEBIAC
Daniel Labours	FEDERAUTO
Stakeholder meeting 2 (28 November 2008): USERS AND NON-GOVERNMENTAL ORGANIZATIONS	
Name	**Company / organisation**
Patrick Auwerx	Mobiel 21
Joeri Thijs	Greenpeace
Jeroen Verhoeven	Friends of the Earth
Floris Ampe & Bart Vanham	PriceWaterhouseCoopers
Lieven Beyl	Athlon Car Lease
Moniek Denhaen	Touring
Marc Lebrun	Fleet & Business
Tony Verhelle	Autogids
Stakeholder meeting 3 (1 December 2008): FRENCH SPEAKING (mixed group)	
Name	**Company / organisation**
Paul Verwilghen & Alexander Schmertz	Primagaz
Marc Maes	BioWanze
Luk Duerinck	Belgian Petroleum Federation
Marc Bocqué	PSA (Peugeot – Citroën)
Koen Dekoning	Toyota
Jacques de Selliers	Reva
Frédéric Chemay	Federal Cabinet of the Minister of Climate and Energy (P. Magnette)
Michel Degailler & Sébastien Grogna	FPS Health and Environment
Pascal Théate	Walloon environmental administration
Laurent Bodarwé	Brussels Institute for the Environment

Julien Vandeburie	Walloon Environmental Council for Sustainable Development
Colette Pirlot	Fiscal Cell of the Walloon Region
Marc Lebrun	Fleet & Business
Stakeholder meeting 4 (3 December 2008): POLICY MAKERS	
Marc Roman	Federal Cabinet of the Minister of Mobility (E. Schouppe)
Marc Kwanten	FPS Transport and Mobility
Johan Malcorps	Groen! (Flemish environmental party)
Roland Straetmans	sp.a (Flemish socialist party)
Marleen Govaerts	Flemish Administration, Mobility and Public Works
Yves Dupont & Guido Moermans	City of Hasselt

1.2.2 Discussion and issues

The three meetings in Dutch have been led by VITO (L. Govaerts, T. Denys and M. Vanderschaeghe), the meeting in French (on the 1st of December) by professor W. Hecq, Marion Englert and Fanny Lecrombs of the ULB (Université Libre de Bruxelles). At the beginning of the meeting the objectives of the CLEVER-project have been explained and afterwards the possible policy measures were discussed one by one. This was done by presenting them first with a slightly provocative proposition on a PowerPoint-slide (see Figure 1), which immediately clarified the nature of the measure. The following slide gave a more thoughtful overview of the issues to be discussed concerning that certain measure. Participants were free to speak about all aspects of the measure and those opinions were noted down by the research partners, to be digested in a summarizing report (Chapter 2).

Figure 1. Example of provocative proposition

Issues discussed during the stakeholder meetings, were:

- Definition of a clean vehicle: based on the Euro emission standard, the CO_2-emission, a combination of both, on the Ecoscore[1] or on vehicle technology?
- Registration tax: abolish, base on environmental performance, reduction for older cars?
- Annual circulation tax: abolish (and shift to road pricing?), base on environmental performance?
- Road pricing: congestion tax (zones, prices…?), road pricing (kilometre charge, differentiation, technology and time horizon…?)
- Availability of clean vehicles and fuels: mandating, incentives, standardizing?
- User (dis)advantages: like variable parking fees, environmental zones in cities…
- Subsidies: for replacing older cars, for retrofitting cars with diesel filters, LPG/CNG-systems…?
- Green public fleet: mandatory or voluntary, also for private fleets…?

1.2.3 Evaluation form

After the actual discussion session, an evaluation form was handed out to the attendants. The purpose of this form was to have a simple, summarizing overview of the stakeholders' opinions on all proposed measures. They were asked to fill it in during the last quarter of an hour of the session and to scale each measure from 1 to 3 (from low to high) on the respective factors effectiveness, feasibility and priority. An example of such an evaluation form can be found in Annex A. The forms were collected at the end of the meeting, in order to be processed statistically afterwards. More explication will be given in paragraph 3.1.

[1] The Ecoscore is a comprehensive well-to-wheel emission tool, developped by VITO, VUB and ULB on behalf of the Flemish government. It takes both direct and indirect emissions of passenger cars into account and this for greenhouse gasses, pollutants (like CO, HC, NOx, PM…) and noise.

CHAPTER 2 REPORT OF THE STAKEHOLDER DISCUSSIONS

Hereunder we will present the different opinions of the different stakeholders, as expressed verbally during the meetings. Of course not every single statement will be dealt with, but we have aimed at giving a global overview of all standpoints and positions.
First, we discuss them per measure group. Later on the essence of the position of each different stakeholder group will be summarized in the conclusions.

2.1 Definition of a clean car

Industry:

- Following the majority of the 'industry" group (car manufacturers and fuel suppliers, both conventional and alternative) European rules should be followed as much as possible, since every definition is arbitrary in a way. Moreover, the industry needs a stable framework – for example on a European scale – in order to be able to define a development strategy for (alternative) technologies. However, definitions should be adapted also to the context (e.g. availability of energy sources) and to the objectives they are intended to achieve.
- Whether a car is a clean car depends very much on how the car is used (e.g.: "a car that doesn't drive, doesn't pollute"…) and from a similar point of view it is clear that a segmentation may be necessary (as a multi people carrier will never be as frugal as a small city car).
  Electric car dealers think that we should make more use of small, electric driven cars (for only two persons for example) for our daily (and mostly individual) movements in often urban districts.
- Mainstream car manufacturers said that the definition should not be technology based, since all technological possibilities must be kept open to solve the mobility issue and such a definition can completely take away the chances of a certain technology.
- Some clearly take the polluting emissions of fine particles, nitrogen oxides et cetera into account, others say that bad air quality is a reversible (and almost solved) problem and that we should focus on greenhouse gases, that form a global and long-term challenge.
- An alternative fuel supplier still underlined that not only tank-to-wheel emissions have to be considered, but the whole well-to-wheel cycle.

Users / ngo:

- Environmental organizations said that cars will never be 100% clean, and that immediate action is necessary. They should not base the definition on CO_2 alone since this is only part of the story, nor solely on the Euro emission standards, since these are lobbied conventions, but base it on the Ecoscore, which is a comprehensive well-to-wheel indicator.
- Consultants on the other hand stated that is better to go step by step, with very clear definitions that are easy to communicate. Therefore, CO_2 may be a good

criterion, since everybody is very familiar with the concept nowadays. The Ecoscore is too unknown as a concept.

- Also for the motorcar organisation the Ecoscore is unacceptable, since the car (and the individual mobility) is once again too harshly judged. We should just follow European rules, based on CO_2 and emission standards.

Policy:

- For policy makers it is clear that CO_2 isn't the only criterion, but also local pollutants like tropospheric ozone, particulate matter and nitrogen oxides. The latter two are even likely to become the biggest problem in the near future, as European standards for local air quality won't be met. Moreover the whole LCA (Life Cycle Analysis) of car and fuels must be considered.
- Politicians are however aware of the fact that Belgium is a small country and that the industry wants to align with European standards as much as possible. On the other hand definitions should take the available energy vectors in a certain country into account and they should be dynamic in function of time (more stringent as technology improves) and purpose of the measure.
- After all the environmental impact of a vehicle depends strongly on the number of kilometres driven.

2.2 Policy measures

2.2.1 Registration tax – annual circulation tax

Industry:

- More than one representative of the car industry would be happy to see the registration tax abolished, since it forms a threshold for the purchase of a new car and hence for the renewal of the fleet towards cleaner cars. For the same reasons they wouldn't apply reductions for older and second hand cars.
- The existing taxation rules, based on engine capacity and power are, still according to them, completely outdated, since engines have become ever more efficient, delivering more power with less emissions and a lower fuel consumption. Anyhow, the rules have to be – once again – very clear, transparent and socially correct.
- Alternative car manufacturers have the opinion that the registration tax nor the circulation tax should be abolished since these are good instruments to steer the purchase. On the contrary, they would even increase it or make it for example car size dependent. Road pricing may be an even better taxation system, but it is quite complicated compared to the circulation tax.

Users / ngo:

- A member of the press agreed on the fact that the actual taxation system is totally outdated as it is barely linked to the environmental impact of a car.
- Since the purchase cost is a bad predictor (buyers rather take the running costs into account, see the success of diesel cars because of the less expensive fuel), the accountancy side would modulate more on the running costs and therefore abolish the registration tax, which forms a threshold to the break-through of new technologies, because less new cars are being bought.
- Environmental organizations didn't agree with that, because they state that there are already enough cars on the road and that both the ownership as the use of the car should be discouraged. Owning a car (and having made the big investment) means using the car, not owning a car doesn't mean that the user doesn't have access to individual mobility (there are alternatives like the bicycle, the Cambio car sharing system, public transport…).

- The car users organization found that the focus is too much on the car taxation and too less on a comprehensive view on co-mobility (in which all means of transport are involved). This time environmentalists and cars users did agree, and thought it is a real pity that there is no mobility policy at all in Belgium and that mobility is hardly taken into account in spatial planning and land use decisions. Indeed, firstly there have to be valuable alternatives (integrated in a consistent mobility policy) before car users can be taxed more heavily.
- Another difficult issue concerning taxation is the social aspect: everybody has the right on mobility, so everybody has to be able to pay the taxes due.

Policy:
- Policy makers say that the registration tax is a direct incentive and as such one of the best tools to steer the purchase towards cleaner cars, but nevertheless taxation should be oriented more on the actual use of the car.
- The change in car taxation should happen gradually since the government has been promoting diesel cars (that are more polluting than petrol cars) and as a consequence a lot of people own a diesel car nowadays. This dieselification proves also that fuel prices play an important role, and that cleaner cars and fuels can be promoted by giving advantages (e.g. lower excise duties) to clean fuels.
- To make a kind of social correction the car taxation may be linked to the family size (bigger families need bigger cars), and taxes for really big or extremely powerful cars should then increase exponentially instead of linearly.
- A member of the green party said we have to think very well about social corrections in the form of lower taxes for second hand cars, because the pollution by those older cars (sometimes used as a second car by well-off families) causes most trouble in the cities, where relatively much poorer people are living.
- Policy makers are also aware of the fact that the industry wants to gear their strategy on European standards, and that one (small) country shouldn't deviate too much.

2.2.2 Road pricing

Industry:
- In the case of a congestion tax (e.g. in a city) there is much agreement about the fact that there have to be alternatives first, like extended common transport, parking lots outside and shuttles to the city, e-working… since nobody drives around in a jammed city for his or her pleasure. The revenues of such a tax should also be used to improve the mobility services in and around the city.
- Road pricing on the other hand may be a valuable but complicated taxation system. Therefore some suggest to simply rise the taxes on fuels as a kind of "non-intelligent" road pricing. Road pricing might be a long-term solution as it should be organized on a European scale (difficult to install only in a transit country like Belgium), but this shouldn't stop short-term initiatives for a green car taxation.

Users / ngo:
- The car users organization is not willing to pay a congestion charge, since no coherent mobility policy exists and there are no valuable transport alternatives. The environmental organizations remarked that the seat occupancy is an important issue in this. A fleet operator added that often respectable commuters are the victim and that employers keep demanding more flexibility.
- For the environmental organizations, a kilometre charge is an important issue and technological barriers must not be used as an alibi to retard the introduction of it – there is rather a lack of political guts… Maybe there is still little support for smart kilometre charges nowadays, but this support will grow as people see the benefits of it, according to them. Still: taxes on vehicles and traffic still may be raised, since

there are too much cars and too much congestion, but the tax rise can be mitigated for clean vehicles.
- Consultants stated that a kilometre charge must be in function of a better mobility (e.g. time based) and the car users organization are opposed to a kilometre charge as long as there is no coherent mobility policy.

Policy:
- Also policy makers thought about raising the fuel excise duties as a simple form of kilometre charge, but then it is impossible to differentiate on the basis of time or place. On the other hand, variable prices will only have an effect if price differences are big enough. According to them, GPS is the best suited technology.
- For some, congestion tax in cities is unacceptable from a social point of view, because the rich will simply pay it and the poor will have difficulties to find alternatives. Others said that investing massively in common transport to improve urban mobility is on the other hand a very social measure. Anyhow these taxes should be used not only to mitigate the congestion of the cities, but also to develop common transports, taxis services, cycle tracks… and to change the mentality, because the car is often chosen too easily as a 'solution'.

2.2.3 Availability of clean vehicles and fuels

Industry:
This was an issue on which the stakeholders from the industry of course had a strong view.
- Car manufacturers claim they have invested massively in the development of alternative drive trains. The technology exists, but the costumers are not willing to buy those vehicles because the appropriate fuels aren't available. This is the so-called "chicken or the egg"-problem. Therefore all stakeholders (car manufacturers, fuel suppliers and costumers) need each other and the government should regulate this market, in order to force a breakthrough.
- The government should create a stable framework so that suppliers can draw up business plans and that they have the security that investments will pay. Nowadays, there is no policy at all and the chicken-and-egg problem will stay.
- One should concentrate on what exists already (e.g. electricity, natural gas, LPG, biofuels, hybrid vehicles…) and don't wait for the exactly right thing that may be coming in the far future. Policy makers should support this existing alternatives, like LPG as a starting point.
- Today due to the failing distribution (caused by a lack of rules[2]) the biofuel industry doesn't get the opportunities to develop. Also the development of second generation biofuels (more energy efficient and not longer produced on the basis of agricultural products that could serve also as food) isn't stimulated at all in this way.
- Also conventional fuel suppliers found that biofuels should have a fiscal advantage on the European level.
  Another interesting idea was to tax the fuels on the basis of their carbon-content. As such diesel should be more expensive than petrol, also for reasons of public health. Moreover, due to the disproportional demand in diesel fuel in Europe, diesel has to be imported from Russia and the surplus of petrol to be exported to the States nowadays. This isn't an efficient way of working at all.
- If the government fails to cope with this issue, private partners may cooperate to set up a (local) fleet with alternative fuels. You don't always have to wait for the government. In Berlin e.g. a cooperation between electricity suppliers and manufacturers of EV's introduced 300 EV's in Berlin.

[2] The situation at the beginning of 2009 in Belgium was like this: an excise-free biofuel production quotum was attributed to 7 producers, but there are no incentives or rules at all for the distribution sector to distribute this biofuel fraction, so it hardly happens…

- Mandating the manufacturers won't work at all, because firstly there has to be a stable market. Of course car manufacturers are willing to meet the demand. The voluntary approach for lowering CO_2-emissions did not work either because the other pillars of the CO_2-strategy were not implemented (e.g. fiscal measures) so consumers did not follow the offer of the manufacturers.
- Dealers also have a responsibility in promoting cleaner vehicles to consumers

Users / ngo:

- Also consultants and fleet managers stated that both the government and the manufacturers/suppliers have to take responsibility. The government should play an activating role and create a market. Supply and demand should be regulated by the government.
- Environmental organizations threw in that manufacturers and suppliers like to play the victim, but they are the first to lobby. Since these are huge companies, they have an immense power to keep things just as they want.
- Often, the energy consumption and energy efficiency of a car matters far more than what fuel is used. Internal combustion engines are very energy inefficient as they lose 70% of the energy in heat, compared to electric engines which lose only 20% of their energy in heat and have an energy efficiency of 80%.
- Don't just choose alternative fuels, but look critically at the well-to-wheel impact. Also, use the right fuels for the right application.

Policy:

- Policy makers thought that mandating the manufacturers indeed could be too severe, but that nevertheless strong incentives should be given to them and that the government has a role to play in the creation and stimulation of a market for clean vehicles.
- They admitted that concerning alternative fuels, a lot still has to happen in Belgium, but asked the question if a small country like Belgium, with a limited number of energy vectors should stake on all possible fuels or drive trains. Choices have to be made in function of the needs and the available sources. Choices also depend on the considered term.
- Still regarding alternative fuels, the whole LCA must be considered, from well to wheel, and then, some (but not all) biofuels are a good thing.
- Not only clean vehicles should be promoted (and older vehicles replaced), above all clean fuels (with a low carbon content and less polluting) should be introduced as soon as possible thanks to a lower price at the pump. In a first step these fuels should be compatible with the existing cars. In a next step other alternative fuels should be developed on a European scale in order that car manufacturers can make dedicated models.
- Anyhow, the physical rules of refinery should be followed. If one uses too much diesel, the refinery is more expensive and will emit more CO_2. LPG may be a particularly good instant solution for older (petrol) vehicles, to make them less polluting.
- Again, it would be better to have a visionary European strategy, but maybe it won't be bad to have a kind of ambitious Belgian 5- or 10-year plan - within the European context.

2.2.4 User (dis)advantages

A general remark about these user advantages and disadvantages (like variable parking fees, limited access in urban zones for less or more polluting vehicles…) is that such measures can't work on their own. They have to be embedded in a comprehensive mobility policy, otherwise they don't make sense or can be perceived as not being valid or even unfair.

Industry:
- Without all-embracing mobility policy those measures will have a low impact and besides, there have to be alternatives.

Users / ngo:
- Consultancy people remarked that one has to take care of the implementation costs compared with the benefits.
- Environmental organizations said it’s never a good idea to provide free parking space for cars in the city, even for clean cars, as the city isn’t a place for cars. At the most, they should benefit a reduced fee.
- People shouldn’t only be punished, they have to get something in return too. Therefore: sticks at macro-level and carrots at micro-level, like these (dis)advantages.
- Another idea: special traffic lanes for cars with more than 1, 2… occupants?

Policy:
- In the cities the biggest problem are the fine particles and thus environmental zones can be planned, with scrap premiums as a social correction factor, for less wealthy people with an older and more polluting car.
- Another good alternative is a well organized public transport. The problem is that people only take the fuel costs into account when choosing between their car and bus/tram/train and that is another reason why car driving costs should reflect the total cost.

2.2.5 Subsidies

Industry:
- Subsidies are often a good instrument to make social corrections to a green car taxation, but on the other hand everybody has right to it (a cleaner car is good for everybody), just like there should not only be a premium for retrofitting filters or alternative fuel systems, but also new cars equipped with it in a standard way, should receive such a premium.
- Even though a long term vision may be a better thing, measures should have an effect on the short term (also because terms of office last 4 year in Belgium…). So subsidies may be better than fiscal incentives, as the former have direct financial effects.
- Subsidies are a good tool if older vehicles are replaced by environmental friendly ones. This replacement is a good thing both from an ecological and from an economical point of view (as recently has been proven in e.g. Germany).
- The renewal or adaptation of the fleet has to be durable. Therefore subsidies shouldn’t be just temporary, this will only destabilize the market.

Users / ngo:
- Subsidies may be good measures to give incentives before start punishing.
- Why only subsidies for cleaner cars and not for bikes?

Policy:
- Subsidies are a direct measure, whereas it takes about 2 year to feel the effects of fiscal advantages. The effect of a subsidy also strongly depends on the height of the premium.
- 12.000 people die prematurely each year because of particulate matter. Therefore a subsidy for retrofitting diesel particle filters is an urgent case, even for older diesel cars. But on the other hand, if subsidies are given for retrofitting filters, these cars will keep driving on our roads.
- Why should we only give subsidies to the less rich to hand in their old car for a newer, cleaner one? Some families really need two cars and a clean car instead of

on old car is always good. Therefore, subsidies may be linked to the size of the family and be inversely proportional with the income.
- If the government attributes subsidies, there must be taxes to pay it too. The durability of a measure is something difficult to predict. Measures are evaluated each year: is it still needed and are the books balanced?

2.2.6 Green public fleets

Industry:
- Advanced green fleets may be possible in and around cities, because in that case vehicles are never far away from their special refuelling infrastructure.
- Even more important than making an example, is the possibility to familiarize people with the alternative vehicles.

Users / ngo:
- In the end it's the tax payer who pays for it.
- Green public fleets are already being realized by means of public contracting.

Policy:
- Of course this is a strong signal from the government, but the green cars also have to be available. For normal passenger cars, there are already some alternatives, but for special purpose vehicles there aren't. Moreover, there have to be a certain number of possible suppliers to make a public tender valid.
- The use of cleaner vehicle in public fleets would create small market segments, that would lower the costs and give opportunities to alternative fuels.
- Not only the federal and regional level should use green fleet, but also municipalities can buy more green vehicles.

2.2.7 Note on company cars

Some discussion partners also mentioned the company cars and the often associated fuel card. These cars are often seen as the root of all evil concerning the mobility and environmental issue. Though they can be used as levers also, since they introduce the latest technologies and are renewed every three or four years.
The unlimited use of a fuel card and the following improper use of company cars at the other hand, is a problem. Therefore setting an upper limit on fuel may be part of the solutions. Anyway, some collective agreements contain tools for efficient driving (green driving sessions…).

2.3 Conclusions of the stakeholder discussions

Almost all stakeholders agree on the fact that the current tax system – based on fiscal horsepower – is outdated as there is barely a link with the environmental impact of the car. They also state that it is better to have a comprehensive mobility policy with coherent measures and valuable alternatives for the car, instead of loose measures. Another point of agreement is the urgent need for a stable market for clean vehicles and clean fuels, with well-defined rules so that manufacturers and suppliers can align their development and sales strategy.

Evidently, there are also diverging opinions. According to the 'industry'-side we should follow the European rules in defining a clean vehicle (like the combination of CO_2 and Euro emission standards) and a segmentation of car types is necessary for the

application of this definition. They realize that a well-to-wheel approach is necessary to compare fuels.
Conventional car manufacturers would like to abolish the registration tax to fasten up the renewal of the fleet and would make the annual circulation tax dependent on the environmental performances of the car. Alternative car makers would not abolish the registration tax, but make it a powerful instrument to steer the purchase. A kilometre charge may be a solution, but it will be a long-term solution and will have to happen on a European scale. Still according to them, clean technologies are available, but a stable framework is needed to fully develop them. Subsidies are a good idea, but they have to be durable in order not to destabilize the market. This group of stakeholders don't want more stringent rules for the car only, but see more good in a comprehensive mobility policy with valuable alternatives.

The group of 'users / ngo' is a somewhat heterogeneous group. They emphasize that a well-to-wheel approach is needed in order to define what is a clean car and underline the importance of the seat occupancy and the number of kilometres driven as well. They think the registration tax is a particularly good instrument to steer the purchase of cars, but there has to be modulated also on the actual running costs. For the environmental organizations, kilometre charging is a very important point.

For the policy makers it is clear that not only the CO_2-emissions define a clean car, but also the emissions of CO, NOx, PM, HC… and that it would be easier to follow the European rules in this respect. In order to define a clean car, one has to take the availability of energy sources in a certain country into account too. Next to the maintenance of the registration tax, they also would like to modulate on the running costs and know the importance of the fuel prices (diesel versus petrol or biofuels!). Kilometre charge is indeed a solution, but for the longer term. What is working well on the short term, are subsidies, which have a direct effect. They realize that the fuel card that comes with a lot of company cars is a real problem.

CHAPTER 3 ANALYSIS OF THE EVALUATION FORMS

3.1 Purpose of the evaluation form

The stakeholders were asked to fill in the evaluation form at the end of the discussion session (during the last quarter of an hour). An example of this form can be found in Annex A. In this form an overview was given of all considered measures and this measures had to be scaled on:

- effectiveness: 'Will this measure really facilitate the introduction of clean vehicles?'
- feasibility: 'Will it really be possible to put this measure into practice?'
- priority: 'Should this measure be introduced urgently or rather on the long term?'

Each factor had to be scaled with 1 (= low), 2 (= medium) or 3 (= high).

The purpose of this concluding document was to get the vision of every participant, even of those who had not had the opportunity or did not like to explain his or her stand point during the discussion. Moreover, in the course of the whole session all participants had the opportunity to hear the vision of every party and had the time to think about the whole problem, which may have confirmed, improved or changed the visions.

A possible minus of the evaluation form is the simple set-up, by which it was not possible to give an opinion on policy mixes (as several participants said that some measures only make sense if they are embedded in a comprehensive policy), but only on the separately mentioned measures. On the other hand, the form was meant to be filled in in a quarter of an hour, at the end of the meeting. The evaluation of several policy mixes, or the cross-checking of different measures in one evaluation form would have made it too complicated and too troublesome for the stakeholders and they could have given up after an already intensive discussion session.

3.2 Respondents

In total 40 forms have been filled in and handed in. Table 2 shows the distribution of the respondents.

Table 2: Distribution of the respondents on the evaluation form

TOTAL = *40*			
INDUSTRY *(19)*		Conventional cars/fuels	Alternative cars/fuels
	Car manufacturing and sales	10	2
	Fuel supply	1	6
USERS / NGO *(9)*	Consultancy	2	
	Automobile club	1	
	Fleet owner/manager	1	
	Environmental organization	3	
	Press	2	
POLICY MAKERS *(12)*		12	

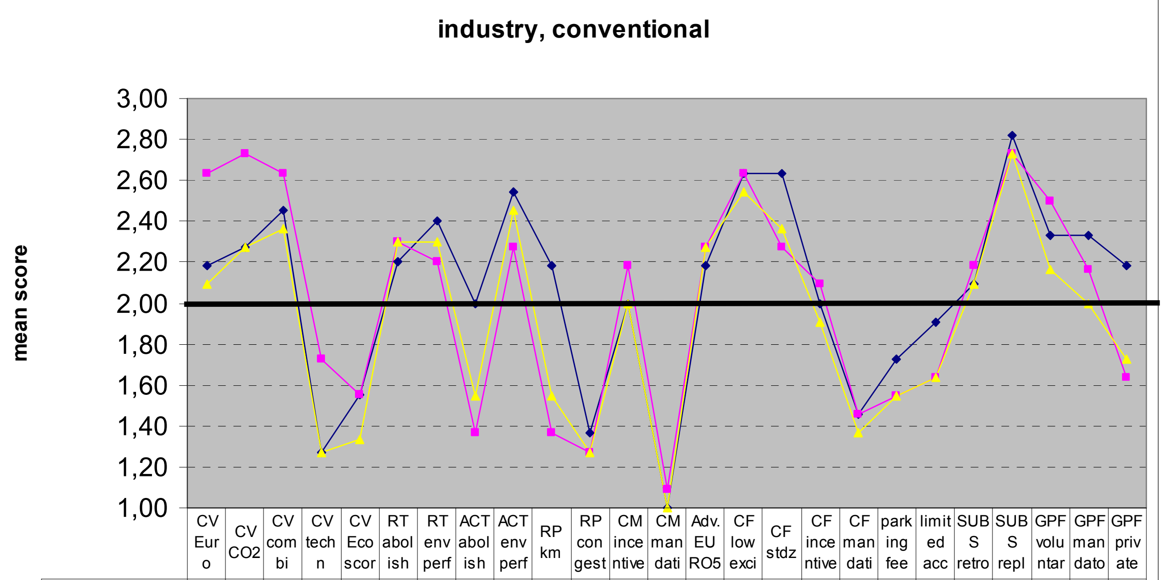
3.3 Statistical analysis of the forms

3.3.1 Mean scores

A first and evident step in analyzing the filled in forms, is to look at the mean scores attributed at the 'effectiveness', 'feasibility' and 'priority' of the proposed measures. We will make a distinction between different stakeholder groups in order not to blur all distinct opinions, because from Chapter 2 it is clear that different stakeholders often have different concerns and thus different opinions.
Remember that a score of 1 means low (effectiveness, feasibility or priority), 2 is medium and 3 is high. In the graphs the value of 2 is marked by a bold line by way of cut-off. If the mean score is above this line, thus above 2, one can say that the proposed measure is supported.

→ ***INDUSTRY, CONVENTIONAL:***

The mean scores of the representatives of conventional car manufacturers and suppliers of conventional fuels are depicted in Figure 2.



	CV Euro	CV CO2	CV combi	CV techn	CV Ecoscor	RT abolish	RT env perf	ACT abolish	ACT env perf	RP km	RP congest	CM incentive	CM mandati	Adv. EU RO5	CF low exci	CF stdz	CF incentive	CF mandati	parking fee	limited acc	SUBS retro	SUBS repl	GPF voluntar	GPF mandato	GPF private
effectiveness	2,18	2,27	2,45	1,27	1,56	2,20	2,40	2,00	2,55	2,18	1,36	2,00	1,00	2,18	2,64	2,64	2,00	1,45	1,73	1,91	2,09	2,82	2,33	2,33	2,18
feasibility	2,64	2,73	2,64	1,73	1,56	2,30	2,20	1,36	2,27	1,36	1,27	2,18	1,09	2,27	2,64	2,27	2,09	1,45	1,55	1,64	2,18	2,73	2,50	2,17	1,64
priority	2,09	2,27	2,36	1,27	1,33	2,30	2,30	1,55	2,45	1,55	1,27	2,00	1,00	2,27	2,55	2,36	1,91	1,36	1,55	1,64	2,09	2,73	2,17	2,00	1,73

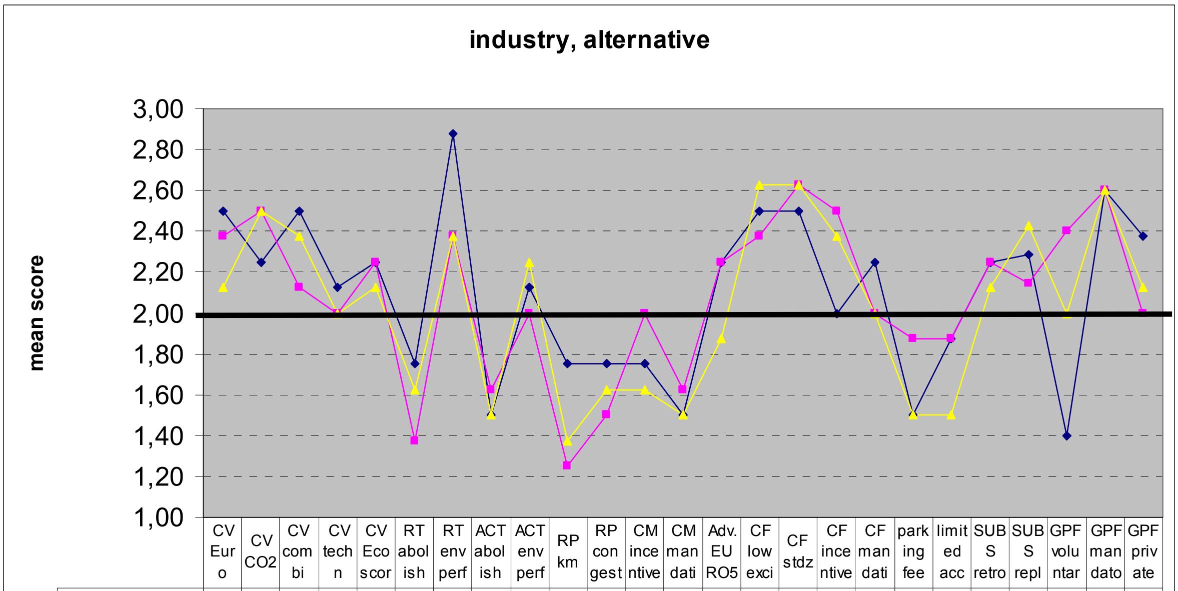
Figure 2: Mean scores of stakeholders from the industry (conventional) on effectiveness, feasibility and priority

<u>Definition of clean vehicles (CV):</u>
The representatives of the conventional car manufacturers and suppliers of conventional fuels think it is best to use well-known criteria like Euro emission standards or the CO_2-emissions to define clean cars. Even better seems to be a combination of both, as the effectiveness is still judged higher.
A definition on basis of the used technology or the Ecoscore is not supported.

<u>Policy measures:</u>
These stakeholders are an advocate of the abolition of the registration tax (RT). However if it persists to exist, they should make it dependent on the environmental performances of the car. Making the annual circulation tax (ACT) dependent on the environmental performances in order to steer the fleet towards cleaner cars even gets more support. Leaving that circulation tax in favour of a kilometre charge (RP, road pricing) has to deal with a low feasibility and as such with a low priority, although the effectiveness of a kilometre charge could be high. A congestion charge as a measure is rejected.
Mandating manufacturers (CM) or fuel suppliers (CF) is not the favourite measure of these stakeholders, giving incentives can count on more support. For them it is much better to advantage the purchase of a Euro 5/6 car, lower the excise duties on clean fuels and having standardized them.
User advantages or disadvantages like variable parking fees or environmental zones with limited access get low scores. Subsidies (SUBS) for retrofitting older cars with filters or alternative fuel systems and especially subsidies for buying new, clean cars (e.g. a scrap premium) get more support.
Quota for green public fleet (GPF) seem to be a good idea, but doing the same for private fleets too will be harder to implement, still according this stakeholder group.

→ ***INDUSTRY, ALTERNATIVE:***

The same analysis is done for suppliers of alternative cars (like electric cars) or alternative fuels (LPG, CNG, biofuels…). This is depicted in Figure 3.



	CV Euro	CV CO2	CV combi	CV techn	CV Eco scor	RT abolish	RT env perf	ACT abolish	ACT env perf	RP km	RP con gest	CM incentive	CM mandati	Adv. EU RO5	CF low exci	CF stdz	CF incentive	CF mandati	parking fee	limited acc	SUBS retro	SUBS repl	GPF voluntar	GPF mandato	GPF private
effectiveness	2,50	2,25	2,50	2,13	2,25	1,75	2,88	1,50	2,13	1,75	1,75	1,75	1,50	2,25	2,50	2,50	2,00	2,25	1,50	1,88	2,25	2,29	1,40	2,60	2,38
feasibility	2,38	2,50	2,13	2,00	2,25	1,38	2,38	1,63	2,00	1,25	1,50	2,00	1,63	2,25	2,38	2,63	2,50	2,00	1,88	1,88	2,25	2,14	2,40	2,60	2,00
priority	2,13	2,50	2,38	2,00	2,13	1,63	2,38	1,50	2,25	1,38	1,63	1,63	1,50	1,88	2,63	2,63	2,38	2,00	1,50	1,50	2,13	2,43	2,00	2,60	2,13

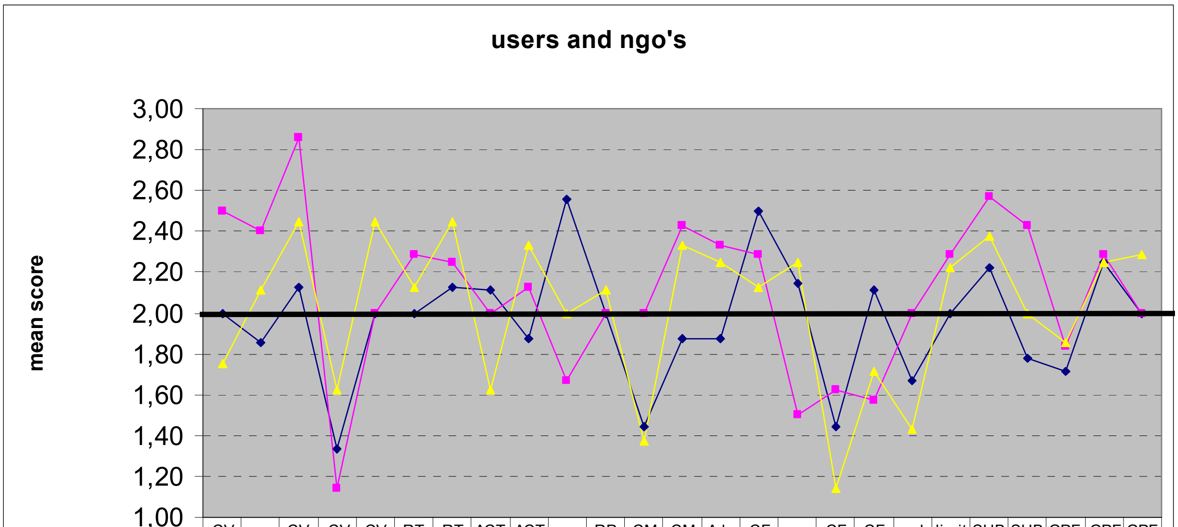
Figure 3: Mean scores of stakeholders from the industry (alternative) on effectiveness, feasibility and priority

<u>Definition of clean vehicles (CV):</u>
Representatives of alternative car or fuel makers are in favour of almost all proposed definitions. Although a CO_2-based definition may be the most feasible, it would not be the most effective. That role is granted to a definition on the basis of the Euro standard or a combination of CO_2-emissions and the Euro standard. Also the Ecoscore gets good points and even a technology based definition scores more than 2 on all aspects, although it is rated lower than other definitions.

<u>Policy measures:</u>
In contrary to the conventional industry side, there is absolutely no support here to abolish the registration tax (RT) and all the more to give it an environmental impact. The annual circulation tax (ACT) should not be abolished too, and made dependent on the environmental performances.
Propositions on road pricing schemes (RP), like a kilometre charge or congestion charge, get only a lukewarm response, just like incentives or mandates for car manufacturers (CM), although the aversion is not that big here like in the above case.
For these stakeholders it is clear also that clean fuels (CF) have to be standardized, excise duties lowered and cleaner cars, like Euro 5 or 6 cars, advantaged. There is even support to give incentives to clean fuel suppliers, or even to mandate them. The latter may be more effective, but less feasible.
Users (dis)advantages are not seen to be that good, subsidies (SUBS) may have positive effects.
If green fleet quota are being installed, they should be mandatory to be effective and also private fleets should be concerned.

→ ***USERS AND NGO's:***

Although the group 'users and ngo's' (non governmental organizations) is a very heterogeneous group, with e.g. environmental organizations next to a car users organization, the data are treated as a whole (in Figure 4) because there is no objective ready-to-use criterion to divide them in separate categories.



	CV Euro	CV CO2	CV combi	CV techn	CV Eco scor	RT abol ish	RT env perf	ACT abol ish	ACT env perf	RP km	RP con gest	CM ince ntive	CM man dati	Adv. EU RO5	CF low exci	CF stdz	CF ince ntive	CF man dati	park ing fee	limit ed acc	SUBS retro	SUBS repl	GPF volu ntar	GPF man dato	GPF priv ate
effectiveness	2,00	1,86	2,13	1,33	2,00	2,00	2,13	2,11	1,88	2,56	2,00	1,44	1,88	1,88	2,50	2,14	1,44	2,11	1,67	2,00	2,22	1,78	1,71	2,25	2,00
feasibility	2,50	2,40	2,86	1,14	2,00	2,29	2,25	2,00	2,13	1,67	2,00	2,00	2,43	2,33	2,29	1,50	1,63	1,57	2,00	2,29	2,57	2,43	1,83	2,29	2,00
priority	1,75	2,11	2,44	1,63	2,44	2,13	2,44	1,63	2,33	2,00	2,11	1,38	2,33	2,25	2,13	2,25	1,14	1,71	1,43	2,22	2,38	2,00	1,86	2,25	2,29

Figure 4: Mean scores of stakeholders from users and NGO's on effectiveness, feasibility and priority

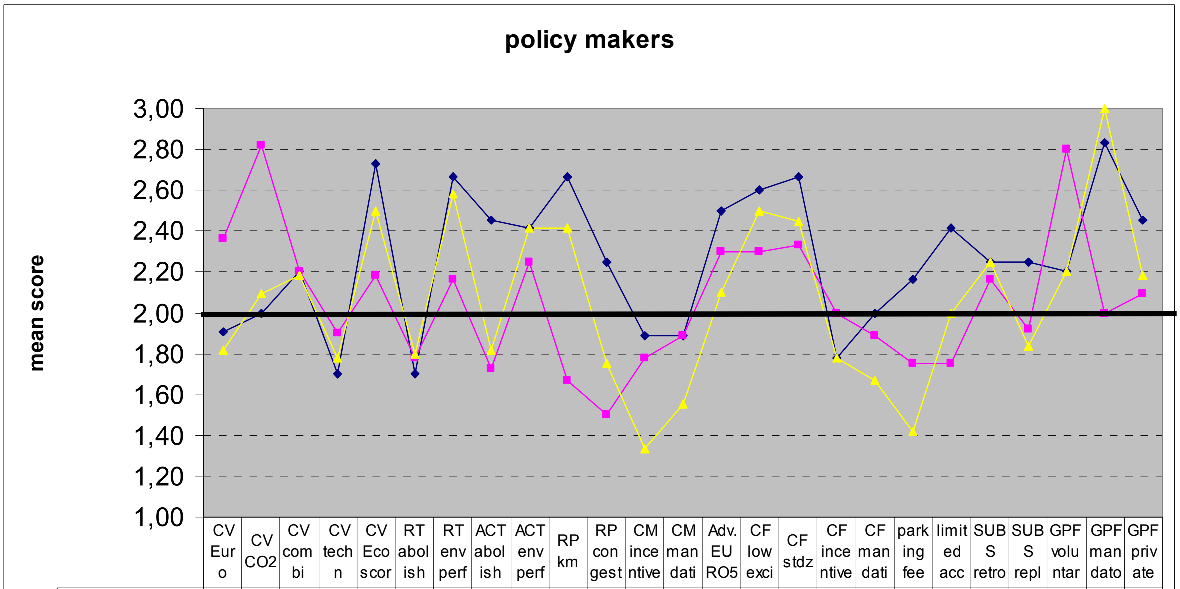
<u>Definition of clean vehicles (CV):</u>
CO_2-emissions as the only criterion is perceived as less effective than the Euro emission standard or a combination of both. This last definition gets the highest priority and is also seen as easily feasible. The introduction of the Ecoscore to define clean vehicles also gets high priority, but the feasibility of this measures should be lower. As in the case of the stakeholders from the conventional industry, a technology based definition is not thought to do the job.

<u>Policy measures:</u>
As the considered stakeholder group is quite heterogeneous here the opinions from the evaluation forms are not that pronounced. However it is remarkable that the 'feasibility'- and 'priority'-scores don't follow the 'effectiveness'-score that good as in the two graphs above. In general those scores are situated higher than the 'effectiveness'-score here, meaning that these stakeholders feel some urge. "Don't waste no more time, just let's do something about it!"
There is a tendency to abolish the registration tax (RT) and the annual circulation tax (ACT) and to replace them by a kilometre charge (RP). These stakeholders also realize that this quite effective measure will be a bit hard to implement. The effect of making the registration tax dependent on the environmental performances is seen as somewhat bigger than doing the same with the circulation tax. In contrast with the other stakeholder groups talked about above, a congestion charge gets any support here. Especially environmental organizations would like to reduce the car use with such road pricing schemes.

Car manufacturers (CM) and suppliers of (clean) fuels (CF) rather should be mandated to bring cleaner products on the market than given incentives. Anyhow there is not much support to advantage the purchase of vehicles, even if these are cleaner Euro 5/6 cars. See also the 'effectiveness'-score for subsidies (SUBS) to replace older cars by new ones. Clean fuels (CF) on the other should be standardized and supported with lower excise duties.
Variable parking fees won't do it, but limited access environmental zones would make more sense. Also subsidies to retrofit clean systems get good scores.
Quota for green public fleet (GPF) will be most effective when they are mandatory and private fleet should be included also in such measure.

→ ***POLICY MAKERS:***

In a last graph (Figure 5) the opinions of policy makers (from cabinets, political parties, governmental organizations and city councils) are analyzed.



	CV Euro	CV CO2	CV combi	CV techn	CV Ecoscor	RT abolish	RT envperf	ACT abolish	ACT envperf	RP km	RP congest	CM incentive	CM mandati	Adv. EU RO5	CF low exci	CF stdz	CF incentive	CF mandati	parking fee	limited acc	SUBS retro	SUBS repl	GPF voluntar	GPF mandato	GPF private
effectiveness	1,91	2,00	2,20	1,70	2,73	1,70	2,67	2,45	2,42	2,67	2,25	1,89	1,89	2,50	2,60	2,67	1,78	2,00	2,17	2,42	2,25	2,25	2,20	2,83	2,45
feasibility	2,36	2,82	2,20	1,90	2,18	1,78	2,17	1,73	2,25	1,67	1,50	1,78	1,89	2,30	2,30	2,33	2,00	1,89	1,75	1,75	2,17	1,92	2,80	2,00	2,09
priority	1,82	2,09	2,18	1,78	2,50	1,80	2,58	1,82	2,42	2,42	1,75	1,33	1,56	2,10	2,50	2,44	1,78	1,67	1,42	2,00	2,25	1,83	2,20	3,00	2,18

Figure 5: Mean scores of policy makers on effectiveness, feasibility and priority

<u>Definition of clean vehicles (CV):</u>
Although CO_2-emissions would be by far the most easy definition to implement, a combination with the Euro emission standards would have more effect. The criterion of choice however is the Ecoscore, which is perceived as very effective as well as feasible.

<u>Policy measures:</u>
The present policy makers are not likely to abolished the registration tax (RT) but to give it an environmental component instead. Doing the same with the annual registration tax (ACT) is an urgent matter, but abolish it and replace it by a kilometre charge (RP) could be even more effective. Because of the estimated lower feasibility however this type of measure gets a lower priority.
The stakeholders from the policy side are not inclined to give incentives to the car manufacturers or fuel suppliers, nor to mandate them, but the advantages should

rather go to the products themselves: advantages for cleaner Euro 5/6 cars, standardization and lower excise duties for clean fuels.
User (dis)advantages like variable parking fees or limited access zones get high ‘effectiveness’-scores but lower ‘feasibility’-scores. Subsidy-regulations (SUBS) also would be successful, but a scrap premium (or put in other words, a subsidy to accelerate the renewal of the fleet) could be harder to implement.
These stakeholders are strongly in favour of (mandatory) quota to green public fleets (GPF), and also the fleet composition of private fleets should be regulated.

3.3.2 Highest and lowest rated measures per stakeholder group

We will investigate the most important ‘do’s’ and ‘don’ts’ of the different stakeholders, in order to get further insight in the various interests and sensitivities, and as a kind of summary. We split up the stakeholders in the same groups ‘industry’ (conventional / alternative), ‘users/ngo’ and ‘policy makers’.

Only the scores on ‘effectiveness’ are investigated, because primo this was the first aspect to be scored and this reflects best the global idea of a stakeholder about the measure and secondly because the effectiveness is closely connected to the willingness of a stakeholder to support a certain measure. Ultimately the effectiveness of a measure is also the most important aspect of it – feasibility is something that can and must be overcome and priority is an assessment of the urgency.

The scores are sorted descending for each stakeholder group and a horizontal bar shows the central score of 2 (= moderate). In each case we just list up the most and the least effective measures according to the different stakeholder groups. We are confining to the five highest and lowest scores.

→ ***INDUSTRY, CONVENTIONAL:***

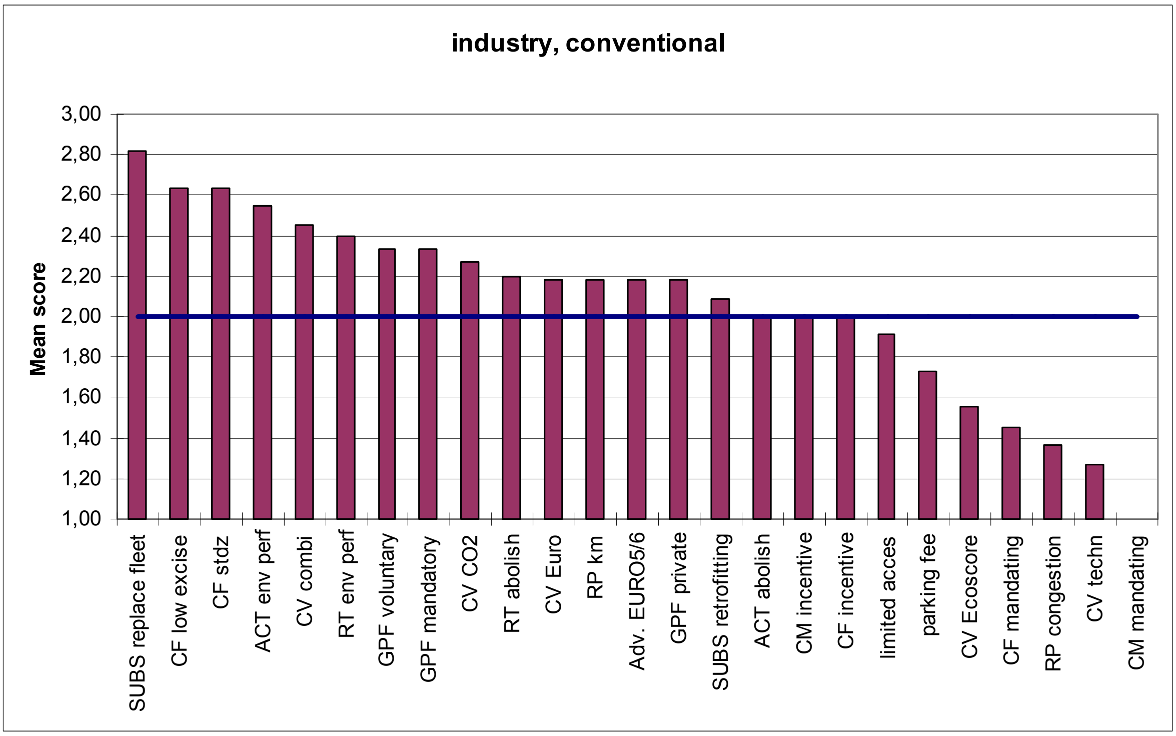


Figure 6: Ordered mean scores on effectiveness (industry, conventional)

INDUSTRY, conventional	
Most effective	**Least effective**
Subsidies to replace the fleet	Mandating car manufacturers
Lower excise duties for clean fuels	Definition clean vehicle: technology based
Standardization of clean fuels	Road pricing: congestion charge
Annual circulation tax ~ environm. perf.	Mandating (clean) fuel suppliers
Definition clean vehicle: Euro + CO_2	Definition clean vehicle: Ecoscore

The conventional car manufacturers and suppliers of conventional fuels are won over to subsidies to fasten up the replacement of the fleet by newer and cleaner cars (which is quite logical, this would stimulate the sales) and to measures to promote clean fuels, like lower excise duties and standardization. The annual circulation tax should also be linked to the environmental performances of the car (like also the registration tax (RT) does!). As a definition for clean vehicles, the conventional industry side wants to have a combination of the Euro emission standard and the CO_2-emissions.

