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Fuel excise reform in Belgium

Long term effects on the environment, traffic and public finance

December 2015

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Abstract - This paper analyzes the long term effects on traffic, environmental quality and public finance of the planned reform of fuel excise duties in Belgium. We find that without measures to abate NOx emissions by euro 6 cars, the planned excise rate equalization would by 2030 diminish CO_2 emissions by the transport sector by 0.5%, emissions of Particulate Matter by 0.6% and of NOx by 2.6%. This yields society an environmental benefit of 4.2 cents per euro of tax revenue raised, of which 2.7 cents are from lower local air pollution.

The diesel reform will diminish time costs borne by users of transport by 32 cents per euro of tax revenue. An alternative congestion charge at peak period would yield 3 cents per euro of tax revenue in environmental quality of which 1.9 are due to lower air pollution. A congestion charge would yield time gains over the whole projection period amounting to 81 cents per euro.

The difference in efficiency in tackling time costs between the excise reform and a congestion charge rises over time. Sensitivity analysis shows that if the new European standards in NOx emissions based on real driving tests are strictly imposed by 2020, the long-term gain in environmental welfare from the excise reform drops to 3.4 cents per euro of revenue raised.

Jel Classification - H21, H23, Q53, Q55, Q58
Keywords - Optimal Taxation, Externalities, Air Pollution, Technological Innovation, Government Policy

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Executive summary

This paper seeks to analyze the long term effects on traffic, environmental quality and public finance of the planned reform of fuel excise duties in Belgium. In the framework of a large scale tax reform, the Belgian federal government will implement an equalization of diesel and petrol excise rates over the 2016-2018 period.

Using the PLANET long term projection model for transport, we are able to analyze the effects over the 2015-2030 period of the policy changes in vehicle taxation, in this case – fuel excise reforms. This is all the more interesting because the vehicle fleet tend to be renewed over time, diminishing the share of cars of an older vintage and bringing in cars with newer, mostly cleaner, technologies.

Given what we know about real driving emissions by the latest euro 6 vehicles, diesel cars will remain more polluting than gasoline cars over the whole of the projection period, despite the technical progress that has been made so far.

If implemented fully, the fuel excise reform by 2030 diminishes CO_2 emissions by the transport sector by 0.5%, emissions of Particulate Matter by 0.6% and of NOx by 2.6%. This yields society an environmental benefit value at 4.2 cents per euro of tax revenue raised, of which 2.7 cents are from lower local air pollution. The diesel reform will diminish time costs borne by users of transport by 32 cents per euro of tax revenue.

An alternative congestion charge at peak period would yield 3 cents per euro of tax revenue in environmental quality of which 1.9 are due to lower air pollution. A congestion charge would yield time gains over the whole projection period amounting to 81 cents per euro. The difference in efficiency in tackling time costs between the excise reform and a congestion charge rises over time.

Sensitivity analysis shows that if the new standards in NOx emissions based on real driving tests are strictly imposed by 2020, the long-term gain in environmental welfare from the excise reform drops to 3.4 cents per euro of revenue raised. This suggests raising excise duties on diesel fuel would be necessary to correct for elevated NOx emissions for years to come, if no action is taken to comply with European standards.

Synthèse

Cette étude analyse les effets à long terme sur le trafic routier, l'environnement et les finances publiques de la réforme du régime des droits d'accises sur les carburants prévue en Belgique. Le gouvernement fédéral doit en effet, dans le cadre d'une grande réforme fiscale, progressivement uniformiser les accises sur le diesel et l'essence entre 2016 et 2018.

Le modèle de projection du transport à long terme PLANET permet d'analyser les effets de changements de politiques liées à la fiscalité des véhicules – comme dans ce cas, la réforme des accises sur les carburants – au cours de la période 2015-2030. Cet exercice est d'autant plus pertinent que le parc automobile se renouvelle dans le temps, diminuant la part des anciennes voitures au profit de voitures neuves, dotées, en principe, de technologies plus respectueuses de l'environnement.

Sur la base des informations disponibles concernant les émissions en « conduite réelle » des derniers véhicules Euro6, les voitures diesel resteront plus polluantes que les voitures essence au cours de la période de projection, et ce malgré les progrès techniques accomplis.

Si l'ensemble de la réforme des accises sur les carburants est mise en œuvre, les émissions de CO_2 relatives au transport diminueront de 0,5 % à l'horizon de 2030, les émissions de particules fines de 0,6 % et les émissions de NOx de 2,6 %. La collectivité engrangera un gain environnemental valorisé à 4,2 cents par euro de recettes fiscales supplémentaires, dont 2,7 cents liés à la baisse des émissions de polluants locaux. La réforme des accises sur le diesel fera baisser le coût en temps supporté par les usagers des transports de 32 cents par euro de taxe prélevé.

Une alternative, consistant en un péage de congestion pendant les heures de pointe, dégagerait 3 cents de gains environnementaux par euro prélevé, dont 1,9 cent en raison d'une baisse des émissions de polluants locaux. Un péage de congestion génèrerait, sur l'ensemble de la période de projection, un gain en temps de 81 cents par euro prélevé. L'écart d'efficacité au niveau des coûts en temps entre la réforme des accises et un péage de congestion se creuserait dans le temps.

Une analyse de sensibilité montre que si les nouvelles normes d'émissions de NOx sont strictement appliquées à l'horizon 2020, les gains environnementaux générés par la réforme des accises diminuent à 3,4 cents par euro prélevé. Ces résultats suggèrent qu'a contrario, si aucune action n'est menée pour se conformer aux normes européennes, augmenter les accises sur le diesel s'imposera pour corriger les niveaux d'émissions élevés de NOx dans les années à venir.

Synthese

Deze paper wil de lange termijn effecten op het verkeer, het leefmilieu en de openbare financiën van de geplande hervormingen in de brandstoffiscaliteit in België analyseren. In het kader van een omvangrijke belastinghervorming plant de federale overheid een gelijkschakeling van de diesel en benzineaccijnzen over de periode 2016-2018.

Met het lange termijn projectiemodel voor transport PLANET, kunnen we de effecten over de periode 2015-2030 van veranderingen in de autofiscaliteit, in dit geval van de brandstofaccijnzen, in kaart brengen. Dit is des te belangrijker, aangezien het wagenpark over de tijd wordt vernieuwd, zodat het aandeel oudere wagens daalt ten voordeel van, in principe, milieuvriendelijker technologieën.

Gegeven wat we weten over de emissies in reële omstandigheden door de laatste euro 6 modellen, zullen dieselwagens over de hele projectieperiode meer vervuilend blijven dan benzinewagens, ondanks de beperkte technologische vooruitgang die is geboekt.

Als de hervorming volledig wordt doorgevoerd, zullen CO_2 emissies door de transportsector tegen 2030 dalen met 0,5%, emissies van fijn stof met 0,6% en NOx emissies met 2,6%. Dat levert de maatschappij een winst op ter waarde van 4,2 cent per euro extra belastinggeld, waarvan 2,7 cent als gevolg van lagere uitstoot van lokale luchtvervuiling. De hervorming van de dieselaccijns zal de tijdskosten van gebruikers van transport doen dalen met 32 cent per opgehaalde euro.

Een alternatieve congestiebelasting op piekmomenten zou een 3 cent per euro in milieuwinsten opleveren, waarvan 1,9 cent door lagere uitstoot van lokale luchtvervuiling. Een congestiebelasting levert over de hele projectieperiode tijdwinsten op van 81 cent per euro. Het verschil in efficiëntie in de aanpak van tijdskosten en congestie tussen de accijnshervorming en de congestiebelasting loopt op naarmate de tijd vordert.

Een gevoeligheidsanalyse toont dat wanneer de nieuwe normen voor NOx emissies gebaseerd op real – driving test tegen 2020 strict worden afgedwongen, de milieuwinsten van de accijnshervorming dalen tot 3,4 cent per euro. Dit suggereert dat accijnzen op diesel nog lang nodig blijven om te corrigeren voor verhoogde NOx emissies, als geen actie wordt ondernomen om te voldoen aan de nieuwe Europese standaarden.

1. Introduction

In the framework of a large scale tax overhaul, the Belgian federal government will implement a reform of fuel excise duties. Excise rates on diesel fuel are set to increase substantially while those on petrol will be lowered to equalize rates, thus ending the historical differential in per litre excise rates between the two most common fuel types. This reform should yield additional revenue to finance a reduction in labour income taxes.

This reform takes place in a context where research reveals that diesel cars, even those of the newest euro 6 technical standard, continue to score badly in terms of local air pollution. This problem seems particularly severe for harmful NOx emissions. Also, congestion is a major problem in Belgium that is expected to increase in importance (Daubresse e.a. (2015)).

On the basis of the PLANET long term projection model, this paper will show the impact of the planned excise reform on traffic, the environment and public finances. Special attention is paid to the impact on local pollutants, and the interaction with technical norms on the European level.

In a first paragraph, we will briefly review the pre – reform taxation of transport fuels into a historical and cross – country perspective.

Second, we will provide a detailed projection of marginal external environmental and congestion costs by fuel technology, if no action is taken to ensure compliance with the new European standards based on real driving emissions.

We also show how excise revenues are projected to evolve in the business-as-usual scenario outlined in Daubresse e.a. (2015).

A third paragraph presents long term results on the car stock, transport behaviour of passengers, freight as well as effects on congestion and emissions. This is done for the fuel excise reform, but also for a hypothetical congestion charge. For both policies, we show effects on social welfare in monetary terms.

