Support Study for the Impact Assessment Accompanying the Revision of the Eurovignette Directive (1999/62/EC)

Final Report

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Transport and
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Research

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EXECUTIVE SUMMARY

Purpose and scope of the study

The charging of heavy goods vehicles (HGVs) for the use of road infrastructure in Europe is governed by Directive 1999/62/EC (the "Eurovignette" Directive). The Directive aimed to achieve step-wise harmonisation of vehicle taxes and establishment of fair mechanisms of infrastructure charging.

Following an evaluation of the Directive, certain problems have become apparent in terms of a non-level playing field, discrimination of occasional/non-resident users and degrading quality of road infrastructure in many Member States. There is also increasing concern over adverse impacts of transport, including damage to health and the environment, increasing congestion (inefficient use of existing infrastructure) and high greenhouse gas emissions (GHGs).

The **general objective** of the proposed revision of Directive 1999/62/EC is to promote financially and environmentally sustainable and socially equitable (road) transport through wider application of the 'user pays' and 'polluter pays' principles (fair and efficient pricing).

The **specific objectives** for the proposed revision are the following:

1. Contribute to the reduction of CO_2 emissions in transport (efficiency);
2. Ensure adequate quality of roads in exchange of the user charge (fairness);
3. Ensure that road pricing better reflects the real cost of use, including externalities, and that it treats occasional / non-resident motorists fairly (fairness);
4. Make use of road charging as an effective tool in reducing congestion (efficiency).

Policy options analysed

The following policy options that aimed to address the identified problems were retained for detailed analysis:

- **Policy Option 1: Minimum adjustments and extending the scope of the Directive**
  - Remove exemptions for HGVs <12t;
  - Extend rules on tolls and user charges to coaches designed to carry at least 16 passengers;
  - Revision of caps/values for external cost charging;
  - Extend mark-ups beyond mountain regions to specific types of motorways;
  - Introduce non-discrimination requirement and a maximum relative price for short-term vignettes compared to long-term vignettes for LDVs;
  - Promote zero-emission vehicles through allowing reduced rates (HDVs and LDVs).
- **Policy Option 2: Measures of PO1 + Address CO_2 emissions of HDVs +Phase out vignettes for HDVs + Adjust circulation taxes for HGVs**
  - CO_2 differentiation for HDVs (HGVs >3.5t + buses/coaches;
  - Phase out Euro class-differentiation – more extensive use of external cost charging (optional);

  - Phase out vignettes for HDVs (HGVs >3.5t + buses/coaches;
  - Moderation of circulation taxes for HGVs (>12t).
- **Policy Option 3a - Measures of PO2 + Allow congestion charging of all vehicles**
  - Allow (optional) genuine congestion charging in distance-based environment for all vehicles (LDVs + HDVs).
- **Policy Option 3b - Measures of PO3a + Address CO_2 emissions of LDVs**
  - Differentiation of tolls and user charges (i.e. both distance- and time-based) for LDVs (LGVs and passenger cars) from 2020.
- **Policy Option 4 - Measures of PO3 + Phase out of vignettes for LCVs**
  - Phase out vignettes for LCVs (not including cars);
  - Mandatory external cost charging for noise and air pollution for HDVs;
  - Phasing in of distance based charges for passenger cars.

Sensitivity analysis was performed on PO2 and PO4 to illustrate the potential range of impacts under different choices at Member State level, due to the non-mandatory nature of some of the measures.

Two options were retained that aimed at ensuring fair road quality in return for user charges, which could be used in combination with any of the main policy options above:

- **Policy Option A:** Require Member States to publish regular (annual) infrastructure reports, providing information on toll revenues as well as expenditures on maintenance/operation of toll roads**.**
- **Policy Option B:** Quality indicators would be introduced to ensure that the manager of a toll road will maintain the given road section in sufficiently good/safe condition.
- **Policy Option C:** Both options A and B combined.

Methods

A model suite has been used for the analytical work, combining the strengths of three different models: ASTRA, PRIMES-TREMOVE and TRUST. The model suite covers the entire transport system (e.g. transport activity represented at Member State level, by origin-destination and at link level, technologies and fuels at Member State level, air pollution emissions at Member State and link level and CO_2 emissions at Member State level) and its macro-economic impacts.

The modelling was complemented by a literature review and stakeholder consultation. Input from stakeholders was gathered via an online public consultation, which also invited additional contributions, and a targeted consultation (mainly via interviews, with some written contributions) that aimed to gather more detailed views and factual information on the options that were being considered.

Impacts

The analysis of **economic impacts** shows the most important differences. The main trade off is between the increased costs for transport users and to authorities, balanced against increased revenues and reductions in congestion costs and other externalities. There are also some potentially negative impacts in terms of distribution and impact on SMEs, as a result of increased costs

The main **environmental impacts** relate to the reductions in CO_2 and air pollutants from road transport. These are highest for PO4 and PO4s (0.7 to 1.0% reduction in CO_2 compared to the baseline in 2030, 1.0 to 1.2% reduction in PM and 1.2 to 1.4% reduction in NOx). The reductions under PO1 are negligible. PO2 and PO3a perform similarly, with reductions of 0.4% for CO_2, 0.2% for PM and 1.0% reduction in NOx. PO3b is between PO3a and PO4, with reductions of 0.5% in CO_2, 1.0% for PM and 1.2% for NOx from road transport.