Quite logically, they don't like the idea of mandating the car manufacturers or fuel suppliers. Neither don't they like measures that would mitigate the unlimited mobility, like a congestion charge or limited access zones. The definition of a clean car shouldn't be based on the used technology nor on the Ecoscore.

→ ***INDUSTRY, ALTERNATIVE:***

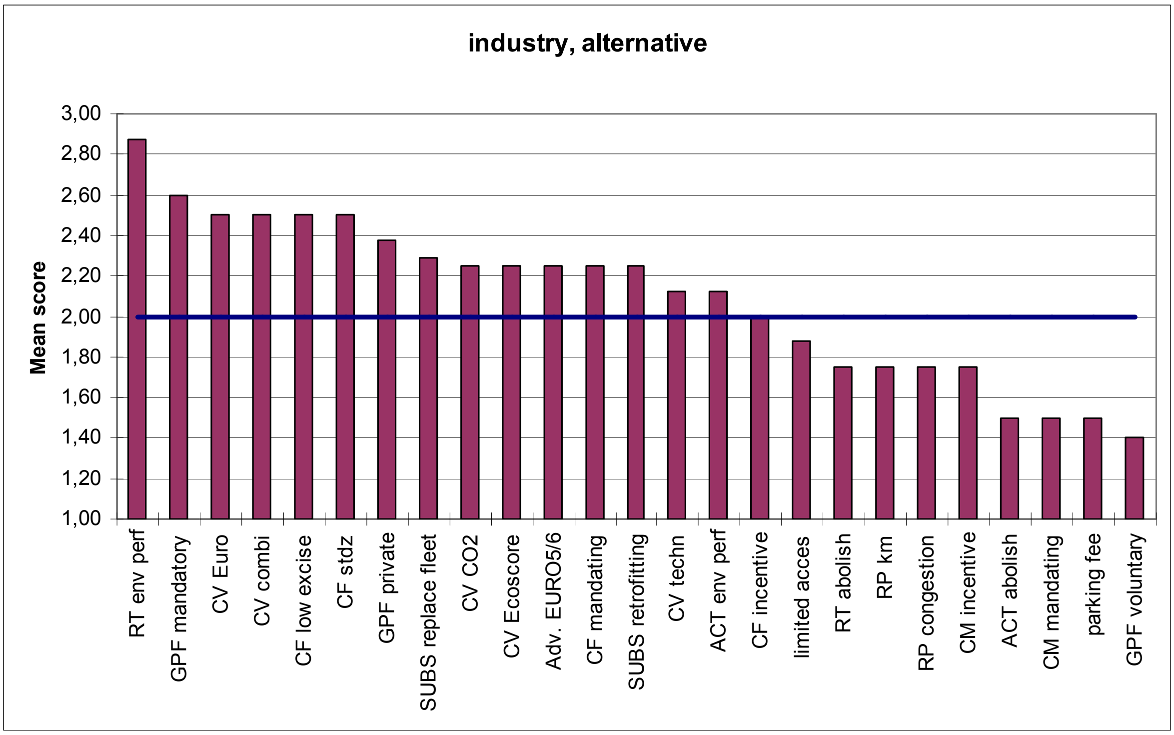


Figure 7: Ordered mean scores on effectiveness (industry, alternative)

INDUSTRY, alternative	
Most effective	**Least effective**
Registration tax ~environm. performance	Voluntary quota for green public fleet
Mandatory quota for green public fleet	Variable parking fees
Definition clean vehicle: Euro standards	Mandating car manufacturers
Definition clean vehicle: Euro + CO_2	Abolition of the annual circulation tax
Lower excise duties for (standardized) clean fuels	----

According to alternative car makers and alternative fuel suppliers, most effective measures may be a registration tax (which should thus not be abolished!) based on the environmental performance of the car. A clean car should be defined on the basis of the Euro emission standards or a combination with the CO_2-emission. Also the alternative industry stakeholders think that lower excise duties for and the standardization of clean fuels may be very effective, which is logical since a lot of fuel suppliers were between them. Quota for more clean cars in public fleets must be mandatory,
as voluntary quota won't have much effect. Also this stakeholder group doesn't believe in mandating the car manufacturers to make and sell more clean cars. The application of variable parking fees on itself won't be effective, as also the abolition of the annual circulation tax won't.

→ ***USERS AND NGO's:***

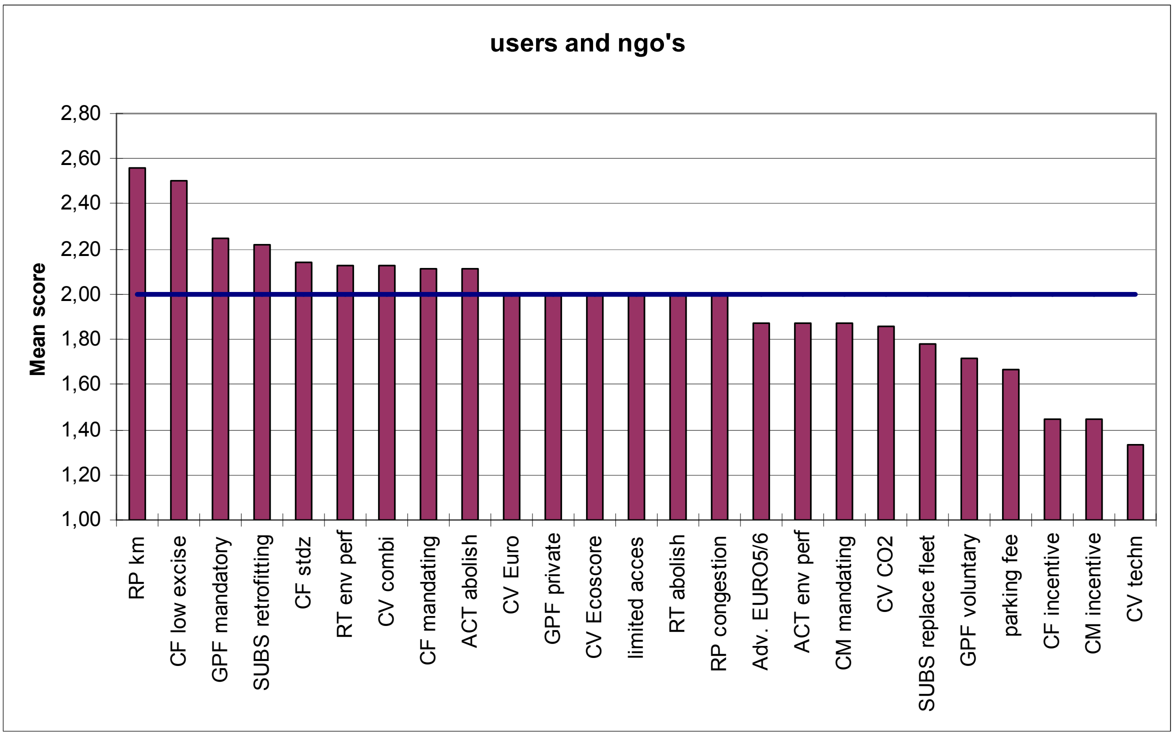


Figure 8: Ordered mean scores on effectiveness (users and ngo's)

USERS and NGO	
Most effective	**Least effective**
Road pricing: kilometre charge	Definition clean vehicle: technology based
Lower excise duties clean fuels	Incentives for car manufacturers
Mandatory quota for green public fleet	Incentives for (clean) fuel suppliers
Subsidies for retrofitting	Variable parking fees
Standardization of clean fuels	Voluntary quota for green public fleet

A lot of stakeholders in this category think that a (smart) kilometre charge will be the most effective solution, in combination with a registration tax that depends on the environmental performances. Clean fuels have to be promoted with lower excise duties and clear regulations about them. For these stakeholders it is an obviousness that public bodies should must the example with mandatory green fleet quota.

A definition based on the used technology won't do – they rather choose for a combination of Euro emission standards and CO_2-emissions – nor won't incentives to incite manufacturers and suppliers to sell clean vehicles and fuels. Variable parking fees are not seen as effective and as written above fleet quota should not be voluntary, but mandatory.

→ ***POLICY MAKERS:***

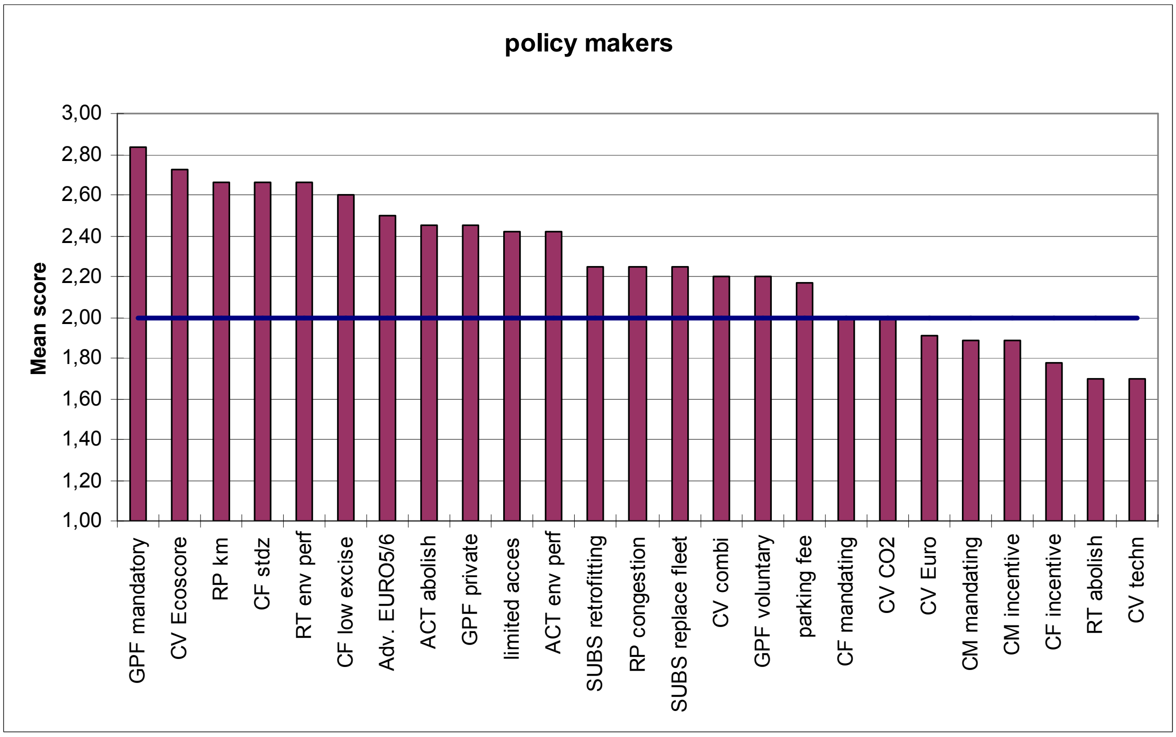


Figure 9: Ordered mean scores on effectiveness (policy makers)

POLICY MAKERS	
Most effective	**Least effective**
Mandatory quota for green public fleet	Definition clean vehicle: technology based
Definition clean vehicle: Ecoscore	Abolition of the registration tax
Road pricing: kilometre charge	Incentives for (clean) fuel suppliers
Standardization of clean fuels	Incentives for car manufacturers
Registration tax ~ environm. performance	Mandating car manufacturers

Policy makers realize they have to give the good example by making their own fleets as green as possible, by means of mandatory quota. Furthermore, they estimate a kilometre charge as one of the most effective measures coupled to a environmental dependent registration tax. The definition that is necessary for this, should be based on the Ecoscore of cars. For them, it is clear too that alternative fuels have to be standardized.

No much good is seen by this stakeholder group in a definition of clean vehicles based on the technology that is used. They wouldn't like the give up the registration tax. Just giving incentives to manufacturers and suppliers won't have much effect neither.

CHAPTER 4 POLICY SCENARIO DEVELOPMENT

Individual policy measures only won't be enough to ease the introduction of clean vehicles, there will have to be a consistent policy mix for the promotion of clean cars. The composition of such a set of measures will be based on the study of the real effectiveness of them, on the barriers to the purchase and use of clean cars, life cost analyses (LCA), the price elasticities et cetera. Another important item that has to be considered in this context is the support of the stakeholders, which is dealt with in this report.
Hereunder we will initiate the composition of the policy scenarios based on the perceived effectiveness, feasibility and priority of the consulted stakeholders. Two scenarios will be proposed at first:

- a realistic scenario (REAL) with measures that get quite unanimous support on most aspects;
- a progressive scenario (PRO) with measures that may be very effective but that are harder to implement (feasibility) or get less support by all stakeholders.

In task 5.3 (Scenario development) these scenarios will be fully worked out and a third, downright visionary scenario will be composed and analysed too.

4.1 Realistic policy scenario (REAL)

Ideal measures to be taken are measures that get a high score on both effectiveness, feasibility and priority (all scores higher than 2, or all but one scores higher than 2). It means that these measures are seen as potentially having a big impact, while they are relatively easy to implement. As such it shouldn't take much time to install those measures.
Nevertheless, there are also measures that could have a high impact, but are difficult to implement, and therefore not adequate to include in a realistic, short-term policy mix scenario. These will be taken up in the progressive scenario.

In Table 3 all mean scores of the different stakeholder groups are shown together and values greater or equal to 2 are marked in green. Policy measures supported by virtually all stakeholders on all aspect are marked in dark green.

Table 3: Overview of all mean scores on effectiveness, feasibility and priority by stakeholder group (green scores: >=2,00)

Policy measure	Industry, conv.			Industry, alt.			Users & ngo's			Policy makers		
	Eff	**Fea**	**Prio**	**Eff**	**Fea**	**Prio**	**Eff**	**Fea**	**Prio**	**Eff**	**Fea**	**Prio**
CV Euro	2,18	2,64	2,09	2,50	2,38	2,13	2,00	2,50	1,75	1,91	2,36	1,82
CV CO2	2,27	2,73	2,27	2,25	2,50	2,50	1,86	2,40	2,11	2,00	2,82	2,09
CV combi	2,45	2,64	2,36	2,50	2,13	2,38	2,13	2,86	2,44	2,20	2,20	2,18
CV techn	1,27	1,73	1,27	2,13	2,00	2,00	1,33	1,14	1,63	1,70	1,90	1,78
CV Ecoscore	1,56	1,56	1,33	2,25	2,25	2,13	2,00	2,00	2,44	2,73	2,18	2,50
RT abolish	2,20	2,30	2,30	1,75	1,38	1,63	2,00	2,29	2,13	1,70	1,78	1,80
RT env perf	2,40	2,20	2,30	2,88	2,38	2,38	2,13	2,25	2,44	2,67	2,17	2,58
ACT abolish	2,00	1,36	1,55	1,50	1,63	1,50	2,11	2,00	1,63	2,45	1,73	1,82
ACT env perf	2,55	2,27	2,45	2,13	2,00	2,25	1,88	2,13	2,33	2,42	2,25	2,42
RP km	2,18	1,36	1,55	1,75	1,25	1,38	2,56	1,67	2,00	2,67	1,67	2,42
RP con-gestion	1,36	1,27	1,27	1,75	1,50	1,63	2,00	2,00	2,11	2,25	1,50	1,75
CM incentive	2,00	2,18	2,00	1,75	2,00	1,63	1,44	2,00	1,38	1,89	1,78	1,33
CM man-dating	1,00	1,09	1,00	1,50	1,63	1,50	1,88	2,43	2,33	1,89	1,89	1,56
Adv. EURO5/6	2,18	2,27	2,27	2,25	2,25	1,88	1,88	2,33	2,25	2,50	2,30	2,10
CF low excise	2,64	2,64	2,55	2,50	2,38	2,63	2,50	2,29	2,13	2,60	2,30	2,50
CF stdz	2,64	2,27	2,36	2,50	2,63	2,63	2,14	1,50	2,25	2,67	2,33	2,44
CF incentive	2,00	2,09	1,91	2,00	2,50	2,38	1,44	1,63	1,14	1,78	2,00	1,78
CF man-dating	1,45	1,45	1,36	2,25	2,00	2,00	2,11	1,57	1,71	2,00	1,89	1,67
parking fee	1,73	1,55	1,55	1,50	1,88	1,50	1,67	2,00	1,43	2,17	1,75	1,42
limited access	1,91	1,64	1,64	1,88	1,88	1,50	2,00	2,29	2,22	2,42	1,75	2,00
SUBS re-trofitting	2,09	2,18	2,09	2,25	2,25	2,13	2,22	2,57	2,38	2,25	2,17	2,25
SUBS replace fleet	2,82	2,73	2,73	2,29	2,14	2,43	1,78	2,43	2,00	2,25	1,92	1,83
GPF vo-luntary	2,33	2,50	2,17	1,40	2,40	2,00	1,71	1,83	1,86	2,20	2,80	2,20
GPF ma-ndatory	2,33	2,17	2,00	2,60	2,60	2,60	2,25	2,29	2,25	2,83	2,00	3,00
GPF private	2,18	1,64	1,73	2,38	2,00	2,13	2,00	2,00	2,29	2,45	2,09	2,18

In accordance with this analysis a realistic scenario should contain at the least these measures (highlighted in dark green):

- A definition of clean vehicles (CV) based on a combination of the CO_2-emission and the Euro emission standard;
- A registration tax (RT) that is based on the environmental performances of the vehicle (thus CO_2 + Euro);
- An annual circulation tax (ACT) based on the environmental performance of the vehicle;
- (Out of the two above mentioned measures advantages are given automatically for Euro 5 or 6 cars);
- Standardization of the clean fuels (CF);
- Lower excise duties in order to promote the use of clean fuels (CF);
- Subsidies (SUBS) for retrofitting older, more polluting cars with clean fuel systems or diesel filters;
- Mandatory quota for green public fleets.

It’s also important to look back at the verbally expressed opinions during the stakeholders’ discussions, summarized in paragraph 2.3. There the wish was expressed for a stable market in order to be able to deploy a development and sales strategy. Thus, the government should urgently make work of the above mentioned standardization of the clean fuels, the extended supply of them (and with that the decision which are going to be supplied) and the promotion by lower excise duties. Since the demand for a consistent mobility clearly exists, the government should work on alternatives for the individual (car) mobility and therefore the revenues coming from the green car taxation should be used to promote those alternatives.

4.2 Progressive policy scenario (PRO)

For the made-up of a progressive, long-term scenario (PRO), we have to look mainly at measures that are perceived as being very effective (high scores on effectiveness), but that possibly score lower on feasibility and/or priority.

In a progressive scenario we may think of the following measures to be pushed forward:

- The definition of clean vehicles based on the Ecoscore. This tool may be better to make the distinction between more and less polluting cars and takes to whole well-to-wheel emissions into account (which is important if alternative fuels like biofuels or electricity are being used). As the Ecoscore is not that know like e.g. CO_2-emissions it is perceived as more difficult to implement.
- The replacement of the annual circulation tax with a kilometre charge. A lot of stakeholders think this would be (very) effective, but they also agree on the fact that the implementation won’t be that easy (infrastructure, on a interregional (European?) scale?). Therefore this is a typical measure to be taken up in the progressive scenario.
- Subsidies to speed up the renewal of the fleet (or scrap premiums) in order to remove the more polluting and give incentives and some financial aid to people who need a new, cleaner car because of the costs of the intelligent kilometre charge.
- The introduction of quota for the number of clean cars in private fleets.

Of course the measures proposed in the REAL-scenario shouldn’t be omitted in this PRO-scenario, but have to be added up. So, it is evident that the standardization and lower excise duties for clean fuels should be kept, just like the subsidies for retrofitting older vehicles or the mandatory green public fleet quota.

Annex A

CLEVER stakeholder meeting - FINAL EVALUATION FORM

Name:	Organization:

(1=low 2=medium 3=high)

Item	Effectiveness*	Feasibility"	Priority°
CLEAN VEHICLE, defined on basis of:			
* Euro emission standard			
* CO2-emission			
* combination of Euro-standard and CO2-emission			
* technology			
* Ecoscore			
Comments:			
POLICY PATHWAYS			
1. Registration tax:			
* abolish			
* base on environmental performance			
Comments:			
2. Circulation tax:			
* abolish and shift to road pricing			
* base on environmental performance			
Comments:			
3. Road pricing:			
* kilometer charge			
* congestion charge (zones)			
Comments:			

(1=low 2=medium 3=high)

Item	Effectiveness*	Feasibility"	Priority°
4. Availability of clean vehicles / fuels:			
CARS * incentives for car manufacturers			
* mandating car manufacturers			
* advantages for Euro 5/6-vehicles			
FUEL * lower excise duties for clean fuels			
* standardizing fuels/facilitate expansion of infrastructure			
* incentives for fuel distribution sector			
* mandating fuel distribution sector			
Comments:			
5. User (dis)advantages:			
* parking fees depending on environmental performance			
* environmental zones/limited access in cities			
Comments:			
6. Subsidies:			
* for retrofitting filters, LPG/CNG-systems…			
* to replace old cars			
Comments:			
7. Green public fleet:			
* voluntary quota for public fleet			
* mandatory quota for public fleet			
* also for private fleet?			
Comments			

* Effectiveness = will this measure really facilitate the introduction of clean vehicles?

" Feasibility = will it really be possible to put this measure into practice?

° Priority = 1 = lowest priority; 3 = highest priority

Clean Vehicle Research: LCA and Policy Measures
(CLEVER)

Scenario Development

Vlaamse Instelling voor Technologisch onderzoek (VITO)

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November, 2010

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LIST OF ABBREVIATIONS

Adv. EURO5/6	Advantages for Euro 5/6 cars
Alt.	Alternative actors in car industry
Avg	Average
BRU	Brussels Capital Region
Cat	Vehicle category
CF incentive	Incentives to supply clean fuels
CF low excise	Lower excise duties for clean fuels
CF mandating	Mandatory quota for clean fuels
CF stdz	Standardization of clean fuels
CM incentive	Incentives for car manufacturers to make and sell clean cars
CM mandating	Mandate car manufacturers to make and sell clean cars
CNG	Compressed Natural Gas
Conv.	Conventional actors in car industry
CS	Charge sustaining hybrid vehicle, uses the combustion engine as a generator for the battery
CV CO2	Definition clean vehicle based on CO_2-emission
CV combi	Definition clean vehicle based on combination of CO_2 emission and Euro emission standard
CV ecoscore	Definition clean vehicle based on the Ecoscore
CV Euro	Definition clean vehicle based on Euro emission standard
CV techn	Definition clean vehicle based on drive technology
€	Euro
E70	Blend of 70% ethanol and 30% gasoline
E85	Blend of 85% ethanol and 15% gasoline
Eff	Effectiveness
Fea	Feasibility
FFV	Flexible Fuel Vehicle
FL	Flemish Region
GPF mandatory	Mandatory green public fleet quota
GPF private	Green fleet quota for private fleets
GPF voluntary	Voluntary green public fleet quota
IC	Internal combustion
Impl	Implicit
Km(s)	Kilometre(s)
Kmch	Kilometre charge
limited access	Environmental city zones with limited access
M1	EU category of vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat
parking fee	Variable parking fees (lower for clean vehicles)
PHEV	Plug-in hybrid electric vehicle, uses the electricity grid for charging the battery

PM	Particulate matter
PM2.5	All particles with an aerodynamic diameter ≤ 2.5µm
PM10	All particles with an aerodynamic diameter ≤ 10µm
Prio	Priority
RP congestion	Road pricing: congestion charge
RP km	Road pricing: kilometre charge
RT abolish	Abolition of the registration tax
RT env perf	Registration tax dependent on environmental performance of the car
SUBS replace fleet	Subsidies to replace older cars by new ones in order to speed up the fleet renewal
SUBS retrofitting	Subsidies for retrofitting older cars with (diesel) filters or cleaner fuel systems (LPG, CNG…)
VMT	Vehicle Miles Travelled
WALL	Walloon Region
Yr	Year

1. Introduction

Task 5.3 – *Scenario development* - of the CLEVER-study focuses on policy scenarios that may ease the introduction of cleaner vehicles for companies, individuals and public authorities, by policy measures.

We organised stakeholder meetings in November and December 2008 where several stakeholders (industry, users, policy makers…) met to discuss possible policy measures that could ease the introduction of cleaner vehicles and – as a result – green the whole fleet.

The analysis of the support of these policy measures by the different stakeholders has led to the elaboration of different policy scenarios (from rather conservative to frankly progressive).

The impact on the fleet composition and environmental burden of the different scenarios will be investigated in Task 6. The scenario development itself, with a detailed description of the policy measures and their effects on fleet and kilometres, is explained below.

2. Summary results stake-holder meeting

Almost all stakeholders agree on the fact that an environmental basis for car taxes is needed and that a well-to-wheel-approach is necessary to compare all kinds of vehicles and fuels. Modulating on the running costs, which is possible with a kilometre charge, may be a very effective solution, but will be hard to implement in the near future.

In each case all partners feel the urgent need for a coherent mobility policy. Stakeholders from the industry ask for a stable market and clear views for the future to be able to develop their products.

Report 5.2 - *Stakeholder support for proposed policy measures* – gives an overview of the participants, the discussions themselves, analysis of the evaluation forms and the selected policy scenarios. The proposed policy measures, on the other hand, are only briefly discussed there. The reason for this is that the measures adopted in the scenarios are more thoroughly explained in the current report (5.3).

Table 1 shows all mean scores on effectiveness, feasibility and priority of the different policy measures for the different stakeholder groups together. Policy measures supported by virtually all stakeholders on all aspects are marked in dark green.

Policy measure	Industry, conv.			Industry, alt.			Users & ngo's			Policy makers		
	Eff	Fea	Prio	Eff	Fea	Prio	Eff	Fea	Prio	Eff	Fea	Prio
CV Euro	2.18	2.64	2.09	2.50	2.38	2.13	2.00	2.50	1.75	1.91	2.36	1.82
CV CO2	2.27	2.73	2.27	2.25	2.50	2.50	1.86	2.40	2.11	2.00	2.82	2.09
CV combi	2.45	2.64	2.36	2.50	2.13	2.38	2.13	2.86	2.44	2.20	2.20	2.18
CV techn	1.27	1.73	1.27	2.13	2.00	2.00	1.33	1.14	1.63	1.70	1.90	1.78
CV ecoscore	1.56	1.56	1.33	2.25	2.25	2.13	2.00	2.00	2.44	2.73	2.18	2.50
RT abolish	2.20	2.30	2.30	1.75	1.38	1.63	2.00	2.29	2.13	1.70	1.78	1.80
RT envperf	2.40	2.20	2.30	2.88	2.38	2.38	2.13	2.25	2.44	2.67	2.17	2.58
ACT abolish	2.00	1.36	1.55	1.50	1.63	1.50	2.11	2.00	1.63	2.45	1.73	1.82
ACT envperf	2.55	2.27	2.45	2.13	2.00	2.25	1.88	2.13	2.33	2.42	2.25	2.42
RP km	2.18	1.36	1.55	1.75	1.25	1.38	2.56	1.67	2.00	2.67	1.67	2.42
RP congestion	1.36	1.27	1.27	1.75	1.50	1.63	2.00	2.00	2.11	2.25	1.50	1.75
CM incentive	2.00	2.18	2.00	1.75	2.00	1.63	1.44	2.00	1.38	1.89	1.78	1.33
CM mandating	1.00	1.09	1.00	1.50	1.63	1.50	1.88	2.43	2.33	1.89	1.89	1.56
Adv EURO5/6	2.18	2.27	2.27	2.25	2.25	1.88	1.88	2.33	2.25	2.50	2.30	2.10
CF low excise	2.64	2.64	2.55	2.50	2.38	2.63	2.50	2.29	2.13	2.60	2.30	2.50
CF stdz	2.64	2.27	2.36	2.50	2.63	2.63	2.14	1.50	2.25	2.67	2.33	2.44
CF incentive	2.00	2.09	1.91	2.00	2.50	2.38	1.44	1.63	1.14	1.78	2.00	1.78
CF mandating	1.45	1.45	1.36	2.25	2.00	2.00	2.11	1.57	1.71	2.00	1.89	1.67
parking fee	1.73	1.55	1.55	1.50	1.88	1.50	1.67	2.00	1.43	2.17	1.75	1.42
limited access	1.91	1.64	1.64	1.88	1.88	1.50	2.00	2.29	2.22	2.42	1.75	2.00
SUBS retrofitting	2.09	2.18	2.09	2.25	2.25	2.13	2.22	2.57	2.38	2.25	2.17	2.25
SUBS replace fleet	2.82	2.73	2.73	2.29	2.14	2.43	1.78	2.43	2.00	2.25	1.92	1.83
GPF voluntary	2.33	2.50	2.17	1.40	2.40	2.00	1.71	1.83	1.86	2.20	2.80	2.20
GPF mandatory	2.33	2.17	2.00	2.60	2.60	2.60	2.25	2.29	2.25	2.83	2.00	3.00
GPF private	2.18	1.64	1.73	2.38	2.00	2.13	2.00	2.00	2.29	2.45	2.09	2.18

Table 1 : Overview of all mean scores on effectiveness, feasibility and priority by stakeholder group (green scores: >=2.00)

In the following sections, we repeat the initiated policy scenarios:

1. Realistic Mid-Term Scenario
2. Progressive Long-Term Scenario

2.1. Realistic Mid-Term Scenario

Ideal measures to be taken are measures that get a high score on both effectiveness, feasibility and priority (all scores higher than 2, or all but one scores higher than 2). It means that these measures are seen as potentially having a big impact, while they are relatively easy to implement. As such it shouldn't take much time to implement those measures.

Nevertheless, there are also measures that could have a high impact, but are difficult to implement, and therefore not adequate to include in a realistic mid-term policy scenario.

In accordance with this analysis a realistic scenario should contain at least these measures (highlighted in dark green):

- A definition of clean vehicles (CV) based on a combination of the CO_2 emission and the Euro emission standard;
- A registration tax (RT) that is based on the environmental performances of the vehicle (thus CO_2 + Euro standard);
- An annual circulation tax (ACT) based on the environmental performance of the vehicle;
- (Out of the two above mentioned measures, advantages are given automatically for Euro 5 or 6 cars);
- Standardization of the clean fuels (CF);
- Lower excise duties in order to promote the use of clean fuels (CF);
- Subsidies (SUBS) for retrofitting older, more polluting cars with clean fuel systems or diesel filters;
- Mandatory quota for green public fleets.

2.2. Progressive Long-Term Scenario

For the construction of a progressive long-term scenario, we looked mainly at measures that are perceived as being very effective (high scores on effectiveness), but that possibly score lower on feasibility and/or priority.

The following measures have to be pushed forward in a progressive scenario:

- The definition of clean vehicles based on the ecoscore. This tool may be better suited to make the distinction between more and less polluting cars and takes to whole well-to-wheel emissions into account (which is important if alternative fuels or energy carriers like bio-fuels or electricity are being used). As the ecoscore is not as well known as e.g. CO_2 emissions, it is perceived as more difficult to implement.
- The replacement of the annual circulation tax with a kilometre charge. Many stakeholders think this would be (very) effective, but they also agree on the fact that the implementation won't be that easy (infrastructure, on an interregional (European?) scale). Therefore, this is a typical measure to be taken up in the progressive scenario.
- Subsidies to speed up the renewal of the fleet (or scrappage premiums) in order to remove the more polluting cars and give incentives and some financial aid to people who need a new, cleaner car because of the costs of the intelligent kilometre charge.
- The introduction of quota for clean cars in private fleets.

Besides these two scenarios, VITO also developed a baseline scenario to start from and a visionary scenario to see what the impact can be of an ideal solution.

3. Baseline Scenario

The year is 2010. Last year, Europe introduced the Euro 5 emission standard setting stricter limits to the maximum allowed air pollution levels of vehicles. Furthermore, legislative measures have been taken to force the automakers to reduce the CO_2 emissions of new passenger cars. Beside a limitation of maximum 130g/km for the average new passenger car in 2015, some additional reduction is expected from complementary measures like mixing bio-fuels, influencing driving behaviour, better types of air conditioning coolants, and the introduction of environmentally friendly tires. On various levels in Belgium, mandatory green public fleet quota have been implemented, setting a good 'lead by' example.

In order to construct the baseline scenario, data are extracted from a wide range of sources. The number of kilometres driven is always taken as a starting point in our model calculations. The total number of historical kilometres, as well as the historical kilometres driven by each technology and age class, was retrieved from the FOD Mobiliteit en Vervoer. The fleet composition up till 2009 originates from the Dienst Inschrijving Voertuigen (DIV). Predictions on the total number of kilometres driven and the distribution over the different technologies are taken from the Flemish MIRA REF scenario from VMM, extrapolated to the whole of Belgium, so taking the growth rate for Flanders as an example for the other two regions. Regarding the future distribution of the kilometres over the various technologies, we focused on the final historical year (2008 in this study) of the FOD Mobiliteit en Vervoer. Newer technologies (e.g., electric, hybrid) are assumed to be driven an amount of kilometres similar to the most resembling historical technology class (e.g., diesel kilometres for a diesel hybrid). More details on the functioning of the model used can be found under section 2.1 in the report of WP6.

Baseline

- Euro 5 and Euro 6 for passenger cars
- CO_2 legislation for passenger cars
- Bio-fuels
- European directive 2006/40/EC - type of coolant in mobile air conditioning
- Mandatory green public fleet quota

3.1. Euro 5 and euro 6 for passenger cars

The European directive 2007/715/EC introduces the Euro 5 and Euro 6 limits for passenger cars. These new limits have an important effect on the PM and NO_X exhaust of new diesel vehicles. The Euro 5 limit focuses on the reduction of PM emissions, whereas the Euro 6 limit focuses on the reduction of NO_X exhaust emissions. The current petrol vehicles already apply to the new standards.

The Euro 5 and Euro 6 limits come into force in respectively September 2009 and September 2014 for new type approvals for passenger cars. They are introduced in January 2011 and September 2015 for first registration of previously type-approved vehicle models.

3.2. CO_2 legislation for new passenger cars

By 2015, automakers will have to reduce the CO_2 emissions from new passenger cars to 130 g/km, with an additional 10 g/km reduction coming from complementary measures. The complementary measures taken into account in the Baseline scenario are:

- Bio-fuels (CO_2 reduction of 5%);
- driving behaviour (CO_2 reduction of 1%);
- environmentally friendly tires (CO_2 reduction of 1.7%).

3.3. Bio-fuels

The assumptions made here are in accordance with the baseline scenario of the Belspo SSD project BIOSES. As from 2013, a volume percentage of 5% biodiesel (of all diesel) and 5% ethanol (of all petrol) is taken into account (gradually introduced).

3.4. European directive 2006/40/EC - type of coolant in mobile air conditioning.

The European directive 2006/40/EC prohibits the use of HFC-134a (tetrafluorethane) as coolant in mobile air conditioning systems from 2011 on for new type approvals and from 2017 for all new vehicles. The alternative R744 system with CO_2 as coolant is taken into account in the Baseline scenario for all new vehicles from 2011 on (no losses from gases containing fluorine and CO_2).

3.5. Mandatory green public fleet quota

Several governmental levels in Belgium implemented mandatory green public fleet quota. They are listed below.

3.5.1. Brussels Capital Region

In the framework of the air quality strategy for the Brussels region, the Brussels government decided to impose a mandatory target of 20% clean vehicles in the fleet of the Brussels government, the Brussels administration and all institutes that fall under its responsibility. The target had to be reached by 2008 at the latest. Since 2009 the Brussels government decided to modify the criteria: they are no longer based on a technology list, but on minimal ecoscores. For the year 2010, these minimal ecoscores range from 56 for passenger cars (M1) with 9 seats, to 70 for passenger cars (M1) with 5 seats. As from 2011, these values increase with 1 unit per year.

3.5.2. Flemish Region

The instruments of the Flemish government implemented for introducing cleaner vehicles in the public vehicle fleet are:

- Voluntary agreements were set up with local authorities (cities, municipalities and provinces) to introduce cleaner vehicles in their fleet for which they can receive a subsidy. For supporting the local authorities in the analysis of the environmental performance of the fleet, the Flemish Government offers them a free software application. This voluntary agreement started in 2002.
- Targets for minimal environmental performance of the total passenger car fleet of the Flemish Government were defined. Measures to reach these targets were defined in an Action Plan.
- Mandatory criteria for the environmental performance of new passenger cars purchased by the Flemish government, the Flemish administration and all institutes that fall under its responsibility.

All measures implemented in Flanders define the environmental performance based on the ecoscore.

3.5.3. Federal Government

In 2004, the federal government decided to implement a ‘renewal quotum’ for the vehicle fleet of the federal cabinets and administration. This meant that 50% of all newly purchased passenger cars had to be clean vehicles. The eligibility criteria were based on a technology list. Since 2009, the main environmental criterion is the ecoscore.

4. Realistic Mid-Term Scenario

The year is 2030. Internal combustion engine cars still drive around. Back in 2010 the government decided to try to reduce emissions of cars under pressure of the public opinion and the European Union. Back then, the taxation system was based on a complex combination of engine size, engine power and benefits for low CO_2 emissions. Due to the strong car lobby it was not possible to change this completely. The major change that was approved by the government was to change the system and base it on the Euro standards and the level of CO_2 emissions.

Due to the taxation system of excise duties on diesel and petrol in the pre-2010 era, the fleet was dominated by diesel cars even though for most users the use of a diesel engine was not compatible with their driving pattern. With the environmental advantages of petrol cars, it was time to stop the further dieselification. In order to accomplish an equal pump price for diesel and petrol, the government reduced the difference between the excise duties of diesel and petrol. However, as diesel engines continued to be more efficient (i.e. consume less fuel) than their petrol-fueled counterparts, these measures did not prevent that the majority of new car purchases were still diesel-fueled. However, the replacement of the existing fleet happened slower for petrol vehicles than for diesels, as the Euro 3 (and better) petrol vehicles were treated (fixed premium of €200 until 2015) equivalently to Euro 6 diesels.

Some other measures were introduced to green the fleet. For older cars, retrofitting particulate filters was promoted by granting a reduction on the cost of the retrofit. Other incentives focused on the retrofitting of LPG installations and CNG installations, and making cleaner fuels (CNG and E85) more readily available.

Baseline scenario

- Euro 5 and Euro 6 for passenger cars
- CO_2 legislation for passenger cars
- Bio fuels
- European directive 2006/40/EC - type of coolant in mobile air conditioning
- Mandatory green public fleet quota

Extra measures realistic mid-term scenario

- Tax system based on combination of CO_2 and Euro standard
- Advantages for Euro 6 vehicles
- Clean fuels: standardization and availability (CNG and E85)
- Change in excise duties
- Subsidies for retrofitting old cars with filters
- Subsidies for cleaner fuel systems (LPG and CNG)

4.1. Tax system based on combination of CO_2 and Euro standard

This new tax system has an effect on:

- new vehicles: huge effect
- existing vehicles: earlier replacement of older vehicles
- driven kilometres: no effect on a per vehicle scale

The current Belgian tax system is based on a combination of a registration tax (RT) and an annual circulation tax (ACT). The calculation of the RT takes into account both the cylinder capacity (fiscal horsepower) and the engine power, whereas the ACT is only computed on fiscal horsepower. Since July 2007, this system is supplemented with a CO_2 bonus for private vehicles emitting less than 105g CO_2/km (15% on the purchase price) and cars emitting less than 115g CO_2/km (3% of purchase price). For company cars, since 2007 the bonus takes the form of a higher tax deductibility (up to 90%) for engines with low CO_2 emissions. Furthermore, there is a social contribution based on CO_2 emissions as well, with a different calculation for petrol, diesel and LPG vehicles.

In the realistic mid-term scenario, we assume that the existing tax system is replaced with a system based on a combination of CO_2 emissions and Euro standards. The system is designed with a view to increase taxes on polluting and older vehicles, otherwise not being replaced. So both the RT and the ACT will be higher for those vehicles. The exact tax levels implemented in this scenario are displayed below:

A) Vehicles emitting less than 105g of CO_2 and using alternative fuels or propulsion technologies (category A): RT = 50 EUR and ACT = 50 EUR. With these levels, we are sure that people will pay less than the minimum level under the existing tax system (website Federale Overheidsdienst Financiën).

B) Vehicles emitting less than 105g CO_2 and using conventional fuels or propulsion technologies (category B): RT = 50 EUR and ACT = 50 EUR. These had to be equal to the ones for category A as we only assume shifts from category C and D to category B (and not to category A).

C) Vehicles emitting 105-115g CO_2 (category C):
RT = 500 EUR, ACT = 500 EUR. For both taxes, 500 EUR is the level with the second-highest mid-point elasticity, as reported by VUB. So, a large shift to category B is realized, given the relatively modest tax level.

D) Vehicles emitting >115g CO_2 (category D):
RT = 1,000 EUR, ACT = 1,000 EUR. This is the price level with the highest elasticity value.

These tax levels are assumed to come into force starting from the year 2015, remaining constant for at least 15 years. For the years before 2015, we use the baseline data.

4.2. Advantages for Euro 6 cars

These advantages have an effect on:
- new vehicles: negligible effect
- existing vehicles: negligible rate of earlier replacements of older vehicles
- driven kilometres: no effect

In order to stimulate the replacement of older vehicles, an advantage of €200 is given in the period 2010-2014, for the purchase of new vehicles already complying with the Euro 6 diesel emission standard. For this measure, petrol engines from Euro 3 onwards are considered as clean as Euro 6 diesel engines.

Since the Euro 6 emission standard will be present on all cars purchased starting from September 2014, the incentive only has to last until this date. Let’s assume that all vehicles already complying with this standard before this date will receive a 200 euro reduction from their usual RT. We do not expect a massive shift in the purchase of new vehicles, resulting from this measure. It is to say, as diesel engines are still consuming less than petrol engines, this consumption argument will continue to dominate the once-only RT reduction.

4.3. Clean fuels: standardization & availability

Standardization and availability of clean fuels has an effect on:
- new vehicles: more vehicles with clean fuels
- existing vehicles: no effect
- driven kilometres: no effect

In Belgium only diesel and petrol are widely available as transport fuel, and to a lesser extent also LPG. In other European countries, a wider variety of clean fuels is available at the pump (CNG, E85, etc.). Car manufacturers already offer many vehicles that are suited to use these fuels. These vehicles are not purchased in Belgium, since consumers can't buy the fuels.
CNG (compressed natural gas) is quite a common fuel in Italy, Germany, Sweden (under the form of biogas), etc. This fuel has many advantages: lower CO_2 emissions (tailpipe but certainly well-to-wheel), very low levels of pollutant emissions, etc. However, only very few Belgian refuelling stations offer CNG at this moment (2010).
E85 is also available in other European countries, but is not allowed on the Belgian market. This is due to a number of issues, one of the main ones being the fact that this fuel is not standardized yet. E85 can have many advantages (with the use of the right feedstock): lower CO_2 emissions on a well-to-wheel basis, the same levels of pollutant emissions as petrol (which are very low), etc.
To conclude this section we can state that several clean fuels can be made readily available to the Belgian consumer by implementing relatively simple policy measures, such as standardization. We foresee in this scenario that these measures are implemented, and in combination with lower excise duties (see § 4.4), the share of vehicles using these clean fuels will increase.

4.4. Change in excise duties

A change in excise duties has an effect on:

- new vehicles: more vehicles with clean engines
- existing vehicles: earlier replacements of older vehicles
- driven kilometres: decrease for diesel cars

In the Belgian context, clean fuels are all fuels except diesel. This is due to the larger air quality impact of this fuel, with large emissions of NO_x (for the future, mainly NO_2) and PM. As the share of petrol cars is dropping rapidly in recent years, we assume that, starting from 2015, excise duties on diesel have to rise to the amount of the excise levied on petrol, i.e. 61.36 eurocent/l on 21/06/2010, in order to counter this trend. This implies a diesel price of ca. 1.50 EUR. We further assume that petrol excises will remain unchanged. Total fuel price is then more or less equal for diesel and petrol, i.e. 1.50 EUR (the ex-refinery price is slightly higher for diesel than for Euro95 petrol (BPF)). Excise duties on LPG are currently already set to zero, thus no changes are needed there as this fuel is considered as being cleaner than petrol and diesel. Excises on relatively 'new' cleaner fuels (E85, biofuel, CNG, hydrogen, electricity) are all set to zero.

4.5. Subsidies for retrofitting old cars with particulate filters for diesel vehicles

This subsidy has an effect on:

- new vehicles: no effect
- existing vehicles: equipment of several diesel vehicles (euro 3 & euro 4) with a half-closed particle filter
- driven kilometres: no effect

There are 3 examples of retrofit particulate filter subsidy schemes, in the Netherlands, in Germany and in Flanders. The Dutch scheme is relatively successful and well documented. Not much information can be found on the German scheme. In the Netherlands, installing a retrofit filter on your passenger car is (or was) worth a subsidy of €400 to €500 (starting in 2006). This amount was in most cases sufficient to cover the installation costs. In one year time, 27,000 subsidies were granted. After 3.5 years this number increased to 80,000 subsidies. In the year 2006, 1,150,000 diesel vehicles were registered, of which the majority was eligible since a particulate filter was not standard equipment for diesel vehicles. Since 2010 a particulate filter is standard equipment on every new diesel vehicle, so there is no need to retrofit them. Therefore, one could state that in the first year of the scheme approximately 2.3% of the eligible diesel vehicles used the subsidy to install a retrofit particulate filter, and this percentage remained fairly stable (8% after 3.5 years).
The Flemish scheme was not successful at all. A subsidy of €400 was granted to owners of vehicles that installed a retrofit filter. After nearly one year, only ca. 75 people applied for the subsidy.

In this 'Realistic Mid-Term Scenario', the amount of the subsidy for retrofit filters is limited to €500, since this amount is likely to cover total installation costs. This subsidy scheme is considered to last for 5 years (2011-2015).

We have to keep several issues in mind when estimating the potential effect of this measure in the Belgian situation:

- approximately 1.3 million diesel vehicles are eligible (only euro 3 & 4 and not already equipped with a closed particulate filter)
- in the Dutch scheme the subsidy covered the total installation costs, and a total of €50 million was set aside, the equivalent of 100,000 subsidies.
- the Dutch scheme resulted in 2,3% of the eligible vehicles equipped per year, or a total of 80.000 vehicles after 3.5 years;
- the Flemish scheme, which covered 80% of the installation costs, was not successful at all;
- the change in the tax system will have an effect on the amount of applications for the subsidy.

4.6. Subsidies for retrofitting old gasoline cars with LPG systems

Estimated effect:

- new vehicles: no effect
- existing vehicles: installation of LPG systems on existing petrol passenger cars
- driven kilometres: no effect

In 2001 and 2002, there has been a subsidy scheme in Belgium for retrofitting petrol passenger cars with LPG systems. A subsidy of € 500 was given to private persons and companies. This scheme ran for 2 years, and approximately 10,000 systems were installed each year.

In this ‘Realistic Mid-Term Scenario’, the amount of the subsidy for retrofit LPG systems is kept at € 500. The price for these LPG systems has increased since 2001, so on a relative basis the subsidy is less than in 2001/2002. However, vehicles equipped with LPG systems would also qualify for other financial benefits, the most important of these being the absence of excise duties on LPG. This subsidy scheme is considered to last for 5 years.

4.7. Quantification of the effect of the different measures in the realistic short-term scenario

4.7.1. Effect on new vehicles

The following measures have an impact on the new vehicle fleet:

- Tax system based on combination of CO_2 and Euro standard
- Clean fuels: standardization
- Change in excise duties

Based on the results from the elasticity survey done by VUB-MOSI, we were able to estimate the amount of people wanting to pick a car from category B, given the imposed tax levels, instead of choosing a more polluting one (category C or D), as they would do under the baseline scenario. This exercise was feasible under the assumption that the survey results are representative for the buyers of each of four car categories separately. We further assume that there will be no switches to category A in this realistic scenario. Those switches are reserved for the progressive scenario.

For all scenario years starting from 2015, we find that **26.0%** of the total new purchases of category C cars in the baseline will switch to category B cars in the realistic scenario. This switch is due to the changed financial context compared to the baseline. A similar rationale applies for switches from category D to B, viz. **33.8%** of new category D purchases in the baseline scenario switch to new cars of category B in the realistic scenario.

The impact of the clean fuels measures on the characteristics of the new vehicles will have an impact on both the number of CNG passenger cars and amount of flexible fuel vehicles (FFVs, i.e. vehicles designed to run on more than one fuel, usually petrol and ethanol) in the Belgian vehicle fleet. Concerning the use of CNG in this ‘Realistic Mid-Term Scenario’ we included an extra increase of CNG passenger vehicles starting from 2015, since CNG will be available on the market. The amount of flex fuel vehicles was kept in line with the assumptions made in the BIOSES project and can be summarized as follows (the % represents the amount of flex fuel vehicles in the new passenger cars in relation to the total amount of new petrol vehicles in the vehicle fleet):

Year	% FFV
2015	5%
2020	50%
2025	100%
2030	100%

Table 2: Share of flexible fuel vehicles in total new purchases of petrol vehicles

Furthermore, we will take into account that E85 biofuels will not be used in practice, but actually E70 blends will be available at the pump. It is to say, theoretically, FFVs are capable of running on an E85 blend. However, in order not to exceed the 85% limit (the engines are not designed to deal with higher levels), it is more realistic to assume blends with a lower ethanol level (e.g., E70).