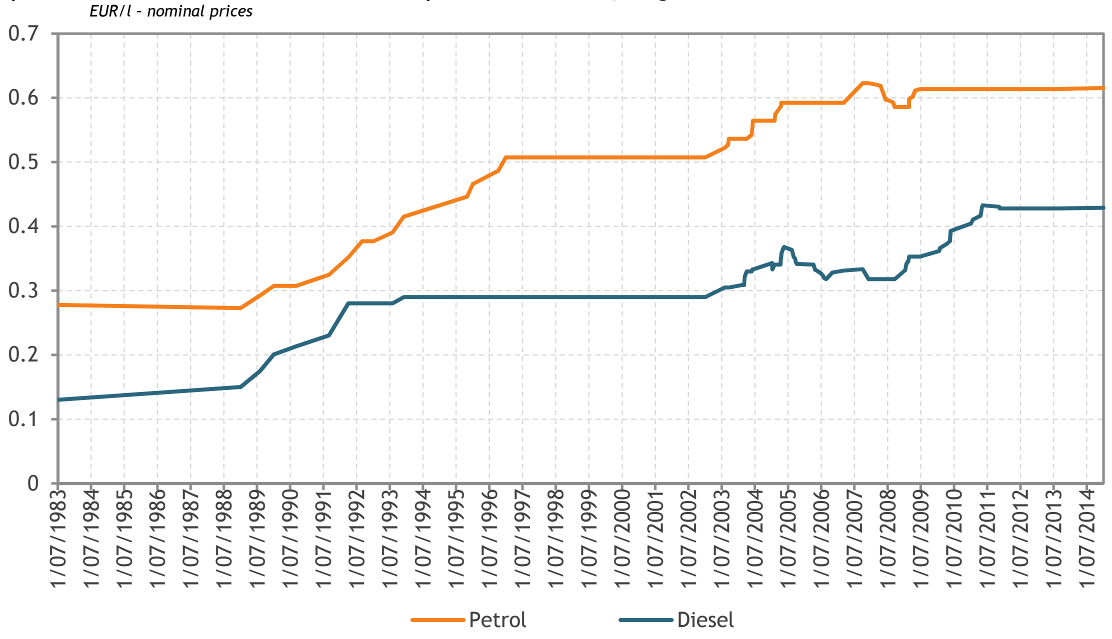
The last paragraph shows sensitivity analysis with respect to the hypotheses on NOx emissions. Specifically, we show the results of the fuel excise reform when the new European standards on NOx emissions from real driving tests are strictly met.

2. Taxation and the car market in Belgium

It is well known that Belgium, like many other European countries, has historically tended to fiscally favour the use of diesel fuels for transport purposes. The well-documented divergence between diesel and petrol excises is indeed a relic from the oil crises in the 70s, when the government intended to support the transport sector by fiscally favouring the relatively fuel efficient diesel technology.

As graph 1 shows, this state of affairs has not fundamentally changed over time. Indeed, the middle 90s saw an increase in the petrol excise, while the diesel excise remained flat. Only between 2009 and 2011 did the diesel excise rate catch up somewhat. In that period the 'ratchet system', a measure introduced in 2003 whereby fuel excises would rise to compensate for the drop in fuel prices, was maintained for diesel fuel only.

Graph 1 Historical evolution of diesel and petrol excise rates, Belgium
EUR/l - nominal prices

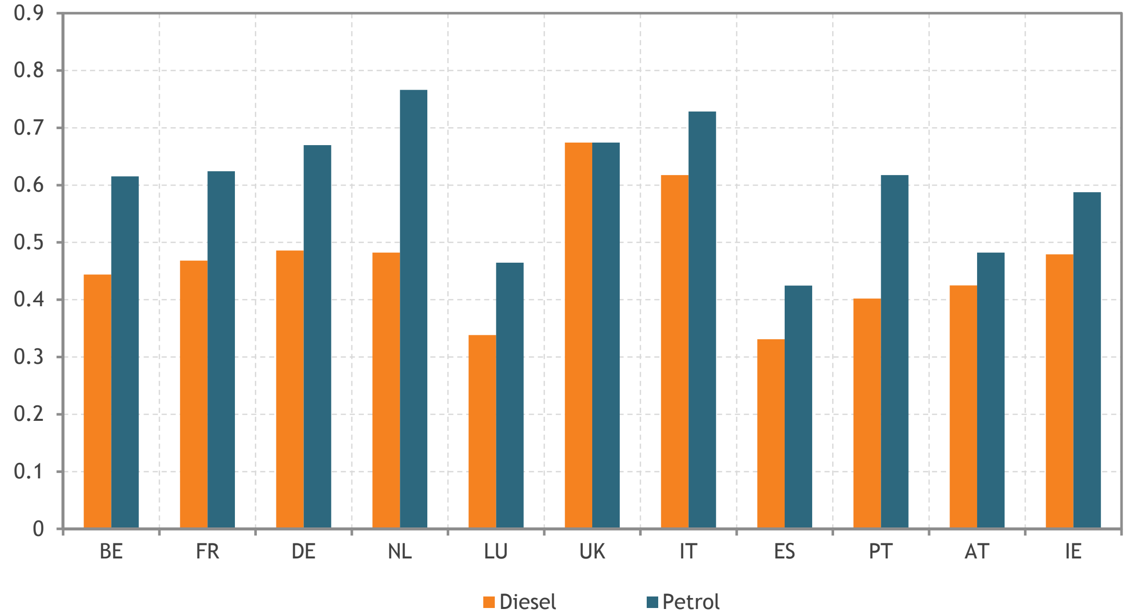


Source: Belgische Petroleumfederatie

As graph 2 shows, Belgium was no exception in Europe when it came to favouring diesel fuel through the excise rate. Only in the UK, which is relatively shielded from cross-border fuel tax competition, are excise rates per litre equalized.

Graph 2 Excise rates in selected EU countries - by fuel type (2015)

EUR/l



Source: European Commission (2015)

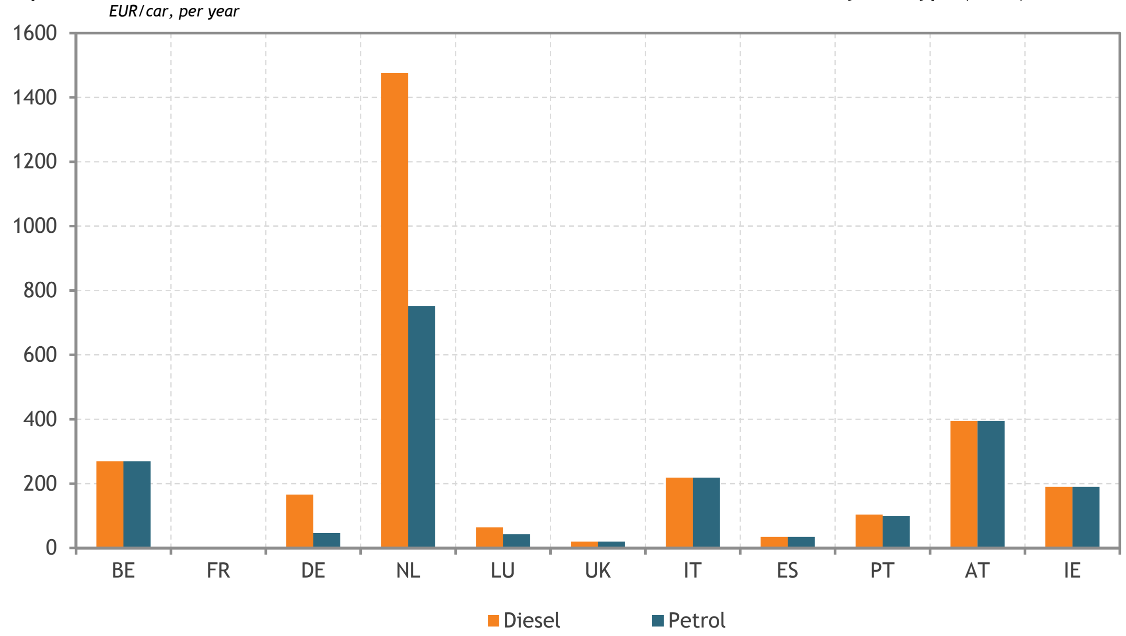
Excise rates are not the only way by which governments can encourage or discourage different fuel technologies. Other instruments such as registration duties and annual circulation taxes can be used successfully to do so as well.

In Belgium, these taxes have until recently been unrelated to environmental performance, with tax rates historically related to engine size instead. Until 2004, an additional annual levy on diesel vehicles was in place, which aimed to compensate somewhat for the fuel excise differential. This scheme has however been phased out and completely abolished in 2008.

In graph 3 we show the 2015 annual circulation tax rate in selected European countries for a variant of the Volkswagen Golf with the following characteristics: 1598 cc, 4 cylinders, 105 HP, 1395 kg net weight and a stated CO_2 emission rate of 102 g per kilometre. Vehicles of this type currently make up the largest share of the market in Belgium. Taxes are calculated for the same diesel vehicle in each European country, and for a hypothetical petrol variant with the same characteristics.

It is shown that in most countries surveyed still no explicit distinction is made by fuel type, even though the introduction of CO_2 related formulas next to or in place of traditional engine size related variables is becoming more popular. But notably in Germany and in the Netherlands, diesel cars of the type that are widespread in Belgium are penalized relative to their petrol equivalent. The Dutch example shows how governments can influence the car market through annual circulation taxes, even when it finds itself constrained by cross border tax shopping on the excise front. While Belgium has a large share of diesel cars in the car market, in the Netherlands private diesel cars are the exception.