In terms of **social impacts**, all policies can be expected to make a minor positive contribution by increasing the fairness of road user charges. PO3 and PO4 are expected to have slightly most positive effects due to greater internalisation of external costs (contributing to fairness) and slightly higher benefits for public health and safety.

Table 0-1: Main economic, environmental and social impacts

Key: Impacts expected				
××	×	O	✓	✓✓
Strongly negative	Weakly negative	No or negligible impact	Weakly positive	Strongly positive

	PO1	PO2	PO3a	PO3b	PO4
Economic impacts					
Transport costs Freight transport (% change)	+0.2%	+0.9% (+1.0% in sensitivity)	+1.0%	+1.1%	+1.5% (+2.0% in sensitivity)
Transport costs Passenger transport (% change)	+0.0%	+0.0% (+0.0% in sensitivity)	+0.1%	0.0%	+1.3% (+2.0% in sensitivity)
Congestion costs	0.0%	-0.2% (-0.2% in sensitivity)	-2.4%	-2.5%	-2.5% (-6.1% in sensitivity)
Tolling revenues	+5%	+15% (+15% in sensitivity)	+28%	+25%	+60% (+160% in sensitivity)
Impact on SMEs	0/× Minor negative impacts due to the lower capacity of SMEs to absorb increases in cost, but no significant distortions expected				
CAPEX to authorities	0 Insignificant	€1,202 m for the main option (€1,387 m for the sensitivity)			€1,334 m for the main option (€2,193 m for the sensitivity)
OPEX to authorities	0 Insignificant	€168 m/year for the main option (€200 m/year for the sensitivity)			€184 m/year for the main option (€313 m/year for the sensitivity)

	PO1	PO2	PO3a	PO3b	PO4
Administrative cost to road users	0 Insignificant	€8 m/year from 2020 to 2025; €198 m/year from 2025 onward for the main option (€228 m/year sensitivity)			€8 m/year from 2020 to 2025; €240m/year from 2025 onward for the main option (€310 myear sensitivity)
Road quality	0/✓ Very minor positive impact due to 5% increase in revenues	✓ Small positive impact due to 15% increase in revenues	✓ Small positive impact due to 28% increase in revenues	✓ Small positive impact due to 25% increase in revenues	✓✓ Positive impact due to 60-160% increase in revenues
Regional impacts	0 Negligible	0 Negligible	✓/× Small positive impact in regions of high congestion. Small negative impact on peripheral regions.		
GDP	0.0%	0.0% (0.0% in sensitivity)	0.0%	0.0%	-0.1% (-0.1% in sensitivity)
Competitiveness	0 No impact on competitiveness of European manufacturing products on the global market.	✓ Minor positive impact on competitiveness due to differentiated CO_2 charging for HDVs leading to improved efficiency	✓ Minor positive impact on competitiveness due to differentiated CO_2 charging for HDVs leading to improved efficiency Increased uptake of congestion charging will be beneficial to the competitiveness of businesses, especially those that make use of just-in-time manufacturing or in which goods are perishable, costly or difficult to warehouse		
Internal market	✓ Small positive impact due to removal of exemptions for HGVs<12t and extension to buses/coaches	✓ Small positive impact due to phase out of vignettes and EURO class differentiation – potentially leading to more tolls and external cost charging (voluntary)	✓ As for PO2, plus allowing genuine congestion charging that would encourage more Member States to apply such charges on congested links		✓✓ Highest uptake of tolls likely due to phase out of LCV vignettes. Mandatory external cost charging
Third countries	0 Minor impacts overall. Positive due to proportionate rules on vignette price. Small increase in costs due to increased transport costs, but not specific to users from third countries as it applies to all road users				

	PO1	PO2	PO3a	PO3b	PO4
Environmental impacts					
CO_2 from road transport	0 Negligible	-0.4% (-0.4% in sensitivity)	-0.4%	-0.5%	-0.7% (-1.0% in sensitivity)
Air pollution from road transport (NOx and PM)	0 Negligible	-1.0% NOx; -0.2% PM (-1.0% NOx; -0.2% PM in sensitivity)	-1.0% NOx; -0.2% PM	-1.2% NOx; -1.0% PM	-1.2% NOx; -1.0% PM (-1.4% NOx; -1.2% PM in sensitivity)
Noise[1]	0.0%	+0.4% (+0.4% in sensitivity)	+0.8%	+0.8%	+1.4% (+4.1% in sensitivity)
Land use	0 Negligible	✓ Very minor positive impact due to transport demand reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction
Social impacts					
Employment	0 Negligible				
Public health & safety	Negligible	Small reductions in external costs of air pollution from road (-0.3%; -0.3% in sensitivity)	Small reductions in external costs of air pollution from road (-0.4%)	Small reductions in external costs of air pollution (-0.5%)	Negligible impact on external cost of air pollution (-0.5%; -0.6% in sensitivity) and accidents (-0.2%; -0.6% in sensitivity)

[1] Noise: note that the model does not take into account possible accompanying measures that would prevent the diversion of traffic into more sensitive areas, which is the reason for higher noise costs

	PO1	PO2	PO3a	PO3b	PO4
Social inclusion	0 Very minor / negligible	✓ Small positive impact due to phase out vignettes	✓✓ Greater internalisation of external congestion costs (all vehicles). Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance		✓✓ Greater internalisation of external congestion costs & air pollution for bus/coach. Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance
Equal treatment of EU citizens	✓ More proportionate charges for occasional users in countries with vignettes (52% lower for passenger cars; 45% for LCVs)				

In terms of the **options to improve road quality,** the **economic impacts** largely relate to the extent to which each Policy Option is capable of improving road quality – larger improvements indicate more positive benefits in terms of reductions in transport and congestion costs, GDP, competitiveness etc. Therefore, the Policy Option that has the greatest potential to improve road quality, also has the most positive economic impacts. In this case, the combination of Policy Option A and B has the most potential.