4.7.2. Effect on existing vehicles

The following measures have an impact on the existing vehicle fleet:

- Tax system based on combination of CO_2 and Euro standard
- Change in excise duties
- Subsidies for retrofitting old cars with filters
- Subsidies for cleaner fuel systems

The first three measures have an effect on the composition (technology) of the existing fleet. A replacement of on the one hand older passenger cars in substitution for new passenger cars, and on the other hand older diesel passenger cars in substitution for second-hand petrol cars. These effects are modelled by changing the survival rate of the passenger cars for future years. The survival rate is dependent of the size, fuel technology and age of the vehicle. In the realistic scenario, we take into account a surplus of replacements, expressed as a percentage. For instance, the survival rate of a certain vehicle in the baseline scenario is 0.95, or in other words, 5% of these vehicles leave the Belgian market in that year. A surplus of 100% (on top of the 5% that leaves the market) then means that twice as much vehicles will leave the market (=10%). Consequently, a survival rate of 0.90 will be accounted for.

Under the proposed scenarios, the survival rate for newer vehicles is higher than those for older vehicles. In this way, we implicitly take into account - with a surplus of 100% - a larger effect on older vehicles compared to newer ones.

The additional replacements taken into account in the realistic scenario are (expressed as a surplus on top of the standard 0.95 survival rate):

- Diesel car:
  - 2011-2012: beginning effect of 50% for older vehicles [→ survival rate 0.925]
  - 2013: age > 4: +50% (pre Euro 5) [→ survival rate 0.90]
  - from 2014 on: age > 4: +50% (advancing effect of the improvement of Euro 5 & Euro 6 technology for fuel consumption) [→ survival rate 0.875]
- Petrol car:
  - effect smaller than for diesel because of:
    - no effect through for following measures

        - advantages for Euro6 vehicles
        - change in excise duties
    - replacement on the second-hand market
- 2011-2012: beginning effect of 50% for older vehicles [→ survival rate 0.925]
- 2013: age > 9: +25% (pre Euro 4) [→ survival rate 0.9125]
- from 2014 on: age > 9: +25% (advancing effect of the improvement of Euro 5 & Euro 6 technology for fuel consumption) [→ survival rate 0.90]

Keeping the reasons mentioned in section 4.5 in mind for subsidies for retrofitting old cars with filters, sound judgement led to an estimated effect of 2.3% of the eligible vehicles equipped per year, and this for 5 years. Table 3 presents the amount of half-closed diesel particle filters that we take into account in 2015 in the realistic scenario. A reduction of 30% in $PM_{2.5}$ for the exhaust emissions will be accounted for.

Amount of half-closed filters in 2015 ($x10^3$)	**Euro 3**	**Euro 4**
Flanders	39	68
Wallonia	21	37
Brussels	5	13

Table 3 : Overview of estimated amount of half-closed filters in 2015 per region.

Since car manufacturers in Belgium are not very willing to install LPG systems on new vehicles, and state that the car's warranty would no longer be valid, we assume that only cars of 4 years or older would apply for the subsidy. We also assume that vehicles older than 10 years would no longer install LPG systems, since this type of investment only pays off after several years while driving a significant mileage per year. The distribution is estimated to be Gaussian, starting with vehicles of 4 years of age, reaching a maximum for vehicles of age 7, and ending with vehicles of age 10. On average, 10,000 vehicles per year will apply for a subsidy for a cleaner fuel system, and this for 5 years.

4.7.3. Effect on driven kilometres

The following measure has an impact on the driven kilometres:

- Change in excise duties

Effects on the amount of kilometres driven can be projected using a price elasticity. For private transport, VITO (Duerinck et al., 2007) calculated the elasticity of total person kilometres with respect to fuel prices as being -0.14. Assuming the number of persons per vehicle remains unchanged, total vehicle kilometres will decline by 1.4% following a 10% increase in total fuel price. A rise in diesel excises to the level of petrol corresponds to a 22% rise of the official price (from 1.22 to 1.49 on 11/06/2010). Using the elasticity mentioned above, we can expect a 22*0.14 = 3% reduction in total diesel vehicle kilometres (compared to the baseline scenario), under the assumption that all vehicles considered have conventional engines. Taking into account the proportion of diesel hybrids (charge sustaining (CS) or plug-in hybrid electric vehicles (PHEV)), the reduced kilometres will be lower. Presuming that the CS and plug-in hybrids are running 70 and 40% on the conventional engine, respectively, the impact of an excise increase will be lower for these vehicles. The total impact on the kilometres driven by the diesel fleet will then amount to:

Percentage decrease in diesel kms = 22*0.14*[1-(0.30*%kms_CS)-(0.60*%kms_plugin)]

Given the information above, the effect of changes in excise duties on driven kilometres are estimated as a decrease by less than 3% for diesel passenger cars. We can summarize this for the three diesel classes, as follows:

- 22*0.14 = 3.08% decrease conventional diesel kms
- 22*0.14*0.70 = 2.16% decrease in diesel hybrid CS kms
- 22*0.14*0.40 = 1.23% decrease in diesel hybrid PHEV

5. Progressive Long-Term Scenario

Lead by the green movement of 2010, the government decided to redesign the composition of the car fleet to a more sustainable one. To accomplish this, they changed the taxation system from a CO_2-based tank-to-wheel and Euro standard taxation system to a well-to-wheel system based on ecoscore. Ecoscore at that time had been around for a while and had proven to be a fair indicator of the eco-friendliness of a vehicle. Thanks to its well-to-wheel approach it also took into account the indirect emissions and because of its 0-100 scale it was easy to understand for the end user. Since it was already used in the decision making of car purchases for the public fleet, it was not difficult to implement. To promote environmentally friendly cars more, a scrappage scheme was set up as an incentive. This stimulus was given to car owners who offered their car for scrappage to buy a car with a higher ecoscore or who wanted to abandon car use in general and switch to public transportation. By using the ecoscore-based approach the government knew it was possible to green the current fleet but they felt a change in car-use was needed in addition.

Furthermore, 'limited access environmental zones' were implemented in certain cities. These were zones that were only accessible to vehicles with a certain minimum ecoscore. The limited access zones not only resulted in (slightly) less traffic in the inner-cities but, even more important, they also led to a faster modernisation of the vehicle fleet. As a result, major improvements in air quality were established for the people living in these areas.

To accomplish the change in car-use, kilometer charging was introduced. The charging scheme was based on the kilometers driven at certain times of the day/night, the types of road used and the ecoscore of the vehicle.

The government also introduced a green private fleet quota, on top of the public fleet quota introduced earlier.

Baseline scenario

- Euro 5 and Euro 6 for passenger cars
- European legislation average CO_2 emission
- Bio fuels
- European directive 2006/40/EC - type of coolant in mobile air conditioning
- Mandatory green public fleet quota

Extra measures realistic mid-term scenario

- Tax system based on CO_2 and euro standard
- Clean fuels: standardization and availability
- Change in excise duties
- Subsidies for retrofitting old cars with filters
- Subsidies for cleaner fuel systems

Extra measures progressive long-term scenario

- Tax system based on ecoscore
- Kilometre charge
- Limited access environmental zones in cities based on ecoscore
- Mandatory green private fleet quota
- Scrappage scheme

5.1. Tax system based on ecoscore

Using ecoscore as a tax indicator has an effect on:

- new vehicles: huge effect
- existing vehicles: earlier replacement of older vehicles
- driven kilometres: no effect on a per vehicle scale

When we implement a registration tax system based on ecoscore instead of the combined measure based on CO_2 and Euro standard, we expect that the incentives are much more clear to the end consumer. Vehicles with low ecoscores will be punished through a high tax level, whereas higher ecoscores are rewarded.

The effects of an ecoscore-based tax system on new vehicle purchases are tested through the elasticity survey. Each of the four car categories corresponds with an ecoscore. The first category (A) consists of vehicles emitting less than 105g CO_2 and using alternative engine technologies or fuels. In category B, all the other cars emitting less than 105g of CO_2 are included. Vehicles emitting more than 105g of CO_2 but less than 115g are classified in category C. Category D then contains all the other vehicles (thus emitting >115g CO_2). We assume that the four categories from the survey correspond with an ecoscore going from >75 (A) over 73-75 (B) and 70-72 (C) to <70 (D). Each ecoscore corresponds on its turn with a certain tax level. Changes in the ecoscore tax structure will thus affect the choices made by the end consumer.

Taking the elasticity values from VUB-MOSI as an input, we decided to calculate the scenario with the following RT values (starting from 2015):

A) Vehicles with an Ecoscore >75:

0 EUR, as it needs to be smaller than the current RT level (ca. 61,5 EUR) and smaller than the amount for ecoscore 73-75 (50 EUR) in order to induce a shift to category A

B) Vehicles with an Ecoscore 73-75:
50 EUR, lower than current RT and smallest possible as it is the first price level reported on by the elasticity survey

C) Vehicles with an Ecoscore 70-72:
500 EUR, because this is the second largest mid-point elasticity reported in the survey

D) Vehicles with an Ecoscore <70:
1,000 EUR, as at this price level, the elasticity reaches a maximum

5.2. Kilometre charge

A kilometre charge (dependent on time, place and ecoscore) has an effect on:

- new cars: shift to higher ecoscore
- existing cars: earlier replacement of vehicles with low ecoscores
- kilometres driven: decrease for all passenger cars

Charging movements per kilometre driven, depending on the time and place at which they take place and the ecoscore of the vehicle used, has the important advantage of making the use of the car 'marginal'. We assume that from 2015 onwards, the kilometre charge will replace the current ACT, all other fiscal instruments remaining unchanged. In contrast with the ACT, which takes the form of a fixed tax per year, a kilometre charge forces the driver each time to balance the benefit of driving versus its cost (i.e., the km charge).

For the year 2007, the annual traffic tax amounts to 268.36 EUR for a vehicle with a cylinder capacity between 1,750 and 1,949 cm^3. We assume this is a good proxy for the traffic tax paid by an average vehicle in Belgium. When we take into account an average annual mileage of 15,244 km (E-motion database 2007, VITO), the implicit kilometre charge currently amounts to 1.8 eurocent/km. If we want to impose taxes with at least the same governmental earnings as under the current system (i.e., reaching budget neutrality), the proposed amount is an absolute minimum. Taxes should be higher in urban areas (let's assume basic tariff x2) and during peak hours (assumption: basic tariff x2). The km charge will also depend on the Ecoscore class of the vehicle.

We assume the imposed annual km charge for the different ecoscore categories will amount to the numbers given in the table below (where the categories A till D correspond with the same ecoscore levels as mentioned in 5.1). This is the total annual charge, if the number of kilometres would remain the same (all expressed in $Euro_{2007}$).

avg annual km charge (€)	ecoscore category			
year	A	B	C	D
2010	268	268	268	268
2015	200	200	400	400
2020	200	200	400	400
2025	200	400	600	600
2030	200	400	600	600

Table 4: Simulated kilometre charge on a yearly basis

Starting from 2015, the annual circulation tax is replaced by a kilometre charge, differentiating for vehicles with higher ecoscores. In 2015 and 2020, a distinction is made between categories A and B on the one hand (€200, smallest amount reported in elasticity survey and lower than implicit baseline tax), and C and D on the other (€400, highest elasticity value and larger than the implicit baseline tax). From 2025 onwards, cars in category B will pay more than A, as we want to induce a shift from B to A. Furthermore, driving cars of category C and D will become more expensive than before. We chose for €600 as this price level has the third-highest elasticity value.

The remainder of this paragraph provides an exploratory analysis of the imposed kilometre charge, in terms of budget neutrality per region and a differentiation for spatial (rural vs urban) and temporal aspects (peak vs off-peak). This part may be skipped without loss of comprehension of the rest of the report).

First of all, we could make a distinction for the different regions. If we want to reach budget neutrality in all three regions, we first need to dispose of the implicit kilometre charge for each of these regions. If we assume the same ACT for all regions, the only influencing factor is the current average number of kilometres driven per car. We extract these from the E-motion database. They are given in the table below, together with the resulting implicit kilometre charge (following the assumed implicit ACT of 268.36 EUR).

region	kms/yr	impl €/km
BRU	6,349	0.0423
FL	14,523	0.0185
WALL	19,479	0.0138

Table 5: Kilometres and the resulting km charge per region

Secondly, we can now consider 4 situations, each of which tells us something about the place and time. Concerning location, we distinguish urban (U) from rural or highway (R), while each trip either takes place during peak (P) or off-peak (O) periods. So, 4 situations arise: UP, UO, RP and RO. A logical and simple assumption could be to start from the situation RO, which is cheapest (basic tariff), and further assume that the situations UO and RP give rise to a doubling of the km charge, while the UP case is the most expensive (4 times the basic tariff).

We further presume that the ratio of peak kilometres versus off-peak kilometres on all road types equals 1 (50% share for both), for all regions. The percentage of car kilometres driven in urban or rural areas for the three regions can be retrieved from E-motion (and are broadly in line with the data in (website FOD Economie, K.M.O., Middenstand en Energie)). We obtain the resulting kilometres driven for each situation in the three regions by multiplying the urban-rural percentages by 50%, as given in the following table:

case	% kms BRU	% kms VL	% kms WALL
UP	14.98	11.76	12.04
UO	14.98	11.76	12.04
RP	35.02	38.24	37.96
RO	35.02	38.24	37.96

Table 6: Distribution of the kilometres driven in each region

For each of the three regions, we now want to find out at what level the current kilometre charge (for the 4 situations) should be set in order to result in the implicit kilometre charge. Task is to find the factors kmch() in the equation below.

$$km\ charge = \%kms(UP) * kmch(UP) + \%kms(UO) * kmch(UO) + \%kms(RP) * kmch(RP) + \%kms(RD) * kmch(RD)$$

Therefore, we combine the results from Table 6 with the right row of Table 5 and use a solver. The result for 2010 is then given in the table below.

kmch() in €/km	BRU	FL	WALL
UP	0.087	0.040	0.030
UO	0.043	0.020	0.015
RP	0.043	0.020	0.015
RO	0.022	0.010	0.007

Table 7: Resulting implicit km charge per region and per case

For the years after 2010, the annual kilometre charge per category is already mentioned in Table 4. As we assumed that those numbers are valid for the number of kilometres remaining unchanged, we can multiply the charge on a per kilometre base (in 2010, from Table 7) by the ratio of annual charges, in order to get a per km cost. This is illustrated in the tables below.

Ratio of annual charges:

avg annual km charge	ecoscore category			
year	A	B	C	D
2010	100%	100%	100%	100%
2015	75%	75%	149%	149%
2020	75%	75%	149%	149%
2025	75%	149%	224%	224%
2030	75%	149%	224%	224%

Table 8: Relative simulated km charge on a yearly basis

Resulting kilometre charge split over the ecoscore categories:

For cars of category A (2015-2030) and B (2015-2020):

€/km	BRU	FL	WALL
UP	0.065	0.030	0.022
UO	0.032	0.015	0.011
RP	0.032	0.015	0.011
RO	0.016	0.007	0.006

Table 9: Resulting km charge for category A (2015-2030) and B (2015-2020) vehicles

For cars of category B (2025-2030) and C and D (2015-2020):

€/km	BRU	FL	WALL
UP	0.130	0.060	0.044
UO	0.065	0.030	0.022
RP	0.065	0.030	0.022
RO	0.032	0.015	0.011

Table 10: Resulting km charge for category B (2025-2030), C and D (2015-2020)

For cars of category C and D (2025-2030):

€/km	BRU	FL	WALL
UP	0.194	0.089	0.066
UO	0.097	0.045	0.033
RP	0.097	0.045	0.033
RO	0.049	0.022	0.017

Table 11: Resulting km charge for category C and D (2025-2030)

5.3. Limited access to environmental zones in cities based on ecoscore

Limited access to certain urban zones has an effect on:
- new vehicles: effect on the amount of new vehicles
- existing vehicles: earlier replacement of vehicles with a low ecoscore
- driven kilometres: decrease in urban kilometres

Limited access to environmental zones prohibits entrance for vehicles with a high environmental impact. They are only accessible for vehicles with a certain minimum ecoscore. The advantage of this measure is that it specifically aims at the highest polluting vehicles. Vehicle owners who invested in clean vehicles will be rewarded since they are able to access all areas.

In Berlin a low emission zone ('Umweltzone' with an area of 85m²) was introduced in March 2007 in two stages for motor vehicles whose emission standards do not meet certain Euro criteria. The Berlin impact study concluded that a low emission zone will *not* reduce traffic per se, but it can significantly increase the pressure to switch to environmentally friendly vehicles (Lutz, 2009). 70% of the registered vehicles in the 'forbidden' vehicle class disappeared in 2008 due to the introduction of the low emission zone. Forecast studies in The Netherlands predict that the implementation of environmental zones will have an impact on both traffic intensities and fleet composition (van den Brink et al., 2008). This impact on mobility can result in vehicle kilometre reductions up to 29% (for large environmental zones, minimum Euro 5 in 2015). These reduction values are however subject to the composition of the traffic within the zone (internal – external – through traffic) and are only relevant for inner-city traffic (rerouting to rural areas possible). Combined with a greener vehicle fleet this mobility reduction can lead to emission reductions up to 32% for NO_X and 35% for PM_{10}.

In the progressive long-term scenario we assume that the limited access environmental zones will be established in all Belgian cities with more than 70,000 inhabitants as reported on January 1st, 2008 (website FOD): Antwerp, Ghent, Charleroi, Liège, Brussels, Bruges, Schaarbeek, Namur, Anderlecht, Leuven, Mons, Sint-Jans-Molenbeek, Elsene, Mechelen, Aalst, La Louvière, Ukkel, Kortrijk, Hasselt, Sint-Niklaas. The environmental zones will mainly have their impact on the composition of the vehicle fleet and the effect on mobility will be limited to a small decrease in the number of urban kilometres (in favour of the rural kilometres). The minimum ecoscore that is allowed in these specific zones is 70 by 2015, 73 by 2020 and 76 by 2030. This implies that starting from 2015, vehicles from category D are banned from these city centres. As from 2020, category C vehicles are banned as well. This prohibition is further extended to category B as from the year 2030.

These measures are implemented in the model by assuming that an infinite urban toll level has the same effect as a ban. The largest toll level available from the survey is 30 EUR per entrance. We assume this is a good proxy for simulating an infinite level.

5.4. Mandatory green private fleet quota

Mandatory green private fleet quota have an effect on:
- new vehicles: no additional effect
- existing vehicles: no effect
- driven kilometres: no effect

In addition to implementing mandatory quota for public fleets (see 3.5), the 'Progressive long-term scenario' further takes into account quota for private fleets.

Assuming that public fleets are a negligible part of the total fleet, we know that the complete fleet is composed of private vehicles (both privately held and company cars). Furthermore, we know that approximately 40% of the newly bought Belgian cars are company cars. As the quota are only meaningful for company car fleets, we further presuppose that at least 40% of the newly purchased company cars need to have a minimal ecoscore as mentioned in the table below. Due to fiscal measures in recent years, company car fleets have become more and more green (website FEBIAC), to the extent that in 2010 they are even cleaner than privately owned new vehicles and we anticipate that trend to further increase (website De Standaard). This implies that when 40% of the new purchases of the whole fleet is meeting the quota in future years, 40% of the new company car fleet will certainly comply as well. We can use this reasoning because the ecoscore module of the E-motion road database does not distinguish between company cars and privately held vehicles. Therefore, basing our judgements on a quotum for the total fleet is a safe method. The figures in the graphs below thus show the **minimal %** of new company car purchases complying with the quota. The real % for the company cars is probably somewhat higher, however, the approximation through the total fleet is our best guess.

Year	Minimal ecoscore for 40% of company car fleet
2015-2019	70
2020-2029	74
2030	80

Table 12: Mandatory green private fleet quota based on ecoscore

These quota are applicable for all company car fleets separately, so that the total Belgian company car fleet complies as well.

We do not expect this measure to have any extra effect. It is to say, we expect the criteria to be met without additional actions. We test this in the paragraphs below.

In fact, we can assume that the conditions for a specific period (eg, 2015-2019) are fulfilled when the conditions for the first year of the period (2015 in this case) are met. After all, if 40% of the new company car purchases is green in 2015, this will definitely be the case in 2019, as cleaner technologies are expected to be developed.

Sure enough, after running the progressive scenario without additional action we see that the cumulative ecoscore frequencies ≥70 of new company car purchases hits the 40% level very easily in 2015, with even more than 80% of all new company cars having an ecoscore of over 70. In 2020, we estimate that 46% of all new company cars can present an ecoscore ≥74. Finally, 44% of all the new cars bought in 2030 are considered green (ecoscore ≥80). This is illustrated in Figure 1 till Figure 3.

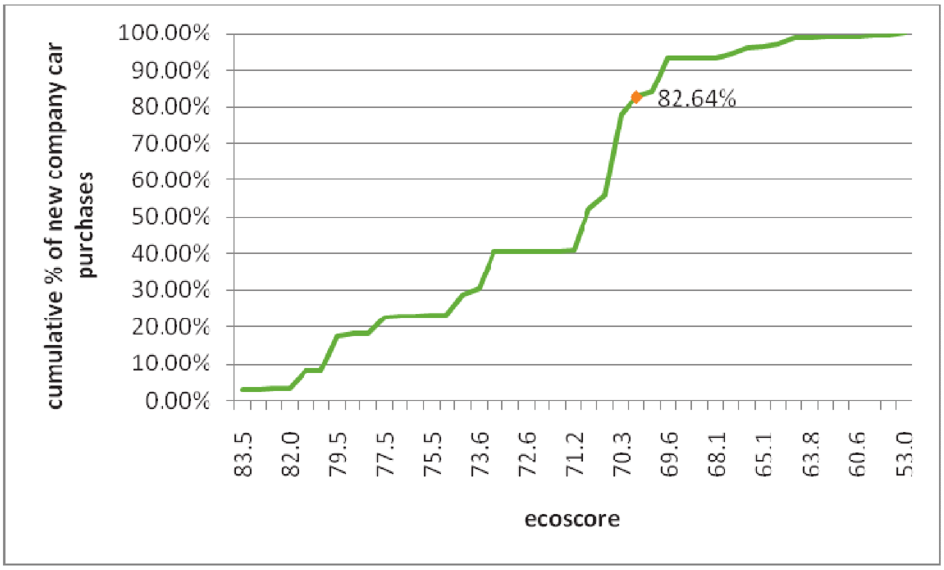

Figure 1: Cumulative frequencies of ecoscores of newly purchased company cars in 2015

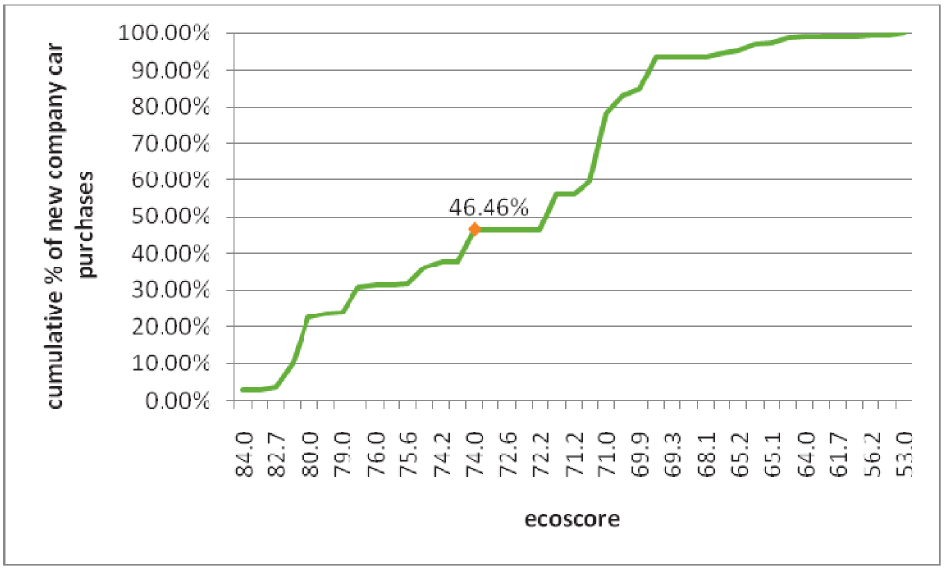

Figure 2: Cumulative frequencies of ecoscores of newly purchased company cars in 2020

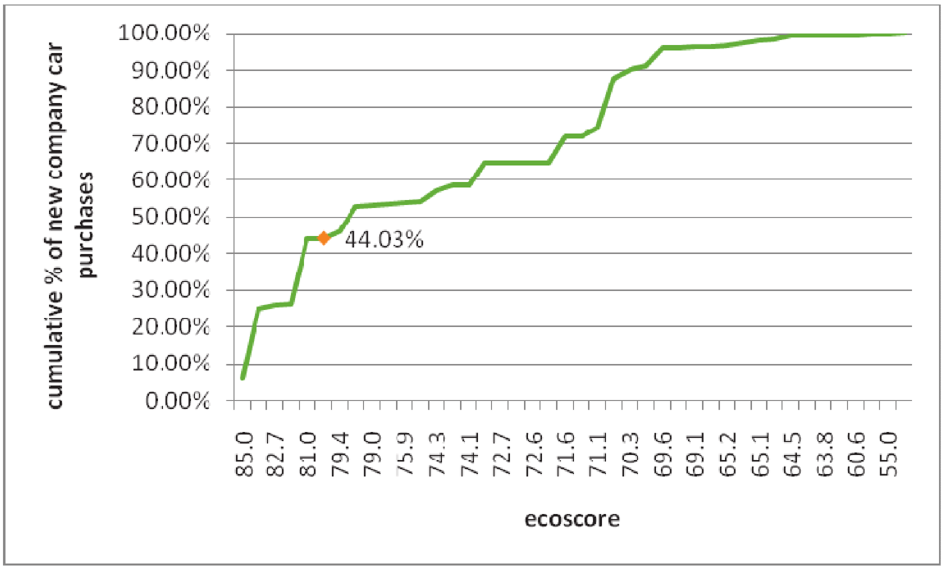

Figure 3: Cumulative frequencies of ecoscores of newly purchased company cars in 2030

5.5. Scrappage scheme

A scrappage scheme has an effect on:

- new vehicles: earlier replacement by new vehicles
- existing vehicles: earlier replacement of older vehicles (>10 years old)
- driven kilometres: no effect

There are two types of scrappage schemes. The cash-for-replacement is less cost-effective than a cash-for-scrappage scheme (CEMT, 1999). The difference between both schemes is that in the cash-for-replacement scheme an incentive is only given if a vehicle with certain characteristics is purchased. In the cash-for-scrappage scheme an incentive is given without the precondition of a new vehicle purchase. In some cases other requirements might apply[1]. Both types of scrappage schemes are a blunt instrument for emission reduction and both are most useful in highly polluted urban areas. Therefore it should only be used as a transitional instrument. The risk of both scrappage schemes is that they may also have an adverse effect on low income household, since used car prices might rise as the total supply of these vehicles is reduced (Hahn, 1995). In general it can be said that scrappage schemes are likely to reduce emissions but probably not as much as expected, particularly not nitrogen oxide and carbon monoxide emissions. This can be explained by the following factors (Dill, 2004):

- scrapped vehicles are generally driven fewer miles than other vehicles of the same model year;
- some of the vehicles would have been scrapped in any case, even without the program or would not have lasted as long as expected;
- emissions for some pollutants may not be as high as predicted because of the fewer kilometres driven.

[1] For example: In Belgium it is possible to get a free pass for public transportation for a year if no other car is purchased within the family.

For these reasons, retrofitting could have a higher impact.

This measure will only have an effect on the older vehicles in the fleet. It will result in a faster renewal of the current fleet. The minimum age of a vehicle eligible for a scrappage incentive is set to 10 years in this scenario. Based on a comparison between different scrappage schemes already implemented in different Member States, an average incentive between €1,300 and €2,100 is considered feasible. In these other Member States, around 3,33% of vehicles older than 10 years were replaced.

From the elasticity survey done by VUB-MOSI, we know that with a scrappage premium set at €2,000, almost 16% of all people willing to buy a new car will make the switch to a car with an alternative fuel/propulsion technology. The highest arc elasticity is reached as the premium rises from €4,750 to €5,000, when a total of 37% of all people wanting to buy a new car, will buy one with an alternative technology. However, this premium level does not seem feasible in the light of governmental budget constraints. Therefore, we consider the €2,000 premium as being the most realistic for this scenario. We take this measure into account from 2015 till 2019, for switches from baseline categories B, C and D to category A. Consequently, switches from C and D to category B are not assumed to be rewarded by a subsidy.

5.6. Quantification of the effect of the different measures in the progressive long-term scenario

5.6.1. Effect on new vehicles

The following measures have an impact on the new vehicle fleet:

- Tax system based on ecoscore (technology)
- Kilometre charge (higher ecoscores)
- Limited access to environmental zones in cities based on ecoscore (amount of new vehicles)
- Scrappage scheme (higher ecoscores)

Just like we did for the realistic scenario, we use the numbers from the VUB-MOSI survey to estimate the amount of people switching vis-à-vis the baseline purchases. We distinguish two groups. One group of people would buy category B, C or D in the baseline scenario but switches to category A in the progressive scenario. Another group would normally buy category C or D. However, under pressure of the new measures, they switch to category B. We repeat that all new measures (compared to the baseline) are introduced in 2015 at the earliest. The exact numbers are given in the table below.

	switch to category	**A**			**B**	
	switch from category	**B**	**C**	**D**	**C**	**D**
year	2015	13.3%	19.2%	23.7%	5.3%	7.8%
	2020	12.5%	23.8%	25.5%	4.9%	6.0%
	2025	14.9%	24.7%	26.4%	5.6%	6.7%
	2030	19.7%	24.7%	26.4%	5.6%	6.7%

Table 13: New car purchase shifts vis-à-vis baseline scenario

5.6.2. Effect on existing vehicles

The following measures have an impact on the existing vehicle fleet:

- Tax system based on ecoscore
- Kilometre charge (early replacement of lower ecoscores)
- Limited access to environmental zones in cities based on ecoscore
- Scrappage scheme

These measures will all have an effect on the composition of the existing vehicle fleet since vehicles with higher environmental scores will be favoured. Vehicles with a low ecoscore will be replaced by vehicles with newer, greener technologies. These effects are simulated in the model by changing the survival rate of the passenger cars for future years. The survival rate is dependent on the size, fuel-technology and age of the vehicle. In the progressive scenario, we take into account a surplus of replacements, resulting in a decrease in the survival rate compared to the realistic scenario.

In the progressive scenario, a doubling of the additional replacement is taken into account as an effect of the limited access to environmental zones in cities and the scrappage scheme compared to the realistic scenario. Since the survival rate for newer vehicles is higher than those for older vehicles, we implicitly take into account a larger effect on older vehicles compared to newer vehicles.

Note that the model adjustments that simulate the impact of the measures on the existing vehicle fleet will influence the estimates for the total amount (and the characteristics) of new vehicles.

5.6.3. Effect on driven kilometres

The following measures have an impact on the number of kilometres driven:

- Kilometre charge
- Limited access to environmental zones in cities based on ecoscore

The implementation of a kilometre charge will affect the number of kilometres driven. We compare the charge per km with the initial (implicit) level, as mentioned in the table with ratios of annual charges under 5.2.

avg annual km charge	**ecoscore category**			
year	**A**	**B**	**C**	**D**
2010	100%	100%	100%	100%
2015	75%	75%	149%	149%
2020	75%	75%	149%	149%
2025	75%	149%	224%	224%
2030	75%	149%	224%	224%

Table 14: Relative simulated km charge on a yearly basis

For vehicles of category A, we see that the cost per km drops. However, we artificially assume that there will be no increase in vehicle miles travelled (VMT) by category A, compared to the baseline scenario. So, the relative difference in kilometres compared to the baseline is 0% for all cars of category A, over all regions, years and road types

For vehicles from category B till D, we take the unweighted average of the relative charge, and assume the average km charge will evolve in this direction. In order to calculate the change in kilometres driven after the introduction of this kilometre charge, we use an elasticity value which only depends on the price level of the measure (i.e. costs of time losses etc. not included). With an assumed price elasticity value of -0.14 (Duerinck et al., 2007), we compute the effects on kilometres driven vis-à-vis the baseline scenario as follows:

		road type		
year	**region**	**urban**	**rural**	**highway**
2010	BRU	0%	0%	0%
	FL	0%	0%	0%
	WALL	0%	0%	0%
2015	BRU	-13%	0%	0%
	FL	-14%	0%	0%
	WALL	-14%	0%	0%
2020	BRU	-13%	0%	0%
	FL	-14%	0%	0%
	WALL	-14%	0%	0%
2025	BRU	-29%	-7%	-7%
	FL	-31%	-9%	-9%
	WALL	-31%	-8%	-8%
2030	BRU	-29%	-7%	-7%
	FL	-31%	-9%	-9%
	WALL	-31%	-8%	-8%

Table 15: Impact of the simulated kilometre charge on distances driven, vis-à-vis baseline scenario

We assume that the impact of implementing environmental zones will be very limited on total traffic intensities. However, the implementation of this measure will lead to a change in vehicle kilometres driven over different road types since unnecessary vehicle trips in the environmental zones will be travelled elsewhere and through traffic will be partly rerouted. In the progressive scenario we therefore assume that 5% of the urban kilometres driven within the environmental zones will be transferred to rural road types (Table 16).

	Urban km in environmental zones	**Shift urban kilometres to rural kilometres**
Flanders	42%	2.12%
Wallonia	39%	1.95%
Brussels	100%	5%

Table 16 : Shift urban kilometres to rural kilometres – limited access environmental zones in cities

6. Visionary Long-Term Scenario

The year is 2060. Some of the older people still remember the time of car ownership and are surprised how people back in 2010 paid so much money to own their own 'mobile polluting plant'. Some of those internal combustion (IC) cars can still be found on the road but they're rare and in nothing comparable with the hybrid cars of 2060. Although there's still an operational taxation system, this is more focused on mobility service providers. These mobility services have replaced car ownership for most people. Thanks to these service providers it is possible to use the cleanest technology available for specific trips. By giving them your current location and destination, they create an optimal mix of intermodal transportation that suits your needs best.

All over the country, zero-emission and low-emission zones have been introduced. Thanks to these zones, traffic pollution in these areas is almost zero.

Towards 2060, we expect the passenger car sector to evolve in the direction of transport sharing. Mobility will no longer be an individual perception, as people are forced to use the cleanest technology available for specific trips. It is not feasible for all individuals to possess a range of vehicles on their own. Therefore, they will appeal to mobility service companies, pooling their available fleet to a range of customers.

6.1. Effect on existing and new vehicles

Following the introduction, we will assume that people will always opt for the cleanest technique available for each trip. This becomes possible as all vehicles will be pooled. In 2060, all passenger cars driving around on Belgium roads will at least comply with the Euro 6 standard.

Regarding the fleet composition, we make a distinction between highways, rural and urban roads.

We expect hybrid diesel vehicles to rule on highways, as their radius is large enough to bridge long distances, and their engine is optimized to rotate with constant and relatively low frequencies. We distinguish two versions of diesel hybrids, namely charge sustaining (CS) and plug-in hybrid (PHEV) vehicles. We assume the share of CS on highways to be 60%, as this technology is best suited for longer distances. The other 40% of vehicles on highways are assumed to be PHEV variants. After all, for long distance transport, batteries are less suited than combustion engines because of the battery weight and loss of volume capacity.

Furthermore, we assume that rural roads are expected to be dominated by hybrid petrol vehicles. As the distances driven are usually smaller than on highways, the beneficial effect of a diesel engine is no longer there. Moreover, as movements on rural roads often pass close to people's homes, there is a strong argument to opt for the cleaner petrol technology. We expect the largest part of this fleet to be PHEV hybrid petrol vehicles (60%), just because of the smaller distances. The remaining 40% are presumed to be hybrid petrol CS cars.

Considering movements in an urban context, we assume that only electric vehicles are allowed into the city centres. This is aimed at minimizing air pollution and noise impacts in these densely populated areas.

6.2. Effect on kilometres driven

The number of kilometres driven will decrease towards 2060, more or less in line with the fall in distances driven in the progressive scenario. This observation can be done thanks to the restricted vehicle use, coordinated by the transport service companies. People will need to think before they make a trip. Each time, the consideration has to be made if the trip is worth the tariff to be paid.

7. Literature

CEMT (1999). *Conclusions and recommendations on scrappage schemes and their role in improving the environmental performance of the car fleet*.
http://www.internationaltransportforum.org/europe/ecmt/environment/pdf/CM199926Fe.pdf

Dill J. (2004). *Estimating emissions reductions from accelerated vehicle retirement programs*, **Transportation Research Part D: Transport and Environment 9**(2): 87-106.
http://www.sciencedirect.com/science/article/B6VH8-49D6Y1S-1/2/e84190a44d37f90fdad21cd6c0be66a3

Duerinck J., Aernouts K., Beheydt D., Briffaerts K., De Vlieger I., Renders N., Schoeters K., Schrooten L. & Van Rompaey H. (2007). *Energie- en broeikasgasscenario's voor het Vlaams gewest - verkenning beleidsscenario's tot 2030*, VITO, carried out for Vlaams Gewest.
http://www.lne.be/themas/klimaatverandering/klimaatconferentie/klimaatbibliotheek/strategie/Algemeen/bau-annexen-april-2007.pdf

FEBIAC (FEBIAC). *Gemiddelde CO2-emissies (in g/km) van nieuwe wagens per gewest en type eigenaar (2007-2009)*, consulted on 27/10/2010.
http://www.febiac.be/statistiques/2009/2.G.3.b.%20%20Emissions%20moy%20de%20CO2%20voitures%20neuves%20r%C3%A9gion%20et%20propri%C3%A9taire.xls

Federale Overheidsdienst Financiën (Federale Overheidsdienst Financiën). *Tarieven van de Verkeersbelasting 2010-2011*, consulted on 27/10/2010.
http://koba.minfin.fgov.be/commande/pdf/Fold_verkeersbelast_2010_2011.pdf

FOD Economie,KMO,Middenstand en Energie (FOD). *Structuur van de bevolking volgens woonplaats: grootste gemeenten*, consulted on 11/6/2010.
http://statbel.fgov.be/nl/statistieken/cijfers/bevolking/structuur/woonplaats/groot/index.jsp

FOD Economie, K.M.O., Middenstand en Energie (FOD Economie, K.M.O., Middenstand en Energie). *Afgelegde Afstanden in het Verkeer 1970-2008*, consulted on 27/10/2010.
http://statbel.fgov.be/nl/statistieken/cijfers/verkeer_vervoer/verkeer/afstand/index.jsp

Hahn R.W. (1995). *An Economic-Analysis of Scrappage*, **Rand Journal of Economics 26**(2): 222-242.
ISI:A1995QY20500004

Lutz M. (2009). *The low emission zone in Berlin - Results of a first impact assessment*, Conference proceedings of Workshop on NOx: Time for Compliance, 01/11/2009, Birmingham, UK.
http://www.berlin.de/sen/umwelt/luftqualitaet/de/luftreinhalteplan/download/paper_lez_berlin_en.pdf

Sertyn Pascal (De Standaard). *Bedrijfswagen in ban van CO_2*, consulted on 13/10/2010.
http://www.standaard.be/artikel/detail.aspx?artikelid=CN30O0UP&word=autovloten

van den Brink J., Aarnink F.F.A., Kampman B. & Otten M. (2008). *Milieu-en kosteneffecten van milieuzonering voor personenauto's*, Goudappel Coffeng, carried out for Ministerie van VROM en CROW.
http://www.vrom.nl/docs/rapport-milieuzonering-personenautos.pdf

CLEVER
Clean Vehicle Research

WP4-6

Clean Vehicle Research: LCA and Policy Measures
(CLEVER)

WP6. Fleet analysis

Vlaamse Instelling voor Technologisch onderzoek (VITO)

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January, 2011

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LIST OF ABBREVIATIONS

BRU	Brussels
CNG	Compressed natural gas
CO_2e	CO_2 equivalents
CS	Charge sustaining hybrid vehicle, uses the combustion engine as a generator for the battery
EF	Emission factor: the emission per distance travelled
Fuel Cell H_2	Hydrogen vehicle with fuel cell
FL	Flanders
H_2 ICE	Hydrogen vehicle with internal combustion engine
Highw	Highway
Km/h	Kilometres an hour
Kms	Kilometres
L	Litre = 1 dm^3
LPG	Liquefied petroleum gas
Mio	Million
PHEV	Plug-in hybrid electric vehicle, uses the electricity grid for charging the battery
TTW	Tank-to-wheel
VOC	Volatile Organic Compounds
vs	versus
WALL	Wallonia

1. Introduction

This report builds upon the scenarios defined and explained in report 5.3 – 'Scenario development'. The policy measures described there act as an input to the 'E-motion Road' model calculations. In this report, the resulting data from the four proposed scenarios are discussed.

Task 6.1 – Environmental performance of Belgian vehicle fleet – of the CLEVER study deals with the outcome of VITO's macroscopic emission road model, with a focus on the baseline scenario. Task 6.2 – Impact of the scenarios – is meant to present the model results for the 3 alternative scenarios (realistic, progressive and visionary). In this report, these tasks are included in chapter 2 and 3, respectively. In the fourth and penultimate chapter, we combine the results from the preceding chapters in order to summarize the differences between the baseline, realistic and progressive scenario in 2020 and 2030.

It has to be stressed that the outcomes mentioned in this report are the result of the complete package of measures included in the scenarios. Consequently, the magnitude of the effects of the separate policy measures are not reported on, as this exercise would go far beyond the scope of this project. Nevertheless, the way each measure was modelled is discussed in report 5.3, briefly mentioning the effects of each measure on new vehicles, existing vehicles and kilometres driven.

2. Environmental performance of the Belgian vehicle fleet (Task 6.1)

2.1. Functioning of the emission model 'E-motion Road'

Before we start with the evaluation of the various scenarios, we kick off by providing a short introduction on the functioning of VITO's 'E-Motion Road' emission model that was used to calculate both the historical (up till 2008) and the future (after 2008) emissions of road transport (see Figure 1).

Concerning the calculation of historic emissions, detailed historical input data on vehicle fleet, mileages, vehicle kilometres, biofuel blends, etc. is inventoried and converted into emissions and energy consumption values by using the emission factor approach from the MIMOSA module. Like most European road transport emission models, MIMOSA belongs to the 'average speed macroscopic emission models', expressing emission and fuel consumption rates as a function of average speed (related to the road type). The same emission factor approach is also used to estimate the future emission and energy results for different scenarios and years. However, this implies that first new estimates of the future transport situation need to be made. To forecast the vehicle stock and kilometres on the road (for different scenarios and different years), the following parameters are very important to mention:

- Survival rates of existing vehicles: this parameter presents the percentage of existing vehicles (per vehicle type and age category) that will 'survive' to the next year and will therefore belong to an older age category the following year. By analyzing the historic trends of the survival rates and the specific measures applied in each scenario, this parameter is estimated for future scenario years. This parameter can differ according to the scenario. Applying a measure such as a scrapping scheme will for example have a large impact on the survival rates of older vehicles since people will tend to change their old vehicle much sooner for a cleaner/newer one.
- Future vehicle technology: this parameter presents the distribution of the vehicle technologies over the new vehicles that enter the vehicle fleet. By analyzing the historic trends of the technology distribution of new vehicles and the specific measures applied in each scenario, this parameter is estimated for future scenario years. Therefore, elasticity values from VUB-MOSI (WP3) were applied for the following measures: a fiscal system based on CO_2 and euro standard, and excises duties (for the realistic scenario) and a RT and kilometre charge based on Ecoscore, excise duties, limited urban access and a scrappage scheme (for the progressive scenario). For the specific switch levels of purchases from one category to another, we refer to sections 4.7.1 and 5.6.1 in report 5.3. A measure such as a tax system based on ecoscore will have an impact on the future technology distribution since vehicles with high ecoscores will be preferred over vehicles with low ecoscores (increasing the share of (hybrid) electric vehicles in the technology distribution).
- Total vehicle kilometres: this parameter represents, per region, the total amount of vehicle kilometres covered on the road (originating from FPS Mobility and Transport). As a baseline estimate for this parameter, the forecasts of the Flemish traffic centre are mainly used (also used in the MIRA REF scenario from VMM), taking into account issues like socio-economic prognoses, demographic forecasts and planned transport infrastructure. The growth figures observed in Flanders can then be applied to the other regions to forecast their future vehicle kilometres. The difference in the total number of kilometres driven between the scenarios is initiated by the following measures: excise duties in the realistic scenario and a kilometre charge and limited urban access in the progressive scenario. More details on the resulting number of kilometres can be found in section 4.7.3 and 5.6.3 of report 5.3.

To estimate the impact of a certain scenario/measure on the different model parameters, both existing literature and inputs from expert evaluations were used. As already mentioned above, information on the levels of the specific measures and the general impacts of these measures/scenarios on the 'existing vehicles', the 'new vehicles' and the 'driven kilometres' is provided in task 5.3 - Scenario Development. Running the model will then result in future vehicle fleet compositions and emission data for different scenario years. Information on the resulting impact of these scenarios on the vehicle fleet and the emissions is presented in the current report.

Besides the emissions of passenger cars, the evolution of the vehicle fleet's ecoscore is modelled as well. Ecoscore is a well-to-wheel indicator expressing the overall environmental impact of a vehicle, taking into account its contribution to global warming, air pollution and noise. Production processes of fuels and electricity generation are probably not the same in 2030 as they were in 2010. However, emissions related to this well-to-tank phase (production and distribution of the fuel) of conventional fuels, are considered to remain unchanged. The reason for this is that the uncertainty on the evolution is too high (e.g., more energy efficient refineries vs. less energy efficient crude oil extraction). Only for electricity generation, we consider the trend to be more positive (higher contribution of renewable energy sources in the electricity mix).

User-friendly databases like EmEneM (emissions and fuel consumptions) and ESCORT (Ecoscores) were developed in order to easily consult the results of the scenario calculations, for example through the use of an SQL browser.

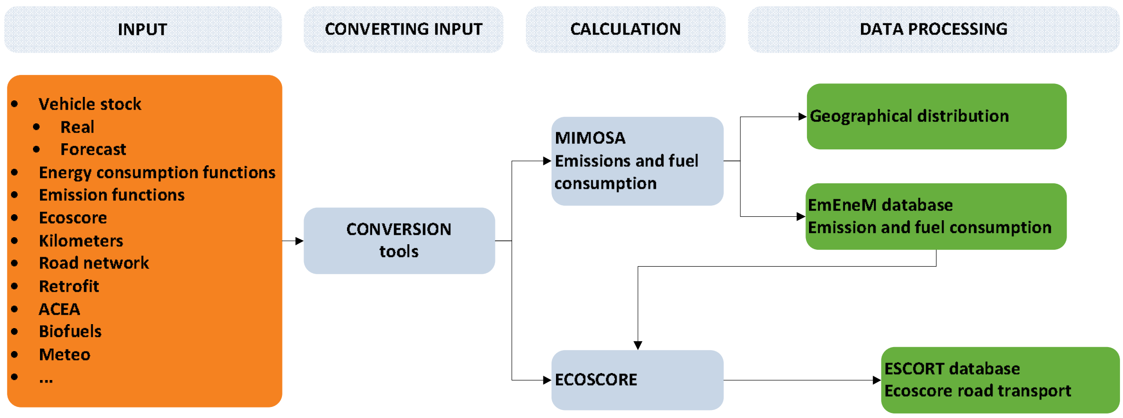

Figure 1: 'E-Motion Road' model

2.2. Results from the baseline scenario

As mentioned in the report from task 5.3, the baseline scenario is an evaluation of the present situation. In other words, in this scenario no extra measures are included on top of the current and planned legislation.

Some of the measures included in this scenario are:

A) Euro 5 and Euro 6 for passenger cars
B) CO_2 legislation for passenger cars
C) Introduction of Biofuels
D) European directive 2006/40/EC - type of coolant in mobile air conditioning
E) Mandatory green public fleet quota (for governmental bodies)

In order to construct the baseline scenario, data are extracted from a variety of sources. In this paragraph, we concisely repeat the particularities mentioned in chapter 3 of report 5.3.

The total number of historical kilometres, as well as the historical kilometres driven by each technology and age class, was retrieved from the FPS Mobility and Transport. The fleet composition up till 2008 originates from DIV. Starting point for the prediction of future total kilometres is the statistics from FPS Mobility and transport, for all three regions. For the benefit of the MIRA REF scenario, the Flemish Traffic Centre has made predictions on total kilometres driven on the three different road types for Flanders up till 2030. For all regions, this relative increase in future kilometres per road type was then taken into account. The future share of the technologies in total fleet composition was also retrieved from this MIRA REF scenario. For the future distribution of the kilometres over the various technologies, we focused on the final historical year (2008 in this study) of the FPS Mobility and Transport. Newer technologies (e.g., electric, hybrid) are assumed to be driven an amount of kilometres similar to the most resembling historical technology class (e.g., diesel kilometres for a diesel hybrid).

We expect the results for this scenario to be the most conservative of all proposed schemes.

In what follows (2.2.1, 2.2.2 and 2.2.3), we will discuss three types of indicators. It is to say, the report is structured around the following blocks: fleet composition (e.g. number of vehicles, unweighted ecoscore), vehicle use (e.g. distances driven) and environmental impact (e.g. emissions and distance-weighted ecoscore), and this for all years from 1995 to 2030. The distance-weighted ecoscore differs from the unweighted variant in that it takes the distance travelled by each separate vehicle into account, instead of giving each vehicle the same weight. More detailed results on these indicators can be found in the tables in annex. For the calculation of ecoscores, the historic data only trace back to 2006.

2.2.1. Fleet composition

2.2.1.1. Number of cars

The most obvious thing to examine is the evolution of the total number of cars in Belgium. This is depicted in Figure 2.