Graph 3 Annual circulation tax for a medium sized car in selected EU countries - by fuel type (2014)
EUR/car, per year



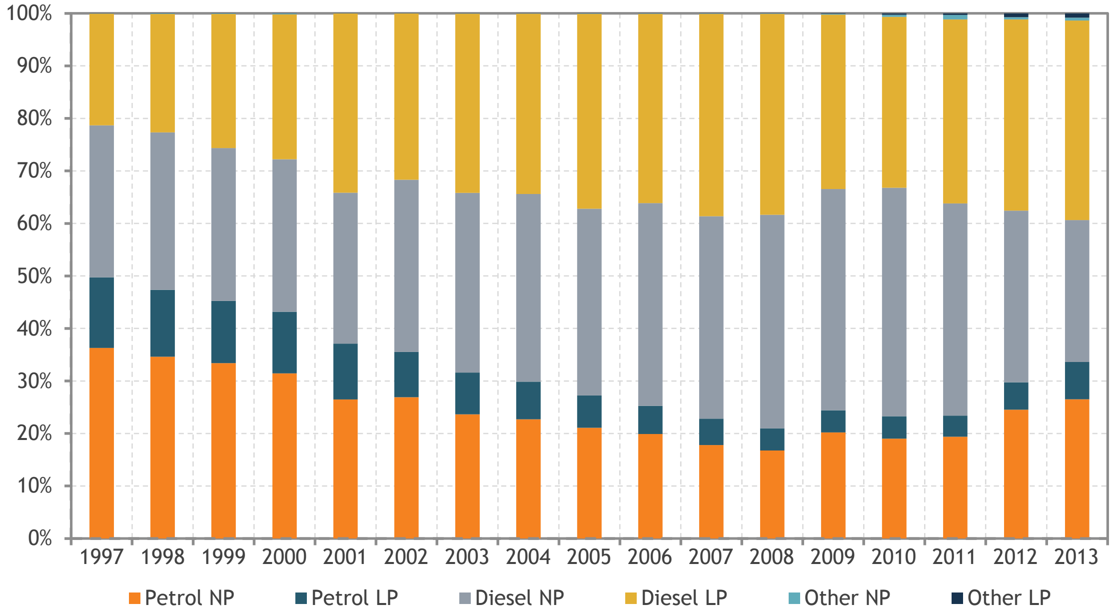
Source: Own calculations based on ACEA Tax guide 2014

Apart from excise duties, another development which should favour the proliferation of diesel cars is the use of CO_2 related incentive schemes. Frequently, registration or annual circulation taxes are reformed to include parameters that relate the tax burden positively to the amount of CO_2 emitted per kilometre. Such a measure should encourage people to buy less fuel consuming cars, but by doing so it also give people an incentive to buy diesel cars, which are on average more fuel efficient. The Walloon malus system in registration taxes is an example of such a policy.

Another incentive scheme with unwanted effects was the annual subsidy for fuel efficient cars, which has only been abolished in 2012. Indeed, it increased the attractiveness of undertaxed diesel cars even more, leading to few gains in environmental quality per euro of subsidy given. (See Mayeres and Proost, 2013)

The Belgian consumer has responded to the incentives that were given to them: diesel cars have over the last decades become increasingly prevalent. Graph 4 suggests that the reforms in the late 90s and the middle 2000s have caused the market share of diesel cars in new car registrations to increase, both for natural and legal persons. Only recently have petrol cars slowly regained market share again, likely due to the fuel excise reforms of the 2009-2011 and the suppression of the subsidy for energy efficient cars. It is unclear whether there is also an effect of the business cycle, since new car registrations have dropped for all types of cars in 2009, 2012 and 2013. The share of diesel cars registered by companies remains high as ever.

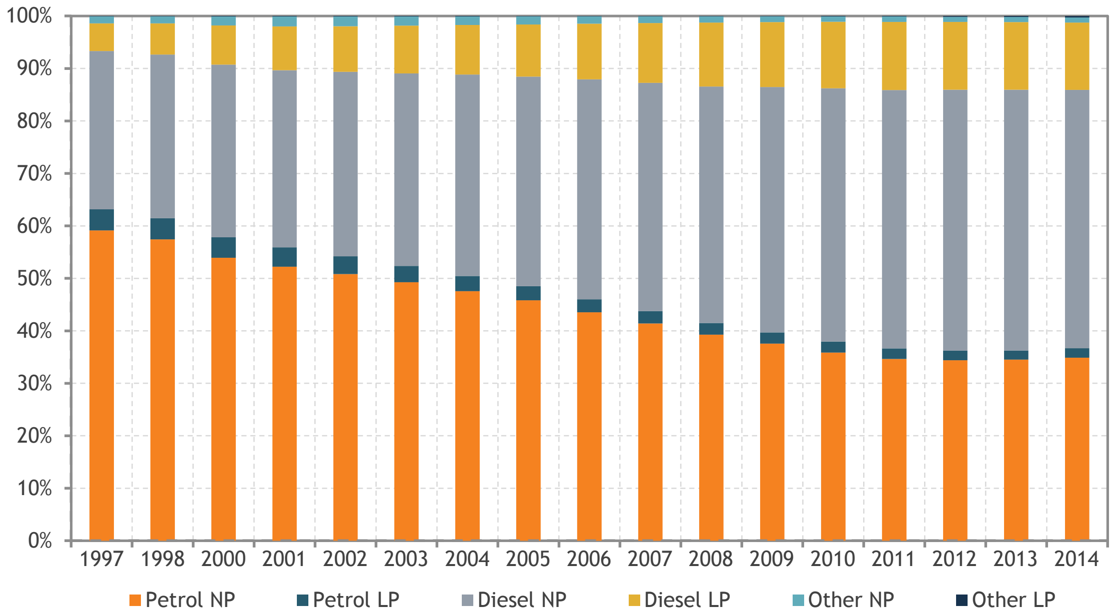
Graph 4 New car registrations by fuel type and ownership category
%



Source: FPB (2015)

As graph 5 shows, the overall car stock is slower to respond to changing conditions. The dieselization of the car stock has been steady since the end of the 90s until reaching its zenith in 2013, a rise from 35% to almost 63%. Only very recently a stagnation is recorded. Note that the share of vehicles owned by legal persons is much lower in the stock than in new registrations, since company cars have a much higher turnover than vehicles owned by natural persons.

Graph 5 Car stock by fuel type and ownership category - natural persons and legal person
%



Source: FPB (2015)

The historically favourable tax treatment of diesel cars seems to have decisively come to an end, however. Not only will the federal government, as part of a comprehensive tax reform, close the gap between excise rates by 2018, the Flemish regional government has reformed its registration and annual taxes to take fuel type and emissions of harmful local air pollutants into account which should penalize the purchase and ownership of a diesel car.

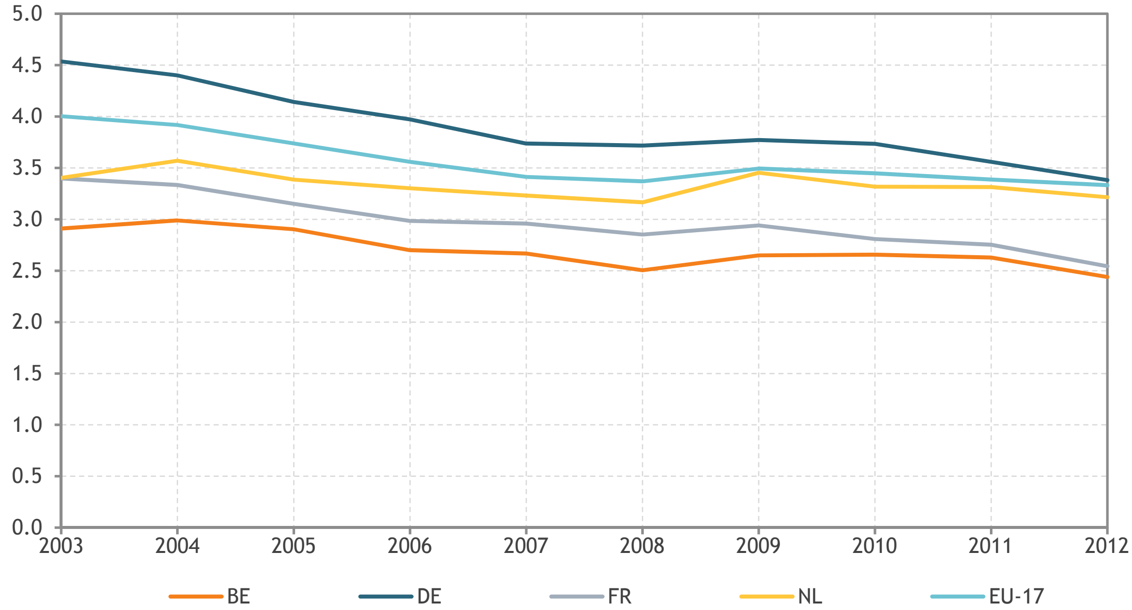
In this paper, we will simulate the reform of the diesel excise, and present its effects on traffic and the environment. We will put this reform into perspective, by comparing its effects with that of a hypothetical kilometre charge at rush hour. Also, we will also attempt to exploit the dynamic nature of the PLANET model to show the effects of the reform over time.

3. Fuel excise duties as public policy instruments: now and in the future

As is well known, the first and foremost objective of environmental taxation is to internalize the external costs associated with the consumption of polluting goods. This is the so-called Pigovian goal of taxation. Standard theory prescribes that taxes levied for these purposes should be set just equal to the marginal environmental damage of the good in question, not more and not less. (Jacobs and de Mooij, 2012).

It should be noted that controlling externalities is not the only role of taxation in general. Providing for a stable source of government revenue is indeed the primary purpose for levying taxes, transport and environmental taxes included. Excise duties do indeed provide for an important part of total tax income[1], as graph 7 shows. In Belgium they amounted to 2.5% of total taxation in 2012, which was one of the lowest levels in the European Union. Since 2003, they have been gradually falling in most neighbouring countries.

Graph 6 **Transport fuel taxes, as a percentage of total taxation**
%



Source: Eurostat (2015)

This chapter evaluates the pre reform alignment of fuel excise duties for cars from both the perspectives of controlling for externalities, and raising public revenue. To this end we will calculate in detail marginal external costs of air pollution and congestion, and implicit excise rates per vkm driven and project these towards 2030 using the PLANET model. Also, we will provide a projection of the revenues that are to be expected from fuel excise duties.

[1] The measure of total taxation used in 'taxation trends in Europe' includes both direct and indirect taxes and social security contributions.

3.1. Marginal external costs versus excise rates

In this paragraph we review in detail the marginal external costs associated with different car fuel technologies. External costs comprise of both environmental damage as well as congestion costs. This should allow us to evaluate the changes in externalities caused by changes in the tax regime for diesel and petrol cars. Since PLANET is a dynamic model, we are also able to provide a projection of external costs associated with car transport.

Special attention is paid to the assumptions driving the evolution of these external costs. More precisely, we clarify the level and evolution of emissions of pollutants by the different car technologies and fuel types in the PLANET model. Likewise, we show the monetary valuation per ton of the environmental damage caused by emissions in the base year and their evolution.