Similarly, the **environmental impacts** are also directly related to the extent to which options are capable of improving road quality – again, the option with the greatest potential to improve road quality has the greater environmental benefits.

Social impacts relate to the risk of accidents, which again are correlated with the extent of improvements in road quality. In addition, the policies may affect equal treatment of EU citizens, where both Policy Option A and B have the potential for positive impacts. Policy Option A achieves this through more inclusive debate and better information, whereas Policy Option B achieves this through mandating a more harmonised approach to liability.

Overall, there is plenty of evidence to connect improved road quality with the main economic and environmental benefits described above, with studies from various EU-15 and EU-13 European countries that report positive interactions[2]. Although it is not possible to quantify any of these benefits due to the uncertain effect of the Policy Options on the most important indicator – road quality itself – it is clear that both options are likely to be beneficial

[2] Reports were found indicating positive benefits in ES, LT, UK, DE, PL.

1. PROBLEM DEFINITION

1.1. Background and policy context

The charging of heavy goods vehicles (HGVs) for the use of road infrastructure in Europe is governed by Directive 1999/62/EC (the "Eurovignette" Directive). The aim of the Eurovignette Directive when it was adopted in 1999 was to preserve the functioning of the internal market and prevent any discriminatory charging by Member States, through achieving step-wise harmonisation of vehicle taxes and establishment of fair mechanisms of infrastructure charging.

The Eurovignette Directive 1999/62/EC has subsequently been amended by Directives 2006/38/EC and 2011/76/EC as follows:

- **Directive 2006/38/EC**: introduced greater possibilities to vary tolls away from the average level to achieve policy objectives linked to the environment, congestion and management of traffic flows, albeit with a maximum ceiling on the degree of variation upwards. The scope was extended to cover commercial vehicles over 3.5 tonnes (a requirement that became mandatory from 2012).
- **Directive 2011/76/EC**: allows Member States to levy an external cost charge which is related to air pollution and/or noise pollution from road traffic. It also allows Member States to vary charges for the purpose of reducing congestion and optimising the use of infrastructure.

Additionally, **Directive 2004/52/EC** (the "Interoperability Directive") and the related **Decision 2009/750/EC** aim to achieve interoperability of all the electronic road toll systems in the European Union. These are the subject of a separate, parallel study.

There is little European legislation in the field of road charging for cars, most notably because of subsidiarity considerations. Still, the principle of non-discrimination must be respected by the national charging systems; therefore the Commission has prepared a Communication explaining how non-discrimination applies in the context of vignettes for cars. The Communication was adopted on 14 May 2012.

The delivery of a sustainable transport system has long been a goal of the EU, with the polluter pays principle enshrined in the Treaty. Imbalances in transport pricing were identified in the 1992 White Paper on a common transport policy. The 1995 Green Paper "Towards fair and efficient pricing in transport" advocated that the user should cover the full social cost of their journey. The internalisation of external costs was taken up in the 1998 White Paper on "Fair Payment for Infrastructure Use" and also in the 2001 "White Paper on transport - time to decide".