It is worth mentioning that the historic figures (up till 2008) from which we start (e.g., 4.88 million in 2005) are corresponding with the real numbers in (website FOD Economie,KMO,Middenstand en Energie) (e.g., 4.92 million in 2005). In 2010, approximately 5.2 million (mio) cars are registered in Belgium. The model predicts that the number of vehicles will continue to rise at least until 2030 (6.1 mio). This corresponds to an increase of 16% over the period 2010-2030. The increase is taking place rather steadily, with a relatively large jump (> 400,000 cars) in the period 2010-2015.

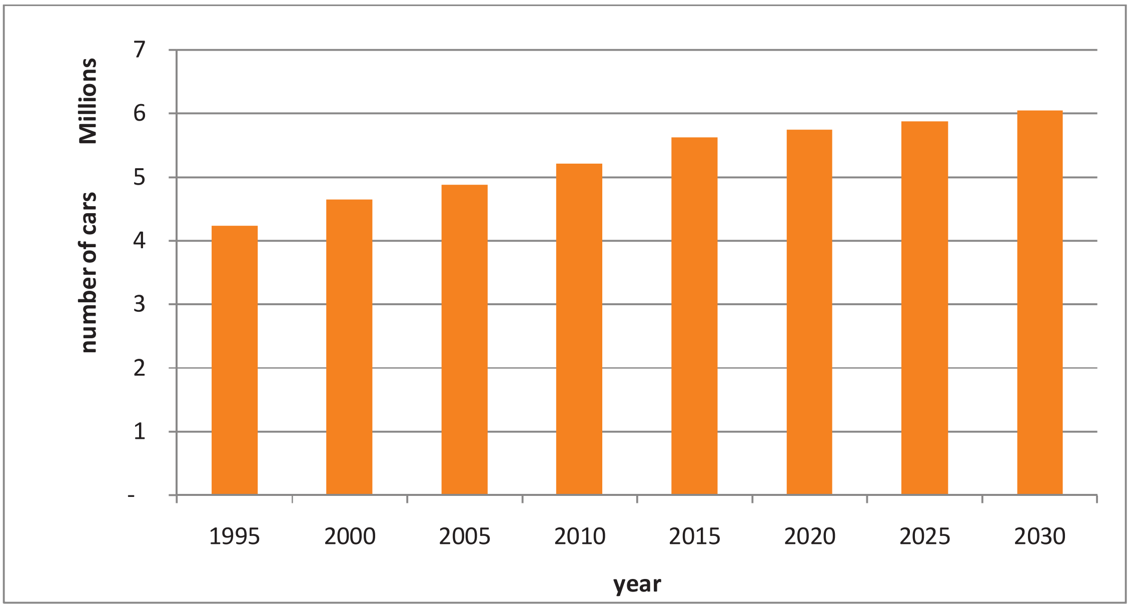

Figure 2: Absolute amount of cars in Belgium

2.2.1.2. Technology

When looking at the fuel technologies of the total fleet, we can arrange Figure 3 below. We chose to merely display the relative distribution in what follows, as the total number is already given in Figure 2. We notice that diesel has overtaken petrol since 2005 as the most important car technology. According to the baseline scenario, the number of conventional diesel cars keeps on growing at least until 2020, to almost 4 mio vehicles. Afterwards, the share of (diesel and petrol) hybrid vehicles starts to climb significantly. We distinguish between charge sustaining (CS) and plug-in hybrid electric vehicles (PHEV). The first category particularly uses its combustion engine to reload its batteries and cannot be connected to the grid. The second category is designed to be plugged into the grid in order to charge its batteries. This category also disposes of a combustion engine, although this should be considered as a range extender. In the mean time, the share of conventional petrol cars is declining steadily. The other alternative fuel systems (CNG, electric, H_2 and LPG) are only playing a marginal role in this scenario.

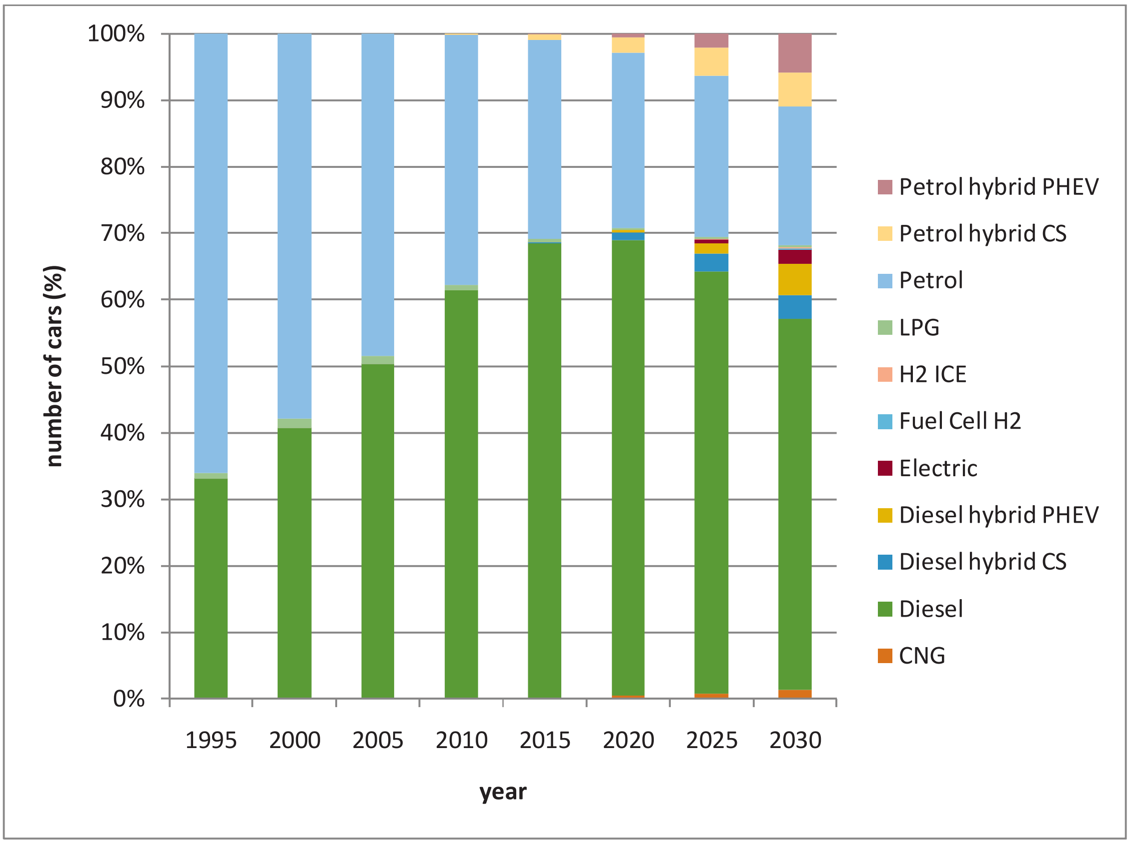

Figure 3: Relative share of cars over different technologies

2.2.1.3. Euro standard

Furthermore, we can study how the introduction of the different euro standards has an effect on the total fleet composition. The relative shares of the euro standards in the total fleet is displayed in Figure 4. Note that the vast majority (75%) of the cars in today's fleet (2010) comply with the euro 3 or 4 standard. The euro 5 standard is partly introduced in 2009, while the euro 6 standard will come into force at the end of 2014. Consequently, after these dates, we notice those categories entering the fleet. Towards 2030, almost 97% of all vehicles is expected to comply with the euro 6 standard (as no additional standard is defined yet, better than euro 6).

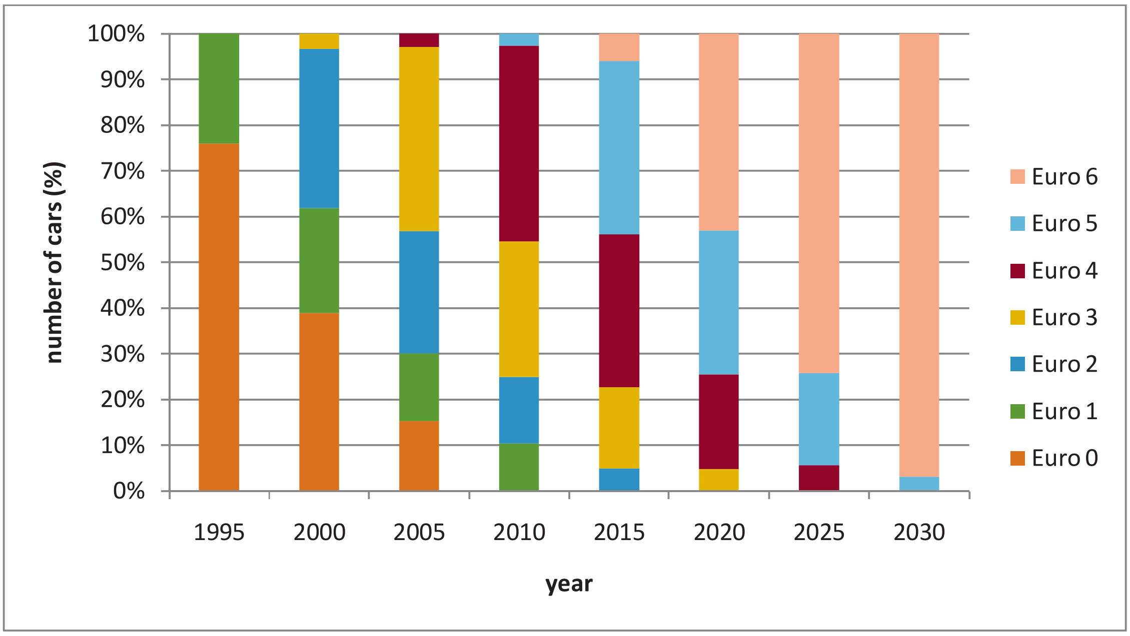

Figure 4: Relative share of cars over different euro standards

2.2.1.4. Engine size

The fleet can also be ordered based on the size of the engine. They are clustered in three categories: small, medium and large vehicles. For conventional engines, these correspond with an engine size of <1.4l, 1.4-2.0l and larger than 2.0l. This notation is also used in the figures that follow through the remainder of this report. Please be aware that for vehicles with (partly) electric engines, we always have to think in terms of small, medium and large vehicles, because cylinder capacities make no sense there. From Figure 5, we conclude that cars with small engines are becoming increasingly popular as from 2010, with an increase from 31 to 51% for the period 2010-2030. This 'downsizing' phenomenon, i.e. the design of engines with an equal power output but a lower cylinder capacity, can be attributed to fiscal incentives and innovation. The number of medium-sized engines are still constituting the largest part of the fleet today (58% in 2010). However, as from 2025, the share of medium-sized engines will have been overtaken by the small engines.

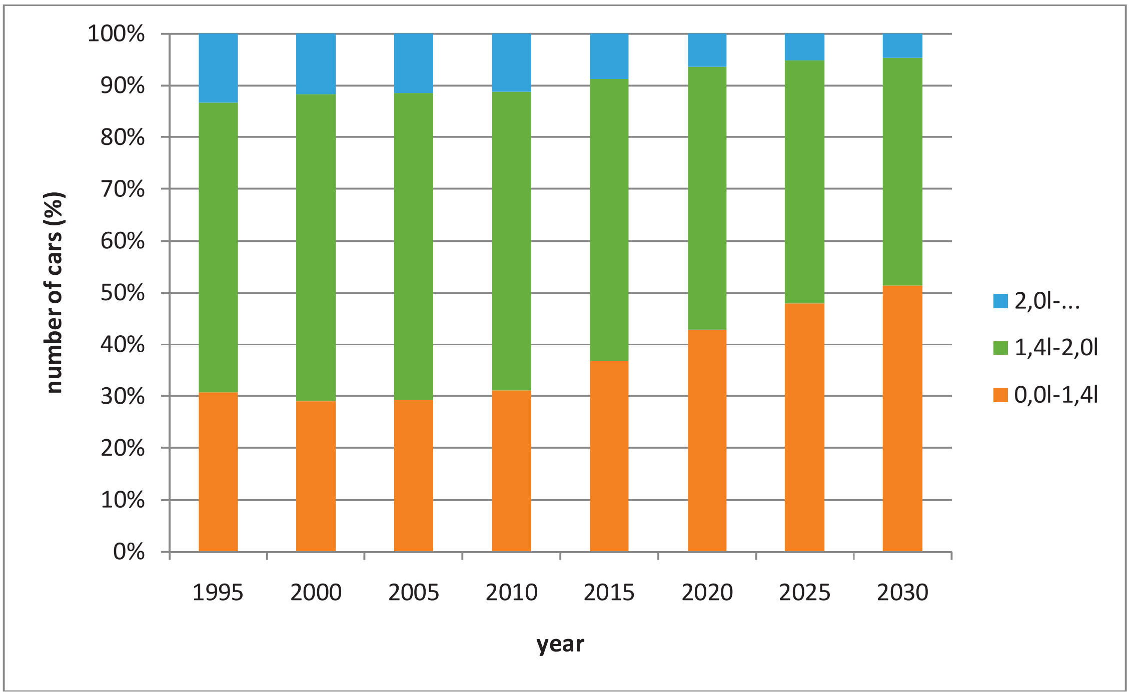

Figure 5: Relative share of cars in the different engine sizes

2.2.1.5. Ecoscore

It is interesting to have an idea of the average ecoscore of the Belgian fleet. The ecoscore can be presented either as an overall (unweighted) average of all the cars in Belgium or as a more sophisticated average, weighted by the number of kilometres driven by each car. Under this section (fleet composition), we discuss the unweighted ecoscore. In the section on the environmental impact, on the other hand, we focus on the weighted average ecoscore, taking into account the distances travelled.

The average ecoscore for the Belgian fleet is displayed in Figure 6. We see that in the four-year period 2006-2010, the average ecoscore already went up by 6 units, from 52 to 58. Our model expects this trend to continue, to an average ecoscore of 73 in the year 2030. This corresponds to an average increase of 0.74 ecoscore units per year over the period 2010-2030. The pace of improvement seems to slow down a bit during the last half of this period (2020-2030).

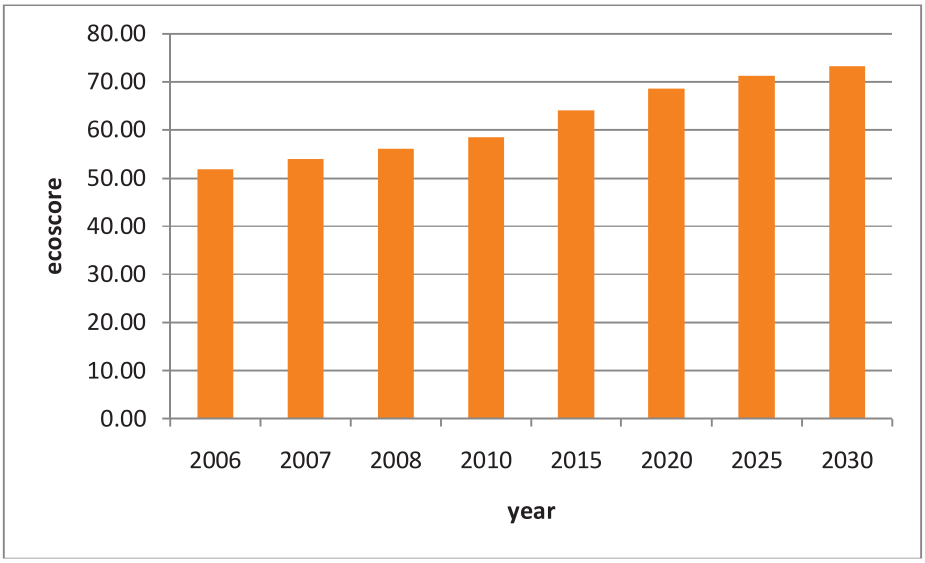

Figure 6: Average ecoscore for Belgian fleet (unweighted)

2.2.1.6. Ecoscore per technology

The average ecoscore for all Belgian cars can also be split for the various technologies. This is depicted in Figure 7.

For each fuel technology separately, it is clear that the ecoscore is expected to grow over the years to come. In this baseline scenario, hybrid vehicles are assumed to be sold on a large scale as from 2015. Their ecoscore is rising rather smoothly during the period 2015-2030. Logically, electric vehicles turn out to be the best performers, with an ecoscore of over 84 in the year 2030. Second-best in class are the hydrogen vehicles (both ICE and fuel cell). However, under this scenario they are expected to be very small in number, even in 2030 (see Figure 3). The ecoscores of the conventional petrol and diesel vehicles are expected to improve as well. As from the year 2020, conventional diesel vehicles are predicted to have caught up the petrol vehicles. Cars running on LPG and CNG are already quite clean today. Therefore, it is no surprise that their expected gain for the future is rather small.

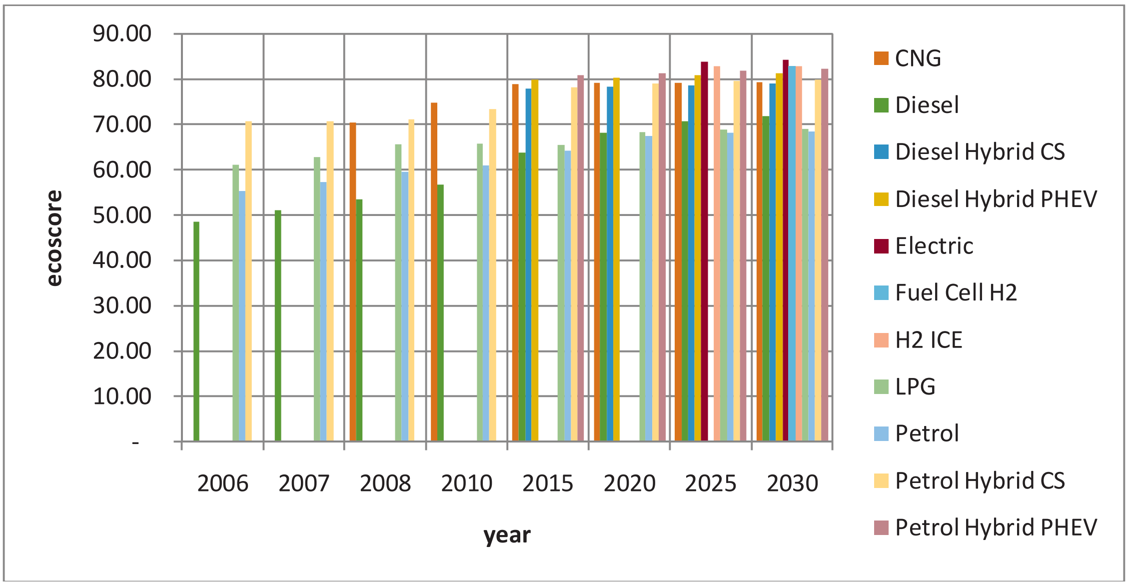

Figure 7: Average ecoscore per technology (unweighted)

2.2.2. Vehicle use

In this section, we are no longer interested in the number of vehicles in one particular year. Instead, we investigate how the vehicle use evolves over time. First of all, we discuss the overall number of kilometres driven in Belgium, for all cars and road types. Afterwards, we continue by distinguishing for road types, technologies, etc.

2.2.2.1. Kilometres driven

The total number of kilometres is displayed in Figure 8. The model forecasts a continuing increase in the total number of kilometres driven, at least until 2030 (94 billion km versus 79 billion km in 2010, i.e. +18%). Remarkable is the sharp increase (+10%) in the period 2010-2015, in line with the jump over the period 2005-2010 (+6.5%).

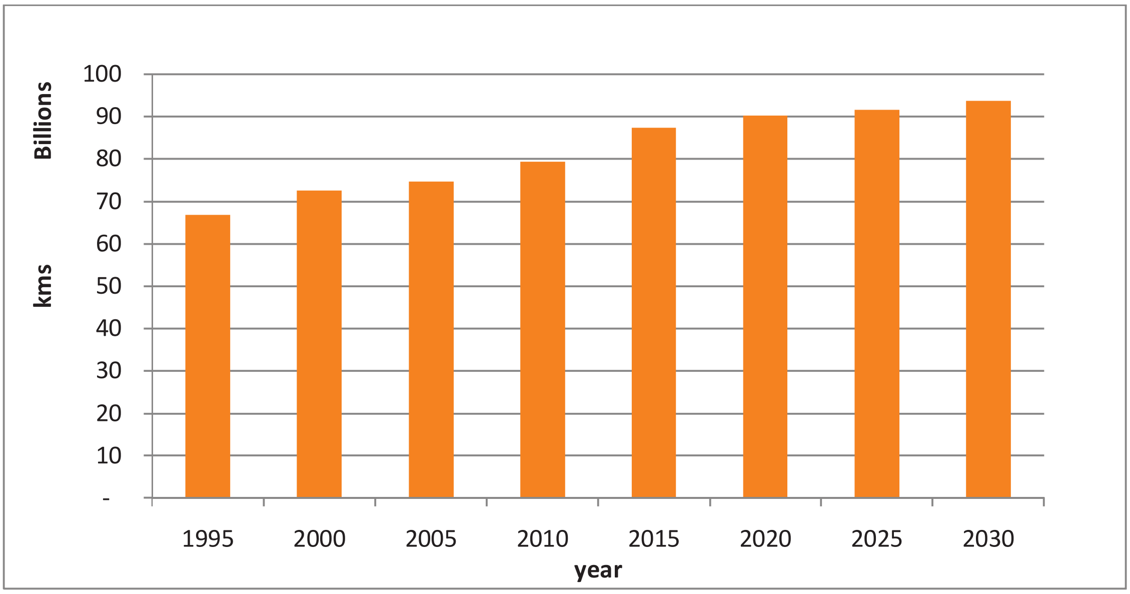

Figure 8: Kilometres driven in Belgium

2.2.2.2. Kilometres per road type

We can split the total number of kilometres according to the road types where the cars are driven. We observe an increasing trend, at least until 2030. In 2010, more than 40% of all kilometres are driven on rural roads, while one third is travelled on highways (highw). Consequently, the remaining quarter is done in an urban context. Those ratios remain practically unchanged over all the years considered.

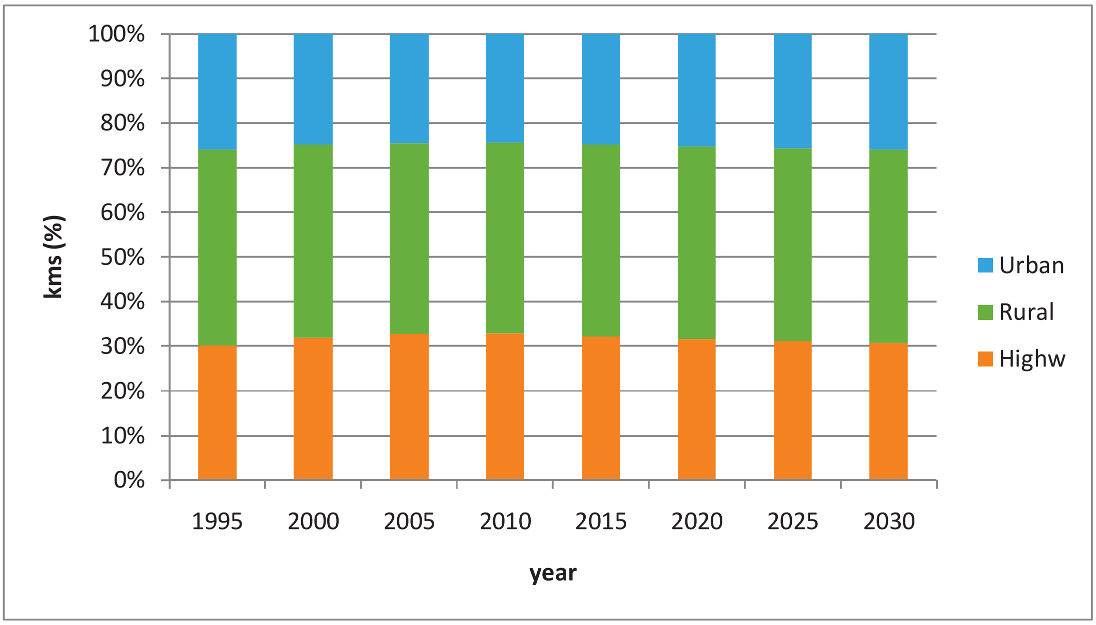

Figure 9: Relative share of kilometres driven over different road types

2.2.2.3. *Kilometres per fuel technology*

When we split the vehicle's distance travelled according to the different fuel technologies, we see that the annual number of diesel kilometres travelled (since 1995) has always been higher than those covered by petrol cars. In 2010, almost 63 billion or 79% of all kilometres is done by diesel cars. According to this scenario, diesel technology will continue to play a major role in the future, especially if distance is concerned (still 63% of all kms in 2030). The diminished share of diesel kilometres after 2015 is now mainly driven by the diesel hybrids (PHEV and to a lesser extent CS).

As we compare those results to Figure 3, it becomes clear that the average diesel vehicle drives more kilometres per year than the average petrol vehicle, as we could have expected based on the current fuel prices. Hybrid vehicles are also used more than their number should make us expect, and this is the case for both diesel and petrol hybrids. Electric vehicles, on the other hand, are driven proportionally less kilometres compared to their sales figures.

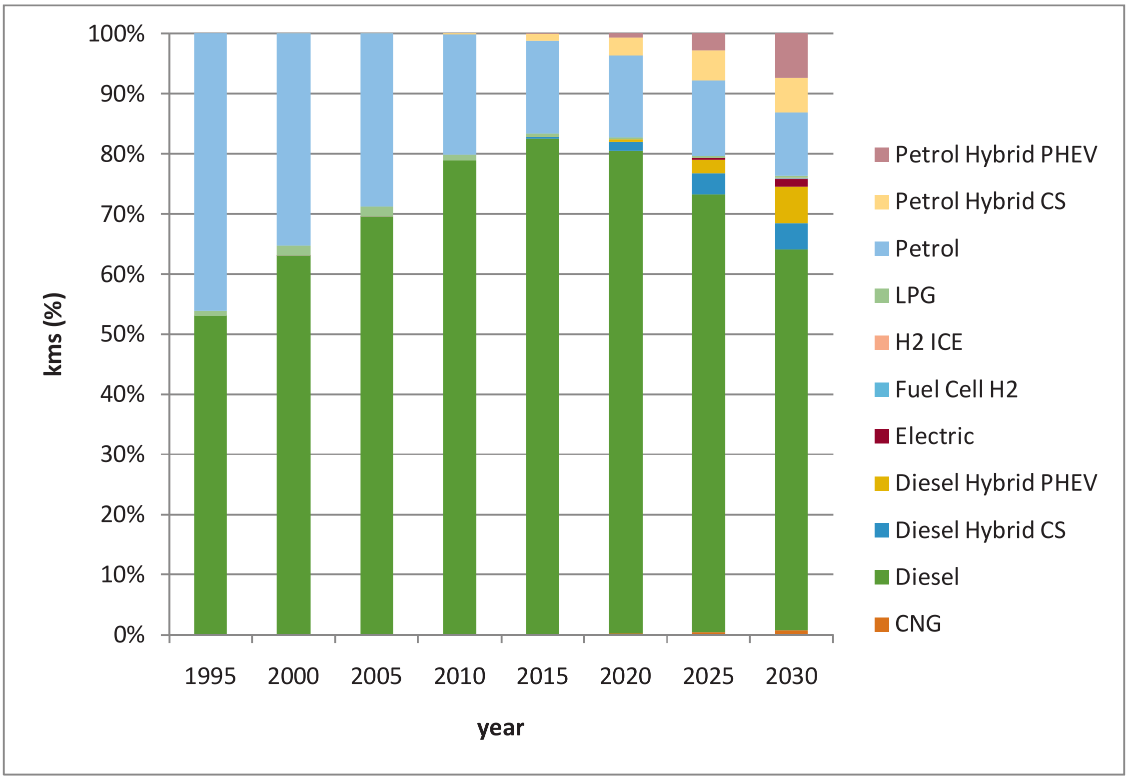

Figure 10: Relative share of kilometres driven by different technologies

2.2.2.4. *Kilometres per euro standard*

The number of kilometres travelled over Belgian roads by the different euro standard classes is displayed in Figure 11. Today, 80% of all kilometres is done by euro 3 and euro 4 vehicles, while only 4% is covered by euro 5 cars. We expect that in 2030, 98% of all kilometres is driven by euro 6 vehicles, or higher.

When we compare this result with the fleet results in Figure 4, we conclude that the newer cars (i.e., with a higher euro standard) are covering more kilometres than the older ones.

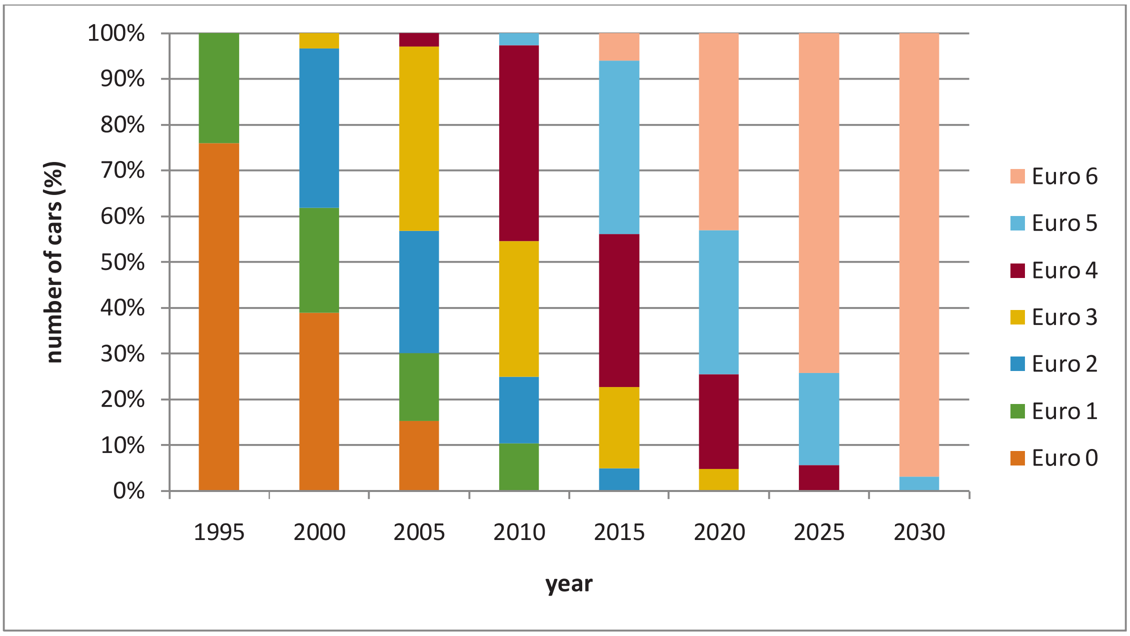

Figure 11: Relative share of kilometres driven by different euro standards

2.2.2.5. Kilometres per engine size

The number of kilometres driven by the various engine sizes is depicted in Figure 12. Until 2010, the number of cars with an engine smaller than 1.4 litres was rather small (23% of all kms in 2010). However, we expect this percentage to massively rise in the future, to approximately 44% in 2030. The share of large engine (>2.0l) kilometres is predicted to drop from 12 to 5% over the period 2010-2030. At the same time, the distances covered by medium-sized engines is expected to fall to 51%, coming from 65% in 2010.

Compared to Figure 5, the share of medium-sized and large engines (>1.4l) is higher for the current section on vehicle use. This implies that those engines are driven more kilometres each year, on average, than the engines with a smaller cylinder capacity (<1.4l).

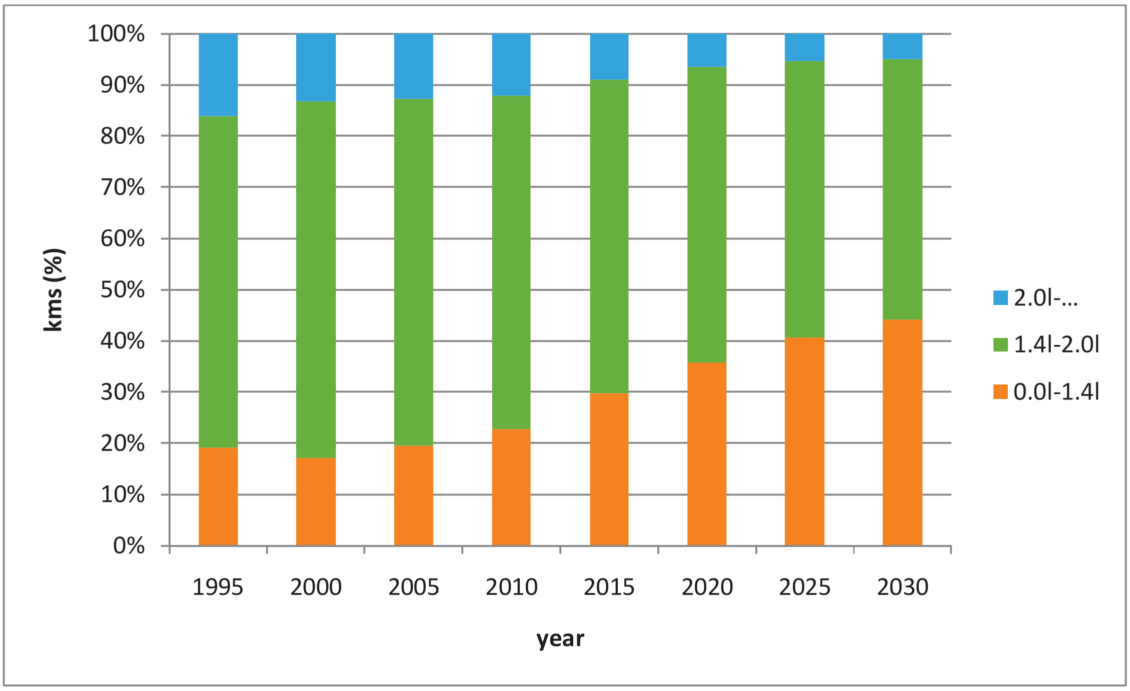

Figure 12: Relative share of kilometres driven by different engine sizes

2.2.3. Environmental impact

2.2.3.1. Ecoscore

As mentioned in section 2.2.1.5, we can calculate an average weighted ecoscore for the Belgian car fleet. Therefore, we weigh the ecoscore for each car type by the (predicted) number of kilometres driven. This indicator gives us a better idea of the overall performance of the Belgian passenger cars.

It is to say, newer cars (i.e. cleaner cars, on average) are usually driven more frequently than older cars. Therefore, we should expect that the weighted average ecoscore is somewhat higher than the unweighted indicator.

Indeed, this observation is confirmed by Figure 13. It is to say, when we compare this figure with the numbers found in section 2.2.1.5, we notice a slight increase (between 0.20 and 0.70 units) in the ecoscore, for all years starting from 2010. The overall weighted ecoscore is expected to rise from 59 till 74 over the period 2010-2030 (versus 58 till 73 for the unweighted indicator), i.e. an average increase of 0.76 units per year.

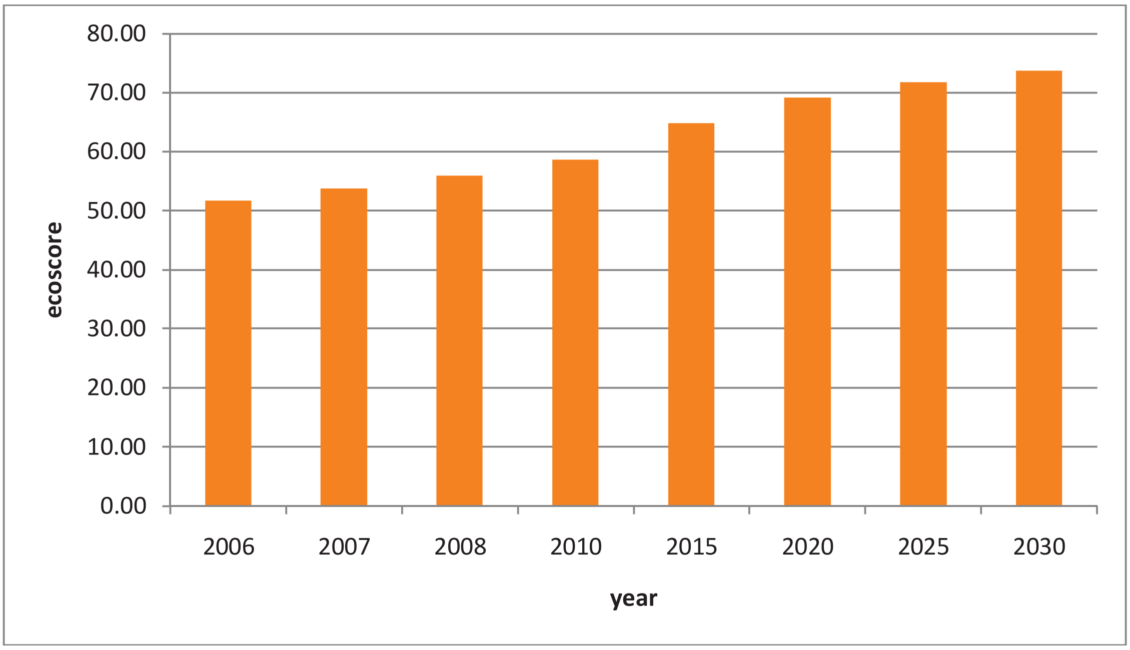

Figure 13: Average ecoscore for Belgian fleet (km weighted)

2.2.3.2. Ecoscore per technology

Again, we can split the overall average over the different vehicle technologies. The differences compared to Figure 7 are quite small, so the same conclusions apply here.

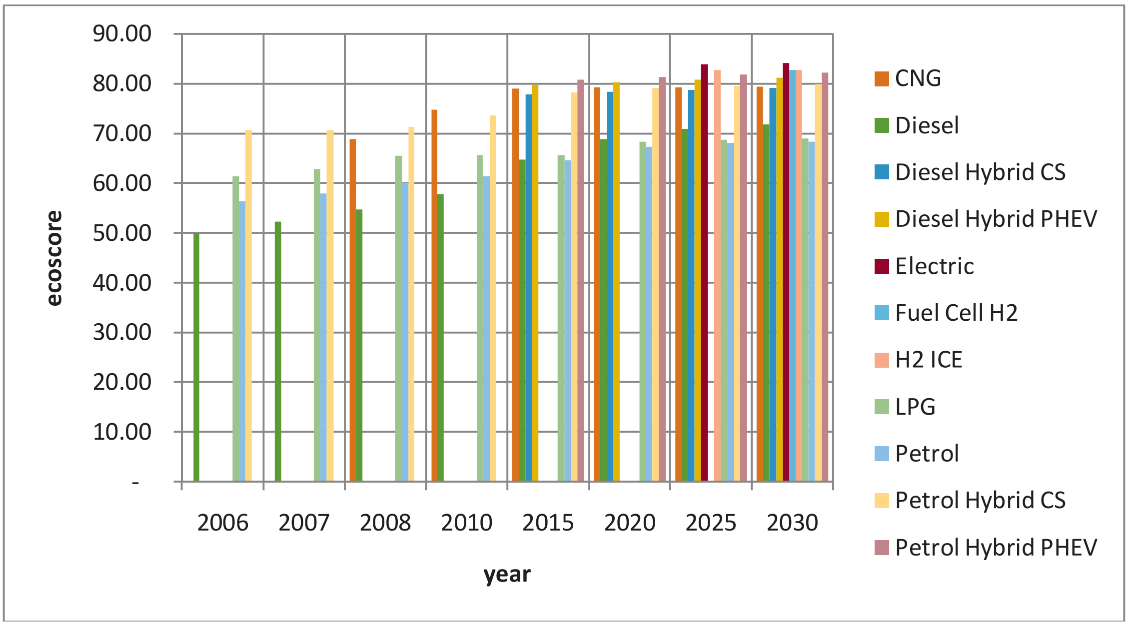

Figure 14: Average ecoscore per technology (km weighted)

2.2.3.3. Emissions

We investigated the emission quantities in Belgium for the following pollutants: CO_2 equivalents (CO_2e), PM2.5, NO_x, CO, VOCs, SO_2 and NH_3. These are also the emission pollutants that will be evaluated throughout the remainder of this report. We think those pollutants cover the most important vehicle emission classes. Please note that only tank-to-wheel (TTW) emissions are taken into account. Under this approach, electric vehicles are causing no emissions at all. We will build our discussion on emissions by a split over the different technologies, in order to give the opportunity to the reader to immediately link the pollutant with their emitting technologies.

The results are presented in Figure 15 until Figure 21.

All greenhouse gas emissions are expressed as CO_2 equivalents, found by weighing each unit of CO_2, CH_4 and N_2O by a factor 1, 21 and 310, respectively (website IPCC). This is called the global warming potential (GWP) and the GWP of CO_2 is by convention equal to one. Today, approximately 12.2 mio tonnes of CO_2e is emitted by the Belgian car fleet. Even under this baseline scenario, this number is expected to fall steadily to 10.4 mio tonnes in 2030.

In spite of the rising trend in the number of vehicles and the distance travelled, we observe a spectacular decrease in the predicted emission levels of PM2.5, CO, VOC, SO_2. Emissions of NO_x and NH_3 will also go down in this scenario, although it will happen slower.

The figures given below display the distribution of emissions over the various technologies as well. For some pollutants, there is a quite strong correlation with certain technologies.

Concerning CO_2e, we know there is a direct relationship between fuel consumption and emissions. Nevertheless, the amount of CO_2 released is higher for a litre of diesel than for petrol, which is again higher than a litre of LPG. From Figure 15, we conclude that diesel vehicles cause the majority of the CO_2e emissions from Belgian cars.

Furthermore, it seems that diesel vehicles are and will be responsible for the majority of the PM2.5 exhaust.

Diesel cars also play a crucial role in the emissions of nitrogen oxides (NO_x): before the year 2000, the largest share of emissions originated from petrol engines. In recent years, however, the amount of NO_x emissions by petrol engines has drastically been reduced, thanks to the application of the three-way catalytic converter. Nowadays, the largest share of NO_x from car transport should be attributed to diesel engines (92% in 2010) and our model predicts that this situation will persist at least until 2030 (87%).

Diesel engines used to emit lots of SO_2 as well, however, this has changed in the early noughties thanks to reduced fuel sulphur contents. Consequently, great progress has already been made in the past, such that the model expects the SO_2 emissions to remain relatively stable (only -15%) over the period 2010-2030.

Concerning emissions of CO and VOC, we observe a quite similar image. It is to say, petrol engines used to be the most important polluters in the past. Nevertheless, when the three-way catalytic converter came available, emissions started to plummet. In 2010, 79% (70%) of all CO

(VOC) car emissions are still originating from petrol vehicles. However, our model expects this share to further drop to 36% (41%) towards 2030.

On the other hand, the widespread introduction of three-way catalytic converters has worsened the level of NH_3 emissions towards the year 2000. This relationship is described by (Whitehead et al., 2004). The decreased number of petrol kilometres (-38% in 2000-2010 and a supplementary -23% towards 2030) are the main reason for the observed emission drop (till 2010) and the projected emission decline in the future.