The model disposes of detailed emission factors by engine and fuel type and by Euro standard, which are calculated with COPERT v4.11. These encompass 3 greenhouse gases (GHG) namely CO_2, CH_4 and N_2O and 4 local air pollutants or non-greenhouse gases (NGHG), i.e. NOx, $PM_{2.5}$, SO_2 and NMVOC. In what follows, these two broad categories will be used to provide a rough breakdown of environmental damage. It should be noted that the model not only calculates direct exhaust emissions, but also indirect[2] and non-exhaust emissions.

Table 1 below reports emission coefficients for three main pollutants: CO_2, NOx and $PM_{2.5}$. They correspond to a medium car and to the conventional ICE[3] technology. CO_2 and $PM_{2.5}$ emission factors as well as NOx emission factors for petrol cars are those provided by COPERT v4.11. However, NOx emission factors for diesel cars are based on real-driving measurements taken from ICCT (2014). Not only are COPERT values for Euro 6 only based on preliminary measurements, but there also seems to be a particularly large discrepancy between the COPERT values and real-driving measurements for previous Diesel Euro standards, too (see e.g. Borge e.a. (2012), Carslaw e.a. (2011), Dilara e.a. (2012) and recently TfL (2015)). Recent gasoline cars seem to perform better in real driving tests.

In table 1, we also confront these emission factors with the successive Euro standards (NOx and $PM_{2.5}$) and the European CO_2 target for new cars. It should be noted that the emission factors for local pollutants used in the model are a weighted average between rural, urban and highway travel.

Like NOx emissions, CO_2 emissions by car lie well above those measured on a laboratory cycle, which are used to evaluate compliance with European CO_2 targets. For instance, the CO_2 emission factors used in the model for the Euro 6 technology outweigh the CO_2 target for new cars by 58% for a petrol car and by 27% for a diesel car in 2015.

NOx emissions are particularly off-target for diesel cars, even though Euro 6 still seems to entail a small improvement in NOx emissions compared to earlier standards. For particulate matter, the standards seem to be easily met, even in a real driving setting (TfL (2015), Samaras (2015)).

2 i.e. emissions produced through the transport and production of (bio)fuels and during power generation.
3 Internal Combustion Engine.

Table 1 Emission factors for different fuel types and technologies (medium sized car, direct emissions - 2015)
g/vkm

	CO_2		NOx		$PM_{2.5}$	
	Model	Target	Model	Norm	Model	Norm
Petrol						
Euro 1	194.3		0.49	0.44	0.00219	
Euro 2	187.9		0.24	0.23	0.00219	
Euro 3	198.8		0.10	0.15	0.00108	
Euro 4	205.3		0.06	0.08	0.00108	
Euro 5	205.3	130	0.04	0.06	0.00152	0.005
Euro 6	205.3	130	0.04	0.06	0.00157	0.005
Diesel						
Euro 1	167.3		0.89	0.87	0.08789	0.14
Euro 2	172.9		0.93	0.63	0.05477	0.08
Euro 3	164.5		1.00	0.50	0.04379	0.05
Euro 4	164.7		0.80	0.25	0.02514	0.025
Euro 5	164.7	130	0.80	0.18	0.00270	0.005
Euro 6	164.7	130	0.60	0.08	0.00188	0.005

Source: COPERT V4.11 and ICCT (2014)

All pollutants are valued according to marginal damage costs taken from Maibach e.a. (2008). The damage cost of greenhouse gases are assumed to grow over time according to the central scenario from that report. Cost of non-greenhouse gases are assumed to grow with GDP per capita, i.e. at a slower rate than GHG (see table 2).

Table 2 Monetary valuation of one ton of pollution avoided
EUR'12/ton

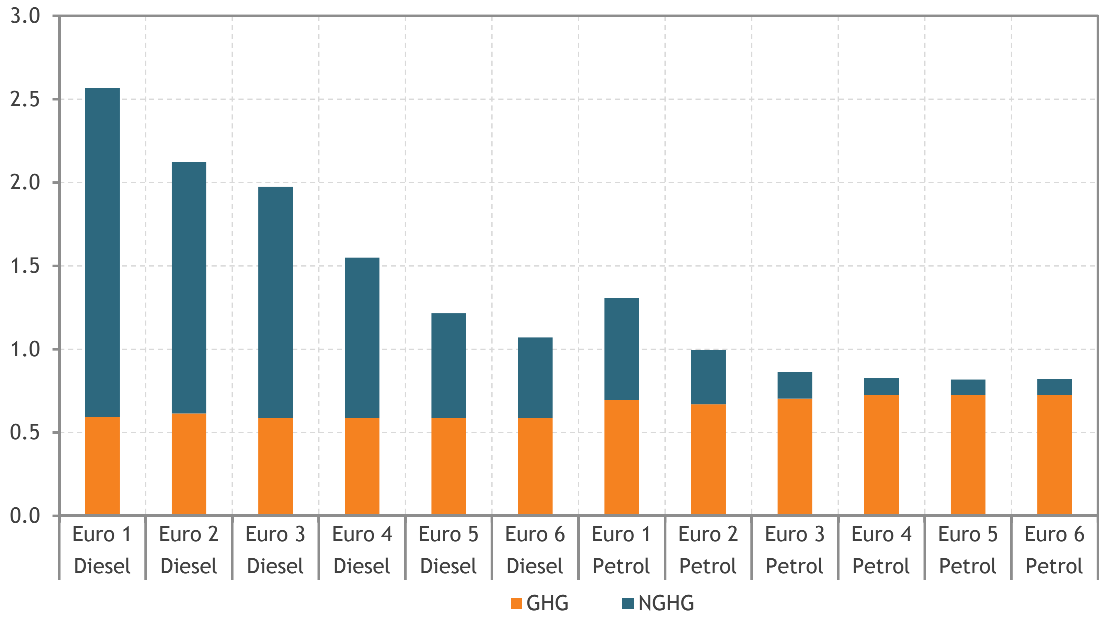
	Pollutant	Emissions	2012	2020	2030
NGHG	$PM_{2,5}$	Direct	146092	157914	174795
	PM_{10}	Indirect	14183	15331	16969
	NO_X	Direct	7160	7740	8567
	SO_2	Direct	15147	16373	18123
	NMVOC	Direct	3442	3721	4118
GHG (CO_2 equivalent)	CENTRAL	Direct + indirect	31	42	58

Source: PTTV 2015

Graph 7 shows the resulting marginal external costs of air pollution for the different Euro standards for a medium sized car, broken down by fuel for the year 2015. It shows that diesel cars cause slightly less climate damage per kilometre driven, due to their better fuel efficiency. GHG emissions are indeed roughly proportional to the amount of fuel consumed.

The major changes concern the marginal external cost associated with conventional air pollution. Moreover, these changes were most pronounced for diesel cars. Consequently, the difference in NGHG external costs between diesel and petrol cars has fallen tenfold, from 1.4 cent per vkm for the Euro 1 standard to 0.4 cents for the Euro 6 standard. But overall, diesel cars remain more polluting than petrol cars, despite their slight relative advantage in terms of greenhouse gases.

Graph 7 Direct marginal external air pollution costs by fuel type and euro class (2015) - medium sized car
Eurocent/vkm



Source: Own calculations with PLANET V3.3 (GHG: greenhouse gas emissions, NGHG: local air pollutants)

Since cars complying with older emission standards are being phased out progressively over time, the external air pollution costs of an average[4] car in a given year are falling steadily. The dynamic feature of the car stock modelled in PLANET enables us to project the external air pollution costs of an average car into the future (see table 3). For instance, at present Euro 3/4 cars are still the dominant standard, but by 2030 the Euro 6 class is projected to make up over 90% of the car stock, assuming no new emission standards will be introduced.

Table 3 Share of Euro class technologies in total car park

	2012	2020	2025	2030
Euro 0	4.3%	1.8%	1.0%	0.6%
Euro 1	3.6%	0.7%	0.4%	0.2%
Euro 2	7.3%	0.9%	0.5%	0.3%
Euro 3	21.9%	3.9%	1.2%	0.6%
Euro 4	44.7%	19.6%	5.9%	1.6%
Euro 5	18.1%	21.8%	11.1%	3.2%
Euro 6	0.0%	51.3%	80.0%	93.5%

Source: Own calculations on PLANET V3.3

Next to environmental externalities through the emission of pollutants, PLANET also provides a projection of external congestion costs into the future. These are calculated each year and are differentiated for peak (P) and off-peak (OP) periods, using a linear congestion function that links traffic levels to the average speed on the road network. Since the model is a national model, no geographical distinction is made, nor is there any distinction between type of road (urban roads versus highways versus rural roads).

[4] i.e. weighted average over Euro standards.

Two factors lead to an increase in marginal external congestion costs in the model. First, traffic levels are expected to increase over the projection period (see Daubresse e.a. (2015)). Furthermore, due to the linear congestion curve, an extra unit of traffic at the peak period will decrease speed relatively more than in the off-peak period, so the projected increase in external congestion costs is more pronounced at peak.

Second, the value of time that is used to express the time spent for a trip in monetary terms is assumed to rise with GDP per capita, with an elasticity of 0.9. Note that the pace of change in the value of time is slower than the change in the monetary value of environmental damages.

Table 4 puts the whole picture together. It shows the marginal external air pollution and congestion costs for an average car in the base year (2012) and in 2030. Figures are provided for a selected number of car technologies and both at peak and off-peak periods. Indeed, congestion costs differ significantly between time periods; they are however the same for all car technologies. Congestion costs at peak hours are almost six times higher than those at off -peak hours in 2012, and are set to increase at a higher pace in the period 2012-2030. Conversely, air pollution costs differ according to car technologies but are identical at peak and off-peak periods.

Table 4 also gives implicit excise rates for different car technologies. By implicit excise rates we mean fuel excise duties expressed in EUR per vehicle-kilometre (vkm) rather than per litre. Implicit tax rates yields more insight than per litre rates, since it allows to take into account different fuel efficiency levels between car types. The gap in implicit excise rates between diesel and petrol cars is even more pronounced than per litre figures would suggest. For ordinary ICE petrol cars, the implicit excise rate is 4.6 cents per vkm, or 84% higher than the implicit excise rate for ICE diesel cars. This discrepancy is projected to hold in the future, despite gains in fuel efficiency that causes implicit excise rates to drop slightly.