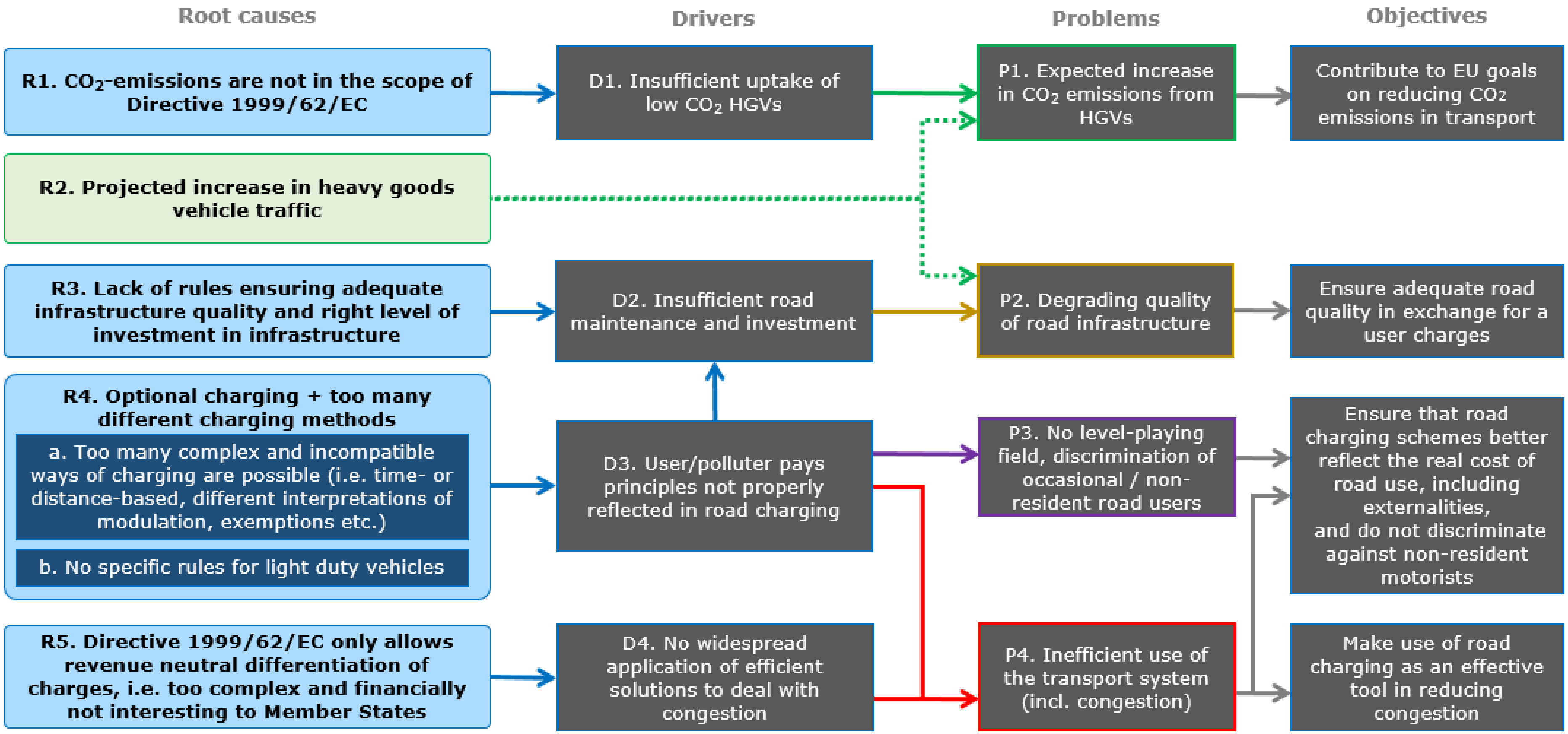
More recently, the Commission's 2011 Transport White Paper announced the aim of gradual introduction of a mandatory infrastructure charge for heavy duty vehicles, which would be harmonised across the EU in terms of tariff structure, cost components and collection method (European Commission, 2011a). This should be based on moving towards the full application of the user pays and polluter pays principles.

The White Paper also foresees measures ensuring greater transparency of tariffs and the respect of the non-discrimination principle in charging all vehicles, including private cars. A visible link between the user pays and polluter pays charges, as well as transparency on the use of revenues will likely improve the acceptability of new charging schemes.

1.2. Problem tree

In relation to the Eurovignette Directive, a number of problems and associated drivers/root causes have been identified and are summarised in Figure 1-1.

Figure 1-1: Problem tree



An efficient network of transport infrastructure is vital to the competitiveness of Europe. And yet, as the transport system has expanded it has become clear that it cannot continue developing along the same path without serious unintended consequences. Whilst the value of transport to people and businesses is undisputed, there is increasing concern over adverse impacts including damage to health and the environment, increasing congestion and high greenhouse gas emissions (GHGs) levels.

The following sections elaborate on the problem definition in more detail.

1.3. Problem area 1 – Insufficient reductions in CO_2 emissions from HGVs

1.3.1. Nature of the problem

The EU climate and energy framework has set the target to reduce greenhouse gas (GHG) emissions from non-Emissions Trading System (ETS) sectors by 30% by 2030 (vs 2005). As one of the major sources of GHG emissions, the transport sector (and in particular the road transport sector), will play a crucial role in achieving this target. Transport accounts for around a fifth of GHG emissions from the European Union, and road about 73% of transport emissions (European Commission, 2016a).

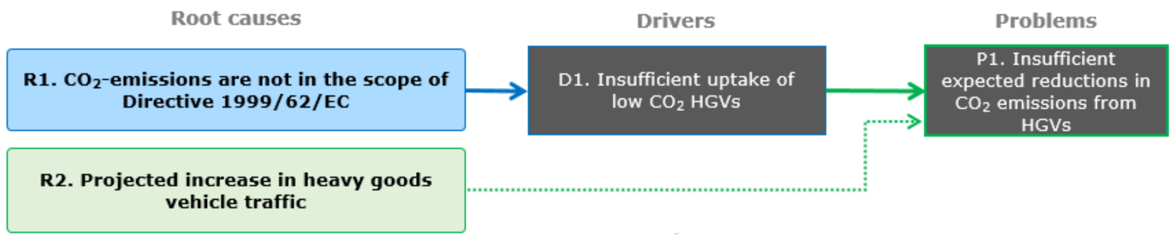
Approximately 25% of CO_2 emissions from road transport in the EU are caused by HGVs and buses (EEA, 2016a). In view of increasing EU freight volumes, between 1990 and 2007 HDV CO_2 emissions have grown by about 31% (EEA, 2016a). Whilst the combination of improvements in energy efficiency of HGVs and a decrease in road transport freight activity have together led to a 13% decrease in HDVs CO_2 emissions between 2007 and 2014, these reductions fall far short of the contribution needed from the transport sector to achieve the targets set by the EU for 2030.