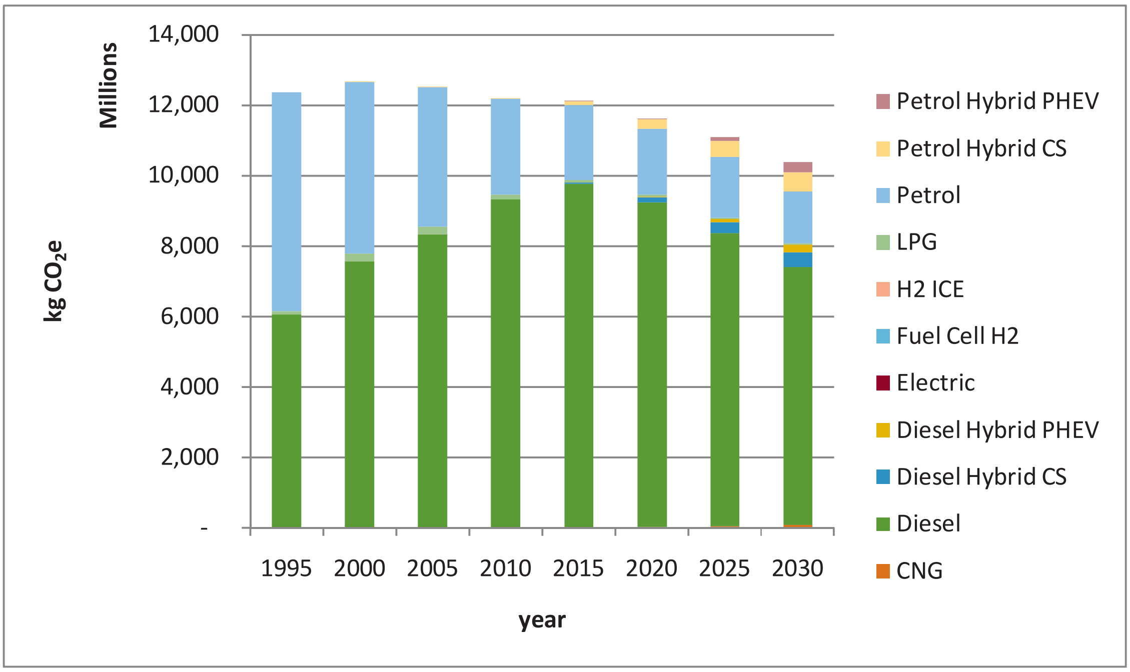

Figure 15: TTW emissions CO_2e per technology

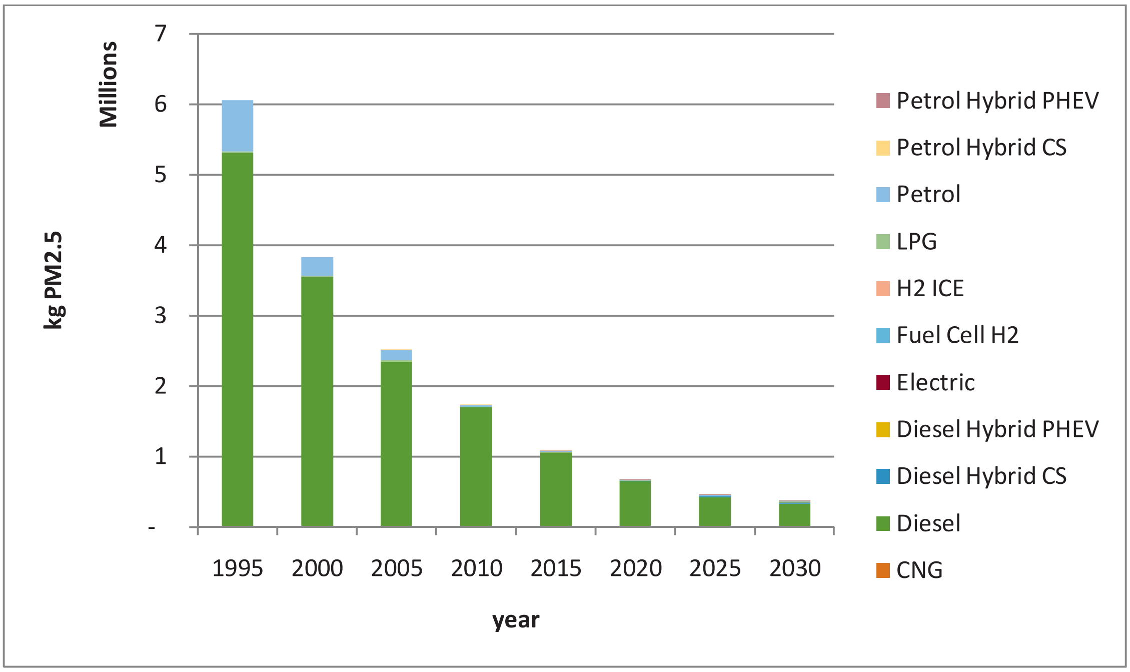

Figure 16: TTW emissions PM2.5 per technology

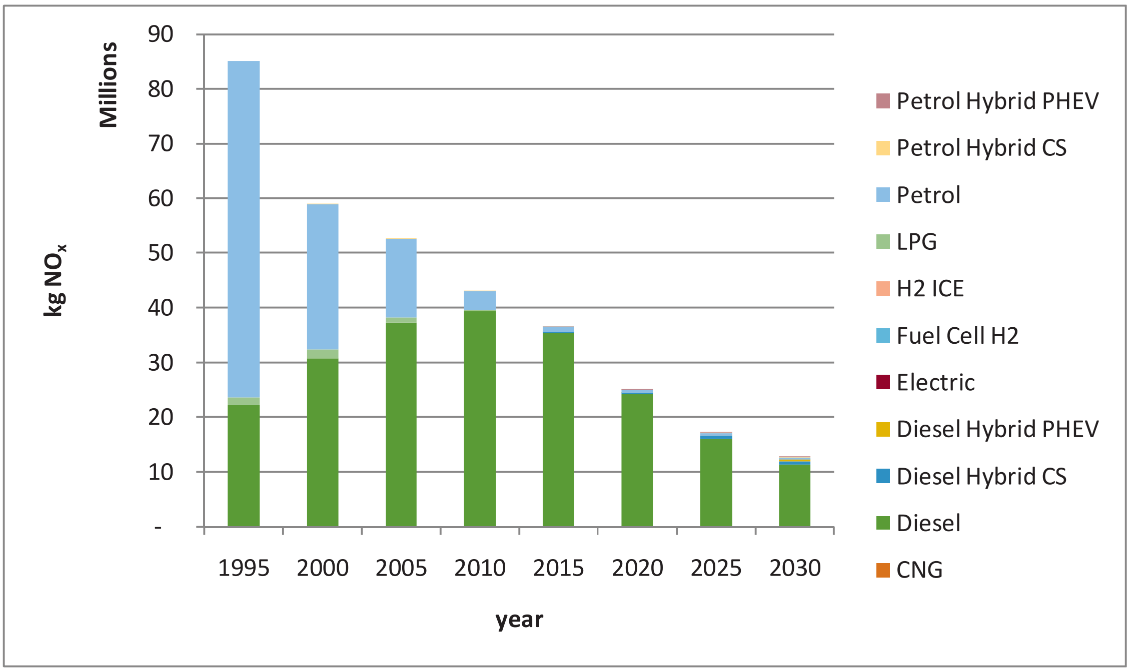

Figure 17: TTW emissions NO_x per technology

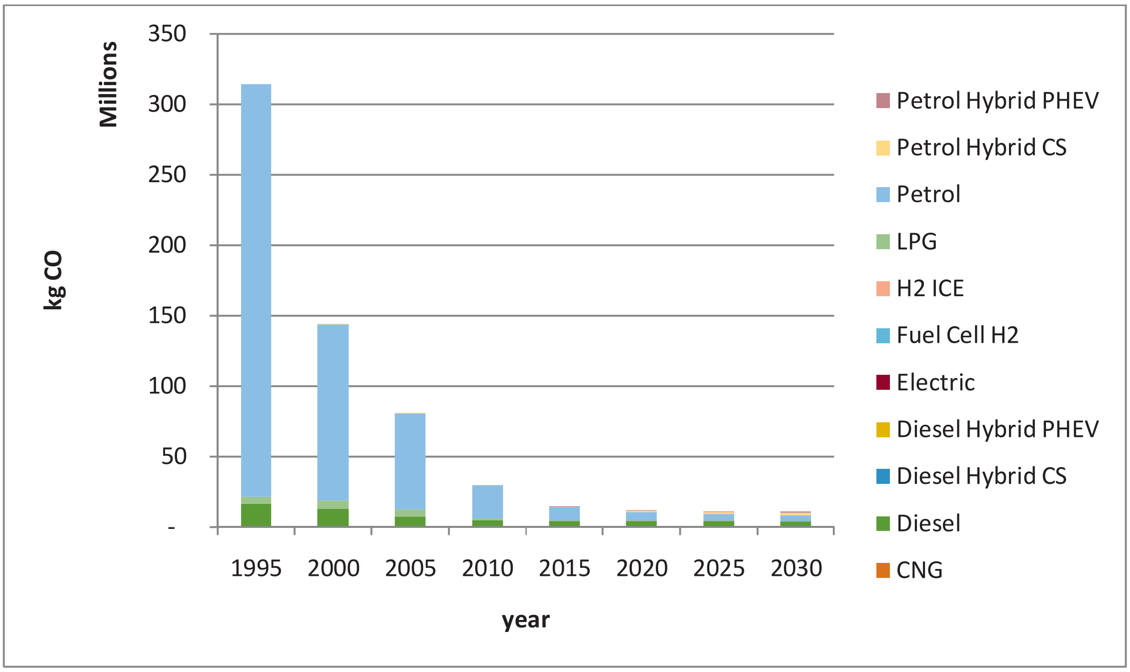

Figure 18: TTW emissions CO per technology

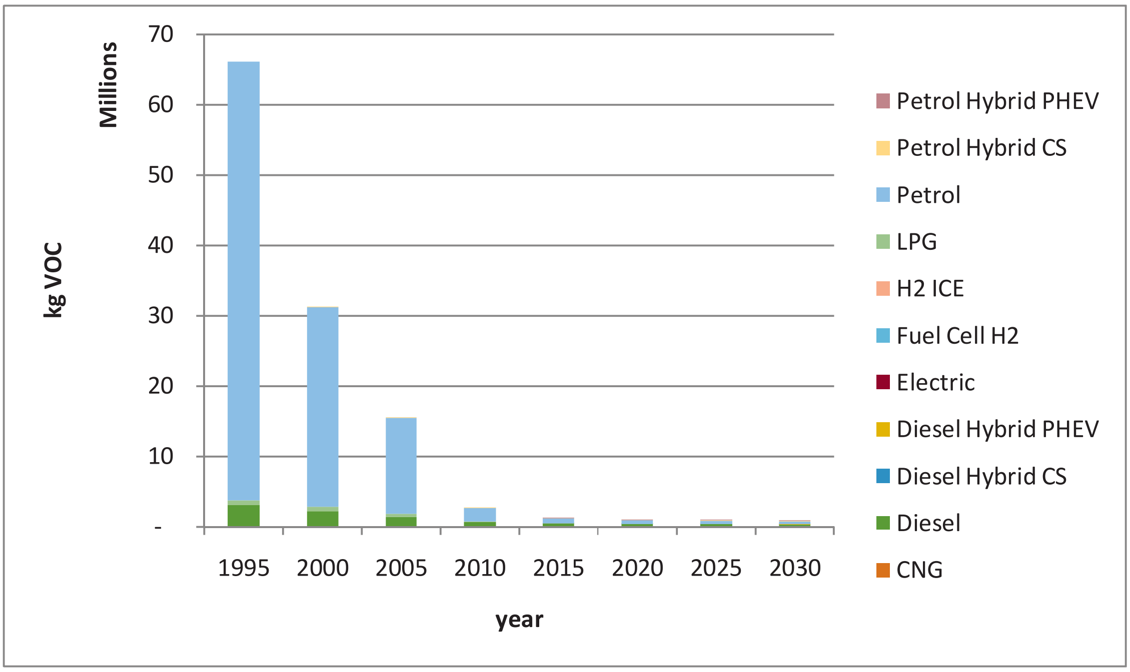

Figure 19: TTW emissions VOC per technology

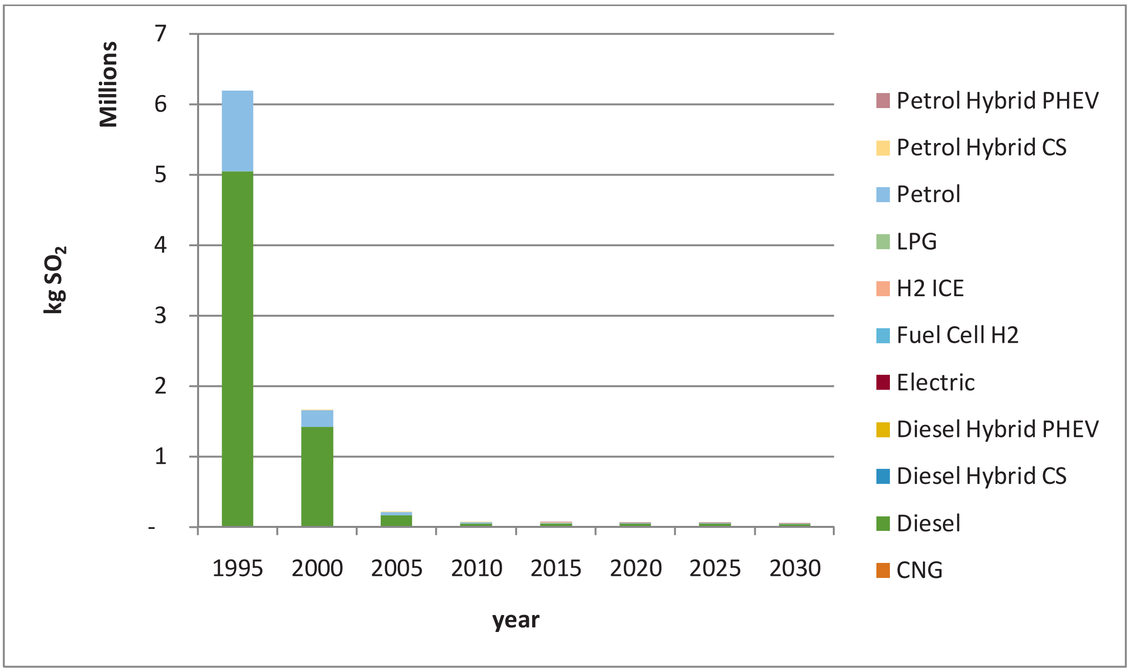

Figure 20: TTW emissions SO_2 per technology

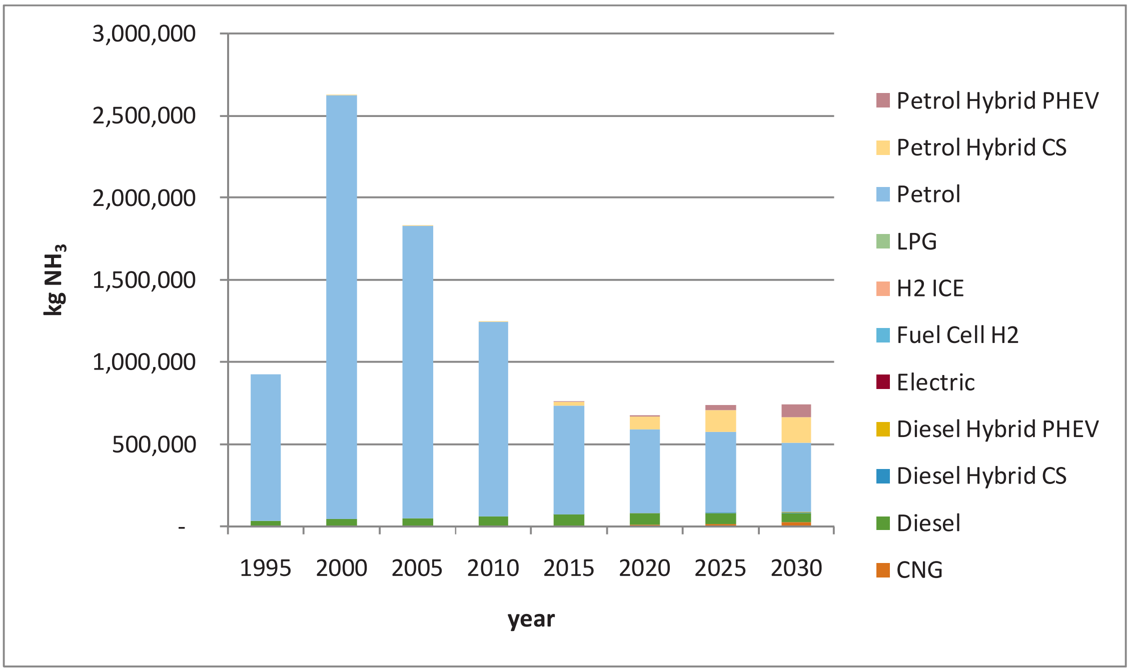

Figure 21: TTW emissions NH_3 per technology

3. Impact of the scenarios (Task 6.2)

In this section, we examine the effects of the 3 alternative setups, viz, the realistic, progressive and visionary scenario. The arrangement is similar as for the baseline scenario: the effects from each scenario are subdivided into fleet composition, vehicle use and environmental impact data. Detailed result tables are again provided in the annex at the end of the report.

3.1. Realistic scenario

The measures introduced under the realistic scenario are repeated below. We also provide a timeline (Table 1) with an indication of the start date and running period (yellow) for a specific measure and a first estimation of the period with the largest effects (or shocks) on fleet and environmental impact (black shading). Please note that the cell under '2000' represents the period from the beginning of the year 2000 till the end of 2004. For a detailed description of all the adopted measures, we refer to the report of task 5.3 'Scenario development'.

Extra measures under the realistic scenario compared to the baseline scenario:

A) Tax system based on combination of CO_2 and Euro standard
B) Advantages for Euro 6 vehicles
C) Clean fuels: standardization and availability (CNG and E85)
D) Change in excise duties
E) Subsidies for retrofitting old cars with filters
F) Subsidies for cleaner fuel systems (LPG and CNG)

	2000	2005	2010	2015	2020	2025
A						
B						
C						
D						
E						
F						

Table 1: Timing of the realistic measures (yellow) and the period with their largest expected impact (shading)

3.1.1. Fleet composition

3.1.1.1. Number of cars

Under the realistic scenario, the total number of Belgian cars is expected to rise to 5.8 million in 2030. This is 4% lower than under the baseline scenario. This difference compared to the baseline is built up steadily over the period 2010-2030.

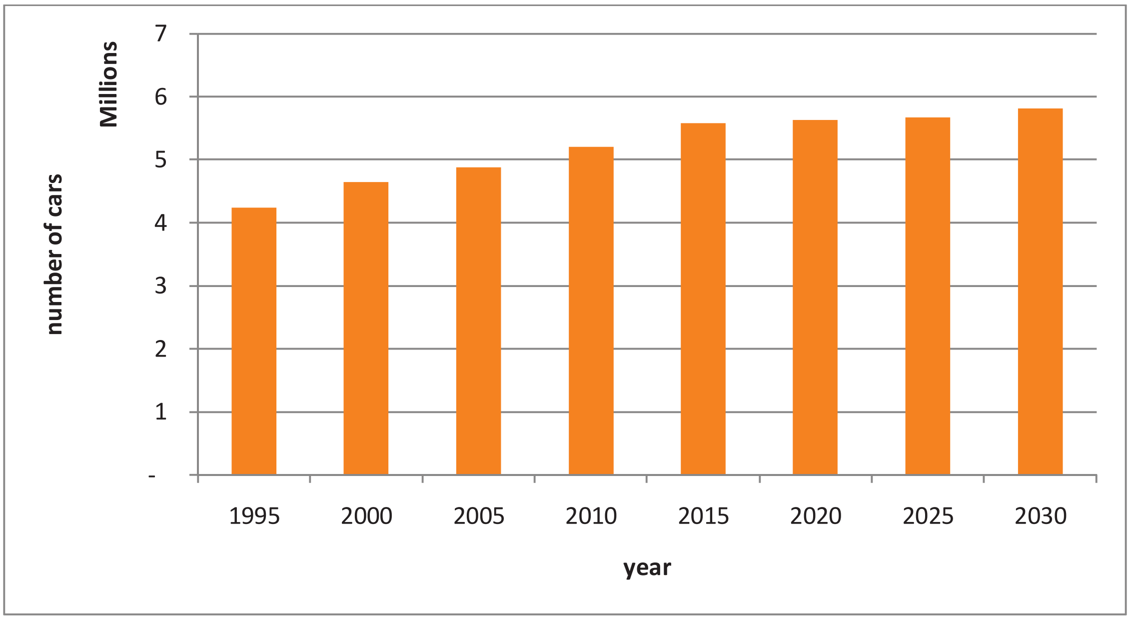

Figure 22: Absolute amount of cars in Belgium

3.1.1.2. Technology

When we split over the various vehicle technologies, we observe the distribution given in Figure 23. There are only some small differences compared to the baseline results. It is to say, the share of LPG and CNG vehicles rises slightly, whereas petrol and petrol hybrid CS cars are losing ground. The share of diesel cars is slightly smaller than under the baseline in 2015 and 2020, but a little bit higher for the years 2025 and 2030. Although the study of the separate effects from the policy measures lies beyond the scope of this report, we can imagine that the retrofit subsidies and the stimulation of clean fuels play an important role here. Moreover, a tax system based on CO_2 is obviously not beneficial for stimulating the purchase of petrol vehicles, as their carbon dioxide emissions are usually substantially higher compared to diesel engines.

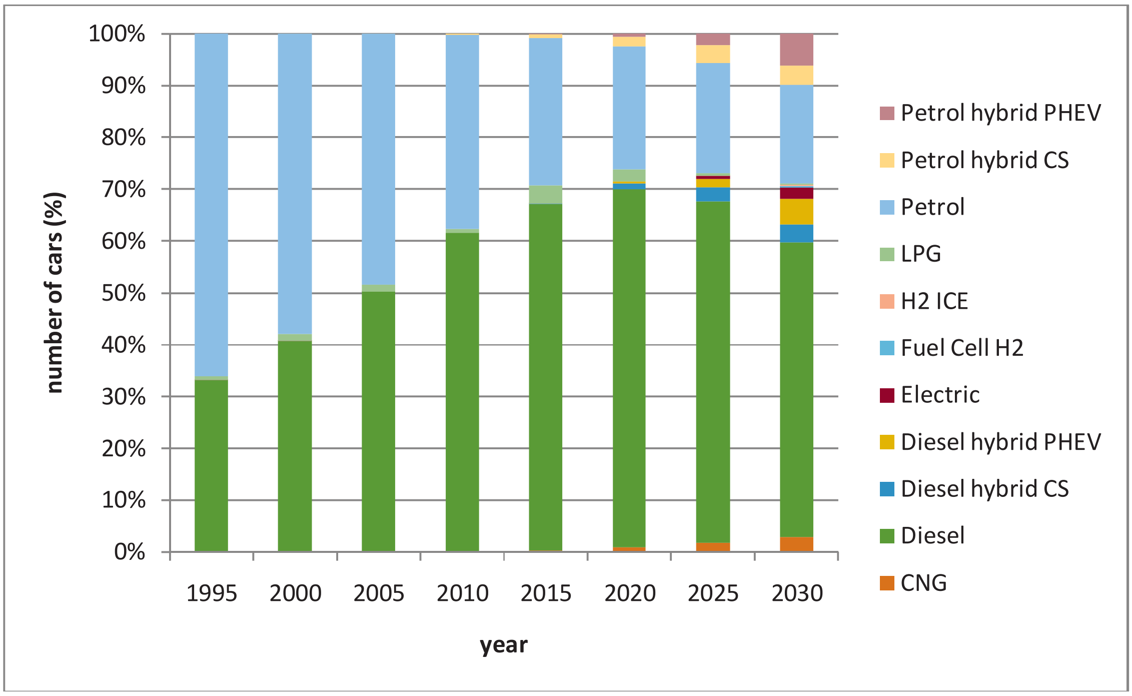

Figure 23: Relative share of cars over different technologies

3.1.1.3. Euro standard

The split over the euro standards is given in Figure 24. Newer standards are picked up somewhat earlier under this realistic scenario than under the baseline, for the period 2010-2030 (41 vs 38% Euro 5 in 2015 and 46 vs 43% Euro 6 in 2020). This is probably due to the benefits for vehicles complying with these standards. However, the distribution for the two scenarios is similar in 2030 (97% Euro 6), as the rate of improvement for the realistic scenario relatively decelerates in the last few years before 2030.

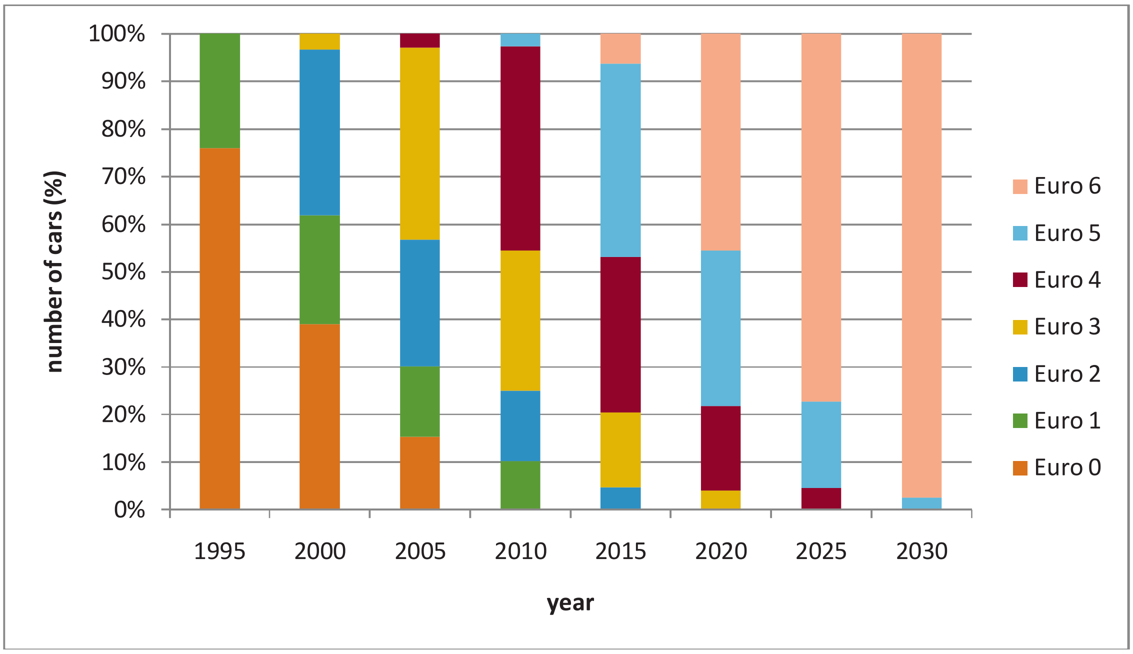

Figure 24: Relative share of cars over different euro standards

3.1.1.4. Engine size

When we split over the engine sizes of the fleet, we notice that the difference vis-à-vis the baseline is negligible. Again, the downsizing trend is clearly visible, and the smallest category constitutes 51% of the total fleet towards 2030.

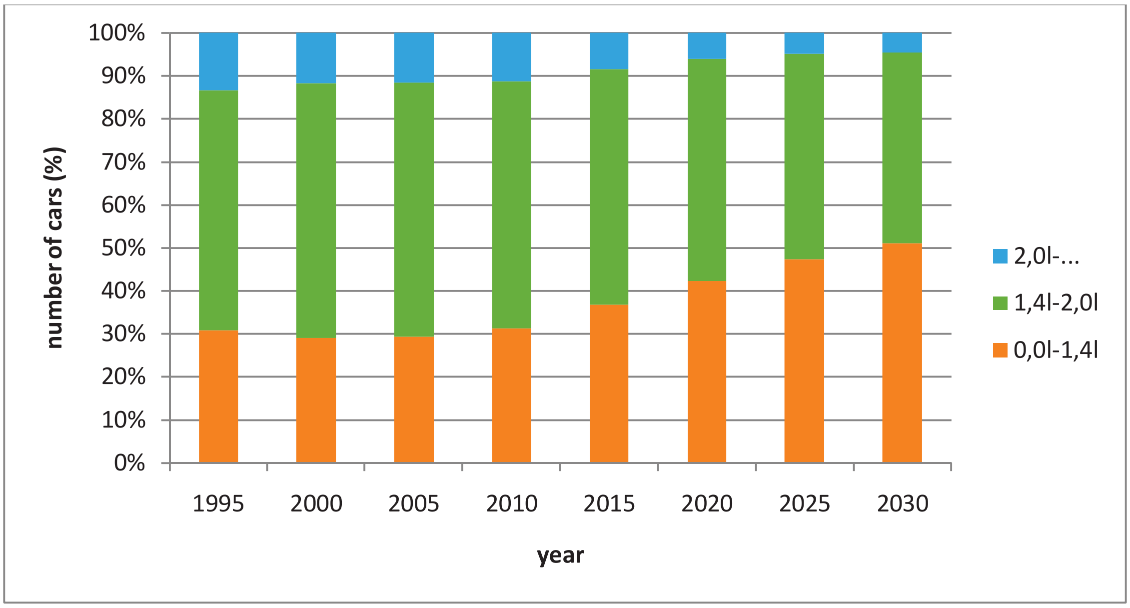

Figure 25: Relative share of cars over different engine sizes

3.1.1.5. *Ecoscore*

The rate of increase of the average ecoscore is somewhat higher under this scenario compared to the baseline (0.75 vs 0.74 units/year) over the period 2010-2030. The largest shift is observed for 2010-2015, when the ecoscore is expected to rise from 58.40 to 64.78. See Figure 26.

The split of ecoscores over the technologies is not repeated here (nor under the progressive scenario), as the differences compared to the baseline are marginal. However, the result table can be found in the annex at the end of this report.

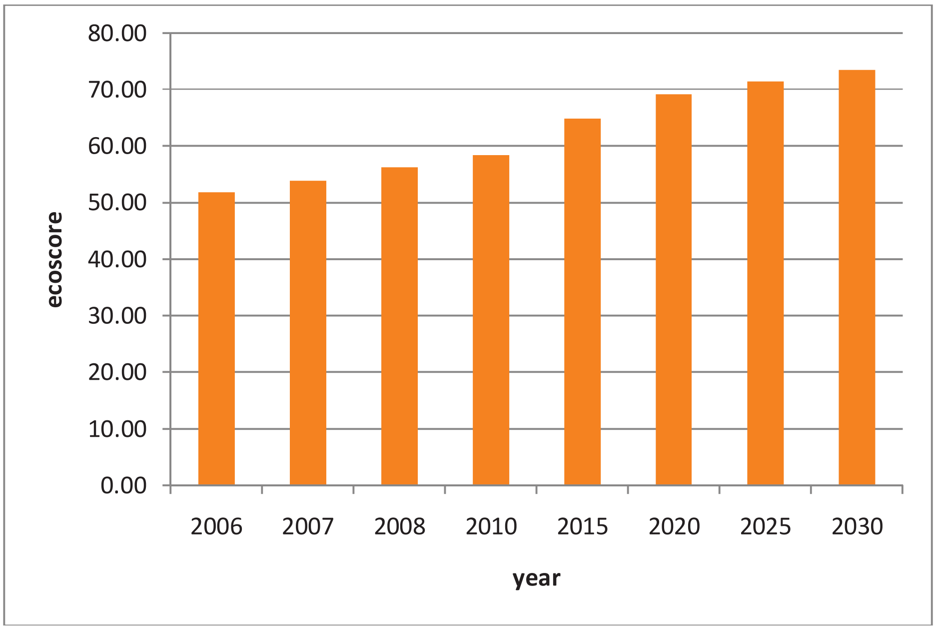

Figure 26: Average ecoscore for Belgian fleet (unweighted)

3.1.2. Vehicle use

3.1.2.1. *Kilometres driven*

The total number of kilometres driven is depicted in Figure 27. The total distance travelled now only increases to 92 billion kilometres in 2030. It is to say, we expect a smaller climb in the total distance travelled, compared to the baseline (+16 vs 18% over the period 2010-2030).

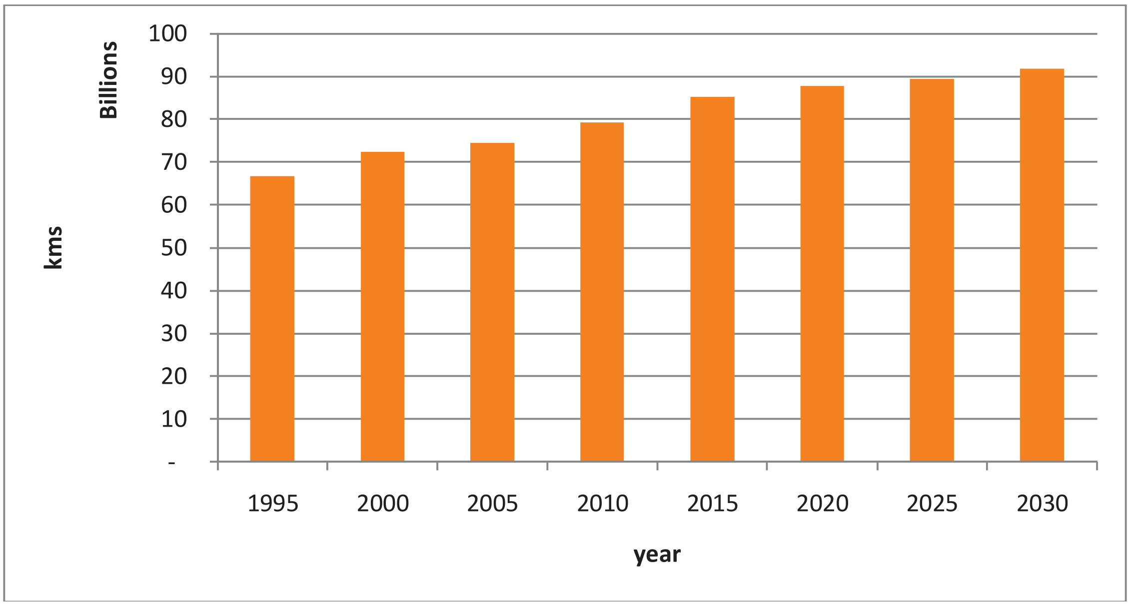

Figure 27: Kilometres driven in Belgium

3.1.2.2. Kilometres per road type

The relative shares mentioned in 2.2.2.2 do also apply for the realistic scenario, as the differences between the relative shares are infinitesimal.

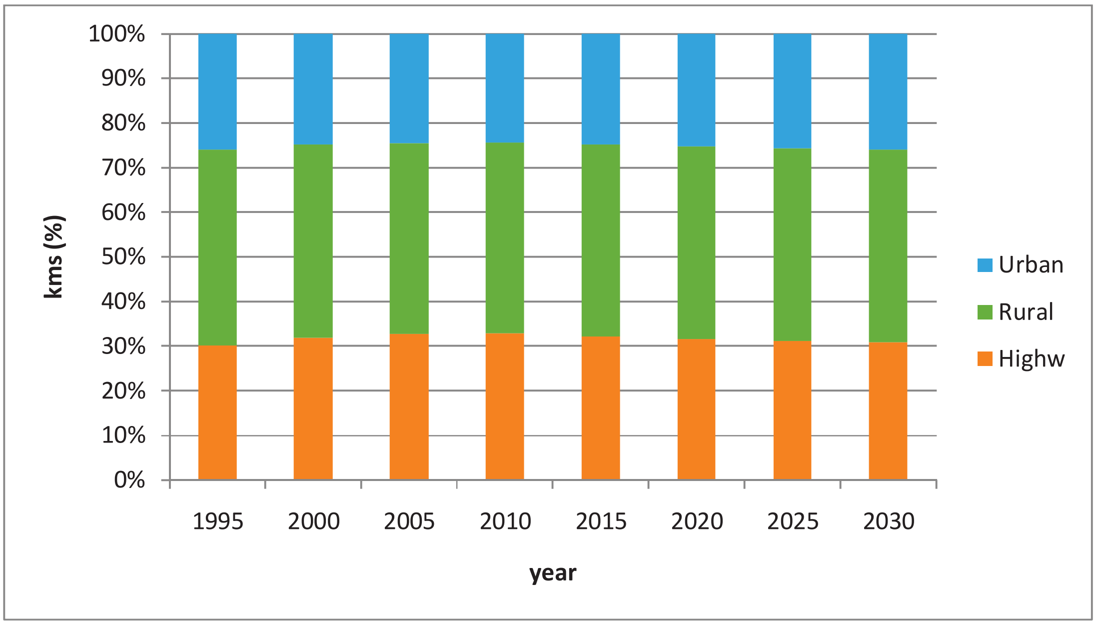

Figure 28: Relative share of kilometres driven over different road types

3.1.2.3. *Kilometres per fuel technology*

Just like we saw in 3.1.1.2, the technology distribution is only slightly different from the one in the baseline scenario. We clearly observe an increased distance covered by LPG (2015 and 2020) and CNG vehicles (2025 and 2030), whereas petrol and petrol hybrid CS cars are driven a smaller relative share. The relative share of diesel kilometres is again slightly smaller for the years 2015 and 2020 compared to the baseline, and somewhat higher for 2025-2030.

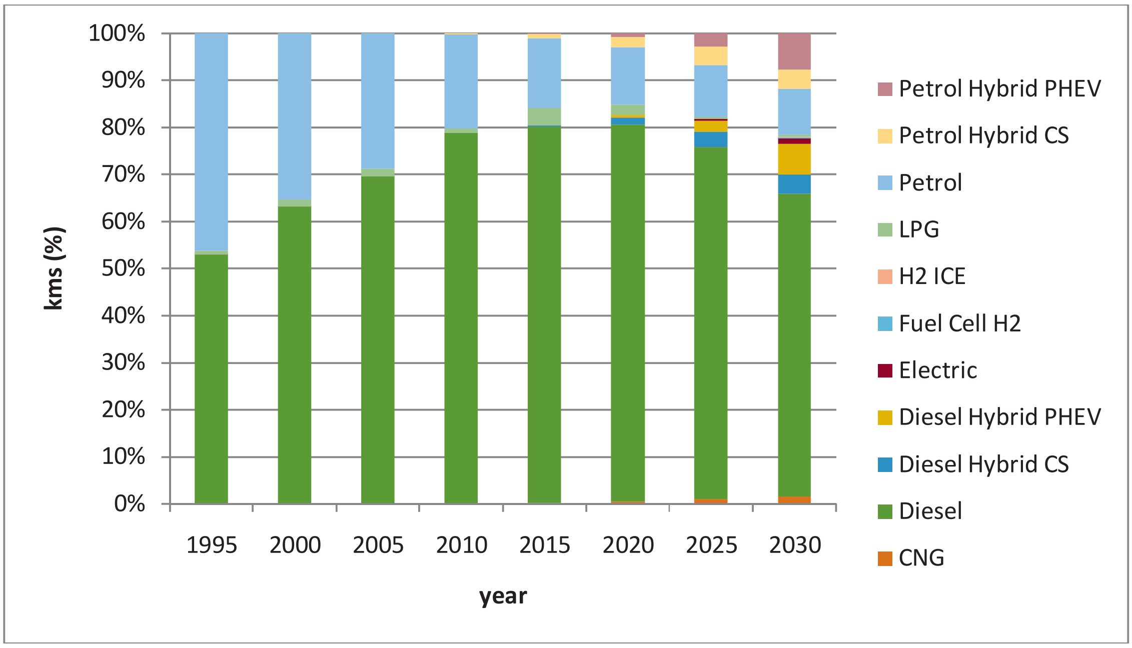

Figure 29: Relative share of kilometres driven by different technologies

3.1.2.4. *Kilometres per euro standard*

We observe the same trend as mentioned under 3.1.1.3 (number of vehicles). The fact is that the recent standards are picked up earlier and driven accordingly than under the baseline (46 vs 44% Euro 5 in 2015 and 52 vs 51% Euro 6 in 2020).

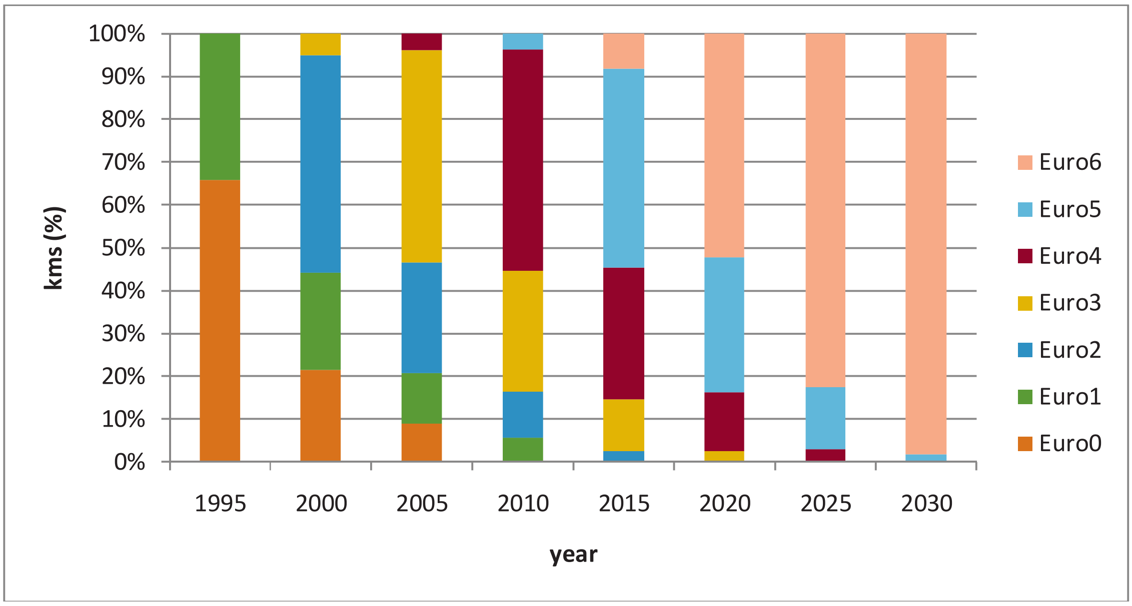

Figure 30: Relative share of kilometres driven by different euro standards

3.1.2.5. Kilometres per engine size

The effects from the realistic scenario on the distance distribution over the engine size are negligible, as all comments stated under 2.2.2.5 are valid for the current paragraph as well.

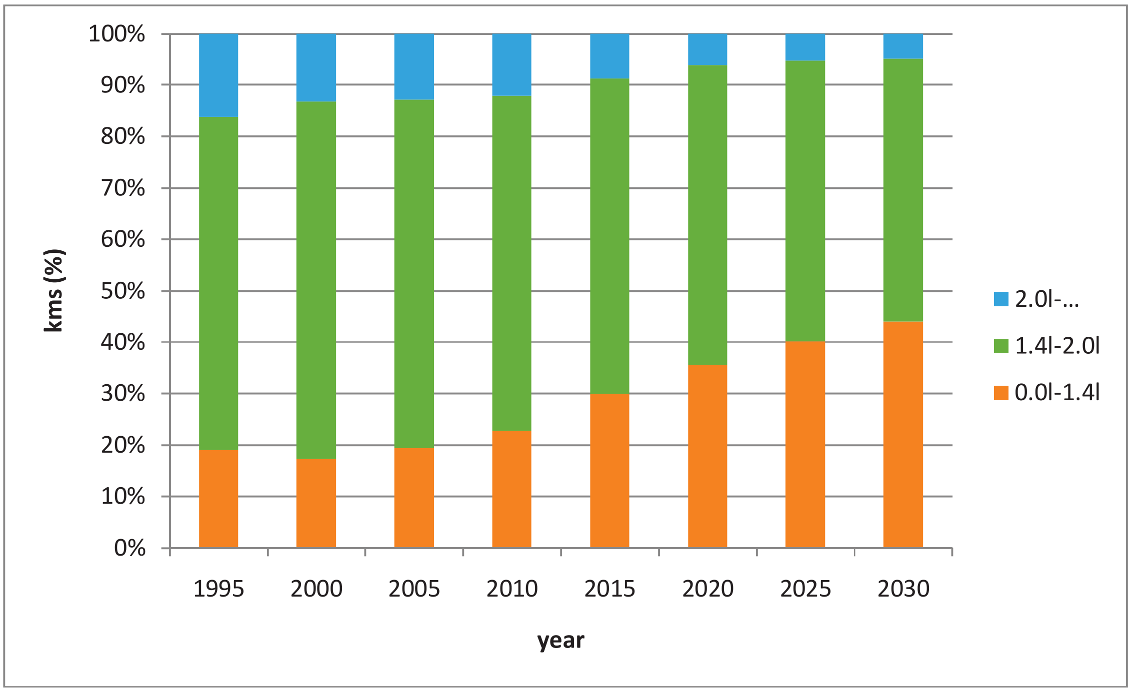

Figure 31 : Relative share of kilometres driven by different engine sizes

3.1.3. Environmental impact

3.1.3.1. Ecoscore

The expected evolution of the km-weighted ecoscore over the period 2010-2030 is very similar to the one in the baseline (from 59 to 74, or an average of 0.76 units/year). However, the realistic scenario forces the weighted ecoscore to follow a steeper path (compared to baseline) in the near future (2010-2015), and a more modest evolution in the years thereafter.

Please note that the technology split is not discussed in more detail here (nor in the progressive scenario). Nevertheless, the raw data tables can be found in the annex on detailed results.

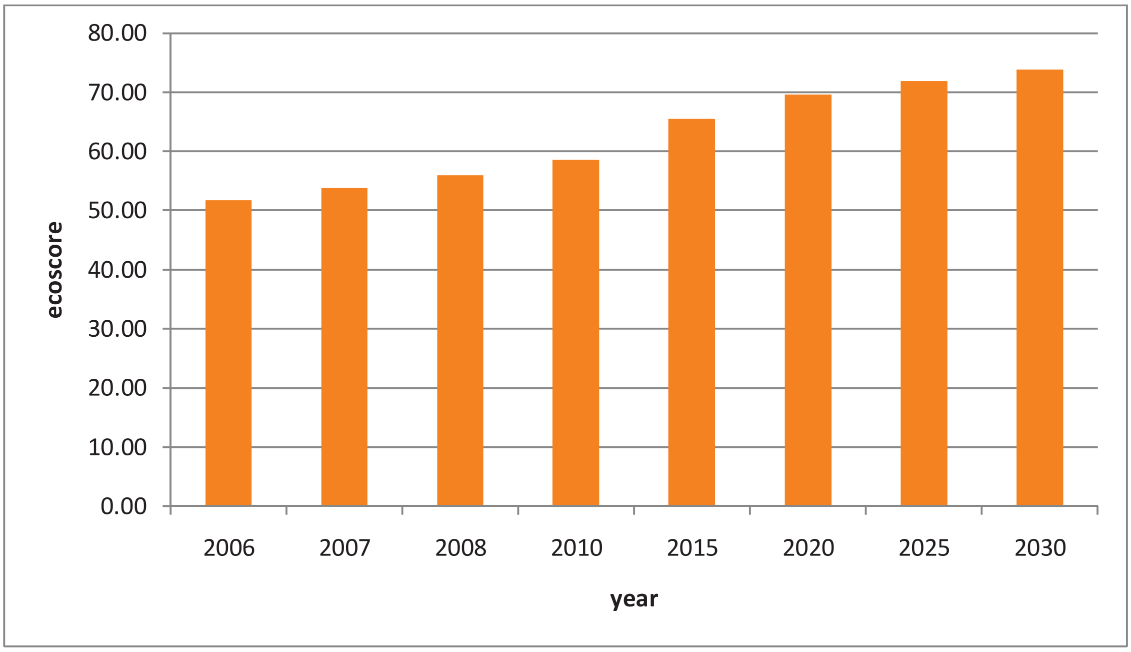

Figure 32: Average ecoscore for Belgian fleet (km weighted)

3.1.3.2. Emissions

For the realistic and the progressive scenario, we decide to restrict the discussion to emissions of CO_2e, PM2.5 and NO_x, as we believe these are the most important pollutants in the current Belgian context. As a consequence, emissions of CO, VOC, SO_2 and NH_3 are no longer dealt with. However, you can still find them under the annex on detailed results.

Emissions of CO_2e (Figure 33) are now expected to fall to 9.3 mio tonnes towards 2030, which implies a 24% decrease over the period 2010-2030 (vs 15% for the baseline scenario). For the years 2015 and 2020, the relative share of CO2e emissions from diesel, petrol and petrol hybrid CS vehicles will be slightly lower than under the baseline scenario, whereas the emissions originating from LPG will be higher. In 2025 and 2030, the share of CO2e emissions from diesel cars is significantly higher than for the baseline, while the petrol and petrol hybrid CS vehicles will continue to emit relatively less CO2e.

Speaking in relative terms, there is no significant difference in the technology distribution of PM2.5 emissions between the baseline and the realistic scenario. Also the absolute numbers differ only to a very small extent (Figure 34). The absolute amount of emission is estimated at 375 tonne in 2030 vs 380 tonne under the baseline.

From Figure 35, it is clear that regarding NO_x emissions, the differences in relative shares compared to the baseline are negligible. So, all conclusions for NO_x given in 2.2.3.3 do also apply here. Total NO_x emissions differ only slightly compared to the baseline, and are now expected to amount to 12,670 tonne in 2030 (vs 12,886 under the baseline scenario).

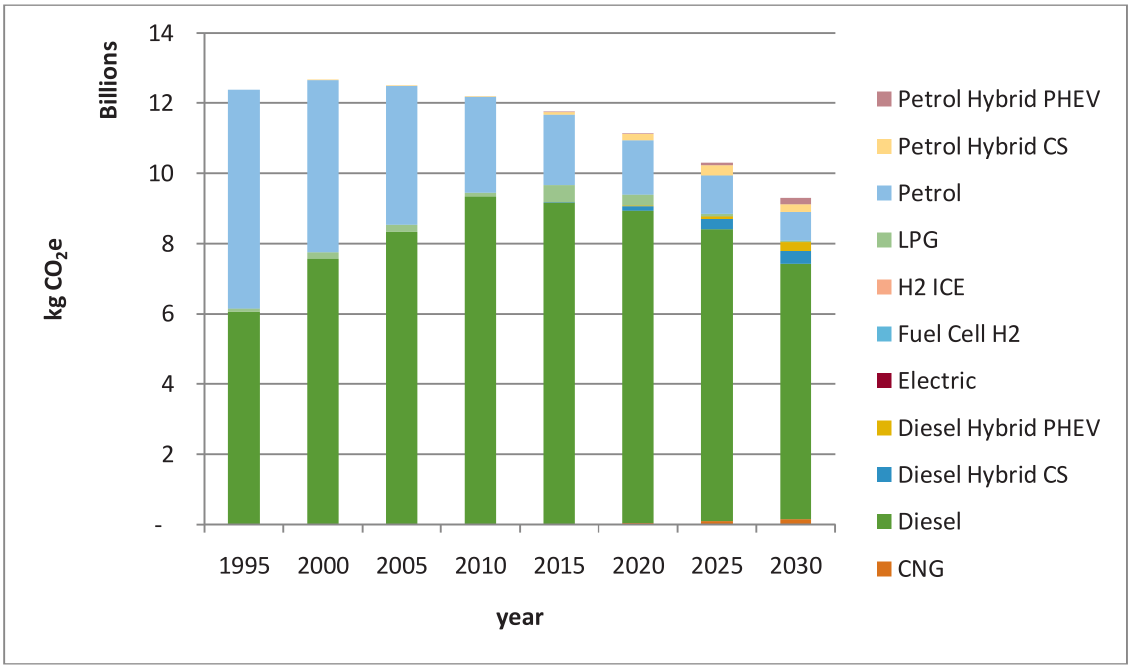

Figure 33: TTW emissions CO_2e per technology

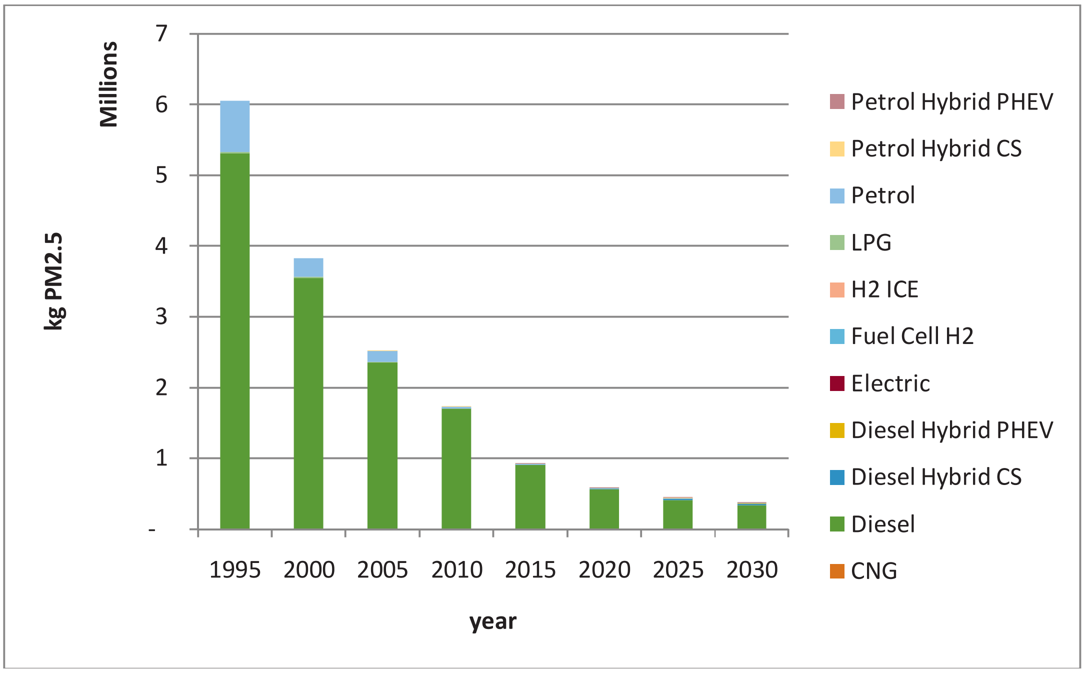

Figure 34: TTW emissions PM2.5 per technology

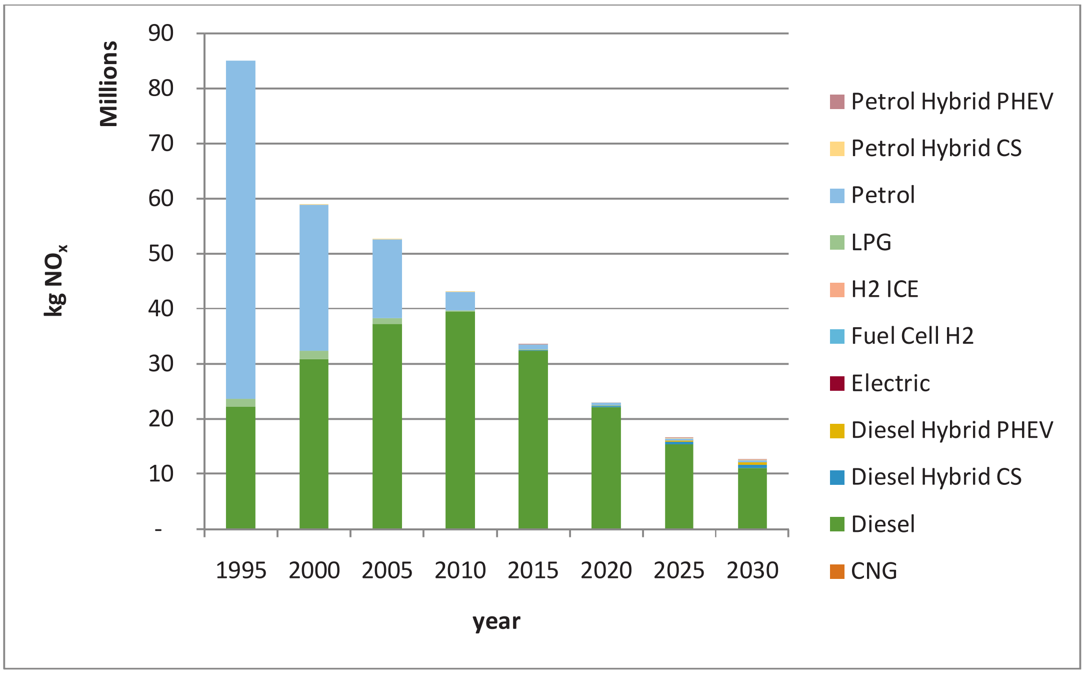

Figure 35: TTW emissions NO_x per technology

3.2. Progressive scenario

The measures introduced under the progressive scenario are very briefly repeated below. Furthermore, Table 2 provides an overview of the measure implementation period (yellow), and the period with the largest expected impact (shaded). For a detailed description of all the adopted measures, we refer to the report of task 5.3 'Scenario development'.