Table 4 Marginal external air pollution and congestion costs and implicit excise rates according to different car technologies and travel period (direct emissions)
Eurocents 2012/vkm

	MEAC - GHG (2012)	MEAC - Non GHG (2012)	MECC (2012)	Excise Rate (2012)	MEAC - GHG (2030)	MEAC - Non GHG (2030)	MECC (2030)	Excise Rate (2030)
Off-Peak Period								
PETROL ICE	0.6	0.4	10.7	4.6	1.0	0.2	19.8	4.4
PETROL Hybrid - CS	0.4	0.0	10.7	3.4	0.8	0.1	19.8	3.3
PETROL Hybrid - PHEV	0.2	0.0	10.7	1.8	0.4	0.0	19.8	1.7
DIESEL ICE	0.5	1.0	10.7	2.5	0.9	0.6	19.8	2.4
DIESEL Hybrid - CS	0.4	0.5	10.7	2.1	0.7	0.4	19.8	1.8
DIESEL Hybrid - PHEV	0.3	0.3	10.7	1.2	0.3	0.2	19.8	0.8
Peak Period								
PETROL ICE	0.6	0.4	63.6	4.6	1.0	0.2	139.8	4.4
PETROL Hybrid - CS	0.4	0.0	63.6	3.4	0.8	0.1	139.8	3.3
PETROL Hybrid - PHEV	0.2	0.0	63.6	1.8	0.4	0.0	139.8	1.7
DIESEL ICE	0.5	1.0	63.6	2.5	0.9	0.6	139.8	2.4
DIESEL Hybrid - CS	0.4	0.5	63.6	2.1	0.7	0.4	139.8	1.8
DIESEL Hybrid - PHEV	0.3	0.3	63.6	1.2	0.3	0.2	139.8	0.8

Note: ICE = internal combustion engine; CS = charge sustained, PHEV = Plug-in Hybrid Electric Vehicle; MEAC = marginal external air pollution cost; MECC = marginal external congestion cost; GHG = greenhouse gas emissions; non-GHG = local air pollutants; vkm = vehicle-kilometre.

Source: Own calculation based on PLANET V3.3

The table shows that implicit excise rates (before the 2016-2019 reform) are not sufficient to cover the full external costs of transport, which includes both air pollution and congestion. They exceed the total external costs of air pollution, however, for all car technologies. But, even though diesel cars cause more environmental damages in 2012 due to far higher non-greenhouse gas emissions, the implicit excise rate was in 2012 more than 2 eurocents lower than for petrol cars.

Due to the phasing in of new euro standards, the environmental damages fall over time, even though the monetary valuation of these damages rises. The difference in damages between diesel and petrol cars drops but remains positive in 2030 (0.4 cents). In other words, given real driving emissions for NOx, the external air pollution cost of a diesel car remains on average higher compared to a petrol car, if no additional action is taken.

A notable result is the lower implicit excise rate for hybrid cars. Since they consume on average less fuel, this is to be expected. They do cause the same amount of congestion costs, however. Insofar as excise duties already act as an imperfect instrument to control for congestion, they are even more inefficient in doing so for hybrids.

Clearly, the current setting of excise rates is not appropriate for capturing the total external costs. As explained by Mayeres and Proost (2013), in an ideal world different externalities are best targeted by different instruments. Since congestion costs depend heavily on time and place, they are best tackled by a differentiated kilometre charge. The cost of climate change is almost directly related to fuel consumption, so that traditional excises are better placed for that case. Emissions of non-greenhouse gasses depend heavily on the technology of the vehicle in question, such as the fuel used or Euro standard. In this case a fixed levy such as registration or annual circulation taxes are ideal to steer the market to the socially desired outcome.

A full ideal tax system is not likely to materialize in the real world. Administrative problems, tax competition, issues with implementation and compliance, and limited political acceptability of large scale reforms all serve to reduce the likelihood that an optimal tax system will be set in place overnight, if ever.

Real world considerations therefore matter, too. If tax competition and cross – border shopping reduces the scope for raising diesel excise rates, then fixed levies may be used. This has been successfully done in the Netherlands, as we have seen.

If differentiated kilometre charges are not feasible for private passenger transport, excise duties can then still be used to reduce congestion, albeit in a very rough way since excises allow no differentiation by time and place whatsoever. Since they far exceed the marginal environmental cost, excise duties already partially contribute to the reduction of congestion. Insofar as external congestion costs during peak and off-peak periods will diverge over time – as they do in our projection – excise duties will become less suited in their function to control congestion, even though congestion will be of higher concern. The geographical dimension of congestion may add to this problem. The more local congestion becomes, the less suitable are excise duties as a second best instrument to tackle external congestion costs.

Increasing excise rates may also encourage the adoption of more fuel efficient cars, such as hybrid vehicles. As has been shown, while they are slightly more environmentally friendly, they contribute to congestion like any other vehicle. The more widely available these new technologies become, the less excise duties seem fit as a congestion-controlling instrument.

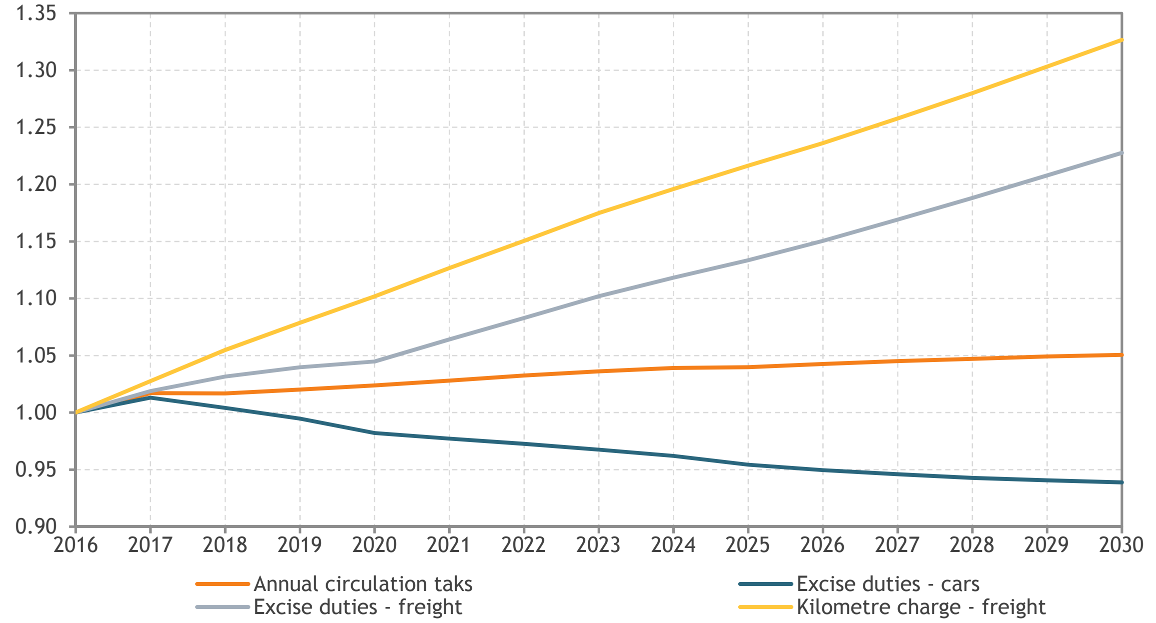
3.2. The revenue raising potential of excise duties

The PLANET model allows us to project tax revenues from transport into the future. Graph 8 does so for different categories of taxes: excises from cars, excises from road freight transport, the annual circulation tax and the kilometre charge on heavy duty vehicles.

Revenue from the kilometre charge on heavy duty vehicles is projected to grow the fastest, ahead of the excise duties from freight transport. This reflects the steady growth of vehicle kilometres driven by trucks in the reference scenario. The slower growth in excise duties from freight transport largely reflects the assumed gains in fuel efficiency.

Revenues from car related taxes are projected to grow much slower, with excise duties even recording negative growth in real terms from 2017 onwards.

Graph 8 Projected evolution of selected sources of tax revenue
(2016 = 100)



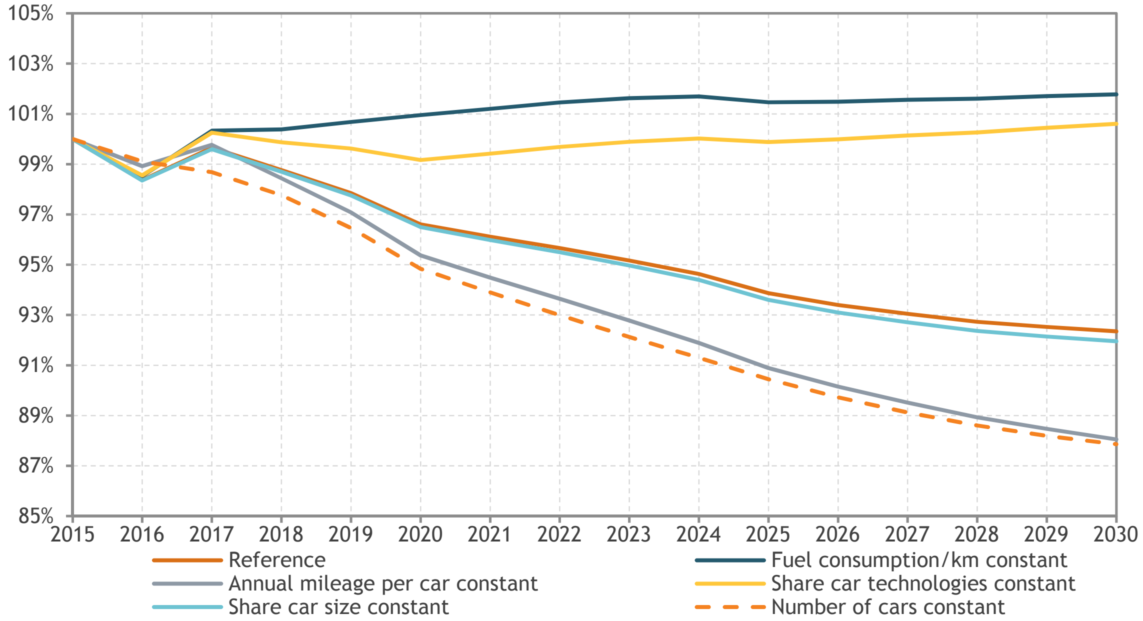
Source: Own calculations based on PLANET V3.3

The evolution of excise duties from passenger cars requires a more detailed explanation. To better understand the causes of the projected decline in excise revenue, we show in graph 9 the projected excise revenue in the base year of the perspectives of 2012-2030, and some counterfactual simulations which serve to capture the impact of different underlying trends on total revenues.

