Clean **Ve**hicle **R**esearch: LCA and Policy Measures
(CLEVER)

Scenario Development

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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.

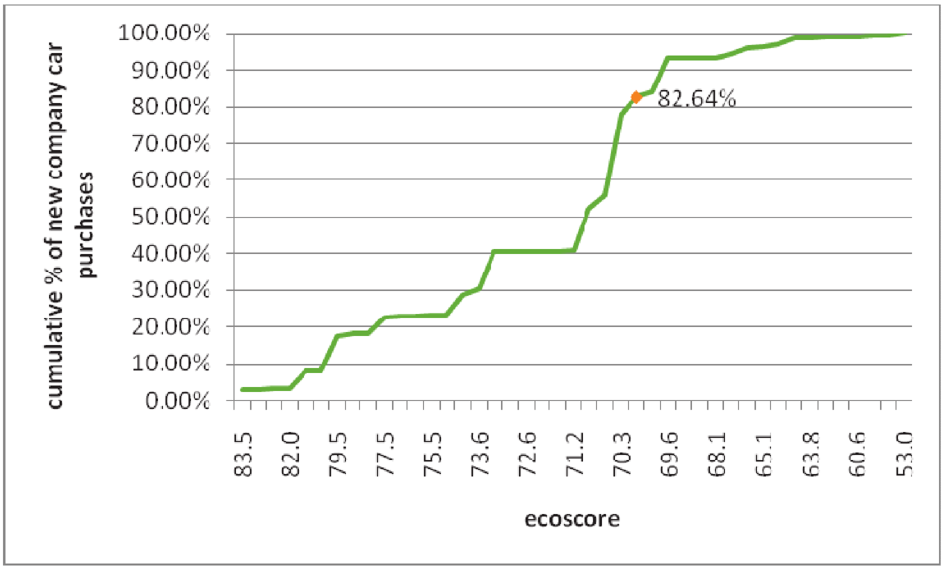

Figure 1: Cumulative frequencies of ecoscores of newly purchased company cars in 2015

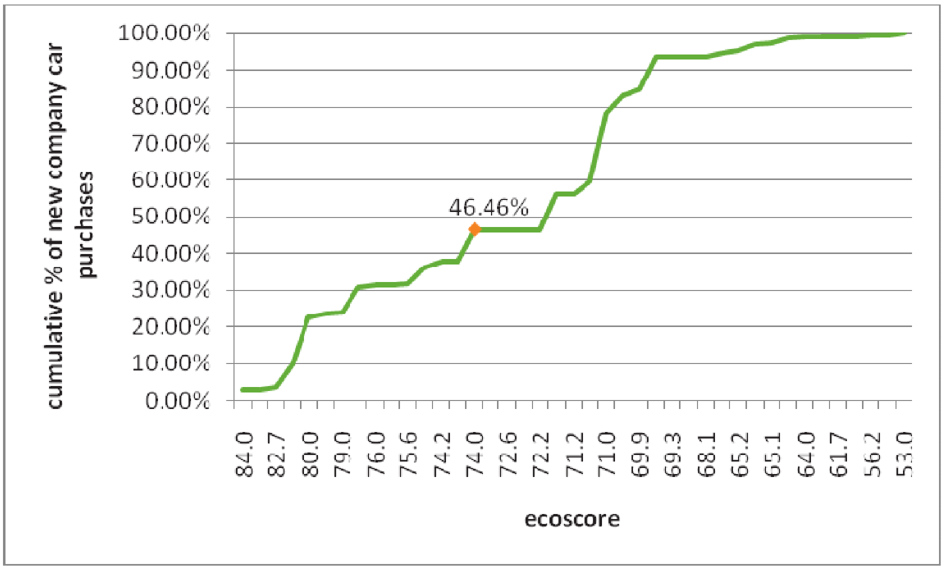

Figure 2: Cumulative frequencies of ecoscores of newly purchased company cars in 2020

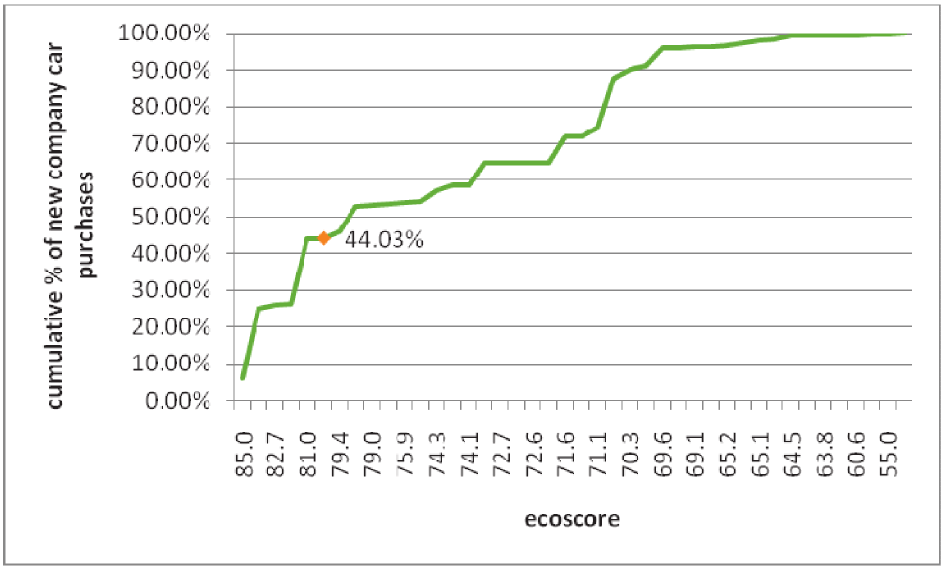

Figure 3: Cumulative frequencies of ecoscores of newly purchased company cars in 2030

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.

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