Extra measures progressive scenario (besides baseline and realistic measures):

A) Tax system based on ecoscore
B) Kilometre charge
C) Limited access environmental zones in cities based on ecoscore
D) Mandatory green private fleet quota
E) Scrappage scheme

	2000	2005	2010	2015	2020	2025
A						
B						
C						
D						
E						

Table 2: Timing of the progressive measures (yellow) and the period with their largest expected impact (shading)

3.2.1. Fleet composition

3.2.1.1. Number of cars

Under the progressive scenario, the total number of cars is expected to rise to 5.9 million in 2030, i.e. just 2% lower than under the baseline, and higher than under the realistic scenario. In what follows, we will see that this is largely due to an increase in the number of small vehicles and alternative technologies, and at the same time a decline in the number of vehicles with a conventional engine, compared to the realistic scenario. On the other hand, only looking at the years 2015 and 2020, the number of cars is expected to be lower than under the realistic scenario.

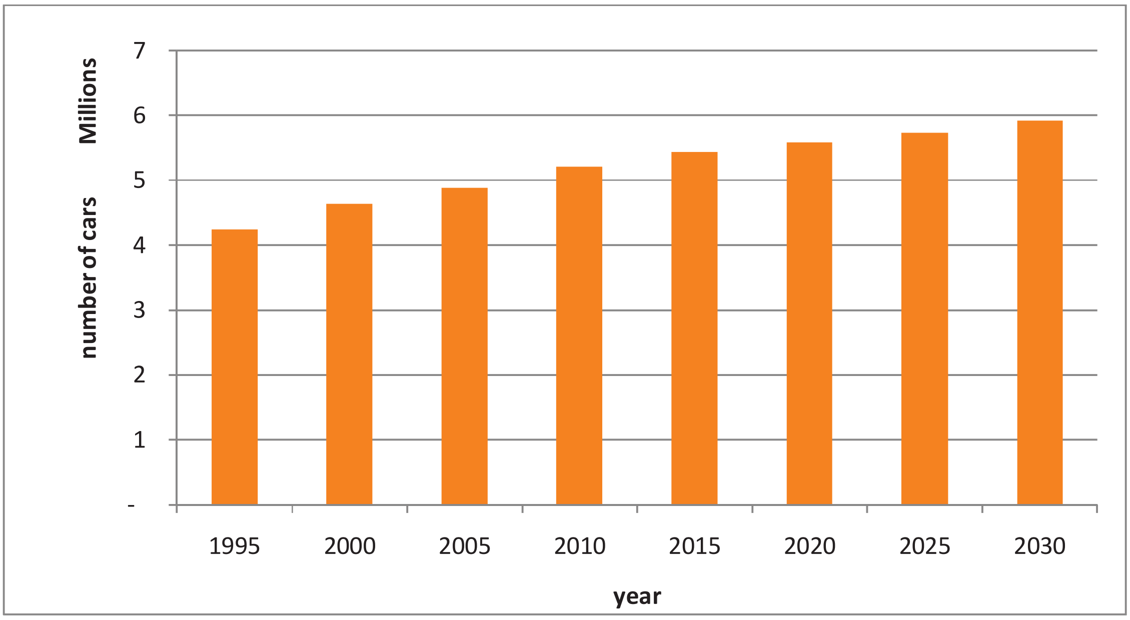

Figure 36 : Absolute amount of cars in Belgium

3.2.1.2. Technology

Figure 37 depicts the split of the fleet over the various technologies. Compared to the baseline scenario, the pace of improvement proceeds much quicker for the period 2010-2030. It is to say, petrol hybrids (+2 and +4% vs baseline, for CS and PHEV resp.), diesel hybrids (+3 and +4%, idem) and electric vehicles (+4%) are expected to fill in large parts of the share lost by conventional diesel vehicles (-17%). The additional measures in the progressive scenario seem to be effective in increasing the share of clean vehicles and removing older (and thus more polluting) vehicles.

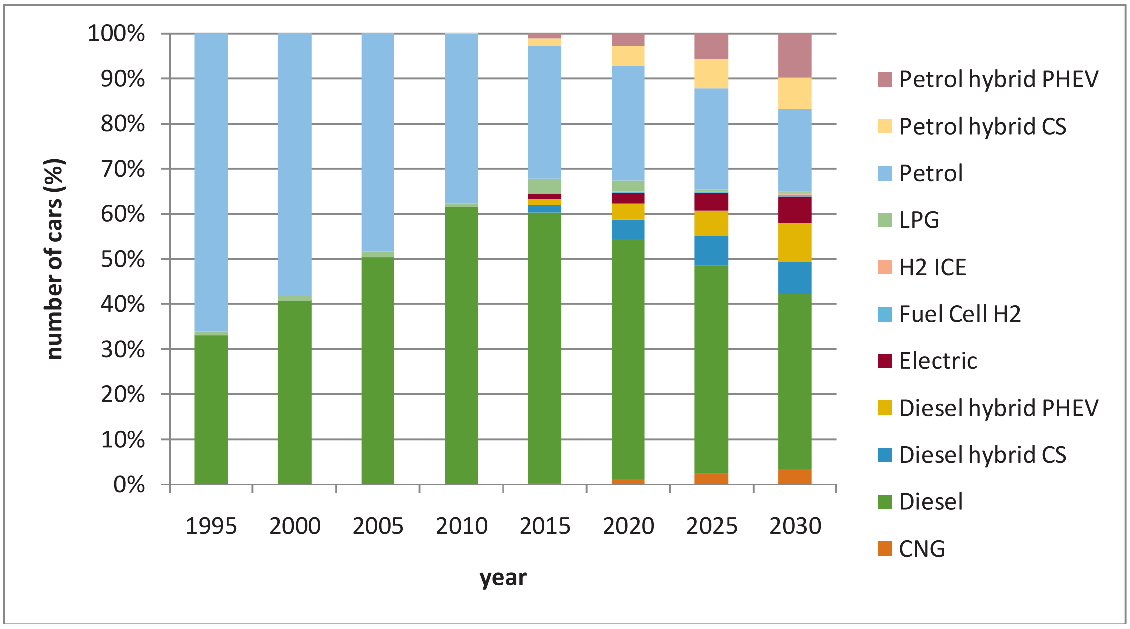

Figure 37: Relative share of cars over different technologies

3.2.1.3. Euro standard

As we could have expected, the adoption of newer euro standards is taking place much quicker than under the baseline scenario (44 vs 38% Euro 5 in 2015 and 51 vs 43% Euro 6 in 2020). See Figure 38. The difference versus the baseline survives at least until 2030 (98 vs 97% Euro 6).

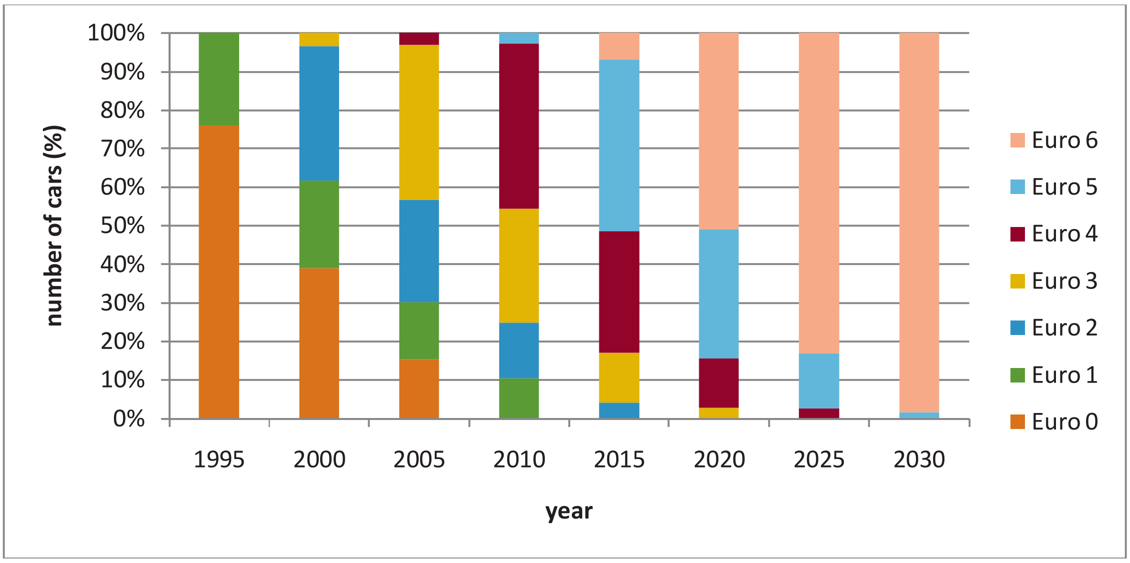

Figure 38: Relative share of cars over different euro standards

3.2.1.4. Engine size

The split over the 3 engine classes is given in Figure 39. In contract to the realistic scenario, we now observe a remarkably higher share of small engines (+5%) at the expense of the medium-sized cars (-5%), compared to the baseline in 2030. In this case, the small engine category constitutes more than half of the total fleet as from 2025 (54% in 2025), and continues to increase up to 56% in 2030.

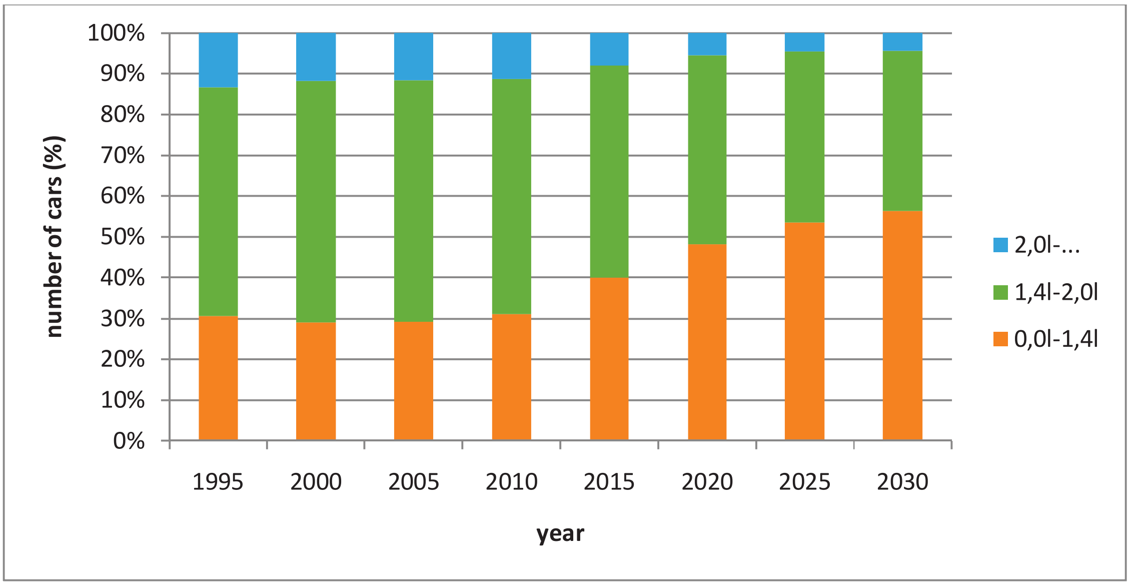

Figure 39: Relative share of cars over different engine sizes

3.2.1.5. Ecoscore

The unweighted ecoscore for the Belgian fleet is expected to rise faster than under the previous scenarios, with an average climb of 0.84 units per year. The largest jump can again be observed in the period 2010-2015 (from 58.40 to 66.01), and the average ecoscore reached in 2030 is predicted to slightly exceed 75 (75.15).

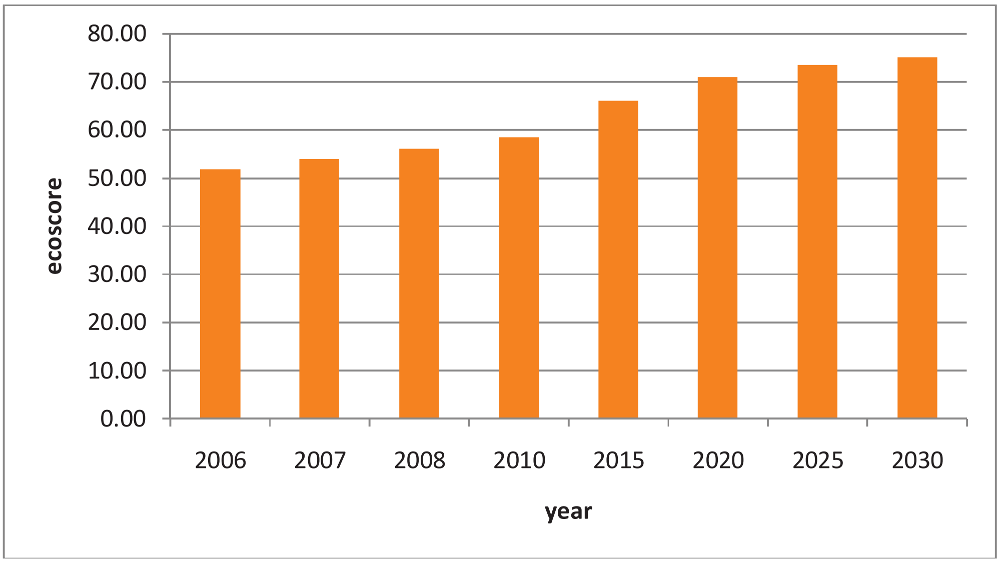

Figure 40: Average ecoscore for Belgian fleet (unweighted)

3.2.2. Vehicle use

3.2.2.1. Kilometres driven

Figure 41 displays the total amount of kilometres driven under the progressive scenario. The total distance travelled in 2030 now amounts to 85 billion kilometres. The predicted increase over the period 2010-2030 is considerably smaller than under the baseline scenario (+7 vs +18%). The substantial drop over the period 2020-2025 is almost completely compensated for by the rebound effect (Small & Van Dender, 2005) in the period 2025-2030. It is to say, the use of clean technologies (e.g., PHEV hybrids, electric, hydrogen) is increasing rapidly whereas conventional technologies (diesel, petrol) are driven less frequently. The recovery of the distance over the period 2025-2030 is thus completely attributable to a climb in clean technology utilization, as a result of the tighter policy measures. We suspect that the rising km charges (for polluting vehicles) and the limited access policy to environmental city zones have had a significant impact on the number of kilometres driven, as both measures were assumed to evolve over time.

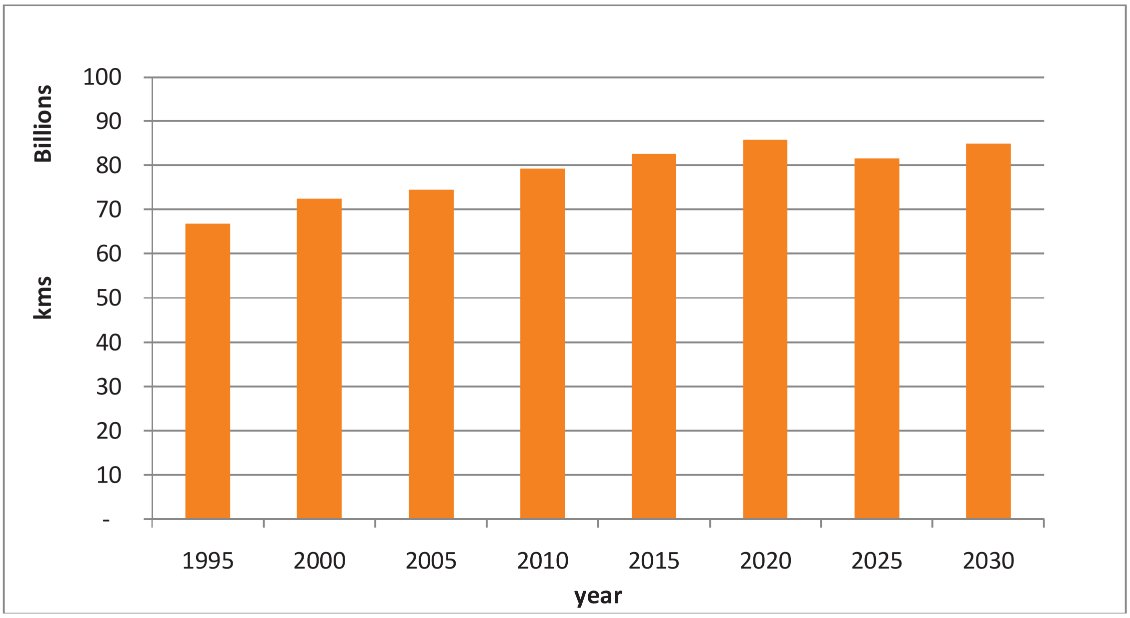

Figure 41: Kilometres driven in Belgium

3.2.2.2. Kilometres per road type

Compared to the baseline scenario, the share of kilometres travelled on rural roads and highways will be somewhat higher (+1 and +2%, respectively, in 2030) for the period 2010-2030, at the expense of the urban kilometres (-3%). This shift away from city centres is observed thanks to the limited access measure. See Figure 42.

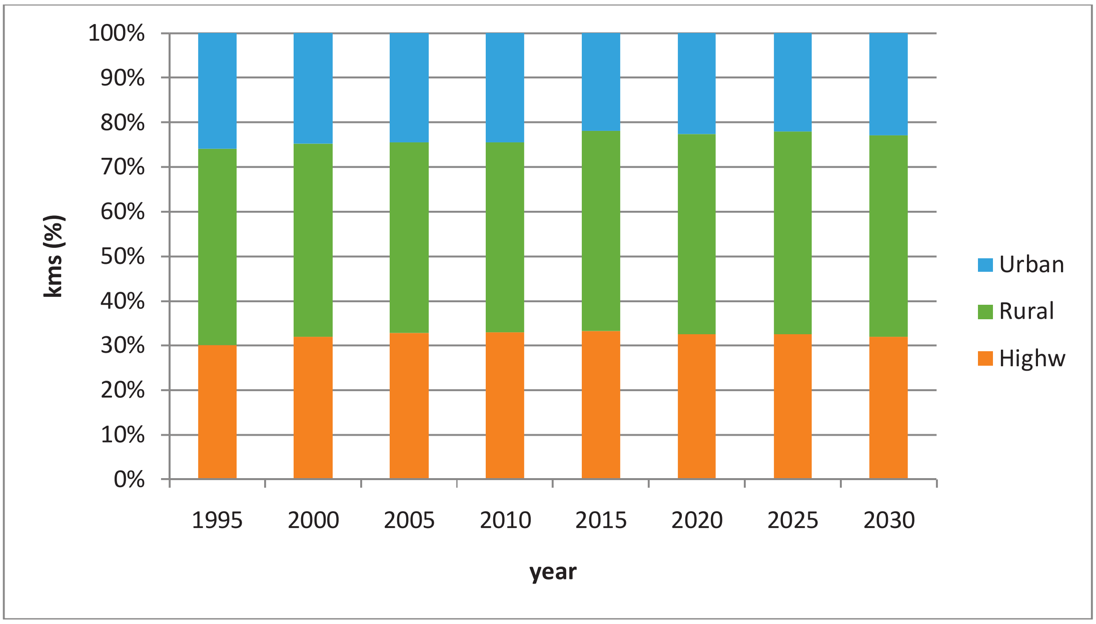

Figure 42: Relative share of kilometres driven over different road types

3.2.2.3. Kilometres per fuel technology

Focussing on the technology split of kilometres, we refer to Figure 43. In comparison with the baseline results, electric, diesel hybrid CS and PHEV, petrol hybrid CS and PHEV and LPG (2015 and 2020) and CNG (2025 and 2030) vehicles are expected to be driven (relatively) more frequently. On the other side, especially conventional diesel vehicles are losing ground (-21% in 2030 compared to baseline). This implies that the share of conventional diesel-fueled kilometres will decrease to 42% in 2030.

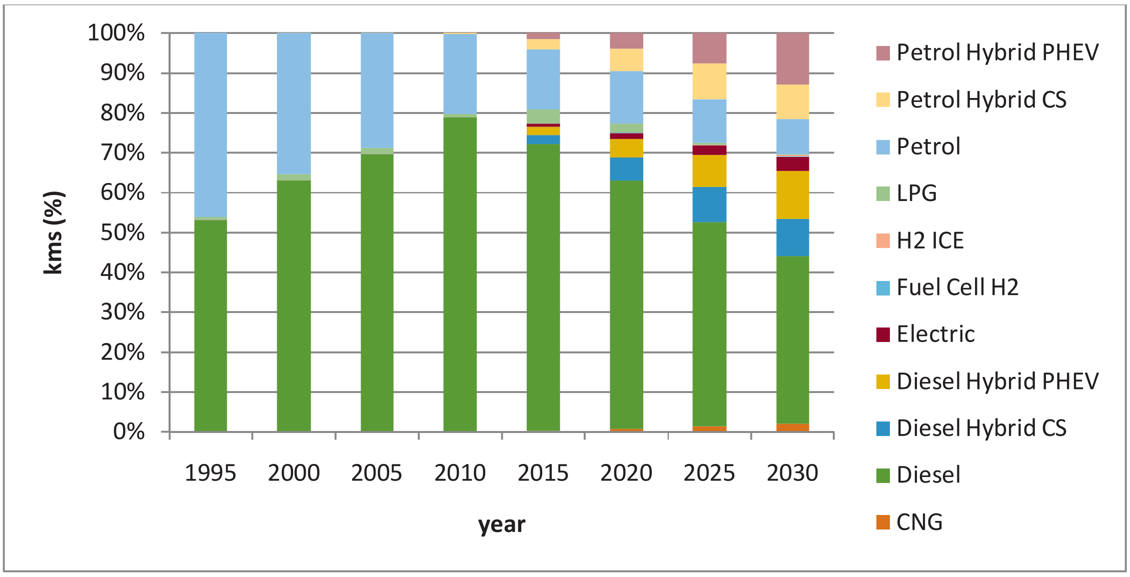

Figure 43: Relative share of kilometres driven by different technologies

3.2.2.4. Kilometres per euro standard

Concerning the split over the euro standards, we observe that the introduction of euro standards in the fleet takes place even quicker when the distance travelled is taken into account (Figure 44). Under this progressive scenario, the share of euro 5 vehicles in total distance amounts to 51% (vs 44% in baseline) in 2015, whereas the share of euro 6 cars is estimated to reach 58% (vs 51%) in 2030.

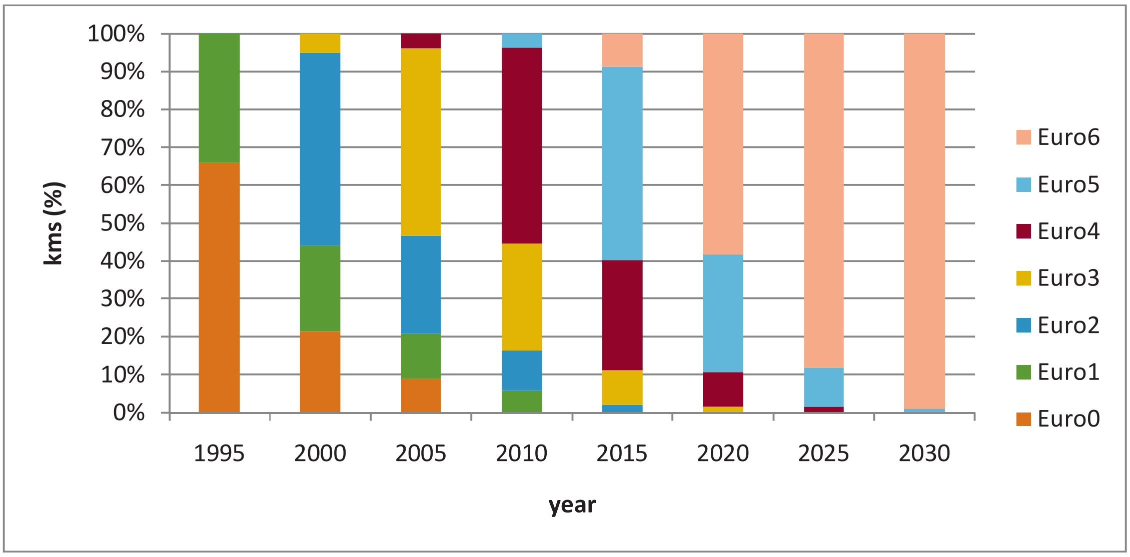

Figure 44: Relative share of kilometres driven by different euro standards

3.2.2.5. Kilometres per engine size

Based on Figure 45, we conclude that the share of small engines in total fleet kilometres is almost hitting the 50% level in 2030. Compared to the baseline shares, an increase is observed again in the share of small engine kilometres (+5% in 2030), at the expense of the medium-sized engine distance (-5% in 2030).

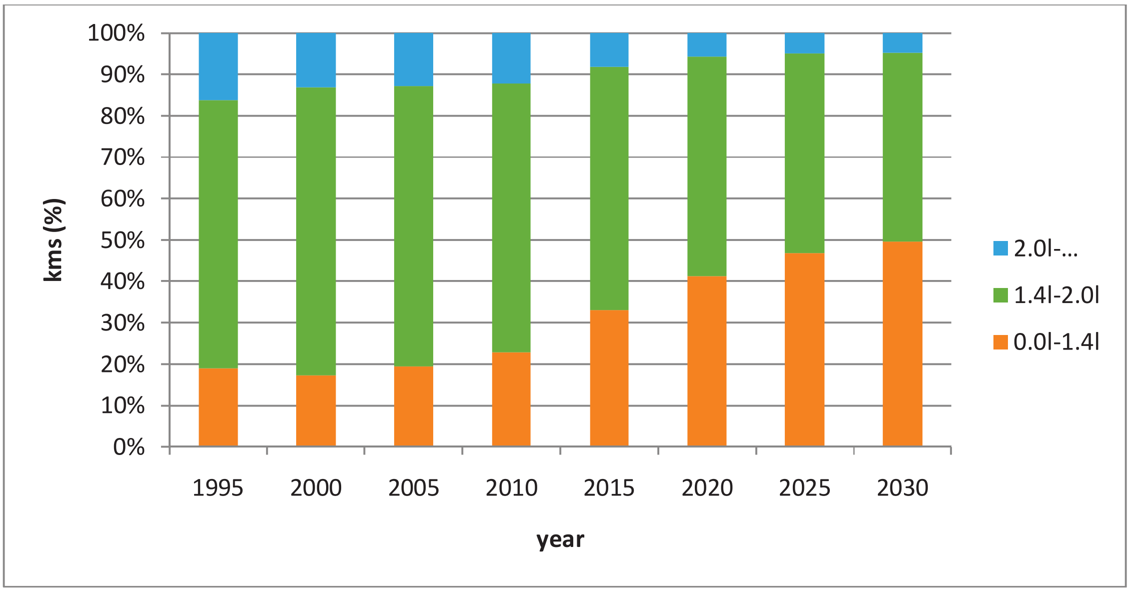

Figure 45: Relative share of kilometres driven by different engine sizes

3.2.3. Environmental impact

3.2.3.1. Ecoscore

Following the fact that the cleaner vehicles are on average driven more frequently than the older (and more polluting) ones, the average weighted ecoscore is somewhat higher than its unweighted counterpart over the period 2010-2030. However, the average annual increase remains unchanged at 0.84 units/year, as both the beginning and end position are higher than for the unweighted ecoscore (58.61 in 2010 and 75.43 in 2030 under progressive scenario). This rate of increase can be compared to the 0.76 units/year for the baseline scenario.

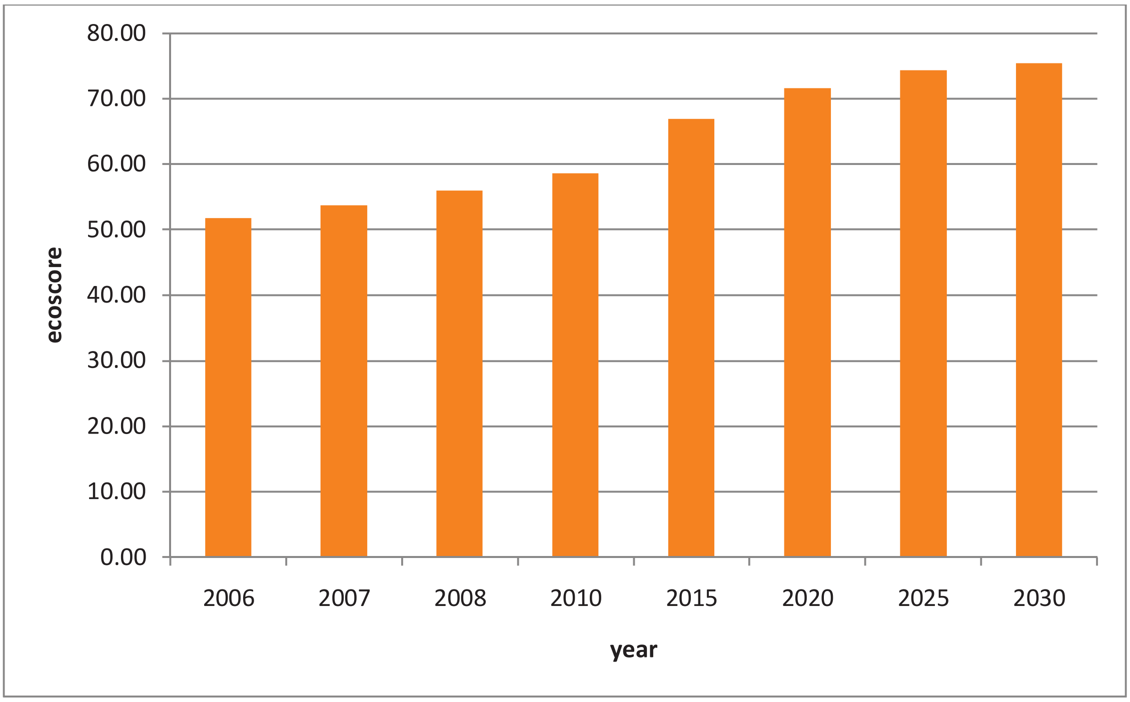

Figure 46: Average ecoscore for Belgian fleet (km weighted)

3.2.3.2. Emissions

Given the measures adopted in the progressive scenario, we see the emissions of CO_2e (Figure 47) drop to 7.2 mio tonnes in 2030 (Figure 47). This implies a 41% decrease since 2010 (vs 15% in baseline). More or less in line with the number of kilometres driven, the relative share of emissions by conventional diesel and petrol vehicles in the years after 2010 will be lower than those for the baseline. On the other hand, the share of emissions by diesel and petrol hybrids, LPG (2015 and 2020) and CNG (2025 and 2030) vehicles has increased compared to the baseline and realistic scenario.

Concerning emissions of PM2.5 and NO_x (Figure 48), the drop of the emission share for conventional diesel vehicles is especially compensated for by increased emission shares from diesel hybrids (both CS and PHEV) over the period 2010-2030. The absolute amount of PM2.5 emission is estimated at 271 tonne in 2030 (vs 380 tonne under baseline); whereas for NO_x we expect 9,127 tonne emissions (vs 12,886 tonne for baseline).

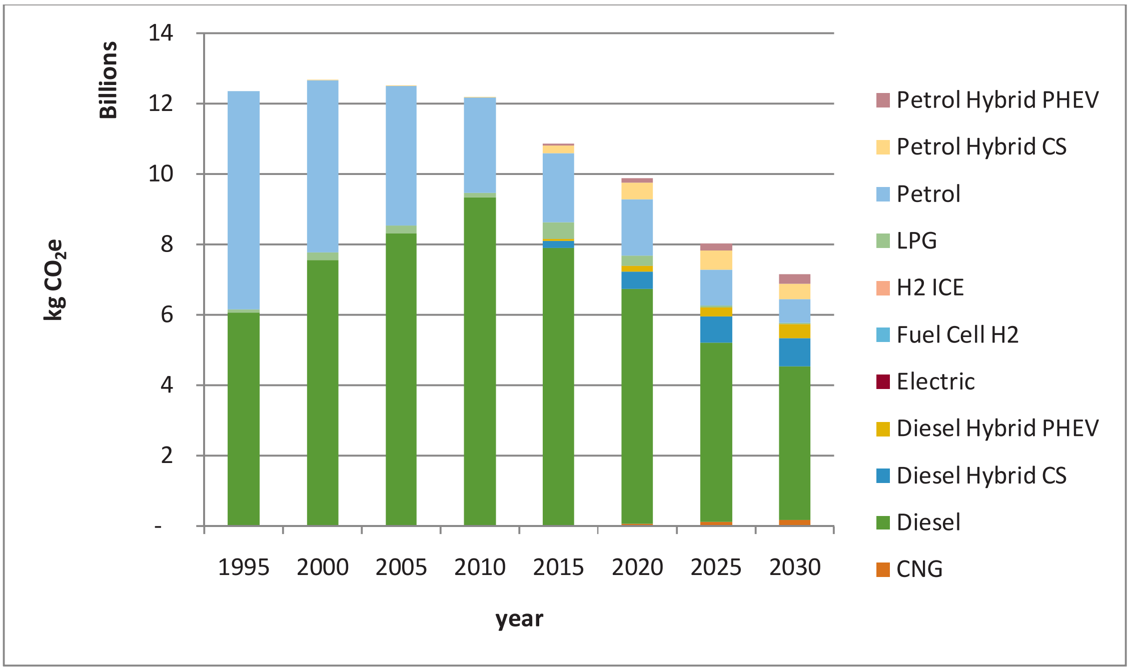

Figure 47: TTW emissions CO_2e per technology

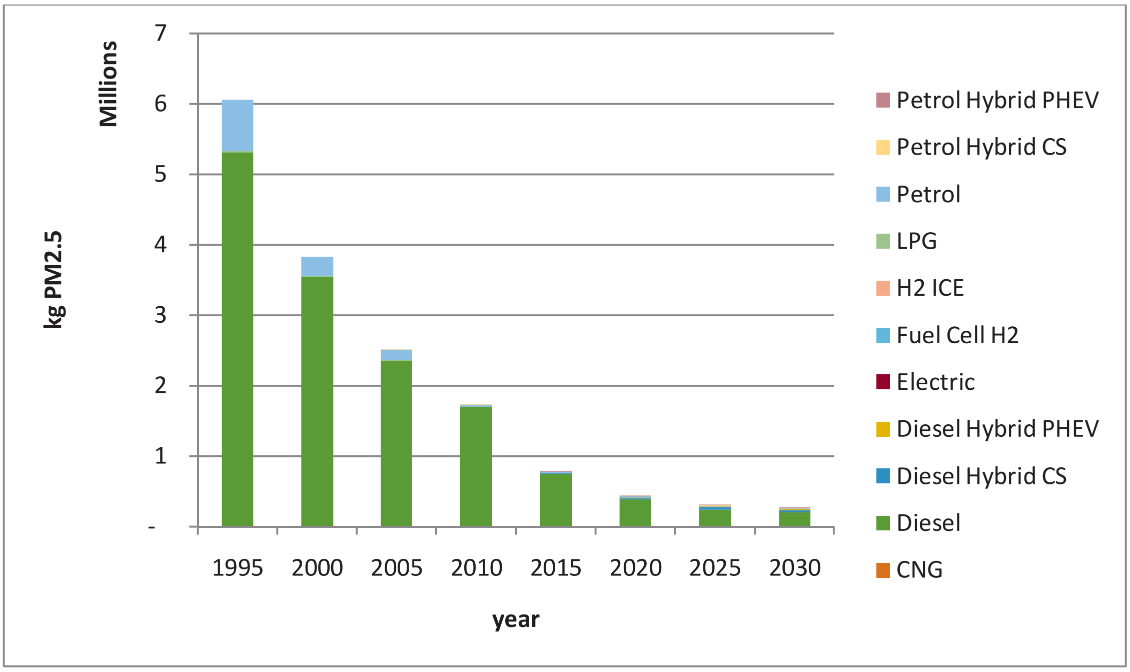

Figure 48: TTW emissions PM2.5 per technology

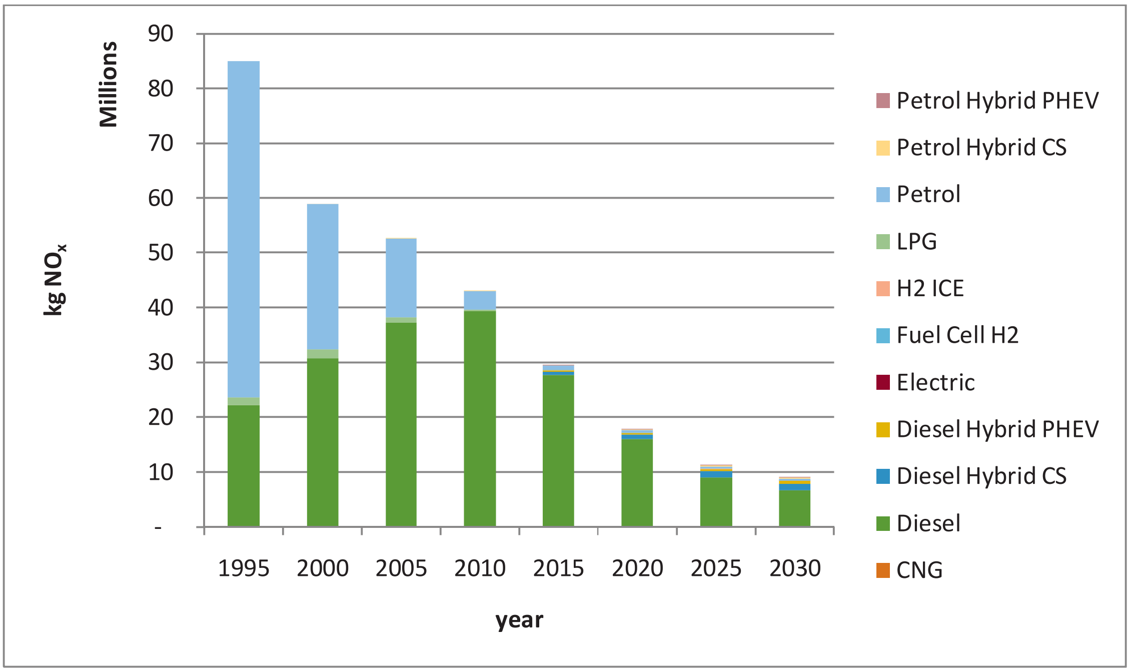

Figure 49: TTW emissions NO_x per technology

3.3. Visionary scenario

In this section, we will focus on the vehicle use and environmental impact indicators from the visionary scenario.

The most important assumptions made under this scenario were:

A) Mobility as a service instead of vehicle ownership
B) Cleanest available technology used for each trip, i.e.
   All urban trips by EVs
   All trips on rural roads by petrol hybrids (60% of kms by PHEV, 40% by CS)
   All trips on highways by diesel hybrids (40% of kms by PHEV, 60% by CS)
C) Total amount of kilometres driven assumed to decrease in line with progressive scenario

Fleet composition data (number of vehicles, unweighted ecoscore) are not discussed for this scenario, as no meaningful assumptions are made as to that.

3.3.1. Vehicle use

3.3.1.1. Kilometres driven

The number of kilometres driven in the 2060 visionary scenario is extrapolated from the progressive scenario. It is to say, we expect the distances travelled to decrease, in line with the drop in kilometres in the progressive scenario.

Unfortunately, we see that the number of kilometres driven under the progressive scenario drops for the period 2020-2025, but resumes in the years thereafter (2025-2030). As already mentioned in section 3.2, this is due to the fact that the end consumer has found its way to alternative vehicle technologies, and is using those vehicles more extensively than before, because the traditional fuel technologies are punished through all channels. In economics, the ratio of the lost benefit over the total expected benefit (decrease in kms) is called the rebound effect (Small & Van Dender, 2005).

However, we assume that the relative drop in kilometres in the progressive scenario between 2020 and 2025 could be representative for simulating a simple long-term linear decrease towards 2060 (visionary). This is depicted in Figure 50. Consequently, 52.2 billion kilometres are expected to be driven in 2060, more than 50% of which is driven on rural roads.

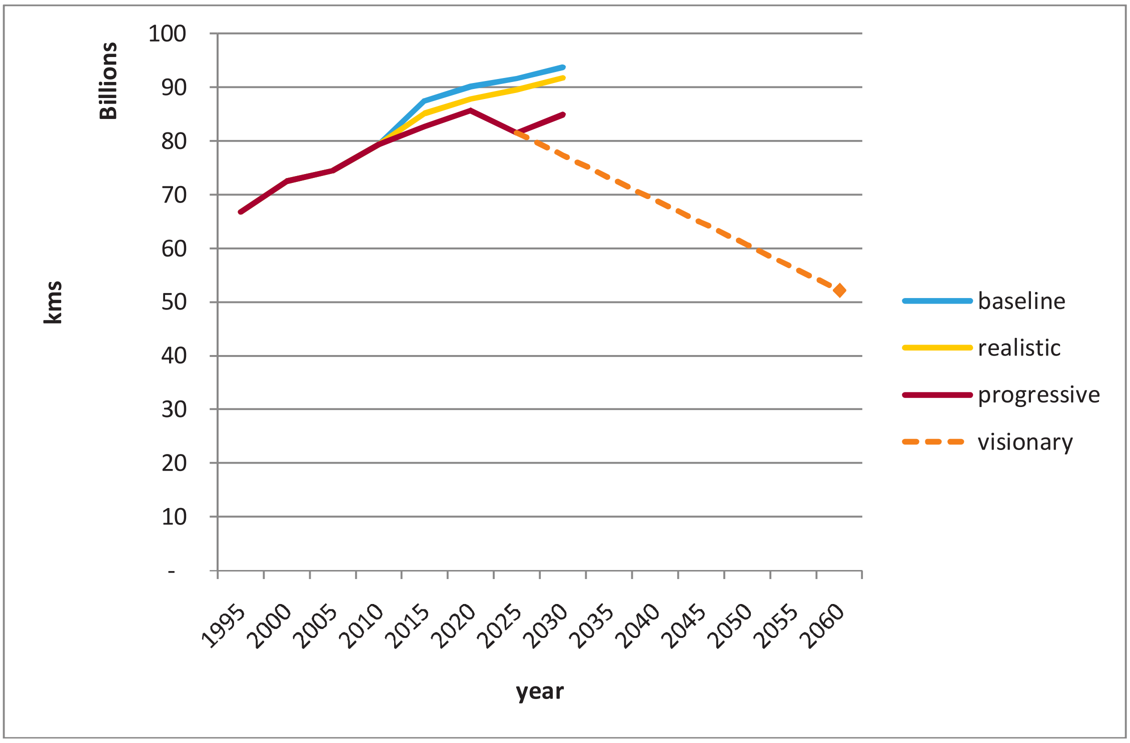

Figure 50: Total number of kilometres in the scenarios

3.3.1.2. Kilometres per road type

As already mentioned in the previous section, more than half of all distances is travelled on rural roads. Highway trips count for approximately one third of all kilometres, while urban trips constitute the remaining 15%. This is displayed in Figure 51.

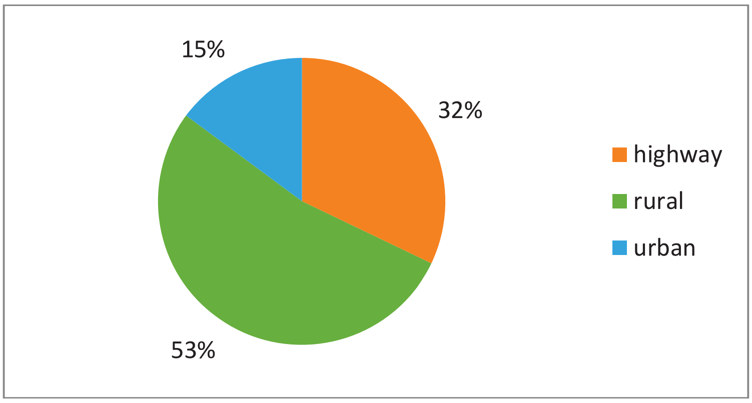

Figure 51: Distribution of kilometres over different road types

3.3.1.3. Kilometres per fuel technology

Assuming that there is no difference, on average, in the number of kilometres travelled between a CS and a PHEV vehicle, the relative share of the kilometres travelled by the various technologies is given in Figure 52. Under this scenario, approximately 15% of all kilometres is driven by full-electric vehicles in 2060. Petrol hybrids constitute another 53% of all distances travelled.

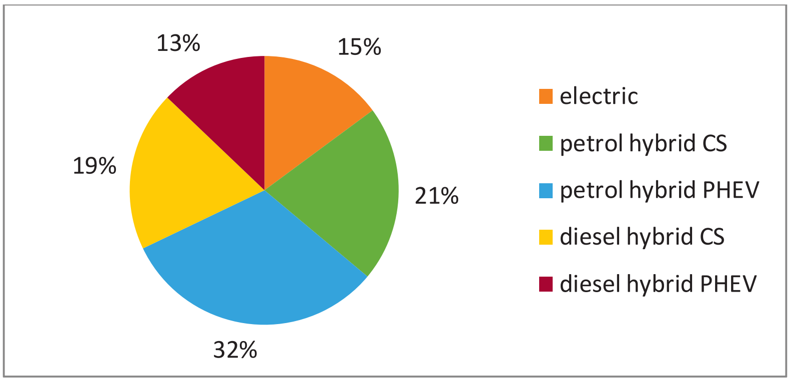

Figure 52: Distribution of kilometres over different technologies

3.3.1.4. Kilometres per euro standard

As assumed in the scenario setup, all the cars considered here comply with the euro 6 emission standard.

3.3.1.5. Kilometres per engine size

We do not provide a split of the distances over engine sizes as no scenario assumptions are made with respect to that.

3.3.2. Environmental impact

3.3.2.1. *Ecoscore – km weighted*

For the new vehicle fleet in 2060, we can now also calculate an average ecoscore. As we assume that, on average, there is no difference between the number of kilometres travelled by a PHEV and a CS vehicle (as mentioned in 3.3.1.3), it immediately follows that the number of cars is directly related to the number of kilometres. This implies that the weighted ecoscore exactly matches the unweighted indicator. Therefore, there is no need to distinguish between both indicators.

The resulting average ecoscore then amounts to 82.49. We found this number by searching the ecoscores for small vehicles per region in the progressive 2030 scenario, for the 5 considered car technologies in 2060. For reasons of simplification, we only focused on small vehicles, because the car was no longer considered as an individual property under this scenario, and the market is expected to tend towards using the most sustainable transport mode in each situation. As we exactly knew on which road types the different technologies are driven (according to the scenario setup), it was straightforward to find the average ecoscore by multiplying the road type ecoscores by their respective distance weights.

3.3.2.2. *Emissions per fuel technology*

We need to find emission factors (e.g. kg/km) and kilometres driven in order to compute the total emissions for this scenario.

We decide to perform the calculations for a small euro 6 car in the progressive 2030 scenario, for reasons mentioned under section 3.3.2.1. Of course, we take into account that emission factors (EFs) will depend on the different fuel technologies observed in the visionary scenario (electric, petrol hybrid CS and PHEV, diesel hybrid CS and PHEV), and the 3 different road types. These data are extracted from the E-motion database. Please note that the resulting EFs can be considered as an upper limit, as no additional decrease of EFs for the 5 technologies is taken into account for the period 2030-2060. We expect that EFs in 2060 will be lower than the ones applied here. However, it is impossible to make decent predictions on that. Therefore, this upper limit is our best guess.

Subsequently, the distance travelled on each of the 3 road types is taken from section 3.3.1.2.

The EFs can then be multiplied by the distances travelled on each road type, in order to retrieve the total emissions for all Belgian car transport. In Figure 53 till Figure 54 below, we present the emission totals for CO_2e, $PM_{2.5}$ and NO_x, and the contribution per fuel technology. The emission levels for the other pollutants are not depicted here. However, you can find their corresponding numbers in the annex at the end of the report.

Emissions of CO_2e are predicted to amount to 2.2 million tonnes per year in 2060. A large part (45%) of the emissions can be attributed to diesel hybrid CS vehicles. In spite of their significant share in total kilometres (Figure 52), diesel and petrol hybrid PHEV vehicles only constitute a modest share of total CO_2e emissions. This can be attributed to a pretty large share of kilometres driven by these vehicles in the electric mode, with no resulting TTW emissions at all (see Figure 53).

Regarding emissions of PM2.5 (Figure 54), the share of diesel hybrid CS cars is even higher (66%). Total emissions are only 73 tonnes/year.

We do a similar observation for emissions of NO_x (Figure 55). Diesel hybrid CS cars are expected to emit 65% of the total of 3,127 tonnes in 2060.