More precisely, the determinants of total revenues are decomposed into 5 different components: total number of cars, the share of size classes (small, medium, big) in the total car stock, the share of different fuel technologies (which apart from traditional petrol and diesel comprises also of hybrids, electric vehicles and natural gas), the number of mileage driven by each car type and fuel consumption per mileage.

Each component in turn is then held constant from 2015 onwards to present counterfactual total revenues. It is shown that in the absence of gains in fuel efficiency or the emergence of new technologies excise duty revenues would stabilize. Indeed, the PLANET model projects that by 2030 about 30% of vkm will be driven by cars with other technologies than the traditional internal combustion engine. Most of these new technologies will be hybrid vehicles. (Daubresse e.a. (2015)) On the contrary, the projected number of vehicles and the amount of mileage consumed serves to increase the amount of fuel consumed, and thus has a positive impact on revenues.

Graph 9 Evolution of excise revenue from passenger cars and counterfactual simulations
(2015 = 100)



Source: Own calculations based on V3.3

4. The effects of the 2016–2018 reform: traffic, pollution and welfare

In this chapter, we present the impacts on traffic, pollutant emissions and welfare of the 2016-2018 fuel excise reform. Each year, that reform is introduced in two steps. In the first step the diesel excise duty increases gradually in order to raise just enough revenue to finance the intended labour tax reduction policy. In the second step the diesel excise rate is raised further while the petrol excise rate is simultaneously reduced so as to equalize the per litre excise rates. This second step should be budget neutral and will only be implemented when the revenue target for the first step is raised. The first step is in the following denoted DIES-1 and the second step, DIES-2.

The gains from an incremental reform of diesel excises is best evaluated against what can be achieved with some 'ideal', optimal tax system. The PLANET model is not designed to calculate optimal taxes, instead we present for the impact of a congestion charge for car and road freight transport during the peak period. This scenario is called PEAK. Given what we know about marginal external costs, this scenario ought to be the marginal revenue raising reform that targets best the source of the most important externality, namely congestion.

Table 5 below presents the excise rates used in the different policy simulations, along with the values of the benchmark Reference scenario. DIES-1 assumes an increase in the diesel excise on cars and light duty vehicles from 0.428 euro per litre in 2016 towards 0.524 in 2018. Rates for heavy duty vehicles are assumed to stay unchanged. In DIES-2 the additional raise on the diesel excise is used to finance a decrease in the petrol excise. This would equalize rates at 0.564 euro per litre by 2018.

Instead of raising excise rates, the PEAK scenario imposes a congestion charge at peak period for cars of 1.8 cents per kilometre by 2018. Trucks pay a charge of 3.6 cents per kilometre at peak period (in addition to the newly introduced km tax), light duty vehicles of 2.7 cents. Higher rates for road freight transport could be justified since due to their relative size trucks and vans contribute more to congestion than cars.

Table 5 Tax rates at BAU and Policy scenarios
EUR/l (excise rates), EUR/vkm (congestion charge)

		2015	2016	2017	2018	2019-2030
No policy change	Diesel Excise	0.428	0.428	0.428	0.428	0.428
	Petrol Excise	0.614	0.614	0.614	0.614	0.614
DIES-1	Diesel Excise	0.428	0.454	0.481	0.524	0.524
	Petrol Excise	0.614	0.614	0.614	0.614	0.614
DIES-2	Diesel Excise	0.428	0.461	0.496	0.546	0.546
	Petrol Excise	0.614	0.591	0.568	0.546	0.546
PEAK	Diesel Excise	0.428	0.428	0.428	0.428	0.428
	Petrol Excise	0.614	0.614	0.614	0.614	0.614
	Congestion charge Car	0.004	0.009	0.013	0.018	0.018
	Congestion charge LDV	0.007	0.013	0.018	0.027	0.027
	Congestion charge HDV	0.012	0.018	0.027	0.036	0.036

Before we turn to the analysis of the effects of the policy scenarios, we would like to stress that the equalization of the per litre excise rate in the DIES-2 scenario does not imply the equalization of implicit excise rates per kilometre driven. Indeed, the excise figures in the DIES-2 scenario imply that by 2019, the per km rates are 4.2 cents for a petrol car and 3.2 cents for a diesel car.

Table 6 presents the impact of the policies on the car stock by 2030. Scenario DIES-1 should diminish the market share of new diesel cars by 1.9%. For DIES-2, the decrease amounts to 3.1%. The impact on the car stock as a whole is less pronounced, since diesel cars have a higher scrappage rate than petrol cars. This impact is in line with the calibrated elasticities as outlined in annex.

Note that the congestion charge (PEAK) also affects the car stock, since by assumption demand for diesel cars is more sensitive to changes in monetary costs.

Table 6 Impact on the vehicle stock by 2030
% difference wrt. BAU - 2030

	DIES-1	DIES-2	PEAK
Share Car Stock			
Petrol	1.7%	2.8%	0.8%
Diesel	-1.8%	-2.8%	-0.8%
Other	0.1%	0.2%	0.0%
Share New Car Sales			
Petrol	1.7%	2.9%	0.8%
Diesel	-1.9%	-3.1%	-0.8%
Other	0.1%	0.2%	0.0%
Total vkm driven	-0.8%	-0.9%	-0.7%
Share in Total Vkm Driven			
Petrol	1.3%	2.2%	0.6%
Diesel	-1.4%	-2.4%	-0.6%
Other	0.1%	0.2%	0.0%

Source: Own calculations with PLANET V3.3

Table 7 shows the effects on the number of passenger km (pkm) driven in Belgium.

All scenarios have negative impacts on the total number of pkm driven. For other motives this is because the number of trips depends explicitly on generalized costs. Despite time gains, generalized costs rise due to the tax increase. For school and work related trips, the total number of trips is kept constant, but the geographical distribution changes. Rising generalized costs will induce people to make trips to less far off destinations, so that the total number of kilometres driven drops.

Different effects by motive depend on the relative impact of the different measures. In the PEAK scenario, commuting transport is hit hardest since these make up the biggest part of the trips made at that the rush hour whereas in the DIES scenarios the impact is also relatively pronounced for other motives.

The impact of the DIES scenarios on the modal split presents no great surprises. Fewer people will choose to drive a car, more will choose to be a passenger, reflecting an increase in carpooling. Tax rises will make it more worthwhile to share a car rather than to drive alone, so that carpooling increases ('car passenger'). This is reflected in the increase in pkm driven in the 'car passenger' category. Public transport also gains, with bus and tram winning relatively more than metro and train. This is due to the fact that increasing the diesel excise also decreases congestion (albeit to a lesser amount then in the PEAK scenario), which indirectly benefits bus and tram since they partially run on the congested road network. This is not the case for train and metro.

Table 7 Traffic effects persons (PKM)
% difference wrt. BAU - 2030

	DIES-1	DIES-2	PEAK
Total PKM driven	-0.3%	-0.3%	-0.3%
By motive			
Other motives	-0.3%	-0.3%	-0.1%
School	-0.1%	-0.1%	-0.3%
Work	-0.3%	-0.4%	-0.7%
By mode			
bus	1.8%	2.1%	3.4%
cardriv	-0.8%	-0.9%	-0.7%
carpas	0.2%	0.3%	0.1%
metro	0.4%	0.4%	-0.2%
moto	2.7%	3.0%	2.5%
slow	0.4%	0.4%	-0.5%
train	0.9%	1.0%	0.5%
tram	0.9%	1.0%	0.9%
Period			
Off peak	-0.4%	-0.4%	0.0%
Peak	-0.1%	-0.1%	-0.9%

Source: Own calculations with PLANET V3.3

The PEAK scenario gives roughly comparable results on the modal split. However, it is not surprising that it hits transport in the peak period much harder. The DIES-1 and DIES-2 scenarios cause off-peak transport to drop whereas in the PEAK scenario it actually rises marginally.

Table 8 gives the effects on freight transport. The DIES-1 and DIES-2 scenarios only partially affect the number of ton-kilometres (tkm) through the increased diesel excise for light duty vehicles. Indirectly, tkm driven by heavy duty vehicles are affected too, since road flow diminishes slightly. This should diminish time costs for trucks, which are indeed a substantial part of total generalized costs per ton transported. Transit freight is also positively affected by this evolution.

The DIES-1 scenario sees a substantial modal shift from LDV and other modes, towards HDV transport. Overall, tkm do not change by much since the effect of time gains for HDV cancels the effect of the excise hike on LDV. The PEAK scenario sees the same pattern for the modal split, with HDV gaining at the expense of other modes, despite the higher extra km tax paid HDV. This reflects the importance of time costs for heavy duty vehicles. Lower time costs due to less peak traffic has a positive influence for heavy duty vehicles, which outweighs the negative costs of the congestion charge.

Table 8 Traffic effects freight (TKM)
% difference wrt. BAU - 2030

	DIES-1	DIES-2	PEAK
Total TKM driven	0.0%	0.0%	-0.1%
By activity			
Import	0.0%	0.0%	-0.1%
Domestic	0.2%	0.2%	-0.1%
Export	0.0%	0.0%	-0.1%
Transit	0.1%	0.1%	0.2%
By mode			
IWW	-0.3%	-0.3%	-0.6%
Rail	-0.2%	-0.2%	-0.4%
HDV	0.2%	0.2%	0.2%
LDV	-0.4%	-0.5%	-0.3%
SSS	0.0%	0.0%	0.0%

Source: Own calculations with PLANET V3.3

The table 9 below shows the impact on speed, public finance and emissions of greenhouse gases (GHG) and local air pollutants (NGHG). These impacts provide major insight into the ultimate welfare effects of the different policies.