Although supply-side measures to reduce CO_2 emissions from new HGVs are in the pipeline (namely, proposals for CO_2 standards), such measures should be complemented by demand-side incentives to ensure that the road freight transport sector can effectively contribute to the EU's CO_2 emission reduction targets. Road infrastructure charging could help to stimulate demand for more efficient vehicles, in a role that would be complementary to other pricing instruments (such as fuel taxes, which already internalise the external costs of CO_2 to some extent).

1.3.2. Drivers and root causes of the problem

An extract of the problem tree is shown in Figure 1-14, which illustrates the drivers and root causes of this problem area.

Figure 1-2: Drivers and root causes of the problem "Insufficient expected reductions in CO_2 emissions from HGVs"



Driver D1: Insufficient uptake of low CO_2 HGVs

Regarding **CO_2 emissions**, uptake of cleaner HGV technologies tends to be slow (European Commission, 2014b). Projections under current trends and adopted policies by the end of 2015 show that diesel will continue to be the primary fuel for HDVs by 2030 (i.e. 89% of their energy use), followed by liquid biofuels and gas[3]. About 89% of the HGV fleet would be made of conventional diesel powertrains and 91% of the buses and coaches fleet. The remaining fleet would be largely made up of diesel hybrids and vehicles running on gas (i.e. LNG for HGVs and CNG for buses). Specific fuel consumption of heavy goods vehicles is projected to go down by 15% between 2010 and 2030 and that of buses and coaches by around 8%. However, these improvements in energy intensity and in the carbon intensity would not be even able to offset the increase in CO_2 emissions[4].

Root cause R1: CO_2 emissions are not in the scope of Directive 1999/62/EC

The current provisions of the Eurovignette Directive do not allow Member States to differentiate road charges according to vehicles' CO_2 emissions. There is currently no standard method of reporting vehicle fuel economy for HGVs although such reporting will be introduced in the coming years.

Root cause R2: Projected increase in HGV traffic

Road freight activity (measured in t-km) is projected to increase by about 35% between 2010 and 2030 (56% for 2010-2050) under current trends and adopted policies by the end of 2015, with similar developments for HGVs activity. Such developments will make CO_2 intensity reductions in the sector increasingly important.

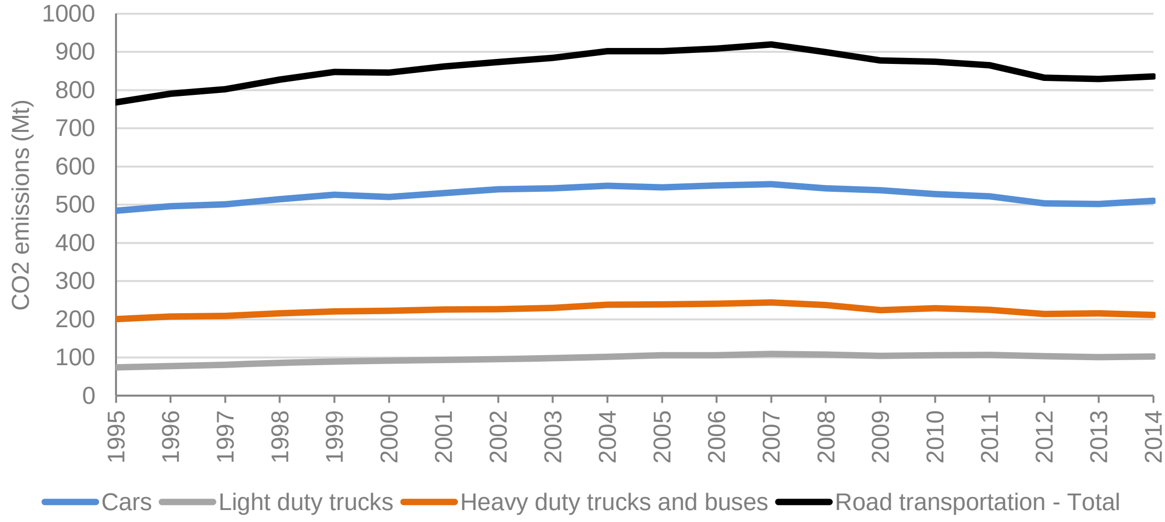
1.3.3. How the problem has developed over time and how it is expected to develop without further action

Figure 1-3 shows that CO_2 emissions from road transport today are 9% higher than in 1995, despite their decreasing trend over the past seven years.

[3] The Baseline scenario used for this study builds on the EU Reference scenario 2016 but additionally includes some updates in the technology costs assumptions (i.e. for light duty vehicles) and few policy measures adopted after its cut-off date (end of 2014) like the Directive on Weights and Dimensions, the 4th Railways Package, the NAIADES II Package, the Ports Package and the replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonized Light-vehicles Test Procedure (WLTP). The Baseline scenario has been developed with the PRIMES-TREMOVE model (i.e. the same model used for the EU Reference scenario 2016) by ICCS-E3MLab and provides projections under current trends and adopted policies by the end of 2015. Both ASTRA and TRUST models have been calibrated on these Baseline scenario projections.