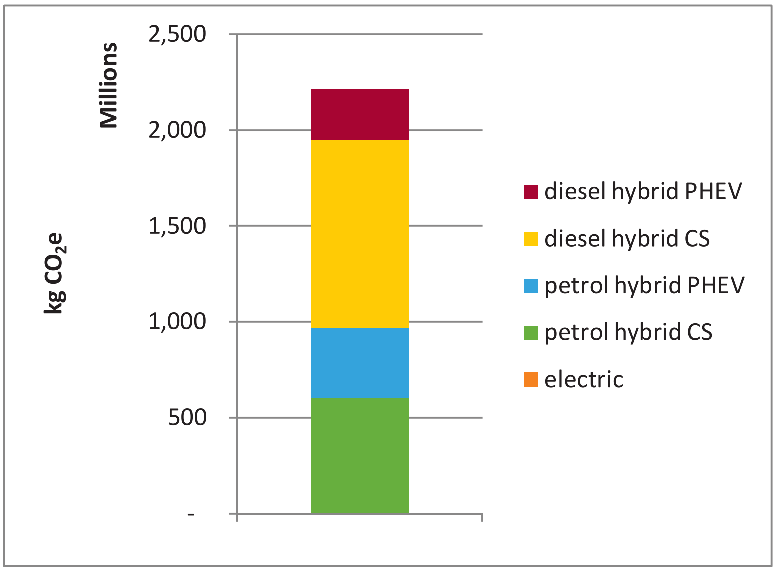

Figure 53: TTW emissions of CO_2e over the different technologies

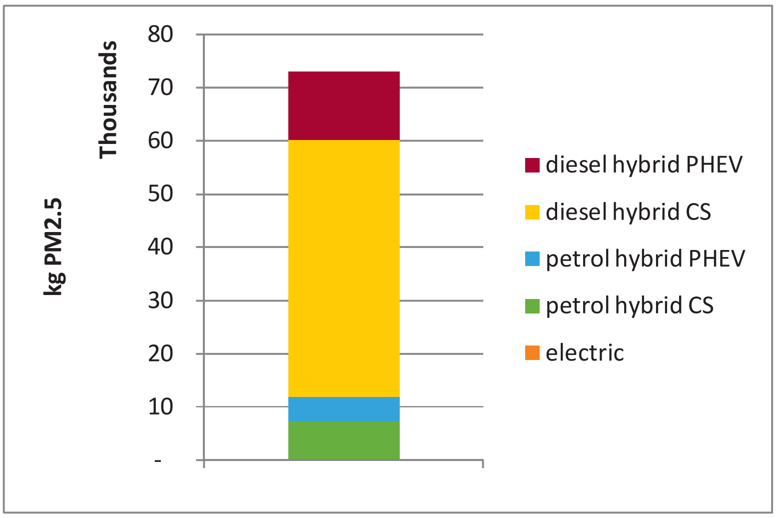

Figure 54: TTW emissions of PM2.5 over the different technologies

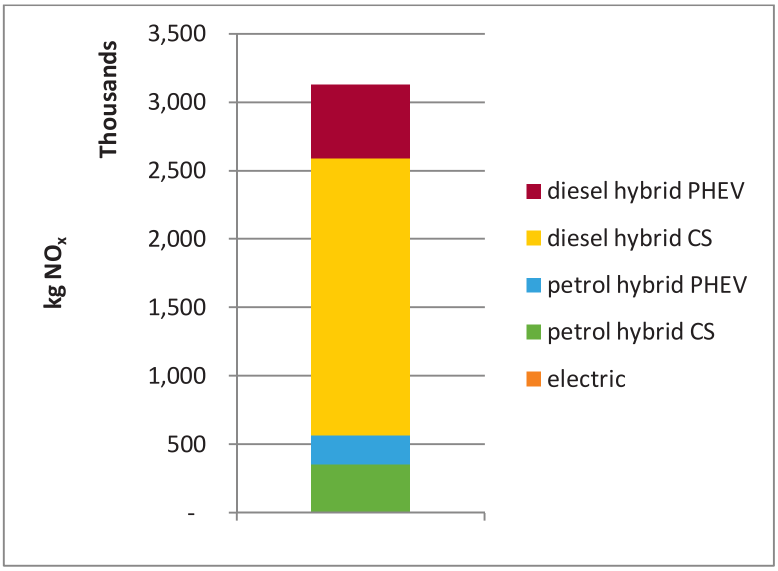

Figure 55: TTW emissions of NO_x over the different technologies

Although the assumptions made under this scenario concerning the number of kilometres driven and the fleet composition (optimal use of technologies: only electric, diesel hybrid, petrol hybrid) are quite stringent, we still observe a significant amount of direct carbon emissions. The ideal conditions would bring us to a complete decarbonisation of the fuels used. However, today this still seems to be a distant future.

4. Scenario comparison

The final chapter of this report deals with the comparison of the baseline, realistic and progressive scenario for the years 2020 and 2030. This leads to six combinations: baseline_2020, baseline_2030, realistic_2020, realistic_2030, progressive_2020 and progressive_2030. As the timeframe is different for the visionary scenario (2060), we decided not to give a broad discussion on these results in the comparison below. However, we thought it was useful to display the visionary scenario results (visionary_2060) as a seventh case in the graphs, wherever applicable (mainly vehicle use and environmental impact). This gives the opportunity to the reader to clearly see the possible improvements compared to the progressive 2030 scenario.

This chapter is subdivided into the three sections used before: fleet composition, vehicle use and environmental impact. For each of the indicators discussed in chapter 1 till 3, we provide a summarizing figure for the years 2020 and 2030, and briefly recapitulate the most interesting evolutions. For your information, the summarizing numbers are again provided in a separate section on detailed results.

This chapter can be considered as a conclusion to chapter 1 till 3.

4.1. Fleet composition

4.1.1. Number of cars

Figure 56 depicts the total Belgian fleet size for the three scenarios. For 2020, it is clear that the most sophisticated scenario (i.e. progressive) results in the smallest amount of cars (5.58 mio). This proposition is no longer valid for the year 2030, where the smallest fleet size (5.82 mio) is attained by the policy measures in the realistic scenario. The higher figure for the progressive scenario in 2030 is due to an increased purchase of small and clean (hybrid and electric) vehicles (see section 4.1.4 and 4.1.2), which are on average driven less frequently (see section 4.2.5 and to a lesser extent also section 4.2.3). Generally speaking, the fleet size is expected to follow an increasing trend when comparing 2030 to 2020, in spite of all the measures introduced.

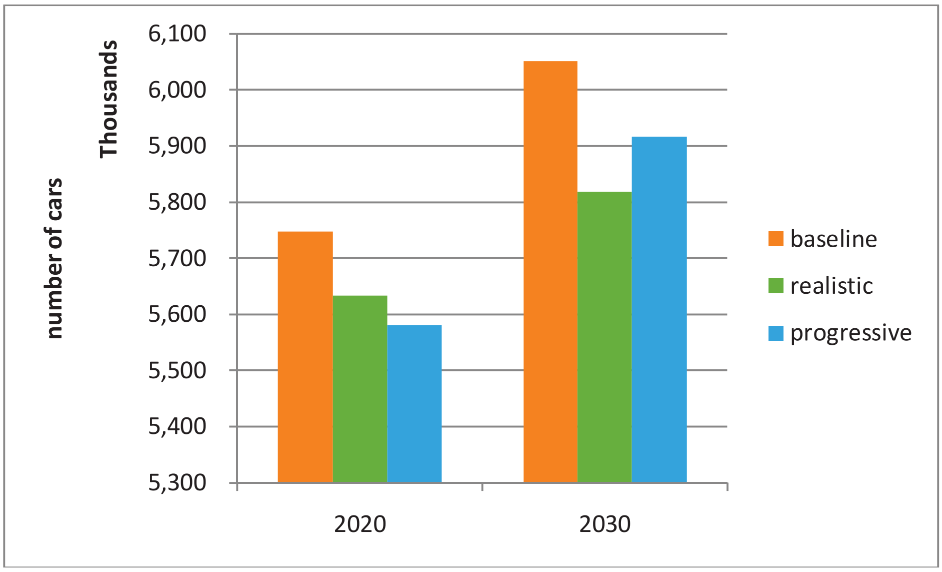

Figure 56: Absolute amount of cars in Belgium

4.1.2. Technology

We decided again to focus on the relative numbers from now on. The result for the technology split can be found in Figure 57. Some interesting trends can be derived. It seems that the more sophisticated the scenario is and the further we look into the future, the smaller the share of conventional diesel engines will be. The realistic scenario has a much smaller impact on the introduction of the cleaner technologies than the progressive scenario. If we want to facilitate the market introduction of especially hybrids and electric vehicles, it seems we will have to resort to the measures from the progressive scenario. This presumption is valid in both 2020 and 2030.

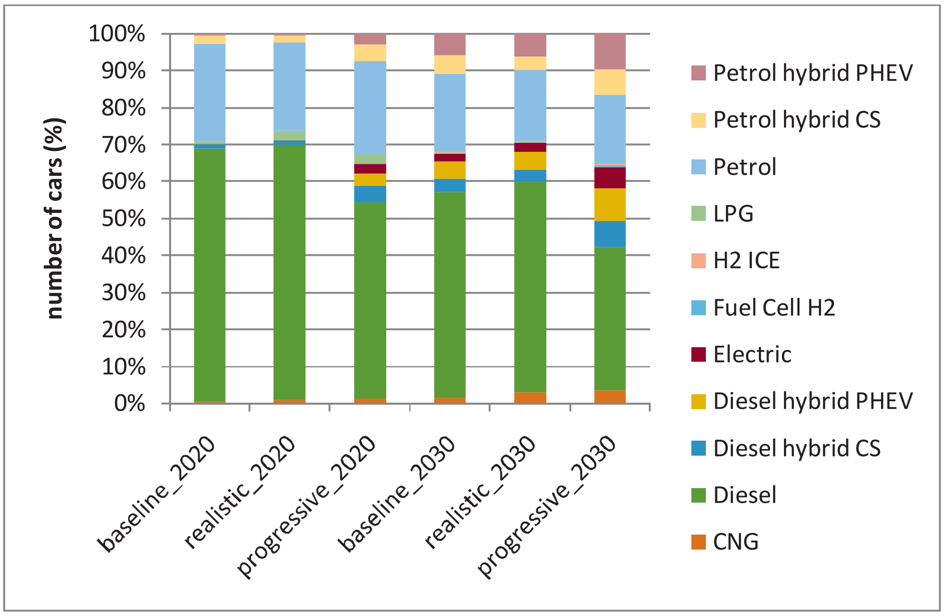

Figure 57: Relative share of cars over different technologies

4.1.3. Euro standard

Figure 58 clearly indicates that a tighter transport policy results in an accelerated adoption of the newer euro standards. For example in 2020, 51% of the whole fleet already complies with euro 6 under the progressive scenario, versus 43 and 46% under the baseline and the realistic scenario, respectively. The differences are less pronounced in 2030, as no successor for euro 6 is defined yet.

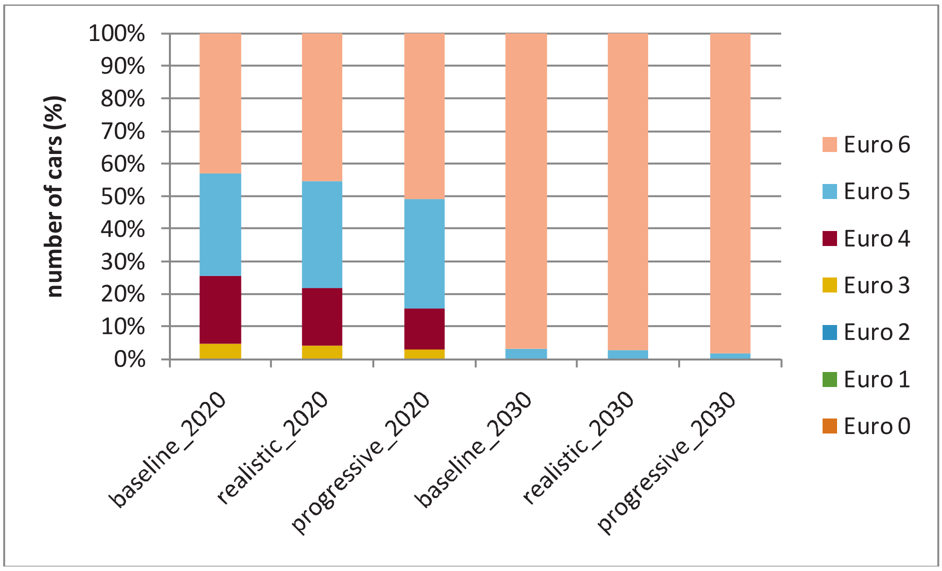

Figure 58: Relative share of cars over different euro standards

4.1.4. Engine size

Concerning the split over the engine size (Figure 59), we clearly observe a downsizing trend (i.e. the increasing popularity of smaller engines with a comparable performance as their larger predecessors) for the three scenarios. However, this trend takes place at a larger pace in the progressive scenario compared to the other two scenarios. The share of large engines (>2.0l) remains fairly constant over the scenarios within the same timeframe. Nevertheless, large engines are losing ground the further we look into the future.

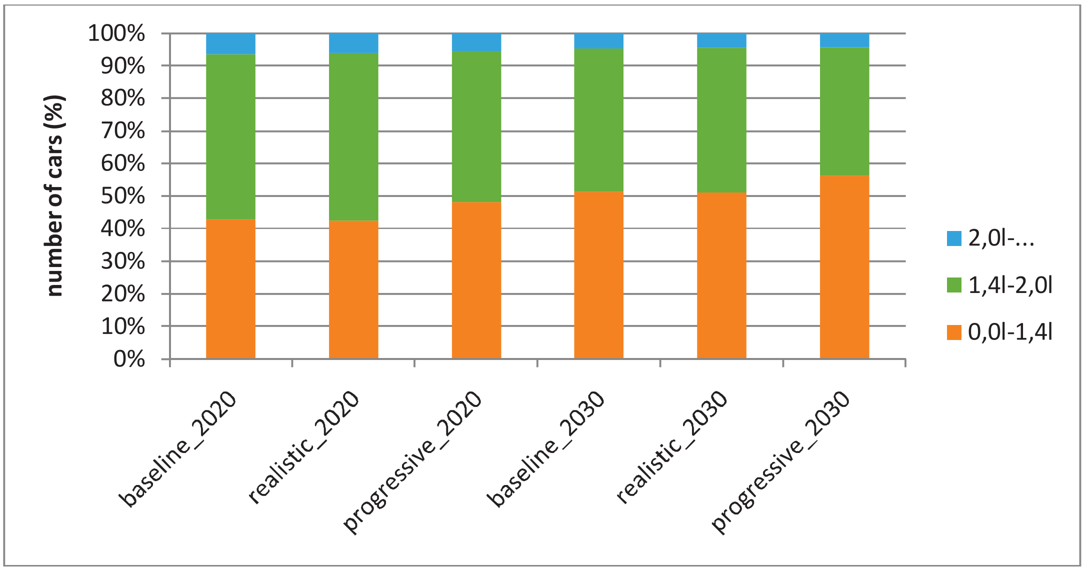

Figure 59: Relative share of cars over different engine sizes

4.1.5. Ecoscore

Figure 60 displays the unweighted ecoscore for the three scenarios. The surplus of the progressive scenario vis-à-vis the baseline and realistic scenario is remarkable (respectively 70.95 vs 68.50 and 69.08 in 2020 and 75.15 vs 73.22 and 73.37 in 2030). This also indicates that the benefit of the realistic versus the baseline scenario is rather limited.

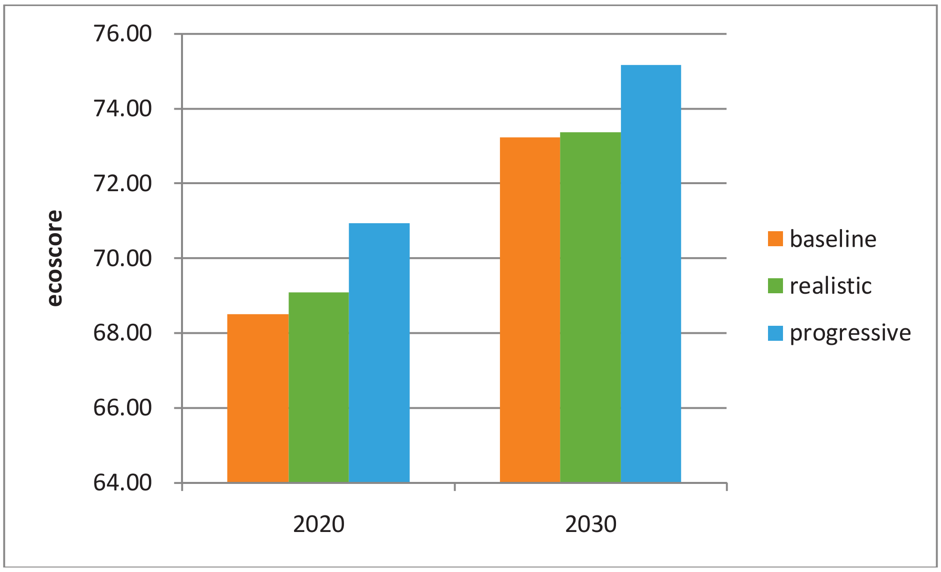

Figure 60: Average ecoscore for Belgian fleet (unweighted)

4.2. Vehicle use

4.2.1. Kilometres driven

As we can see in Figure 61, the total number of kilometres is expected to rise under the baseline and the realistic scenario over the period 2020-2030. On the other hand, the total number of kilometres under the progressive scenario is declining over this period. In 2030, the benefit from the progressive scenario is no less than 6.8 billion kilometres per year vis-à-vis the realistic scenario. Please compare those results with Figure 56: the diverging image for the progressive scenario in 2030 can most probably be attributed to the increased share of small and clean vehicles, which are driven less than the average vehicle in the fleet (see further sections 4.2.3 and 4.2.5).

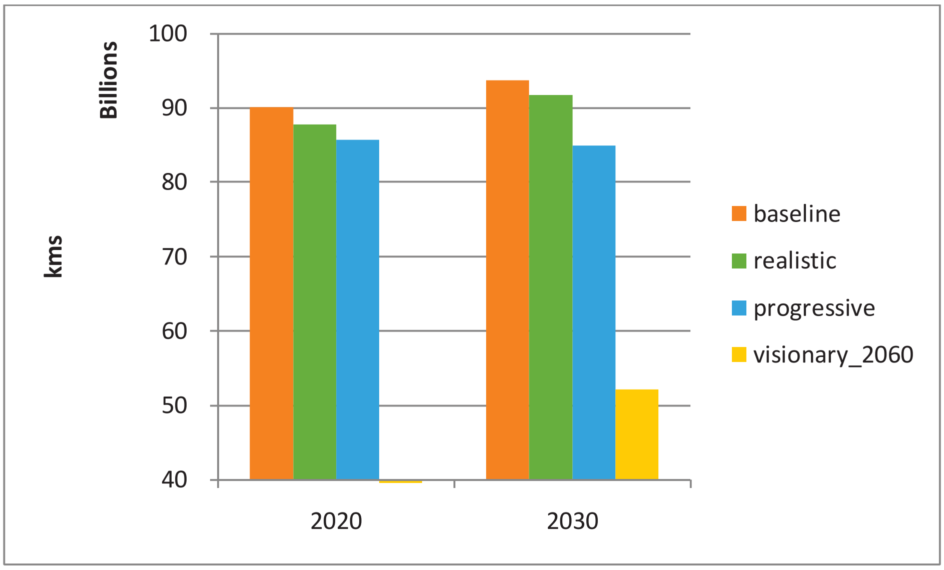

Figure 61: Kilometres driven in Belgium

4.2.2. Kilometres per road type

As shown in Figure 62, the relative difference in road type split between baseline and realistic is negligible, both for 2020 and 2030. On the other hand, for the progressive scenario, we perceive a modest shift to rural roads (+2%) and highways (+1%), away from the city centres (urban roads, -3%). This shift is mainly observed thanks to the introduction of the limited access environmental zones.

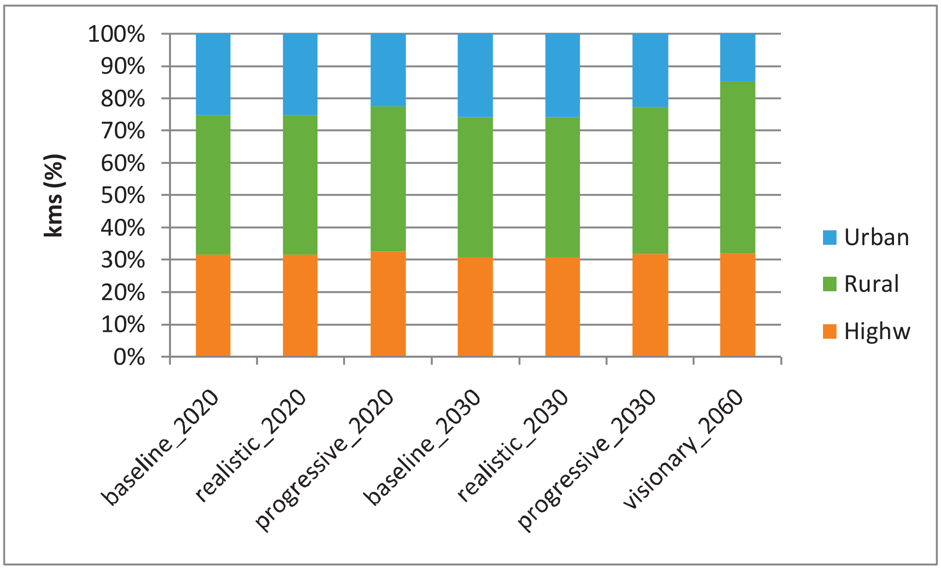

Figure 62: Relative share of kilometres driven over different road types

4.2.3. Kilometres per fuel technology

If we want to reduce the relative share of conventional diesel kilometres vis-à-vis the baseline, the only solution is to introduce the measures proposed in the progressive scenario, as the realistic scenario seems to be even slightly beneficial (especially after 2020) for the use of conventional diesel vehicles. In the realistic scenario, it appears that the increased excise duties on diesel are missing their effect. In fact, it seems that they are partly or completely offset by the consumption advantage of diesel engines, combined with lower taxes (compared to petrol) under the CO_2-based tax system. The share of kilometres driven by the newer clean vehicle technologies (diesel hybrid, petrol hybrid and electric) is strongly encouraged under the progressive scenario (see Figure 63).

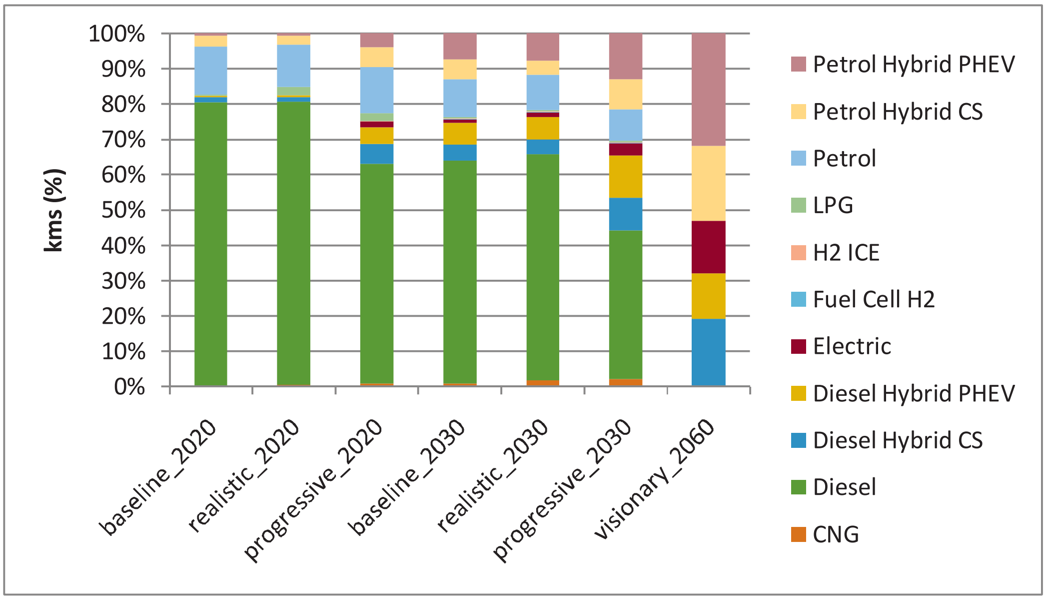

Figure 63: Relative share of kilometres driven by different technologies

4.2.4. Kilometres per euro standard

Figure 64 shows the relative split of kilometres over the euro standards. The more sophisticated the scenario, the faster the share of kilometres done by the most recent euro standards will increase. In 2020, 58% of all kilometres driven are attributable to euro 6 vehicles in the progressive scenario, versus 51 and 52% for the baseline and realistic scenario, respectively. This difference disappears towards the future (99% vs 98% and 98%), as no additional euro standard is set yet. Compared with Figure 58, the adoption of newer standards happens faster, as newer (on average, i.e. cleaner) vehicles are usually driven more intensively than older ones.

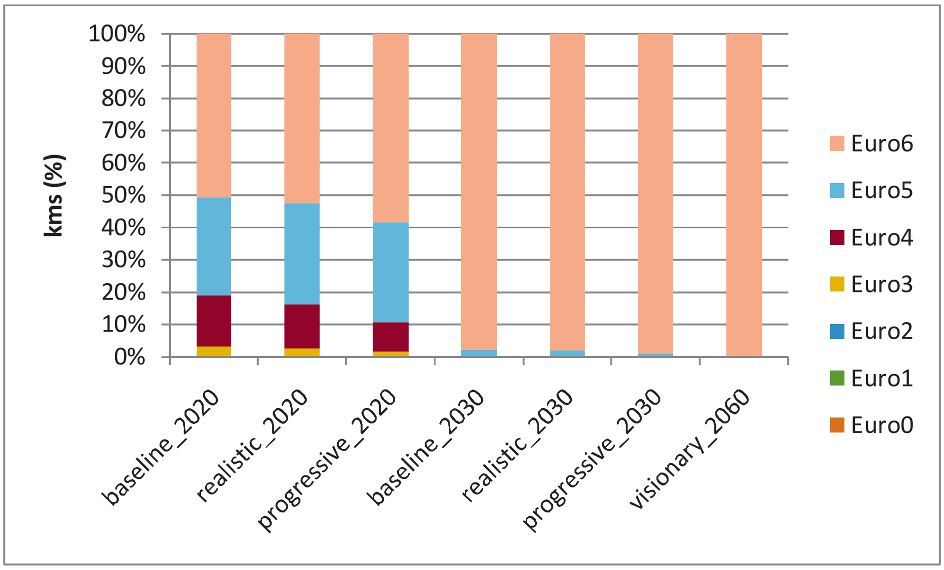

Figure 64: Relative share of kilometres driven by different euro standards

4.2.5. Kilometres per engine size

All comments given in 4.1.4 are also valid for Figure 65. Looking at the kilometres, however, the share of small engines is somewhat smaller. This is again a confirmation of the notion that smaller vehicles (<1.4l) are on average driven less kilometres than their larger counterparts (>1.4l). If we want to reach a target of 50% of all kilometres travelled by small engines in 2030, the measures proposed under the progressive scenario could offer a solution.

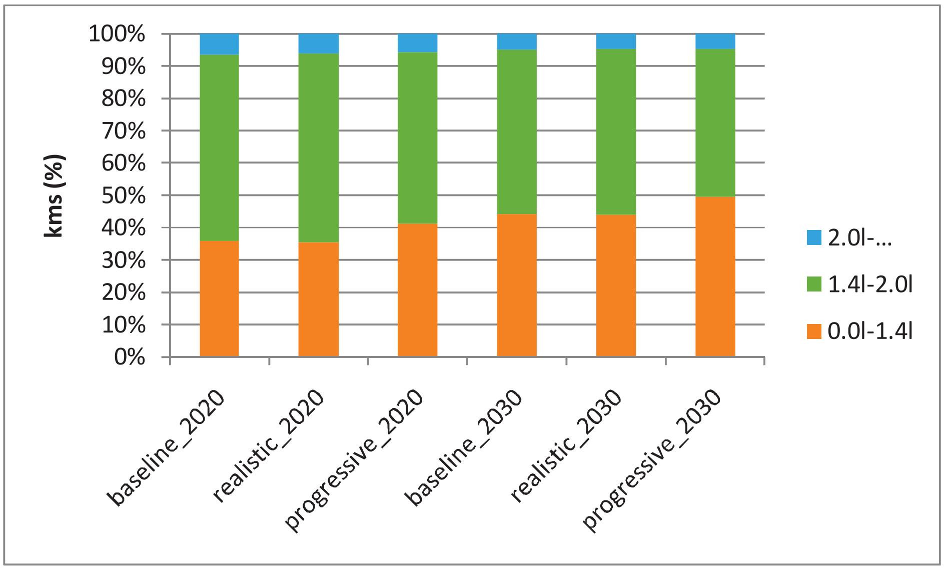

Figure 65: Relative share of kilometres driven by different engine sizes

4.3. Environmental impact

4.3.1. Ecoscore

The average ecoscore, weighted for the kilometres driven, is displayed in Figure 66. Again, it is clear that the progressive scenario provides a substantial benefit compared to the baseline and realistic scenario (71.65 vs 69.16 and 69.59 in 2020 and 75.43 vs 73.73 and 73.77 in 2030). These values are slightly above the unweighted ones observed in Figure 60, which indicates that cars with higher ecoscores are driven more kilometres compared to cars with lower ecoscores, on average.

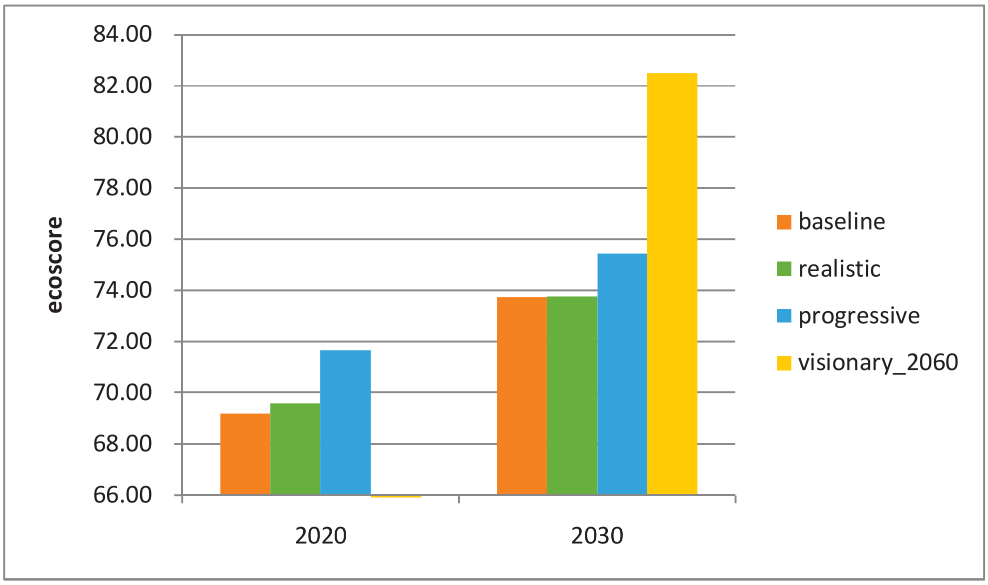

Figure 66: Average ecoscore for Belgian fleet (km weighted)

4.3.2. Emissions

Emission levels of CO_2e, PM2.5 and NO_x are displayed in Figure 67 till Figure 69. We can classify these emissions in two groups: CO_2e on the one hand and PM2.5 and NO_x on the other hand.

Concerning emissions of CO_2e, emission differences between the various technologies rule, rather than the (automatic) technological progress over time. This can be observed in Figure 67, where the baseline emissions in 2030 exceed 2020 emissions under the progressive scenario. Therefore, the importance of policy measure implementation for the benefit of lowering CO_2e emissions cannot be stressed too much. The share of CO_2e emissions originating from diesel vehicles is substantial, but not so large as for PM2.5 and NO_x.

Regarding $PM_{2.5}$ and NO_x, we conclude from Figure 68 and Figure 69 that all engine technologies seem to benefit from a large level of technological improvement. This happens automatically over the years, because we see for example that the total level of emissions under the baseline in 2030 is lower than emissions under the progressive scenario in 2020. Nevertheless, compared to the other technologies, diesel vehicles (both conventional and hybrid) relatively contribute a lot to the total emission levels of PM2.5 and NO_x.

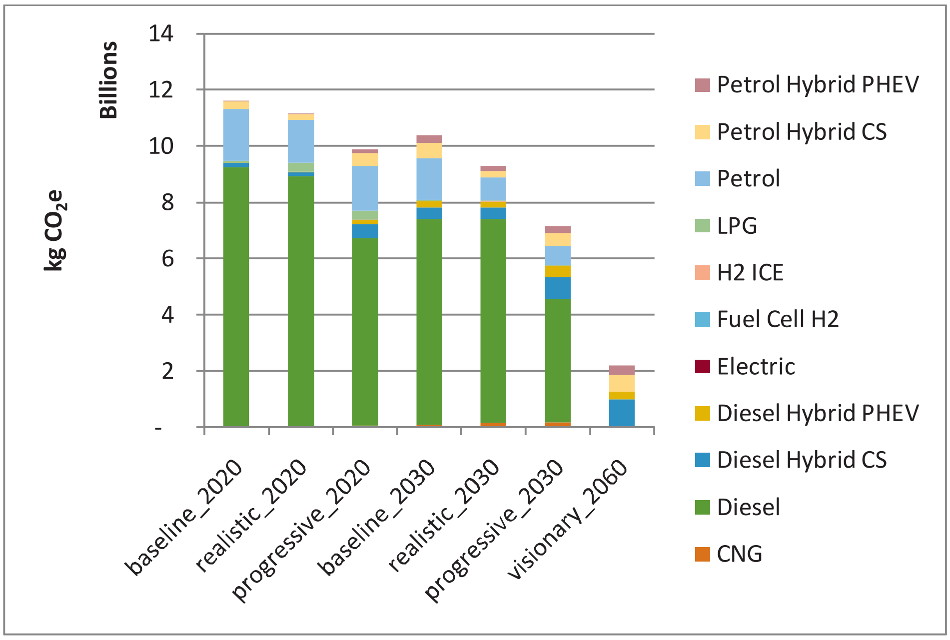

Figure 67: TTW emissions CO_2e per technology

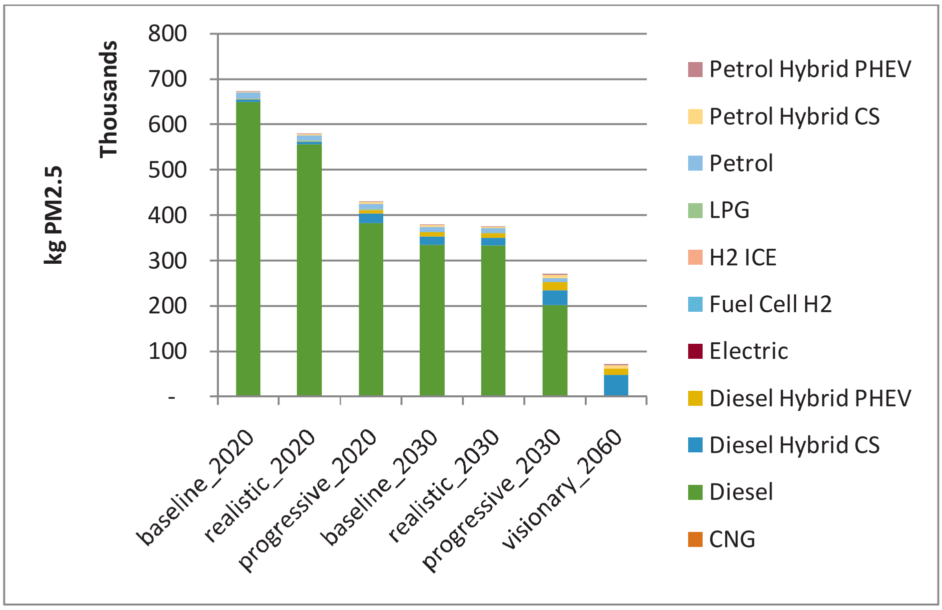

Figure 68: TTW emissions PM2.5 per technology

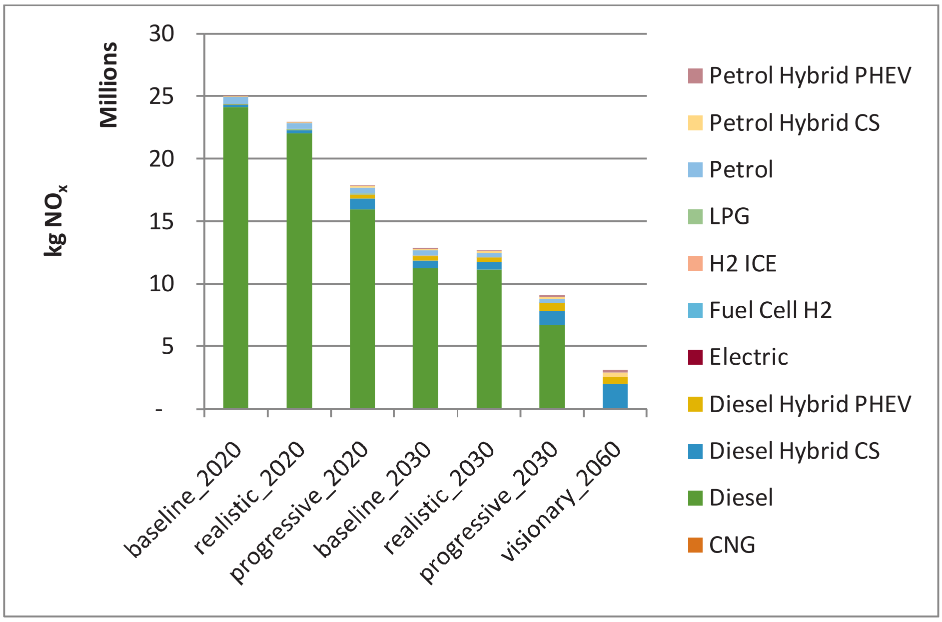

Figure 69: TTW emissions NO_x per technology

5. Conclusion

In this report, we discussed the results on fleet composition, vehicle use and environmental impact for the baseline, the realistic as well as the progressive scenario. For the visionary scenario, the evaluation was constrained to data on vehicle use and environmental impacts.

The results from the baseline scenario describe the situation if no additional measures are taken on top of the current and planned legislation. This is an interesting benchmark for the other scenario results to be compared with.

Under the realistic scenario, the modelled reforms are rather confined. Not very surprising then, the difference compared to the baseline in terms of total fleet size, distance travelled, ecoscore and emissions is quite small. However, this new tax system based on CO_2 emission and Euro standard seems to be more righteous within the scope of the 'polluter pays principle'.

The progressive scenario adds some interesting features to the realistic setting. It is to say, a kilometre charge replaces the annual circulation tax, and is partially based on the ecoscore of the vehicle, as is the registration tax . The imposed limitation on traffic in city centres is another remarkable measure adopted in this scenario. The results show that these rather stringent policy measures will pay off, not only in terms of a massive reduction in total kilometres travelled, but also in terms of emissions and weighted ecoscores. The fact is that the results from this scenario easily tower above the resulting indicators from the other two scenarios. Therefore, it should be kept in mind that making an additional effort, as done under the progressive scenario, can make a difference in order to obtain some pretty hopeful results.

Please note that the scenario results not only depend on the type of measures introduced, but also on the specific level of each measure. From the figures given above, we can deduce that the progressive setup indeed yields better results than the realistic scenario, but this is only true for the specific levels of the simulated measures, given in report 5.3. As a consequence, the results of the realistic scenario could have been much more encouraging, for example if the excise duties on diesel had been significantly higher than those on petrol. In conclusion, we can say that we can only judge on the impact of the complete set of measures in the scenarios, as described in report 5.3.

The results from the visionary scenario indicate that there is a huge gap between the well-founded model results for 2030 and the visionary exercise for the year 2060, both in terms of the amount of kilometres travelled and environmental performance indicators. Seemingly, the predefined vehicle fleet distribution and the other assumptions made under this scenario promise to be quite beneficial for traffic intensities and the corresponding ecoscores and emissions. However, we should take account of the fact that direct carbon emissions still exist, so, even under this scenario, there is room for improvement. Finally, we should always bear in mind that this is an exercise basically founded on expert judgements.

6. Literature

European Union (2007). *Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on Type Approval of Motor Vehicles with Respect to Emissions from Light Passenger and Commercial Vehicles (Euro 5 and Euro 6) and on Access to Vehicle Repair and Maintenance Information*, **Official Journal of the European Union 171**(1): 1-16, published by European Union.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:171:0001:0016:EN:PDF

FOD Economie, K.M.O., Middenstand en Energie (FOD Economie,KMO,Middenstand en Energie). *Grootte van het Voertuigenpark (1977-2010)*, consulted on 15/10/2010.
http://statbel.fgov.be/nl/statistieken/cijfers/verkeer_vervoer/verkeer/voertuigpark/index.jsp

Intergovernmental Panel on Climate Change (IPCC). *Direct Global Warming Potentials*, consulted on 25/11/2010.
http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

Small K. & Van Dender K. (2005). *The Effect of Improved Fuel Economy on Vehicle Miles Traveled: Estimating the Rebound Effect Using U.S. State Data, 1966-2001*, **Energy Policy and Economics 014**(1): 1-39, published by University of California Energy Institute, UC Berkeley.
http://escholarship.org/uc/item/1h6141nj#page-1

Whitehead J., Longley D., Coe H. & Gallagher M. (2004). *Hourly Concentrations of Ammonia During the Winter in Manchester, UK, Related to Traffic and Background Sources*, University Manchester Institute of Science and Technology (UMIST), Conference proceedings of Fifth Conference on Urban Environment, 23/08/2004, Vancouver, Canada.

7. Annex: Detailed scenario results

7.1. Baseline scenario

This section can be considered as an annex to 2.2. The results are now displayed more thoroughly in tabular form.

7.1.1. Fleet composition

	TOTAL
1995	4,239,972
2000	4,644,944
2005	4,878,446
2010	5,207,513
2015	5,621,179
2020	5,746,763
2025	5,869,847
2030	6,051,956

Table 3: Total number of cars

	CNG	Diesel	Diesel hybrid CS	Diesel hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol hybrid CS	Petrol hybrid PHEV	TOTAL
1995	-	1,405,524	-	-	12	-	-	32,629	2,801,807	-	-	4,239,972
2000	1	1,891,009	-	-	66	-	-	64,255	2,689,597	16	-	4,644,944
2005	2	2,454,024	-	-	19	-	-	59,901	2,363,805	695	-	4,878,446
2010	39	3,203,601	-	-	-	-	-	37,520	1,958,102	8,251	-	5,207,513
2015	7,188	3,842,965	10,631	1,116	-	-	-	23,451	1,684,413	47,502	3,913	5,621,179
2020	24,372	3,939,701	64,784	18,018	-	-	-	17,220	1,519,068	134,161	29,439	5,746,763
2025	50,774	3,722,247	153,844	94,171	34,689	-	3,404	15,344	1,422,731	245,257	127,386	5,869,847
2030	83,004	3,378,335	215,426	281,198	127,957	14,351	12,597	15,041	1,262,850	308,542	352,655	6,051,956

Table 4: Total number of cars per technology

	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	TOTAL
1995	3,221,408	1,018,564	-	-	-	-	-	4,239,972
2000	1,807,642	1,063,466	1,614,940	158,896	-	-	-	4,644,944
2005	748,242	723,245	1,295,406	1,964,227	147,326	-	-	4,878,446
2010	3,062	534,960	762,820	1,538,727	2,225,404	142,540	-	5,207,513
2015	-	-	279,853	999,086	1,871,827	2,138,106	332,307	5,621,179
2020	-	-	-	277,945	1,190,314	1,804,505	2,473,999	5,746,763
2025	-	-	-	-	328,801	1,185,984	4,355,062	5,869,847
2030	-	-	-	-	-	190,424	5,861,532	6,051,956

Table 5: Total number of cars per Euro standard

	0,0l-1,4l	1,4l-2,0l	2,0l-...	TOTAL
1995	1,302,352	2,373,322	564,298	4,239,972
2000	1,347,518	2,753,282	544,144	4,644,944
2005	1,429,280	2,887,121	562,045	4,878,446
2010	1,621,781	2,997,700	588,032	5,207,513
2015	2,069,403	3,060,250	491,526	5,621,179
2020	2,458,962	2,916,489	371,312	5,746,763
2025	2,812,919	2,753,733	303,195	5,869,847
2030	3,104,700	2,664,591	282,665	6,051,956

Table 6: Total number of cars per engine size

2006	2007	2008	2010	2015	2020	2025	2030
51.82	53.85	56.17	58.40	64.11	68.50	71.18	73.22

Table 7: Average ecoscore (unweighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	70.45	74.79	78.87	79.15	79.24	79.28
Diesel	48.56	51.01	53.47	56.69	63.80	68.19	70.62	71.77
Diesel Hybrid CS	-	-	-	-	77.82	78.28	78.66	79.01
Diesel Hybrid PHEV	-	-	-	-	79.84	80.34	80.77	81.20
Electric	-	-	-	-	-	-	83.87	84.23
Fuel Cell H2	-	-	-	-	-	-	-	82.70
H2 ICE	-	-	-	-	-	-	82.72	82.72
LPG	61.06	62.65	65.61	65.73	65.52	68.36	68.83	69.05
Petrol	55.34	57.22	59.61	61.00	64.19	67.41	68.20	68.52
Petrol Hybrid CS	70.72	70.62	71.09	73.37	78.08	79.05	79.56	79.93
Petrol Hybrid PHEV	-	-	-	-	80.85	81.31	81.75	82.17

Table 8: Average ecoscore per technology (unweighted)

7.1.2. Vehicle use

	TOTAL
1995	66,832,777,716
2000	72,487,048,804
2005	74,500,719,217
2010	79,315,275,512
2015	87,397,629,037
2020	90,104,118,929
2025	91,665,482,613
2030	93,735,449,770

Table 9: Total amount of kilometres driven

	Highw	Rural	Urban	TOTAL
1995	20,180,123,013	29,372,470,660	17,280,184,043	66,832,777,716
2000	23,126,920,622	31,342,298,555	18,017,829,627	72,487,048,804
2005	24,379,942,836	31,882,470,269	18,238,306,112	74,500,719,217
2010	26,130,753,803	33,843,702,278	19,340,819,431	79,315,275,512
2015	28,118,435,873	37,599,609,811	21,679,583,353	87,397,629,037
2020	28,538,709,235	38,845,011,636	22,720,398,058	90,104,118,929
2025	28,637,534,361	39,570,464,065	23,457,484,187	91,665,482,613
2030	28,915,939,274	40,535,617,915	24,283,892,581	93,735,449,770

Table 10: Total amount of kilometres driven per road type

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,398.45	-	-	0.13	-	-	604.63	30,829.56	-	-	66,832.78
2000	0.02	45,709.21	-	-	0.58	-	-	1,166.95	25,609.81	0.48	-	72,487.05
2005	0.02	51,816.93	-	-	0.17	-	-	1,249.61	21,418.61	15.39	-	74,500.72
2010	0.37	62,569.35	-	-	-	-	-	713.44	15,856.94	175.17	-	79,315.28
2015	65.83	72,094.48	233.51	24.78	-	-	-	438.45	13,490.86	967.15	82.56	87,397.63
2020	220.05	72,241.03	1,394.85	396.50	-	-	-	326.71	12,262.74	2,651.55	610.69	90,104.12
2025	444.63	66,781.66	3,132.47	2,013.10	320.52	-	31.47	291.64	11,451.62	4,618.72	2,579.65	91,665.48
2030	703.50	59,333.40	4,061.51	5,762.21	1,141.69	131.05	112.59	283.49	9,929.32	5,424.04	6,852.64	93,735.45

Table 11 : Total amount of kilometres driven per technology (mio kilometres)

	Euro0	Euro1	Euro2	Euro3	Euro4	Euro5	Euro6	TOTAL
1995	43,962,207,284	22,870,570,432	-	-	-	-	-	66,832,777,716
2000	15,533,821,791	16,485,907,640	36,847,854,405	3,619,464,968	-	-	-	72,487,048,804
2005	6,665,646,549	8,754,950,192	19,263,391,263	36,950,200,466	2,866,530,747	-	-	74,500,719,217
2010	52,829,474	4,458,471,977	8,479,542,370	22,391,535,805	40,954,819,105	2,978,076,781	-	79,315,275,512
2015	-	-	2,457,825,328	11,673,223,014	27,845,396,561	38,653,586,616	6,767,597,518	87,397,629,037
2020	-	-	-	2,746,723,333	14,512,095,294	27,291,630,235	45,553,670,067	90,104,118,929
2025	-	-	-	-	3,459,186,027	14,549,434,684	73,656,861,902	91,665,482,613
2030	-	-	-	-	-	2,040,504,851	91,694,944,919	93,735,449,770

Table 12: Total amount of kilometres driven per euro standard

	0.0l-1.4l	1.4l-2.0l	2.0l-…	TOTAL
1995	12,751,387,563	43,267,168,545	10,814,221,608	66,832,777,716
2000	12,485,109,334	50,420,615,031	9,581,324,439	72,487,048,804
2005	14,486,763,280	50,510,126,237	9,503,829,700	74,500,719,217
2010	18,111,297,712	51,621,782,252	9,582,195,548	79,315,275,512
2015	25,916,958,125	53,658,712,238	7,821,958,674	87,397,629,037
2020	32,240,500,727	52,001,886,856	5,861,731,346	90,104,118,929
2025	37,314,178,136	49,468,287,820	4,883,016,657	91,665,482,613
2030	41,409,411,368	47,698,830,305	4,627,208,097	93,735,449,770