Hiking diesel excises reduces road traffic, increase speed on the road and thus decreases marginal external congestion costs. Because speed is more sensitive to traffic flows at the peak period than at the off-peak period, speed increases slightly more at peak even though the diesel excise hike increases monetary costs uniformly across time periods.

As a second order effect, the above result makes driving at peak cheaper than during off-peak period. Consequently, the number of pkm decreases more at off peak than at peak periods (see table 7). If one wishes to steer traffic fundamentally away from the congested peak, excises are not the way to achieve that goal.

The 2016-2018 reform reduces greenhouse gas emissions from the transport sector by 0.5% in 2030, while abating local air pollutants by 1.0% reflecting the changing composition of the vehicle stock, the decrease in kilometres driven per car as well as the overall decline in pkm. The drop in emissions is less pronounced for greenhouse gases, since the number of petrol cars increases. Their higher CO_2 emission rate per vkm is however more than counterbalanced by the decline due to less mileage driven by diesel cars.

Even though the diesel reform also influences speed, the PEAK scenario does so where it counts the most. At peak period, speeds will increase by more than 3%, with traffic levels falling by almost 2%. The congestion charge causes a much smaller drop in non-greenhouse gasses, because it is not targeted towards diesel cars.

Table 9 Impacts on speed, road flow and emissions
% difference wrt. BAU - 2030

	DIES-1	DIES-2	PEAK
Average speed			
Peak	0.8%	0.9%	3.4%
Off Peak	0.3%	0.4%	0.1%
Marginal External Congestion Cost			
Peak	-1.4%	-1.5%	-6.1%
Off Peak	-1.0%	-1.1%	-0.5%
Road flow			
Peak	-0.3%	-0.4%	-1.4%
Off Peak	-0.6%	-0.7%	-0.2%
Direct emissions			
CO_2	-0.5%	-0.5%	-0.4%
NOx	-1.8%	-2.6%	-1.1%
$PM_{2.5}$	-0.5%	-0.6%	-0.5%

Source: Own calculations with PLANET V3.3

Armed with the behavioural effects described above, we can turn to the calculation of the welfare effects of the different policies.

The welfare effects calculated in the PLANET model (see Mayeres et al. (2008)) is the sum of the change in consumer (CS) and producer (PS) surplus, the gain in environmental quality and extra tax revenue. Positive changes in CS and PS can be understood as a fall in generalized costs borne by passengers and freighters respectively.

The change in CS and PS are the traditional textbook rectangles and triangles associated with a linear demand curve. They comprise of the change in the generalized costs of a trip or a ton transported, times the post reform quantity demanded on the one hand, and traditional deadweight loss triangle associated with tax induced price changes on the other hand. For tax increases, this last term contributes negatively to welfare, for subsidies decreases it counts as a welfare gain.

The one difference from the textbooks is the fact we express price changes in terms of generalized costs instead of monetary costs, so that not only the first order tax change matters for the calculation of welfare effects of a policy, but also the second order change in time costs.

In evaluating the impact of tax revenue, Mayeres et al. (2008) propose to weigh additional tax revenue according to the source (commuting transport or other). The same weight can be applied to the taxes that are lowered as part of a budget neutral tax shift (to reduce labour taxes or other purposes). The reason is that labour income tax reductions may yield more economic benefits than other instruments. Likewise, taxing commuting may results in more adverse economic effects than other purposes. To not excessively complicate matters however, here we assume a weighting factor – the so called marginal costs of public funds – of 1. In other words, one euro of tax revenue has the same value as one euro of costs borne by passengers and freight, regardless of its source or how it is used.

Moreover, all effects are expressed in present value terms, using a social discount rate of (2%).

Table 10 shows the welfare effect for two policy scenarios, DIES-2 and PEAK. For each scenario, changes in the different components of welfare are shown in absolute value and in percentage of tax revenue raised. These relative effects can alternatively be interpreted as gains/losses per euro of revenue raised.

Table 10 Welfare gain DIES-2 and PEAK in net present value
Million euro and in % of tax revenue

	DIES-2		PEAK	
	Million Euro	% of tax revenue	Million Euro	% of tax revenue
Consumer surplus (A)	-6175	-94.8%	-3256	-50.8%
School (a1)	*23*	0.3%	*183*	2.9%
Work (a2)	*-1473*	-22.6%	*-1580*	-24.6%
Other (a3)	*-4725*	-72.5%	*-1859*	-29.0%
Producer surplus (B)	-114	-1.8%	1943	30.3%
Other (b1)	*-172*	-2.6%	1913	29.8%
Transit (b2)	*58*	0.9%	30	0.5%
Environmental quality (C)	272	4.2%	194	3.0%
GHG (c1)	*97*	1.5%	*74*	1.2%
NGHG (c2)	*175*	2.7%	*120*	1.9%
Tax Revenue (D)	6514	100.0%	6413	100.0%
Net Welfare Gain (A+B+C+D)	497	7.6%	5294	82.6%
Time Gains (included in CS and PS)	2067	32.1%	5204	81.1%
Passengers	*772*	11.8%	1992	31.1%
Freight	*1322*	20.3%	3212	50.1%

Source: Own calculations with PLANET V3.3

At least as a first order effect, the DIES-2 and PEAK scenarios both cause passengers to lose, since they pay most of the tax increase.

But as a second order effect, benefits accrue to passengers and freight alike in the form of time gains. In the DIES-2 scenario, these represent 32% of tax revenue raised, in the PEAK scenario this amounts to 81% of tax revenue. These time gains show up in the positive welfare gains for producers in the peak scenario, reflecting how congestion caused by cars is borne indirectly by freighters, too.

Air pollution represent in any case a small fraction of welfare gains. In the DIES-2 scenario, it is some 4.2% of tax revenue, the majority of which are due to falling local air pollution. The PEAK scenario yields only 3%, mostly because gains in local air pollutants are less pronounced in that case.

To arrive at total welfare effects, one should add the value of tax revenue to the impact on freight, passengers and the environment. In this example, one euro of tax revenue is valued at the same level as a euro to passengers and freighters.

Overall welfare gains from the diesel excise reform thus represent 8% of total tax revenue. Direct welfare losses due to the tax increase are thus more than compensated for by time gains, air pollution decreases and the alternative use of tax revenue by the government. Peak pricing would yield far more as a percentage of tax revenue, mostly because of larger time gains.

Since PLANET is a dynamic model, it is possible to track gains in welfare from the policies above over time. It is especially noteworthy that the relative efficiency of the different policies in abating congestion changes over time, which reflects the increasing importance of congestion in the reference scenario of PTTV (2015). Traffic demand steadily increases, while infrastructure capacity is assumed to remain the same so that congestion costs rises. Since an extra car unit causes more harm during the peak period, congestion costs rise by more during peak than during off-peak.

Table 11 shows the value of the time gains in percentage of tax revenue for three years within the simulation period, for both the DIES-2 and PEAK. In both scenarios, time gains will become more important over time. Especially noteworthy is the fact that the gap in relative efficiency as measured by gains per euro of tax revenue between the two instruments also widens over time. In 2020 peak pricing yields 52 eurocent more in time gains per euro of tax revenue than raising diesel excises. In 2030 this rises to 60 cent per euro of tax revenue.

Table 11 Evolution of time gains
% of tax revenue raised

	2020	2025	2030
DIES-2	22.7%	29.0%	37.4%
PEAK	75.2%	87.4%	97.8%
gap between PEAK and DIES-2	52.5%	58.3%	60.4%

Source: Own calculations with PLANET V3.3

5. Sensitivity analysis

One of the primary results of the analysis presented in chapter 2 is that with current emission levels diesel cars still cause significantly more environmental damages than petrol cars by 2030. Indeed, real-driving measurement (e.g. by ICCT, 2014) indicates that even with the newest Euro standards for diesel cars NOx emissions remain elevated. Given our assumptions, the progress made so far is not sufficient to reduce the gap in relative external air pollution costs between the two types of fuel.

Given the uncertainty related to NOx emissions by Euro 6 diesel cars, we present in this chapter a thorough sensitivity analysis with respect to the NOx emission factors. We show the impact on marginal external environmental costs of the different car types and the resulting environmental gains from the diesel reforms according to an alternative scenario.

More precisely in the alternative run (Euro 6b/c) NOx emission factors for Euro 6 cars are assumed to decline according to the new rules set by the European Commission. These require car manufacturers to gradually lower emission limits towards 0.18 g/km by 2020, and towards 0.12 g/km by 2021.

It is unclear, however, whether these low values are attainable without altering the emission of other pollutants. For example, the current technologies required to significantly reduce NOx emissions would cause diesel cars to consume more fuel, which in turn may reduce their relative advantage in terms of CO_2 emissions. Or they may increase the purchase cost of a diesel car, also affecting their market share.

Table 12 summarizes the values used for the NOx emission factors in the different scenarios.

Table 12 NOx emission factors diesel cars (sensitivity analysis)
g/vkm

	ICCT(2014)	Euro 6b-c
Euro 1	0.89	0.89
Euro 2	0.93	0.93
Euro 3	1.00	1.00
Euro 4	0.80	0.80
Euro 5	0.80	0.80
Euro 6	0.60	0.60
Euro 6c	0.60	0.12

Source: Own assumtions based on ICCT (2014) and European Commission (2015). ICCT (2014) figures are those used in chapter 2.

Table 13 presents the marginal external environmental costs of an average petrol and diesel car in 2012 and 2030 resulting from these different emission factors. It shows that these alternative NOx values would significantly alter the relative valuation of an average diesel vehicle in the long run. With Euro 6c values, the difference indeed becomes negligible.