[4] The increase in CO_2 emissions from HGVs over 2010-2030 is driven by growth in HGVs transport activity (e.g. 35% increase for 2010-2030), despite some improvements in energy intensity and carbon intensity.

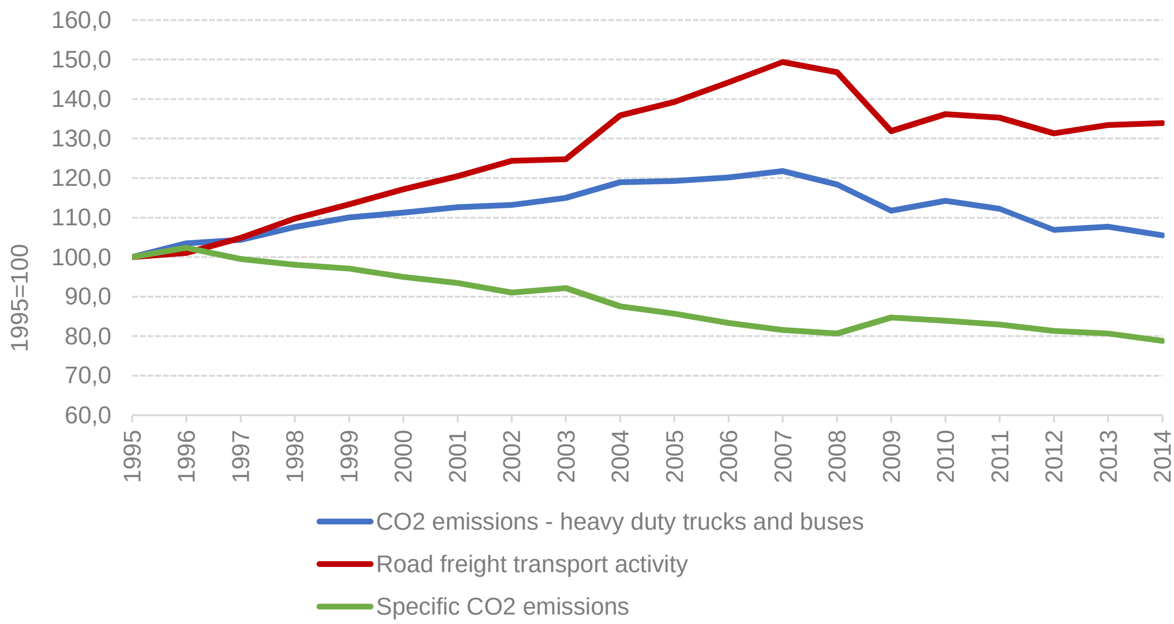
Figure 1-3: CO_2 emissions in road transport 1995 to 2014



Source: Ricardo analysis of EEA data, (EEA, 2016a)

Figure 1-4 shows the development of road freight transport indicators over time. The trends for total CO_2 emissions from heavy-duty trucks and buses broadly follow the same trend as for total transport activity, since activity is an important driver of total emissions. At the same time, improvements in specific CO_2 emissions of about 21% took place between 1995 and 2014. In the coming decades, significant additional improvements in HGV energy efficiency will still be required in order to counterbalance the impacts of predicted increases in road freight activity (see root cause R2).

Figure 1-4: Road freight transport indicators, 1995 to 2014 (indexed to 100 in year 1995)



Notes: Absolute values for CO_2 emissions in kilotonnes, road freight transport activity in tonne-km and specific CO_2 emissions in grams/tonne-km; Source: (EEA, 2016a), (European Commission, 2016a)

1.3.4. Potential impacts

Under the baseline scenario, the CO_2 emissions from the road freight transport sector (heavy and light goods vehicles) are projected to increase by 6% between 2010 and 2030 (11% for 2010-2050)[5]. For buses, CO_2 emissions are projected to remain relatively unchanged by 2030 and to slightly increase afterwards (3% increase for 2010-2050). Passenger cars and passenger vans are projected to see a reduction in CO_2 emissions of 22% between 2010 and 2030 (32% for 2010-2050).

1.4. Problem area 2 – Degrading quality of road infrastructure

1.4.1. Nature of the problem

It is difficult to compare the quality of road infrastructure between Member States due to a lack of consistency in monitoring and reporting practices. As such, the available data on road quality across the EU tends to fall into two categories: surveys and national reports.

Surveys on the quality of road infrastructure can provide an indication of the perceived quality of roads, and has the advantage of covering all EU countries with standardised survey questions. The survey evidence drawn from both the business community (WEF, 2017) and citizens (Eurobarometer, 2014) in Europe suggests that there is considerable variation in road quality in the EU. Overall, there is a tendency for a higher level of satisfaction with road quality in the EU-15 compared to the EU-13 Member States. This type of evidence can provide an indication of the perceived quality of roads, and has the advantage of covering all EU countries with standardised survey questions. Although a correlation between perceptions and actual road quality should be expected to some degree, such surveys do suffer from key limitations – namely that the results are subjective and may be influenced by factors such as level of exposure to the road network, past experiences etc.