Table 13: Total amount of kilometres driven per engine size

7.1.3. Environmental impact

2006	2007	2008	2010	2015	2020	2025	2030
51.79	53.79	55.97	58.61	64.82	69.16	71.80	73.73

Table 14: Average ecoscore (km weighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	68.72	74.75	78.92	79.22	79.32	79.36
Diesel	49.91	52.25	54.59	57.77	64.61	68.74	70.84	71.73
Diesel Hybrid CS	-	-	-	-	77.79	78.26	78.63	78.97
Diesel Hybrid PHEV	-	-	-	-	79.81	80.31	80.74	81.17
Electric	-	-	-	-	-	-	83.79	84.14
Fuel Cell H2	-	-	-	-	-	-	-	82.65
H2 ICE	-	-	-	-	-	-	82.67	82.67
LPG	61.35	62.81	65.54	65.69	65.58	68.24	68.65	68.84
Petrol	56.38	57.94	59.99	61.41	64.50	67.33	68.05	68.31
Petrol Hybrid CS	70.68	70.65	71.22	73.57	78.19	79.07	79.55	79.90
Petrol Hybrid PHEV	-	-	-	-	80.82	81.28	81.72	82.14

Table 15: Average ecoscore per technology (km weighted)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electr ic	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	6,052,616,511	-	-	-	-	-	100,218,770	6,213,950,564	-	-	12,366,785,845
2000	3,758	7,571,664,700	-	-	-	-	-	195,956,191	4,883,391,149	63,246	-	12,651,079,044
2005	2,735	8,320,179,179	-	-	-	-	-	211,148,523	3,962,190,730	2,165,671	-	12,495,686,838
2010	44,524	9,331,362,873	-	-	-	-	-	119,349,500	2,730,110,681	21,729,812	-	12,202,597,391
2015	6,901,988	9,759,495,119	24,590,626	1,039,921	-	-	-	69,340,338	2,141,092,813	103,971,403	3,513,803	12,109,946,011
2020	22,029,571	9,231,424,974	141,364,343	16,048,979	-	-	-	49,318,431	1,865,476,926	270,217,534	24,750,775	11,620,631,534
2025	44,377,206	8,322,896,487	316,352,812	81,378,046	-	-	97,575	43,178,291	1,707,134,566	467,109,573	104,334,813	11,086,859,368
2030	70,204,727	7,331,815,951	408,876,345	232,651,621	-	-	349,059	41,589,431	1,467,660,443	546,977,780	276,734,435	10,376,859,792

Table 16: CO_2e TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,315,141	-	-	-	-	-	17,986	720,095	-	-	6,053,222
2000	0	3,539,624	-	-	-	-	-	19,194	265,661	1	-	3,824,480
2005	0	2,349,620	-	-	-	-	-	13,556	144,850	13	-	2,508,038
2010	0	1,702,432	-	-	-	-	-	2,650	23,170	145	-	1,728,398
2015	70	1,059,851	1,002	43	-	-	-	556	15,615	796	27	1,077,959
2020	233	649,121	5,980	680	-	-	-	347	13,002	2,177	201	671,740
2025	472	422,151	13,418	3,449	-	-	7	309	12,144	3,786	846	456,582
2030	746	334,211	17,386	9,866	-	-	24	301	10,530	4,440	2,243	379,748

Table 17: PM2.5 TTW emissions per fuel technology kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	22,183,138	-	-	-	-	-	1,472,503	61,392,673	-	-	85,048,314
2000	4	30,803,906	-	-	-	-	-	1,574,784	26,526,093	50	-	58,904,837
2005	1	37,225,553	-	-	-	-	-	1,102,219	14,272,858	735	-	52,601,367
2010	14	39,457,418	-	-	-	-	-	211,135	3,360,945	5,225	-	43,034,737
2015	2,608	35,471,999	68,195	2,879	-	-	-	29,443	963,695	28,099	956	36,567,875
2020	8,767	24,114,642	232,933	24,734	-	-	-	15,432	518,985	77,120	7,104	24,999,717
2025	17,802	16,001,949	482,313	121,340	-	-	3,151	12,407	459,795	134,743	30,110	17,263,610
2030	28,288	11,239,397	610,705	345,641	-	-	11,318	12,068	399,249	158,700	80,220	12,885,586

Table 18: NO_x TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	16,683,629	-	-	-	-	-	4,690,292	292,705,606	-	-	314,079,527
2000	5	12,541,418	-	-	-	-	-	6,120,478	124,940,760	297	-	143,602,959
2005	4	7,230,994	-	-	-	-	-	5,086,080	68,301,464	9,383	-	80,627,926
2010	87	4,443,963	-	-	-	-	-	1,694,712	23,255,429	58,696	-	29,452,888
2015	14,870	4,223,842	10,621	450	-	-	-	589,812	9,335,705	306,388	10,414	14,492,103
2020	49,349	4,258,346	63,864	7,262	-	-	-	309,984	5,540,059	829,348	76,336	11,134,548
2025	99,083	4,077,547	144,212	37,081	-	-	-	242,154	4,433,336	1,433,629	320,078	10,787,120
2030	155,893	3,674,052	187,880	106,654	-	-	-	234,194	3,792,577	1,672,938	844,880	10,669,068

Table 19: CO TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	3,150,628	-	-	-	-	-	579,117	62,272,533	-	-	66,002,278
2000	0	2,134,790	-	-	-	-	-	613,777	28,397,895	20	-	31,146,483
2005	0	1,355,141	-	-	-	-	-	427,924	13,690,808	348	-	15,474,222
2010	3	674,679	-	-	-	-	-	84,615	1,809,554	3,346	-	2,572,197
2015	565	484,834	1,006	43	-	-	-	8,224	703,570	18,525	806	1,217,573
2020	1,884	399,827	6,017	684	-	-	-	2,900	480,259	51,279	6,014	948,865
2025	3,799	362,797	13,531	3,478	-	-	269	1,802	432,684	90,853	25,661	934,874
2030	6,000	325,709	17,564	9,968	-	-	960	1,757	379,350	109,712	69,631	920,650

Table 20: VOC TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,046,387	-	-	-	-	-	334	1,141,277	-	-	6,187,998
2000	0	1,421,124	-	-	-	-	-	647	235,907	3	-	1,657,682
2005	0	166,043	-	-	-	-	-	698	36,754	20	-	203,515
2010	0	49,324	-	-	-	-	-	394	12,100	97	-	61,916
2015	25	51,528	130	5	-	-	-	229	9,615	470	16	62,019
2020	80	48,704	746	85	-	-	-	163	8,373	1,222	112	59,484
2025	161	43,894	1,669	429	-		-	142	7,653	2,112	472	56,533
2030	255	38,662	2,157	1,228	-	-	-	136	6,578	2,474	1,252	52,741

Table 21: SO_2 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,400	-	-	-	-	-	-	889,867	-	-	925,267
2000	3	45,708	-	-	-	-	-	-	2,581,614	41	-	2,627,366
2005	1	51,817	-	-	-	-	-	-	1,779,089	476	-	1,831,383
2010	14	62,571	-	-	-	-	-	-	1,182,758	5,366	-	1,250,708
2015	2,287	72,095	193	8	-	-	-	-	658,383	28,765	982	762,712
2020	7,526	72,241	1,148	131	-	-	-	-	509,273	77,625	7,148	675,093
2025	14,954	66,781	2,575	662	-	-	0	-	489,436	133,017	29,700	737,126
2030	23,252	59,335	3,336	1,893	-	-	0	-	423,881	153,599	77,579	742,876

Table 22: NH_3 TTW emissions per fuel technology (kg)

7.2. Realistic scenario

This section can be considered as an annex to section 3.1. The results are now displayed more thoroughly in a tabular form.

7.2.1. Fleet composition

	TOTAL
1995	4,239,972
2000	4,644,944
2005	4,878,446
2010	5,207,513
2015	5,576,002
2020	5,633,480
2025	5,670,240
2030	5,818,109

Table 23: Total number of cars

	CNG	Diesel	Diesel hybrid CS	Diesel hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol hybrid CS	Petrol hybrid PHEV	TOTAL
1995	-	1,405,524	-	-	12	-	-	32,629	2,801,807	-	-	4,239,972
2000	1	1,891,009	-	-	66	-	-	64,255	2,689,597	16	-	4,644,944
2005	2	2,454,024	-	-	19	-	-	59,901	2,363,805	695	-	4,878,446
2010	39	3,203,601	-	-	-	-	-	37,520	1,958,102	8,251	-	5,207,513
2015	15,436	3,728,103	10,810	1,197	-	-	-	183,078	1,592,892	40,298	4,188	5,576,002
2020	51,125	3,889,549	63,569	18,587	-	-	-	136,572	1,336,407	107,177	30,494	5,633,480
2025	104,230	3,735,130	147,188	95,380	35,211	-	3,460	21,814	1,212,259	185,832	129,736	5,670,240
2030	168,804	3,309,345	201,016	284,017	130,790	14,711	12,876	15,018	1,110,440	211,403	359,689	5,818,109

Table 24: Total number of cars per technology

	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	TOTAL
1995	3,221,408	1,018,564	-	-	-	-	-	4,239,972
2000	1,807,642	1,063,466	1,614,940	158,896	-	-	-	4,644,944
2005	748,242	723,245	1,295,406	1,964,227	147,326	-	-	4,878,446
2010	3,062	534,960	762,820	1,538,727	2,225,404	142,540	-	5,207,513
2015	-	-	256,529	889,716	1,815,282	2,258,469	356,006	5,576,002
2020	-	-	-	229,476	997,969	1,839,062	2,566,973	5,633,480
2025	-	-	-	-	255,129	1,031,937	4,383,174	5,670,240
2030	-	-	-	-	-	151,914	5,666,195	5,818,109

Table 25: Total number of cars per euro standard

	0,0l-1,4l	1,4l-2,0l	2,0l-...	TOTAL
1995	1,302,352	2,373,322	564,298	4,239,972
2000	1,347,518	2,753,282	544,144	4,644,944
2005	1,429,280	2,887,121	562,045	4,878,446
2010	1,621,781	2,997,700	588,032	5,207,513
2015	2,055,367	3,051,594	469,041	5,576,002
2020	2,388,129	2,905,534	339,817	5,633,480
2025	2,681,516	2,709,929	278,795	5,670,240
2030	2,974,594	2,578,068	265,447	5,818,109

Table 26: Total number of cars per engine size

2006	2007	2008	2010	2015	2020	2025	2030
51.82	53.85	56.17	58.40	64.78	69.08	71.45	73.37

Table 27: Average ecoscore (unweighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	70.45	74.79	78.81	79.08	79.18	79.24
Diesel	48.56	51.01	53.47	56.69	64.70	69.03	70.90	71.83
Diesel Hybrid CS	-	-	-	-	77.82	78.28	78.67	79.04
Diesel Hybrid PHEV	-	-	-	-	79.84	80.34	80.78	81.21
Electric	-	-	-	-	-	-	83.87	84.23
Fuel Cell H2	-	-	-	-	-	-	-	82.70
H2 ICE	-	-	-	-	-	-	82.72	82.72
LPG	61.06	62.65	65.61	65.73	66.58	67.25	68.41	69.06
Petrol	55.34	57.22	59.61	61.00	64.15	67.37	68.19	68.51
Petrol Hybrid CS	70.72	70.62	71.09	73.37	77.96	79.02	79.55	79.90
Petrol Hybrid PHEV	-	-	-	-	80.85	81.30	81.74	82.17

Table 28: Average ecoscore per technology (unweighted)

7.2.2. Vehicle use

	TOTAL
1995	66,832,777,716
2000	72,487,048,804
2005	74,500,719,217
2010	79,315,275,512
2015	85,163,464,302
2020	87,812,046,627
2025	89,481,412,888
2030	91,748,869,089

Table 29: Total amount of kilometres driven

	Highw	Rural	Urban	TOTAL
1995	20,180,123,013	29,372,470,660	17,280,184,043	66,832,777,716
2000	23,126,920,622	31,342,298,555	18,017,829,627	72,487,048,804
2005	24,379,942,836	31,882,470,269	18,238,306,112	74,500,719,217
2010	26,130,753,803	33,843,702,278	19,340,819,431	79,315,275,512
2015	27,399,266,441	36,638,238,118	21,125,959,743	85,163,464,302
2020	27,811,931,394	37,855,703,422	22,144,411,811	87,812,046,627
2025	27,953,296,640	38,629,362,524	22,898,753,724	89,481,412,888
2030	28,302,696,038	39,676,325,798	23,769,847,253	91,748,869,089

Table 30: Total amount of kilometres driven per road type

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,398.45	-	-	0.13	-	-	604.63	30,829.56	-	-	66,832.78
2000	0.02	45,709.21	-	-	0.58	-	-	1,166.95	25,609.81	0.48	-	72,487.05
2005	0.02	51,816.93	-	-	0.17	-	-	1,249.61	21,418.61	15.39	-	74,500.72
2010	0.37	62,569.35	-	-	-	-	-	713.44	15,856.94	175.17	-	79,315.28
2015	136.75	68,163.44	224.86	25.36	-	-	-	3,086.76	12,647.41	793.36	85.54	85,163.46
2020	449.57	70,318.42	1,301.77	391.85	-	-	-	2,030.85	10,644.58	2,060.79	614.22	87,812.05
2025	912.18	66,930.00	2,937.07	2,007.18	323.01	-	31.76	381.65	9,851.92	3,489.90	2,616.73	89,481.41
2030	1,460.20	58,966.88	3,824.34	5,852.67	1,183.22	135.54	116.63	290.69	9,069.07	3,748.50	7,101.13	91,748.87

Table 31: Total amount of kilometres driven per technology (mio kilometres)

	Euro0	Euro1	Euro2	Euro3	Euro4	Euro5	Euro6	TOTAL
1995	43,962,207,284	22,870,570,432	-	-	-	-	-	66,832,777,716
2000	15,533,821,791	16,485,907,640	36,847,854,405	3,619,464,968	-	-	-	72,487,048,804
2005	6,665,646,549	8,754,950,192	19,263,391,263	36,950,200,466	2,866,530,747	-	-	74,500,719,217
2010	52,829,474	4,458,471,977	8,479,542,370	22,391,535,805	40,954,819,105	2,978,076,781	-	79,315,275,512
2015	-	-	2,200,375,056	10,205,859,424	26,291,676,951	39,447,827,362	7,017,725,509	85,163,464,302
2020	-	-	-	2,221,989,308	12,067,764,158	27,567,413,564	45,954,879,597	87,812,046,627
2025	-	-	-	-	2,689,080,171	12,993,331,174	73,799,001,543	89,481,412,888
2030	-	-	-	-	-	1,687,985,771	90,060,883,318	91,748,869,089

Table 32: Total amount of kilometres driven per euro standard

	0.0l-1.4l	1.4l-2.0l	2.0l-...	TOTAL
1995	12,751,387,563	43,267,168,545	10,814,221,608	66,832,777,716
2000	12,485,109,334	50,420,615,031	9,581,324,439	72,487,048,804
2005	14,486,763,280	50,510,126,237	9,503,829,700	74,500,719,217
2010	18,111,297,712	51,621,782,252	9,582,195,548	79,315,275,512
2015	25,453,098,767	52,362,731,454	7,347,634,081	85,163,464,302
2020	31,224,826,800	51,195,758,397	5,391,461,430	87,812,046,627
2025	36,005,608,334	48,895,136,292	4,580,668,262	89,481,412,888
2030	40,350,695,418	46,949,036,332	4,449,137,339	91,748,869,089

Table 33: Total amount of kilometres driven per engine size

7.2.3. Environmental impact

2006	2007	2008	2010	2015	2020	2025	2030
51.79	53.79	55.97	58.61	65.44	69.59	71.93	73.77

Table 34: Average ecoscore (km weighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	68.72	74.75	78.85	79.15	79.26	79.31
Diesel	49.91	52.25	54.59	57.77	65.33	69.35	71.03	71.78
Diesel Hybrid CS	-	-	-	-	77.79	78.26	78.64	79.00
Diesel Hybrid PHEV	-	-	-	-	79.81	80.31	80.74	81.18
Electric	-	-	-	-	-	-	83.79	84.15
Fuel Cell H2	-	-	-	-	-	-	-	82.65
H2 ICE	-	-	-	-	-	-	82.67	82.67
LPG	61.35	62.81	65.54	65.69	66.68	67.38	68.38	68.85
Petrol	56.38	57.94	59.99	61.41	64.41	67.28	68.03	68.30
Petrol Hybrid CS	70.68	70.65	71.22	73.57	78.07	79.05	79.54	79.87
Petrol Hybrid PHEV	-	-	-	-	80.82	81.28	81.72	82.14

Table 35: Average ecoscore per technology (km weighted)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Elec tric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	6,052,616,511	-	-	-	-	-	100,218,770	6,213,950,564	-	-	12,366,785,845
2000	3,758	7,571,664,700	-	-	-	-	-	195,956,191	4,883,391,149	63,246	-	12,651,079,044
2005	2,735	8,320,179,179	-	-	-	-	-	211,148,523	3,962,190,730	2,165,671	-	12,495,686,838
2010	44,524	9,331,362,873	-	-	-	-	-	119,349,500	2,730,110,681	21,729,812	-	12,202,597,391
2015	14,344,011	9,141,187,620	23,678,444	1,064,153	-	-	-	477,052,623	2,007,985,530	85,481,464	3,640,079	11,754,433,924
2020	45,043,924	8,892,225,802	131,913,896	15,861,583	-	-	-	314,205,999	1,534,661,727	198,708,357	23,533,950	11,156,155,237
2025	91,083,816	8,308,941,629	296,520,094	81,135,091	-	-	98,462	57,313,724	1,114,987,217	267,072,837	80,085,865	10,297,238,734
2030	145,763,971	7,272,648,840	384,701,819	236,237,465	-	-	361,546	42,637,111	813,527,344	228,008,551	173,042,389	9,296,929,036

Table 36: CO_2e TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,315,141	-	-	-	-	-	17,986	720,095	-	-	6,053,222
2000	0	3,539,624	-	-	-	-	-	19,194	265,661	1	-	3,824,480
2005	0	2,349,620	-	-	-	-	-	13,556	144,850	13	-	2,508,038
2010	0	1,702,432	-	-	-	-	-	2,650	23,170	145	-	1,728,398
2015	145	897,276	965	44	-	-	-	3,363	14,675	653	28	917,149
2020	477	555,387	5,581	672	-	-	-	2,155	11,287	1,692	202	577,453
2025	967	409,615	12,582	3,439	-	-	7	405	10,448	2,861	858	441,184
2030	1,549	332,129	16,371	10,021	-	-	25	308	9,618	3,069	2,325	375,413

Table 37: PM2.5 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	22,183,138	-	-	-	-	-	1,472,503	61,392,673	-	-	85,048,314
2000	4	30,803,906	-	-	-	-	-	1,574,784	26,526,093	50	-	58,904,837
2005	1	37,225,553	-	-	-	-	-	1,102,219	14,272,858	735	-	52,601,367
2010	14	39,457,418	-	-	-	-	-	211,135	3,360,945	5,225	-	43,034,737
2015	5,417	32,409,351	65,742	2,949	-	-	-	173,365	912,721	23,059	991	33,593,595
2020	17,911	22,053,751	218,071	24,483	-	-	-	95,891	452,039	59,934	7,145	22,929,224
2025	36,520	15,443,878	451,385	120,972	-	-	3,179	16,237	395,589	101,801	30,540	16,600,101
2030	58,708	11,104,342	574,757	351,077	-	-	11,721	12,374	364,606	109,649	83,114	12,670,347

Table 38: NO_x TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	16,683,629	-	-	-	-	-	4,690,292	292,705,606	-	-	314,079,527
2000	5	12,541,418	-	-	-	-	-	6,120,478	124,940,760	297	-	143,602,959
2005	4	7,230,994	-	-	-	-	-	5,086,080	68,301,464	9,383	-	80,627,926
2010	87	4,443,963	-	-	-	-	-	1,694,712	23,255,429	58,696	-	29,452,888
2015	30,903	3,970,399	10,225	461	-	-	-	3,590,624	8,834,094	251,724	10,797	16,699,228
2020	100,832	4,185,369	59,606	7,177	-	-	-	1,933,607	4,857,491	644,782	76,783	11,865,648
2025	203,331	4,094,800	135,216	36,970	-	-	-	317,351	3,817,483	1,083,733	324,820	10,013,704
2030	323,643	3,651,431	176,896	108,317	-	-	-	240,205	3,464,587	1,156,714	875,787	9,997,580

Table 39: CO TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	3,150,628	-	-	-	-	-	579,117	62,272,533	-	-	66,002,278
2000	0	2,134,790	-	-	-	-	-	613,777	28,397,895	20	-	31,146,483
2005	0	1,355,141	-	-	-	-	-	427,924	13,690,808	348	-	15,474,222
2010	3	674,679	-	-	-	-	-	84,615	1,809,554	3,346	-	2,572,197
2015	1,174	434,720	969	44	-	-	-	42,864	666,123	15,410	850	1,162,153
2020	3,850	385,735	5,616	676	-	-	-	18,287	420,682	40,312	6,145	881,302
2025	7,795	364,313	12,688	3,468	-	-	271	2,374	370,456	68,737	26,089	856,191
2030	12,454	323,685	16,538	10,124	-	-	995	1,801	339,765	75,542	71,530	852,433

Table 40: VOC TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,046,387	-	-	-	-	-	334	1,141,277	-	-	6,187,998
2000	0	1,421,124	-	-	-	-	-	647	235,907	3	-	1,657,682
2005	0	166,043	-	-	-	-	-	698	36,754	20	-	203,515
2010	0	49,324	-	-	-	-	-	394	12,100	97	-	61,916
2015	52	48,258	125	6	-	-	-	1,586	9,018	386	16	59,447
2020	163	46,908	696	84	-	-	-	1,044	7,359	960	114	57,328
2025	331	43,819	1,565	428	-	-	-	189	6,890	1,669	500	55,390
2030	529	38,349	2,030	1,246	-	-	-	140	6,455	1,836	1,394	51,979

Table 41: SO_2 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,400	-	-	-	-	-	-	889,867	-	-	925,267
2000	3	45,708	-	-	-	-	-	-	2,581,614	41	-	2,627,366
2005	1	51,817	-	-	-	-	-	-	1,779,089	476	-	1,831,383
2010	14	62,571	-	-	-	-	-	-	1,182,758	5,366	-	1,250,708
2015	4,750	68,164	185	8	-	-	-	-	618,316	23,599	1,018	716,041
2020	15,372	70,319	1,072	129	-	-	-	-	440,288	60,325	7,187	594,693
2025	30,688	66,933	2,415	660	-	-	0	-	420,902	100,549	30,139	652,287
2030	48,269	58,966	3,141	1,923	-	-	0	-	387,160	106,192	80,410	686,061

Table 42: NH_3 TTW emissions per fuel technology (kg)

7.3. Progressive scenario

This section can be considered as an annex to 3.2. The results are now displayed more thoroughly in a tabular form.

7.3.1. Fleet composition

	TOTAL
1995	4,239,972
2000	4,644,944
2005	4,878,446
2010	5,207,513
2015	5,437,851
2020	5,580,439
2025	5,742,004
2030	5,916,124

Table 43: Total number of cars

	CNG	Diesel	Diesel hybrid CS	Diesel hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol hybrid CS	Petrol hybrid PHEV	TOTAL
1995	-	1,405,524	-	-	12	-	-	32,629	2,801,807	-	-	4,239,972
2000	1	1,891,009	-	-	66	-	-	64,255	2,689,597	16	-	4,644,944
2005	2	2,454,024	-	-	19	-	-	59,901	2,363,805	695	-	4,878,446
2010	39	3,203,601	-	-	-	-	-	37,520	1,958,102	8,251	-	5,207,513
2015	23,540	3,257,901	86,123	75,808	58,164	2,056	2,056	181,821	1,597,328	95,706	57,348	5,437,851
2020	73,138	2,966,632	240,334	191,149	142,489	4,972	4,972	136,401	1,410,806	246,357	163,189	5,580,439
2025	137,657	2,652,234	373,059	318,925	236,570	6,849	10,735	22,369	1,278,913	382,093	322,600	5,742,004
2030	205,857	2,302,420	415,220	511,916	346,130	22,980	21,260	15,725	1,088,254	411,002	575,360	5,916,124

Table 44: Total number of cars per technology

	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	TOTAL
1995	3,221,408	1,018,564	-	-	-	-	-	4,239,972
2000	1,807,642	1,063,466	1,614,940	158,896	-	-	-	4,644,944
2005	748,242	723,245	1,295,406	1,964,227	147,326	-	-	4,878,446
2010	3,062	534,960	762,820	1,538,727	2,225,404	142,540	-	5,207,513
2015	-	-	219,657	711,382	1,716,121	2,411,659	379,032	5,437,851
2020	-	-	-	157,456	712,943	1,875,592	2,834,448	5,580,439
2025	-	-	-	-	153,267	819,298	4,769,439	5,742,004
2030	-	-	-	-	-	101,187	5,814,937	5,916,124

Table 45: Total number of cars per euro standard

	0,0l-1,4l	1,4l-2,0l	2,0l-...	TOTAL
1995	1,302,352	2,373,322	564,298	4,239,972
2000	1,347,518	2,753,282	544,144	4,644,944
2005	1,429,280	2,887,121	562,045	4,878,446
2010	1,621,781	2,997,700	588,032	5,207,513
2015	2,172,307	2,830,235	435,309	5,437,851
2020	2,693,678	2,579,814	306,947	5,580,439
2025	3,080,533	2,398,299	263,172	5,742,004
2030	3,331,042	2,325,184	259,898	5,916,124

Table 46: Total number of cars per engine size

2006	2007	2008	2010	2015	2020	2025	2030
51.82	53.85	56.17	58.40	66.01	70.95	73.41	75.15

Table 47: Average ecoscore (unweighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	70.45	74.79	78.86	79.12	79.23	79.28
Diesel	48.56	51.01	53.47	56.69	65.07	69.49	71.18	71.90
Diesel Hybrid CS	-	-	-	-	77.82	78.20	78.62	79.07
Diesel Hybrid PHEV	-	-	-	-	79.82	80.19	80.64	81.16
Electric	-	-	-	-	82.82	83.14	83.54	84.03
Fuel Cell H2	-	-	-	-	82.70	82.74	82.77	82.73
H2 ICE	-	-	-	-	82.70	82.74	82.75	82.73
LPG	61.06	62.65	65.61	65.73	66.61	67.26	68.44	69.05
Petrol	55.34	57.22	59.61	61.00	64.44	67.55	68.27	68.52
Petrol Hybrid CS	70.72	70.62	71.09	73.37	78.45	79.10	79.52	79.90
Petrol Hybrid PHEV	-	-	-	-	80.82	81.17	81.60	81.92

Table 48: Average ecoscore per technology (unweighted)

7.3.2. Vehicle use

	TOTAL
1995	66,832,777,716
2000	72,487,048,804
2005	74,500,719,217
2010	79,315,275,512
2015	82,627,531,170
2020	85,714,987,302
2025	81,526,667,867
2030	84,941,314,028

Table 49: Total amount of kilometres driven

	Highw	Rural	Urban	TOTAL
1995	20,180,123,013	29,372,470,660	17,280,184,043	66,832,777,716
2000	23,126,920,622	31,342,298,555	18,017,829,627	72,487,048,804
2005	24,379,942,836	31,882,470,269	18,238,306,112	74,500,719,217
2010	26,130,753,803	33,843,702,278	19,340,819,431	79,315,275,512
2015	27,431,756,361	37,151,067,559	18,044,707,250	82,627,531,170
2020	27,904,823,056	38,472,126,193	19,338,038,053	85,714,987,302
2025	26,510,171,551	37,126,989,254	17,889,507,062	81,526,667,867
2030	27,094,283,925	38,495,079,835	19,351,950,268	84,941,314,028

Table 50: Total amount of kilometres driven per road type

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,398.45	-	-	0.13	-	-	604.63	30,829.56	-	-	66,832.78
2000	0.02	45,709.21	-	-	0.58	-	-	1,166.95	25,609.81	0.48	-	72,487.05
2005	0.02	51,816.93	-	-	0.17	-	-	1,249.61	21,418.61	15.39	-	74,500.72
2010	0.37	62,569.35	-	-	-	-	-	713.44	15,856.94	175.17	-	79,315.28
2015	220.89	59,418.95	1,893.34	1,682.45	545.75	19.30	19.30	2,968.81	12,594.11	2,027.71	1,236.92	82,627.53
2020	668.71	53,381.82	4,964.17	3,955.59	1,291.83	45.24	45.24	1,961.77	11,219.19	4,906.73	3,274.69	85,714.99
2025	1,215.83	41,603.81	7,336.88	6,397.21	2,062.12	59.01	95.71	338.36	9,016.93	7,157.40	6,243.39	81,526.67
2030	1,773.36	35,731.58	7,818.25	10,218.16	2,979.86	207.84	188.19	260.08	7,520.97	7,240.18	11,002.84	84,941.31

Table 51: Total amount of kilometres driven per technology (mio kilometres)

	Euro0	Euro1	Euro2	Euro3	Euro4	Euro5	Euro6	TOTAL
1995	43,962,207,284	22,870,570,432	-	-	-	-	-	66,832,777,716
2000	15,533,821,791	16,485,907,640	36,847,854,405	3,619,464,968	-	-	-	72,487,048,804
2005	6,665,646,549	8,754,950,192	19,263,391,263	36,950,200,466	2,866,530,747	-	-	74,500,719,217
2010	52,829,474	4,458,471,977	8,479,542,370	22,391,535,805	40,954,819,105	2,978,076,781	-	79,315,275,512
2015	-	-	1,720,730,414	7,467,526,588	24,015,778,759	42,067,748,070	7,355,747,339	82,627,531,170
2020	-	-	-	1,306,582,666	7,802,397,041	26,550,190,539	50,055,817,056	85,714,987,302
2025	-	-	-	-	1,219,797,269	8,305,468,030	72,001,402,568	81,526,667,867
2030	-	-	-	-	-	863,409,691	84,077,904,337	84,941,314,028

Table 52: Total amount of kilometres driven per euro standard

	0.0l-1.4l	1.4l-2.0l	2.0l-...	TOTAL
1995	12,751,387,563	43,267,168,545	10,814,221,608	66,832,777,716
2000	12,485,109,334	50,420,615,031	9,581,324,439	72,487,048,804
2005	14,486,763,280	50,510,126,237	9,503,829,700	74,500,719,217
2010	18,111,297,712	51,621,782,252	9,582,195,548	79,315,275,512
2015	27,270,537,602	48,566,635,921	6,790,357,647	82,627,531,170
2020	35,309,233,729	45,542,569,884	4,863,183,689	85,714,987,302
2025	38,119,528,457	39,431,237,916	3,975,901,494	81,526,667,867
2030	42,102,956,020	38,806,678,787	4,031,679,221	84,941,314,028

Table 53: Total amount of kilometres driven per engine size

7.3.3. Environmental impact

2006	2007	2008	2010	2015	2020	2025	2030
51.79	53.79	55.97	58.61	66.87	71.65	74.27	75.43

Table 54: Average ecoscore (km weighted)

	2006	2007	2008	2010	2015	2020	2025	2030
CNG	-	-	68.72	74.75	78.91	79.21	79.32	79.35
Diesel	49.91	52.25	54.59	57.77	65.73	69.79	71.29	71.51
Diesel Hybrid CS	-	-	-	-	77.79	78.18	78.59	78.29
Diesel Hybrid PHEV	-	-	-	-	79.79	80.17	80.61	80.26
Electric	-	-	-	-	82.74	83.07	83.48	83.18
Fuel Cell H2	-	-	-	-	82.65	82.69	82.72	80.33
H2 ICE	-	-	-	-	82.65	82.69	82.69	80.45
LPG	61.35	62.81	65.54	65.69	66.72	67.39	68.40	68.84
Petrol	56.38	57.94	59.99	61.41	64.75	67.46	68.10	68.32
Petrol Hybrid CS	70.68	70.65	71.22	73.57	78.50	79.10	79.51	79.25
Petrol Hybrid PHEV	-	-	-	-	80.80	81.16	81.58	81.23

Table 55: Average ecoscore per technology (km weighted)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Elec tric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	6,052,616,511	-	-	-	-	-	100,218,770	6,213,950,564	-	-	12,366,785,845
2000	3,758	7,571,664,700	-	-	-	-	-	195,956,191	4,883,391,149	63,246	-	12,651,079,044
2005	2,735	8,320,179,179	-	-	-	-	-	211,148,523	3,962,190,730	2,165,671	-	12,495,686,838
2010	44,524	9,331,362,873	-	-	-	-	-	119,349,500	2,730,110,681	21,729,812	-	12,202,597,391
2015	22,985,966	7,871,818,225	200,020,347	71,103,108	-	-	59,824	457,316,136	1,971,117,244	217,133,086	52,850,130	10,864,404,065
2020	66,546,010	6,657,111,171	504,664,834	160,895,596	-	-	140,257	302,577,777	1,595,634,444	472,939,491	126,034,494	9,886,544,075
2025	120,231,114	5,098,827,237	741,604,741	258,738,866	-	-	296,734	50,486,341	1,006,998,820	548,863,459	191,528,407	8,017,575,718
2030	175,559,453	4,367,680,610	786,799,146	412,468,048	-	-	583,425	37,998,678	668,510,559	441,482,884	268,688,359	7,159,771,163

Table 56: CO_2e TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,315,141	-	-	-	-	-	17,986	720,095	-	-	6,053,222
2000	0	3,539,624	-	-	-	-	-	19,194	265,661	1	-	3,824,480
2005	0	2,349,620	-	-	-	-	-	13,556	144,850	13	-	2,508,038
2010	0	1,702,432	-	-	-	-	-	2,650	23,170	145	-	1,728,398
2015	232	743,939	8,146	2,895	-	-	4	3,197	14,321	1,671	408	774,812
2020	703	382,095	21,329	6,798	-	-	10	2,065	11,800	4,033	1,077	429,910
2025	1,275	245,261	31,530	10,997	-	-	20	355	9,457	5,879	2,051	306,824
2030	1,863	199,880	33,557	17,542	-	-	40	273	7,900	5,935	3,607	270,597

Table 57: PM2.5 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	22,183,138	-	-	-	-	-	1,472,503	61,392,673	-	-	85,048,314
2000	4	30,803,906	-	-	-	-	-	1,574,784	26,526,093	50	-	58,904,837
2005	1	37,225,553	-	-	-	-	-	1,102,219	14,272,858	735	-	52,601,367
2010	14	39,457,418	-	-	-	-	-	211,135	3,360,945	5,225	-	43,034,737
2015	8,523	27,732,100	555,660	197,506	-	-	1,860	164,637	843,387	57,978	14,128	29,575,781
2020	26,031	15,902,076	919,725	299,443	-	-	4,399	91,809	458,529	140,909	37,614	17,880,536
2025	47,126	8,957,103	1,161,203	405,342	-	-	9,270	14,274	350,097	205,143	71,587	11,221,144
2030	69,382	6,603,044	1,179,621	615,814	-	-	18,403	10,991	294,226	208,709	126,900	9,127,090

Table 58: NO_x TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	16,683,629	-	-	-	-	-	4,690,292	292,705,606	-	-	314,079,527
2000	5	12,541,418	-	-	-	-	-	6,120,478	124,940,760	297	-	143,602,959
2005	4	7,230,994	-	-	-	-	-	5,086,080	68,301,464	9,383	-	80,627,926
2010	87	4,443,963	-	-	-	-	-	1,694,712	23,255,429	58,696	-	29,452,888
2015	50,797	3,267,437	83,206	29,575	-	-	-	3,457,741	8,250,863	655,304	159,538	15,954,462
2020	152,295	3,078,702	220,479	70,267	-	-	-	1,872,443	4,956,798	1,565,075	417,716	12,333,776
2025	277,122	2,412,231	323,861	112,958	-	-	-	283,753	3,542,021	2,286,217	797,472	10,035,636
2030	400,471	2,109,561	349,064	182,521	-	-	-	216,283	2,914,694	2,287,585	1,389,728	9,849,907

Table 59: CO TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	3,150,628	-	-	-	-	-	579,117	62,272,533	-	-	66,002,278
2000	0	2,134,790	-	-	-	-	-	613,777	28,397,895	20	-	31,146,483
2005	0	1,355,141	-	-	-	-	-	427,924	13,690,808	348	-	15,474,222
2010	3	674,679	-	-	-	-	-	84,615	1,809,554	3,346	-	2,572,197
2015	1,909	349,351	8,064	2,866	-	-	167	39,236	627,097	38,542	12,021	1,079,252
2020	5,759	285,084	21,199	6,757	-	-	390	16,947	434,475	95,293	33,021	898,924
2025	10,475	220,952	31,254	10,900	-	-	825	2,012	361,048	142,561	64,179	844,206
2030	15,229	191,614	33,408	17,465	-	-	1,616	1,550	304,870	147,551	113,552	826,856

Table 60: VOC TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	5,046,387	-	-	-	-	-	334	1,141,277	-	-	6,187,998
2000	0	1,421,124	-	-	-	-	-	647	235,907	3	-	1,657,682
2005	0	166,043	-	-	-	-	-	698	36,754	20	-	203,515
2010	0	49,324	-	-	-	-	-	394	12,100	97	-	61,916
2015	83	41,566	1,056	375	-	-	-	1,520	8,852	982	239	54,673
2020	242	35,123	2,664	849	-	-	-	1,005	7,648	2,285	609	50,425
2025	436	26,897	3,914	1,366	-	-	-	166	6,222	3,431	1,197	43,630
2030	637	23,037	4,152	2,177	-	-	-	125	5,305	3,556	2,164	41,154

Table 61: SO_2 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
1995	-	35,400	-	-	-	-	-	-	889,867	-	-	925,267
2000	3	45,708	-	-	-	-	-	-	2,581,614	41	-	2,627,366
2005	1	51,817	-	-	-	-	-	-	1,779,089	476	-	1,831,383
2010	14	62,571	-	-	-	-	-	-	1,182,758	5,366	-	1,250,708
2015	7,930	59,420	1,574	559	-	-	0	-	620,243	62,352	15,211	767,290
2020	23,550	53,383	4,116	1,312	-	-	0	-	482,166	148,007	39,510	752,045
2025	42,607	41,605	6,093	2,125	-	-	0	-	399,387	214,944	74,982	781,743
2030	60,800	35,733	6,476	3,386	-	-	0	-	330,397	212,771	129,275	778,838

Table 62: NH_3 TTW emissions per fuel technology (kg)

7.4. Visionary scenario

7.4.1. Vehicle use

Highw	Rural	Urban	TOTAL
16,747,611,016	27,711,030,681	7,749,790,125	52,208,431,822

Table 63: Total amount of kilometres driven per road type

electric	petrol hybrid CS	petrol hybrid PHEV	diesel hybrid CS	diesel hybrid PHEV	TOTAL
7,749,790,125	11,084,412,272	16,626,618,409	10,048,566,610	6,699,044,406	52,208,431,822

Table 64: Total amount of kilometres driven per technology

7.4.2. Environmental impact

2060
82.49

Table 65: Average ecoscore (km weighted)

	CO2e	PM2,5	NOx	CO	VOC	SO2	NH3
electric	-	-	-	-	-	-	-
petrol hybrid CS	603,465,740	7,414	352,825	2,082,614	216,639	4,864	260,053
petrol hybrid PHEV	362,119,411	4,448	211,695	1,249,570	167,943	2,919	156,042
diesel hybrid CS	985,728,418	48,354	2,023,131	188,298	39,955	5,206	9,295
diesel hybrid PHEV	262,882,627	12,894	539,502	50,208	10,654	1,388	2,479
TOTAL	2,214,196,196	73,110	3,127,154	3,570,689	435,191	14,377	427,869

Table 66: TTW emissions per fuel technology (kg)

7.5. Scenario comparison

This section can be considered as an annex to chapter 4.

7.5.1. Fleet composition

	baseline	realistic	progressive
2020	5,746,763	5,633,480	5,580,439
2030	6,051,956	5,818,109	5,916,124

Table 67: Total number of cars

	CNG	Diesel	Diesel hybrid CS	Diesel hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol hybrid CS	Petrol hybrid PHEV	TOTAL
baseline_2020	24,372	3,939,701	64,784	18,018	-	-	-	17,220	1,519,068	134,161	29,439	5,746,763
realistic_2020	51,125	3,889,549	63,569	18,587	-	-	-	136,572	1,336,407	107,177	30,494	5,633,480
progressive_2020	73,138	2,966,632	240,334	191,149	142,489	4,972	4,972	136,401	1,410,806	246,357	163,189	5,580,439
baseline_2030	83,004	3,378,335	215,426	281,198	127,957	14,351	12,597	15,041	1,262,850	308,542	352,655	6,051,956
realistic_2030	168,804	3,309,345	201,016	284,017	130,790	14,711	12,876	15,018	1,110,440	211,403	359,689	5,818,109
progressive_2030	205,857	2,302,420	415,220	511,916	346,130	22,980	21,260	15,725	1,088,254	411,002	575,360	5,916,124

Table 68: Total number of cars per technology

	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	TOTAL
baseline_2020	-	-	-	277,945	1,190,314	1,804,505	2,473,999	5,746,763
realistic_2020	-	-	-	229,476	997,969	1,839,062	2,566,973	5,633,480
progressive_2020	-	-	-	157,456	712,943	1,875,592	2,834,448	5,580,439
baseline_2030	-	-	-	-	-	190,424	5,861,532	6,051,956
realistic_2030	-	-	-	-	-	151,914	5,666,195	5,818,109
progressive_2030	-	-	-	-	-	101,187	5,814,937	5,916,124

Table 69: Total number of cars per euro standard

	0,0l-1,4l	1,4l-2,0l	2,0l-...	TOTAL
baseline_2020	2,458,962	2,916,489	371,312	5,746,763
realistic_2020	2,388,129	2,905,534	339,817	5,633,480
progressive_2020	2,693,678	2,579,814	306,947	5,580,439
baseline_2030	3,104,700	2,664,591	282,665	6,051,956
realistic_2030	2,974,594	2,578,068	265,447	5,818,109
progressive_2030	3,331,042	2,325,184	259,898	5,916,124

Table 70: Total number of cars per engine size

	baseline	realistic	progressive
2020	68.50	69.08	70.95
2030	73.22	73.37	75.15

Table 71: Average ecoscore (unweighted)

7.5.2. Vehicle use

	baseline	realistic	progressive	visionary
2020	90,104,118,929	87,812,046,627	85,714,987,302	-
2030	93,735,449,770	91,748,869,089	84,941,314,028	-
2060	-	-	-	52,208,431,822

Table 72: Total amount of kilometres driven

	Highw	Rural	Urban	TOTAL
baseline_2020	28,538,709,235	38,845,011,636	22,720,398,058	90,104,118,929
realistic_2020	27,811,931,394	37,855,703,422	22,144,411,811	87,812,046,627
progressive_2020	27,904,823,056	38,472,126,193	19,338,038,053	85,714,987,302
baseline_2030	28,915,939,274	40,535,617,915	24,283,892,581	93,735,449,770
realistic_2030	28,302,696,038	39,676,325,798	23,769,847,253	91,748,869,089
progressive_2030	27,094,283,925	38,495,079,835	19,351,950,268	84,941,314,028
visionary_2060	16,747,611,016	27,711,030,681	7,749,790,125	52,208,431,822

Table 73: Total amount of kilometres driven per road type

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
baseline_2020	220.05	72,241.03	1,394.85	396.50	-	-	-	326.71	12,262.74	2,651.55	610.69	90,104.12
realistic_2020	449.57	70,318.42	1,301.77	391.85	-	-	-	2,030.85	10,644.58	2,060.79	614.22	87,812.05
progressive_2020	668.71	53,381.82	4,964.17	3,955.59	1,291.83	45.24	45.24	1,961.77	11,219.19	4,906.73	3,274.69	85,714.99
baseline_2030	703.50	59,333.40	4,061.51	5,762.21	1,141.69	131.05	112.59	283.49	9,929.32	5,424.04	6,852.64	93,735.45
realistic_2030	1,460.20	58,966.88	3,824.34	5,852.67	1,183.22	135.54	116.63	290.69	9,069.07	3,748.50	7,101.13	91,748.87
progressive_2030	1,773.36	35,731.58	7,818.25	10,218.16	2,979.86	207.84	188.19	260.08	7,520.97	7,240.18	11,002.84	84,941.31
visionary_2060	-	-	10,048.57	6,699.04	7,749.79	-	-	-	-	11,084.41	16,626.62	52,208.43

Table 74: Total amount of kilometres driven per technology (mio kilometres)

	Euro0	Euro1	Euro2	Euro3	Euro4	Euro5	Euro6	TOTAL
baseline_2020	-	-	-	2,746,723,333	14,512,095,294	27,291,630,235	45,553,670,067	90,104,118,929
realistic_2020	-	-	-	2,221,989,308	12,067,764,158	27,567,413,564	45,954,879,597	87,812,046,627
progressive_2020	-	-	-	1,306,582,666	7,802,397,041	26,550,190,539	50,055,817,056	85,714,987,302
baseline_2030	-	-	-	-	-	2,040,504,851	91,694,944,919	93,735,449,770
realistic_2030	-	-	-	-	-	1,687,985,771	90,060,883,318	91,748,869,089
progressive_2030	-	-	-	-	-	863,409,691	84,077,904,337	84,941,314,028
visionary_2060	-	-	-	-	-	-	52,208,431,822	52,208,431,822

Table 75: Total amount of kilometres driven per euro standard

	0.0l-1.4l	1.4l-2.0l	2.0l-…	TOTAL
baseline_2020	32,240,500,727	52,001,886,856	5,861,731,346	90,104,118,929
realistic_2020	31,224,826,800	51,195,758,397	5,391,461,430	87,812,046,627
progressive_2020	35,309,233,729	45,542,569,884	4,863,183,689	85,714,987,302
baseline_2030	41,409,411,368	47,698,830,305	4,627,208,097	93,735,449,770
realistic_2030	40,350,695,418	46,949,036,332	4,449,137,339	91,748,869,089
progressive_2030	42,102,956,020	38,806,678,787	4,031,679,221	84,941,314,028

Table 76: Total amount of kilometres driven per engine size

7.5.3. Environmental impact

	baseline	realistic	progressive	visionary
2020	69.16	69.59	71.65	-
2030	73.73	73.77	75.43	-
2060	-	-	-	82.49

Table 77: Average ecoscore (km weighted)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
baseline_2020	22,029,571	9,231,424,974	141,364,343	16,048,979	-	-	-	49,318,431	1,865,476,926	270,217,534	24,750,775	11,620,631,534
realistic_2020	45,043,924	8,892,225,802	131,913,896	15,861,583	-	-	-	314,205,999	1,534,661,727	198,708,357	23,533,950	11,156,155,237
progressive_2020	66,546,010	6,657,111,171	504,664,834	160,895,596	-	-	140,257	302,577,777	1,595,634,444	472,939,491	126,034,494	9,886,544,075
baseline_2030	70,204,727	7,331,815,951	408,876,345	232,651,621	-	-	349,059	41,589,431	1,467,660,443	546,977,780	276,734,435	10,376,859,792
realistic_2030	145,763,971	7,272,648,840	384,701,819	236,237,465	-	-	361,546	42,637,111	813,527,344	228,008,551	173,042,389	9,296,929,036
progressive_2030	175,559,453	4,367,680,610	786,799,146	412,468,048	-	-	583,425	37,998,678	668,510,559	441,482,884	268,688,359	7,159,771,163
visionary_2060	-	-	985,728,418	262,882,627	-	-	-	-	-	603,465,740	362,119,411	2,214,196,196

Table 78: CO_2e TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
baseline_2020	233	649,121	5,980	680	-	-	-	347	13,002	2,177	201	671,740
realistic_2020	477	555,387	5,581	672	-	-	-	2,155	11,287	1,692	202	577,453
progressive_2020	703	382,095	21,329	6,798	-	-	10	2,065	11,800	4,033	1,077	429,910
baseline_2030	746	334,211	17,386	9,866	-	-	24	301	10,530	4,440	2,243	379,748
realistic_2030	1,549	332,129	16,371	10,021	-	-	25	308	9,618	3,069	2,325	375,413
progressive_2030	1,863	199,880	33,557	17,542	-	-	40	273	7,900	5,935	3,607	270,597
visionary_2060	-	-	48,354	12,894	-	-	-	-	-	7,414	4,448	73,110

Table 79: PM2.5 TTW emissions per fuel technology (kg)

	CNG	Diesel	Diesel Hybrid CS	Diesel Hybrid PHEV	Electric	Fuel Cell H2	H2 ICE	LPG	Petrol	Petrol Hybrid CS	Petrol Hybrid PHEV	TOTAL
baseline_2020	8,767	24,114,642	232,933	24,734	-	-	-	15,432	518,985	77,120	7,104	24,999,717
realistic_2020	17,911	22,053,751	218,071	24,483	-	-	-	95,891	452,039	59,934	7,145	22,929,224
progressive_2020	26,031	15,902,076	919,725	299,443	-	-	4,399	91,809	458,529	140,909	37,614	17,880,536
baseline_2030	28,288	11,239,397	610,705	345,641	-	-	11,318	12,068	399,249	158,700	80,220	12,885,586
realistic_2030	58,708	11,104,342	574,757	351,077	-	-	11,721	12,374	364,606	109,649	83,114	12,670,347

progressive_2030	69,382	6,603,044	1,179,621	615,814	-	-	18,403	10,991	294,226	208,709	126,900	9,127,090
visionary_2060	-	-	2,023,131	539,502	-	-	-	-	-	352,825	211,695	3,127,154

Table 80: NO_x TTW emissions per fuel technology (kg)