Table 13 Direct marginal external environmental costs (sensitivity analysis)
Eurocents 2012/vkm

	MEAC – GHG (2012)	MEAC – Non GHG (2012)	MEAC – GHG (2030)	MEAC – Non GHG (2030)
ICCT(2104)				
PETROL	0.6	0.4	1.0	0.2
PETROL Hybrid – CS	0.4	0.0	0.8	0.1
DIESEL	0.5	1.0	0.9	0.6
DIESEL Hybrid – CS	0.4	0.5	0.7	0.4
Euro 6b-c				
PETROL	0.6	0.4	1.0	0.2
PETROL Hybrid – CS	0.4	0.0	0.8	0.1
DIESEL	0.5	1.0	0.9	0.3
DIESEL Hybrid – CS	0.4	0.5	0.7	0.1

Source: Own calculations with PLANET V3.3

Table 14 presents the gains in environmental quality from the different scenarios. It shows that the gain in local pollution (NGHG) from the excise reform would drop to 1.9% of tax revenue if Euro 6b-c values are strictly imposed from 2020 onwards.

Table 14 Gains in environmental quality of DIES-2 (sensitivity analysis)
% of tax revenue raised

	ICCT(2014)	Euro 6b-c
Environmental quality	4.2%	3.4%
GHG	1.5%	1.5%
NGHG	2.7%	1.9%

Source: Own calculations with PLANET V3.3

6. Concluding remarks

This paper has shown that the fuel excise reform as planned by the Belgian federal government will yield substantial benefits in environmental quality. Per euro of revenue raised, the reform will yield 4.2 cents in environmental welfare, of which 2.7% are due to lower local air pollutants. In terms of tackling congestion, the reform does not yield the same benefits than a hypothetical congestion charge would bring. This gap in relative efficiency in tackling the most important source of transport externalities in Belgium will increase over time, making a thorough overhaul in transport taxation in Belgium more pressing as time passes.

The results in this paper hinge strongly on hypotheses with respect to emissions by different cars, especially of NOx emissions. We have shown that, if current emission factors based on real driving tests do not change over time, the diesel excise reform will yield comparatively large results compared to a situation where car manufacturers adhere strictly to new norms set by the European Commission.

Further work should identify and introduce the mechanism on how meeting these norms would affect the emissions of other pollutants. This is important if technologies that tackle NOx would increase fuel consumption and therefore the emission of greenhouse gasses by diesel cars.

In this paper we did not take into account policies that are currently planned by the Belgian regional governments. Since these new policies would also aim to render diesel cars less attractive, their interaction with federal policies should be studied. More precisely, their respective effect on the shared tax base and the corresponding changes in revenue of the different governments makes for an interesting topic for further research.

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8. Annex: Description of the VHS module in the PLANET model

The PLANET model provides a long term projection of transport demand for passengers and freight in Belgium. It provides a detailed breakdown of kilometres driven by mode and time period up to 2030. For passengers, the number of people driving a private car, and therefore the number of vkm demanded is explicitly given.

In a separate module which is described at length in Mayeres e.a. (2009), the number of vkm driven is linked to the number of cars demanded. Given an average mileage per car, which is itself a function of monetary costs and fixed costs associated with owning and operating a car, an aggregate number of cars demanded is calculated.

Each year, this desired car stock is confronted with the remaining number of vehicles after a part of the stock in the previous year has been scrapped. In this way, the amount of new vehicles appearing on the market is obtained.

These new vehicles are broken down into different fuel categories, using a nested discrete choice function. It endogenously models three size classes, and 2 main fuel types, diesel and petrol. The consumer is assumed to decide using fixed costs such as the purchase costs, registration taxes and annual ownership taxes, and monetary costs, such as the fuel price at the pump which included excise duties.

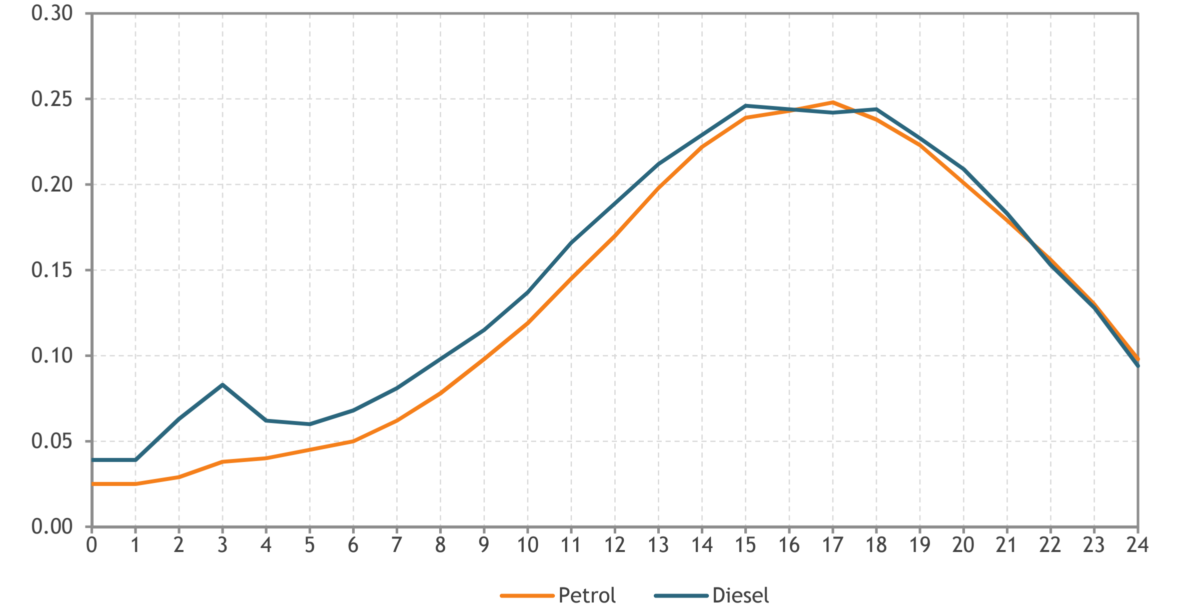
Given the choice of each fuel type by size class, the number of petrol and diesel are exogenously broken down in more narrow fuel types, according to given shares. For diesel cars, these are ordinary diesels, charge sustained hybrids and plugin hybrids. The 'petrol' aggregate includes ordinary petrols, the two hybrids types (CS and PHEV), but also electric and natural gas vehicles. These last two categories in any case are assumed to remain a small share over the projection period.

The rate at which cars of a given age leave the car stock, the scrappage rate, is different for each broad fuel type. The scrappage rate for petrol cars is indeed lower than that for diesels, so that turnover for the last category is much larger. Also, a spike in scrappage rates for diesel cars is observed around the 3th year, which consists of vehicles registered by companies leaving the fleet. We plot scrappage rate by age in graph 10. They are an average over the period 1998 until 2012.

Note the scarprate is exogenous. This could be a weakness of the model if agents are able to take into account future price changes in their decision to scrap their old car. For example, if diesel users will decide to exchange their car sooner for a petrol car, the assumption of a constant scrap rate will underestimate the behavioural reaction of the diesel excise rise.

This could be particularly important for cars owned by legal persons. They typically have shorter lifespans and may be expected to change more 'rationally' in response to prices. Indeed, another weakness of the current model is that it assumes the same behavioural reaction for natural and legal persons.

Graph 10 Average scrappage rates 1998-2012



The elasticities at which vehicle sales and market shares of different fuel types respond to changing prices is based on a literature survey.

Van Meerkerk e.a. (2013) report elasticities of sales with respect to the fuel price for different size classes. They note a larger responsiveness of larger cars to the price of both fuel types.

Table 15 Elasticities to a rise of the petrol rsp. diesel price with 1%

	Petrol < 950 kg	Petrol 950-1150 kg	Petrol 1150-1350 kg	Petrol > 1350 kg	Diesel < 1350 kg	Diesel > 1350 kg
Petrol + 1%	-0.06	-0.23	-0.35	-0.53	1.26	1.12
Diesel + 1%	0.17	0.16	0.15	0.13	-0.68	-0.90

Source: Van Meerkerk e.a. (2013)

Grigolon e.a. (2014) conveniently present the impact of an excise rise on the market share by an excise rise of 20 cents. Although their study covers a wide range of countries, they report specific results for Belgium. According to their results, the diesel-petrol excise differential accounts only for about 4% of the elevated diesel market share.

Table 16 Impact on the market share (Grigolon e.a. (2014))

	Impact market share
Petrol excise + 20ct	-4.0%
Diesel excise + 20ct	-3.7%

Source: Verboven e.a. (2014)

The resulting calibrated elasticities in the model are shown below. Table 17 reports the elasticity of sales with respect to the monetary variable cost of each category in the model. Table 18 does the same for a rise in the fuel price specifically, to ease comparison with the results of Van Meerkerk e.a. (2013). Except for small petrol cars, the elasticity rises with engine size.

Table 17 Elasticity new car sales wrt. monetary variable costs PLANET V3.3

	Cost Petrol Small + 1%	Cost Petrol Medium + 1%	Cost Petrol Big + 1%	Cost Diesel Small + 1%	Cost Diesel Medium + 1%	Cost Diesel Big + 1%
Petrol Small	**-1.05**	0.13	0.01	0.16	1.08	0.20
Petrol Medium	0.28	**-0.71**	0.01	0.08	0.19	0.20
Petrol Big	0.27	0.12	**-1.63**	0.07	1.04	0.10
Diesel Small	0.59	0.13	0.01	**-1.49**	1.08	0.20
Diesel Medium	0.28	0.02	0.01	0.08	**-0.73**	0.20
Diesel Big	0.27	0.12	0.00	0.07	1.04	**-2.33**

Source: Own calculations with PLANET V3.3

Table 18 Elasticity new car sales wrt. the fuel price PLANET V3.3

	Petrol Small	*Petrol* Medium	*Petrol* Big	Diesel Small	Diesel Medium	Diesel Big
Petrol + 1%	**-0.38**	**-0.17**	**-0.47**	0.73	0.24	0.62
Diesel + 1%	0.30	0.13	0.16	**-0.09**	**-0.24**	**-0.63**

Source: Own calculations with PLANET V3.3

The following table shows the impact on market share of a 20 cent excise rise, to ease comparison with the results of Grigolon e.a. (2014). Although not exactly the same, they lie in the same order of magnitude.

Table 19 Impact market share of a given excise rise

	Impact market share
Petrol Excise + 20ct	-2.5%
Diesel Excise + 20ct	-4.5%

Source: Own calculations with PLANET V3.3