National reports suggests that there are concerns over poor road quality in seven Member States, including Bulgaria (BTI, 2016); Belgium (EC, 2016); (CIHT, 2012); Estonia (OECD, 2015), Latvia (EC, 2015); Lithuania, Romania and Spain (European Parliament, 2014). A further four Member States reported mixed road quality and/or a need for additional investment, including: Denmark (FTA, 2013); Austria (European Parliament, 2014); Italy (Ernst & Young, 2012); Poland (OECD, 2016b); Hungary (ASECAP, 2015). This suggests that a high proportion of Member States are facing difficulties in maintaining their road infrastructure. However, the information is not strictly comparable between Member States due to the different methodologies and reporting techniques employed.

Reports of poor road quality are not strongly related to the type of infrastructure charging in place, although they do tend to be associated with Member States in which there is no charging, or use of vignettes. More specifically, Spain is the only Member States with poor road quality and tolls or concessions in place.

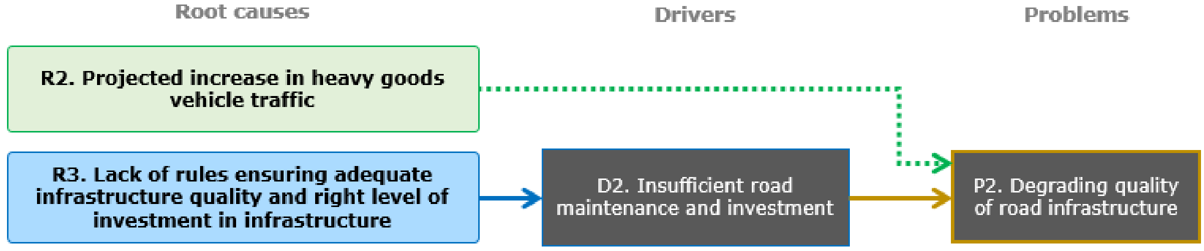
There are many Member States in which the high-level road networks, which are mostly tolled, are of good quality, but free local roads are in poorer condition (e.g. Austria, Germany, France, Italy, Poland).

[5] Ibid 1.

1.4.2. Drivers and root causes of the problem

An extract of the problem tree is shown below, which illustrates the drivers and root causes of this problem area.

Figure 1-5: Drivers and root causes of the problem "Degrading quality of road infrastructure"



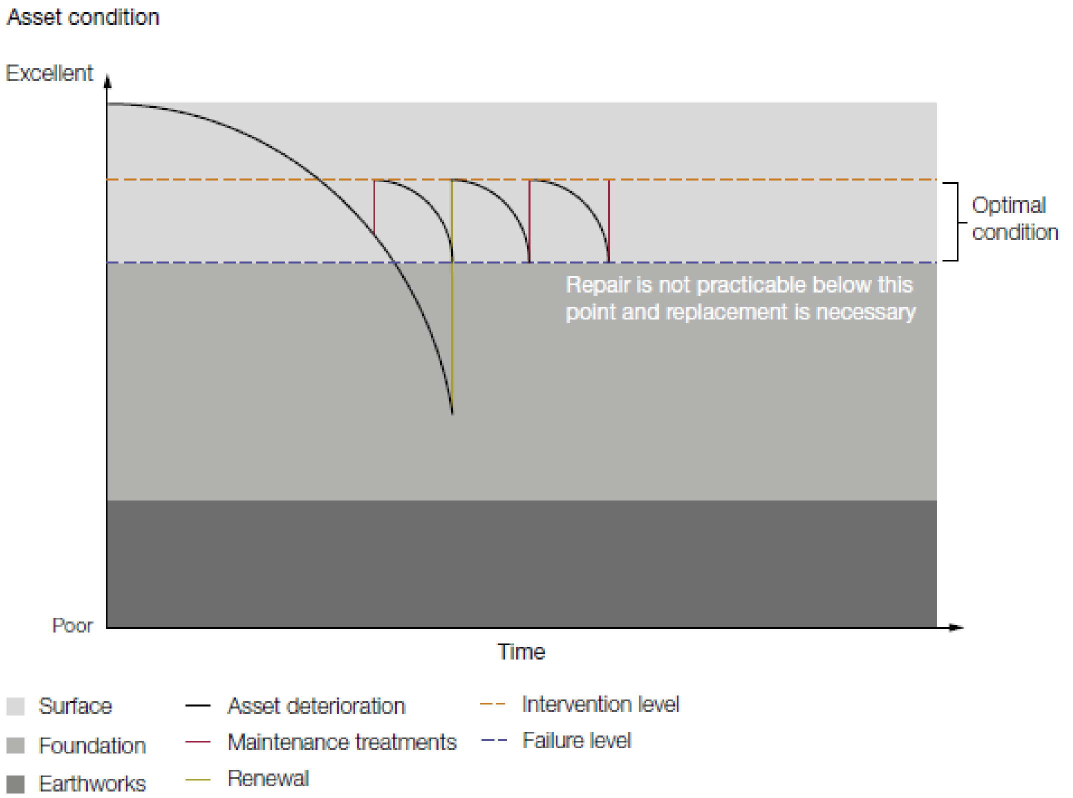
Driver D2: Insufficient road maintenance and investment

In Member States where the roads are recognised as poor (see above), there can be little doubt that there is a clear need for increased road maintenance. Less obvious, but still important, is the case for more maintenance expenditure in Member States that currently report good quality roads – indeed, it takes several years for transport infrastructure to deteriorate to a level that would generate public pressure for more financing. These investment needs are captured in the concept of a "maintenance backlog", which aims to quantify the amount of maintenance and rehabilitation that should have been completed in order to maintain roads in a good condition but has been deferred. Examples of maintenance backlogs are reported in several Member States – all of which currently have reports of overall good road quality:

- **Germany:** the German Institute for Economic Research (DIW) reports a past investment shortfall of almost €4 billion for the maintenance of the transport infrastructure. Assuming that at least this investment is required in order to maintain the transport infrastructure in coming years, and if the cumulative result of years of neglect is also taken into account, the additional annual investment requirement should be at least €6.5 billion (Kunert & Link, 2013). This does not include additional spending that is more difficult to estimate, such as the need for network/capacity expansion in selected areas.
- **UK**: a figure of €9.6 billion for clearing the maintenance backlog in local road network alone (it tends to be the local road network that has been sacrificed to preserve the strategic network). An estimated of 13 years is needed to clear the maintenance backlog (HMT, UK Treasury, 2015).
- **Ireland:** the National Road Authority has highlighted that maintenance works are most effective when carried out on a continuous basis. The Department for Transport, Leisure and Sport quantify this as an annual cost of €1.6 billion up to 2020, the current forecasted expenditure will lead to a shortfall of over €260 million in road investment. (DTTAS, 2014) (CE Delft, 2016).
- **Netherlands** the annual expenditure should be around €600 to €700 million. In the period 1995-2005, the actual expenditures were generally below the steady state level expenditures, implying an underinvestment in road maintenance. Conversely, in the period 2005-2010, expenditures were significantly above steady state levels, which suggests a recovering of overdue maintenance of national roads (CE Delft, 2016).

At times of budget cuts, <u>deferring maintenance</u> and investment in the road sector is a relatively quick way to reduce public spending and this has been pursued by a number of EU countries. For example, case studies on Italy, Spain and the UK revealed significant falls in maintenance expenditure that were reportedly <u>due to budgetary pressures</u> and the need to reduce government spending overall[6] (European Parliament, 2014). Such reductions will lead to increased maintenance needs in the future, since deferring required maintenance is not usually cost-effective in the long run. Figure 1-6 shows road deterioration over time and the effect of maintenance intervention in restoring the condition and prolonging asset lifetimes.

Figure 1-6 Asset Condition Model



Source: NAO, UK (2014)

Figure 1-6 emphasises the point that 'optimal' road condition does not mean 'as new' but rather an acceptable condition (from an outcome point of view, e.g. safety) that avoids costly replacement at a later date. In particular, road surfaces that remain untreated can deteriorate at a faster rate, with the cost of repairs rising disproportionately – deferring preventative maintenance can therefore lead to substantial increases in repair/rehabilitation costs (European Parliament, 2014). If road condition deteriorates to the point that reconstruction is needed, the costs can be three to four times more than if timely maintenance had been adequately funded (PIARC, 2005).

Finally, in terms of future investment needs, there are also increasing needs to invest in new technologies – particularly the rollout of Co-operative Intelligent Transport Systems (C-ITS) and alternative fuel infrastructures, in line with EU strategies.

- **C-ITS:** although the total investments for future EU-wide deployment are quite substantial, the bulk of these costs are due to in-vehicle equipment. The estimated investment needs for roadside infrastructure are relatively small

[6] The Italian operator of national roads (except motorways), ANAS, reported a reduction in the expenditure on road maintenance both in routine and structural budgets, respectively of 16% and 43% in the 2008 to 2012 period. In the UK, funding reduced by 30% between 2011 and 2015 for both the Highways Agency and local governments. In Spain, National government allocation for road infrastructure reduced from €5,989m. in 2008 to €76m in 2012 overall (and from €1,257m in 2009 to €926m in 2012 for maintenance and operational expenditures)

(estimated at €95m p.a. out to 2030); however, this does not guarantee road authorities will easily find and free the budgets required for the support of C-ITS services (Ricardo et al, 2016).

- **Alternative fuels:** there is major uncertainty over investment needs for alternative fuel infrastructure, mainly due to the uncertainties over the size of the future alternatively-fuelled vehicle fleet (i.e. there is a lack of certainty with respect to the future deployment rates for these new technologies in the vehicle fleet). The analytical document supporting the Low-emission mobility strategy shows that in the period 2021-2030, the decarbonisation pathways/scenarios would lead to an average annual increase in investment expenditures of €3 to 5 billion in recharging/refuelling infrastructure compared to developments under current trends and adopted policies by the end of 2014 (i.e. the EU Reference scenario 2016)[7]. There is some uncertainty over which stakeholders will bear the costs of investment, depending on which business models emerge. It is likely that power utility companies, fuel companies, car manufacturers and mobility service provides would have interest in providing charging and/or refuelling stations, with costs recovered through mark-ups on the electricity/fuel prices. However, if recharging/refuelling stations are established by road operators (whether voluntarily or under obligations) the investment costs will likely be recovered through user charges.

Root cause R2: Projected increase in traffic

The problems with road condition will be exacerbated by a projected increase in volume of traffic on the road network. Although HGV traffic has been declining in recent years this is expected to change; under current trends and adopted policies by the end of 2015 an increase in road freight activity of around 35% between 2010 and 2030 (56% for 2010-2050) is projected[8] – see Section 1.3.2 for more detailed data.

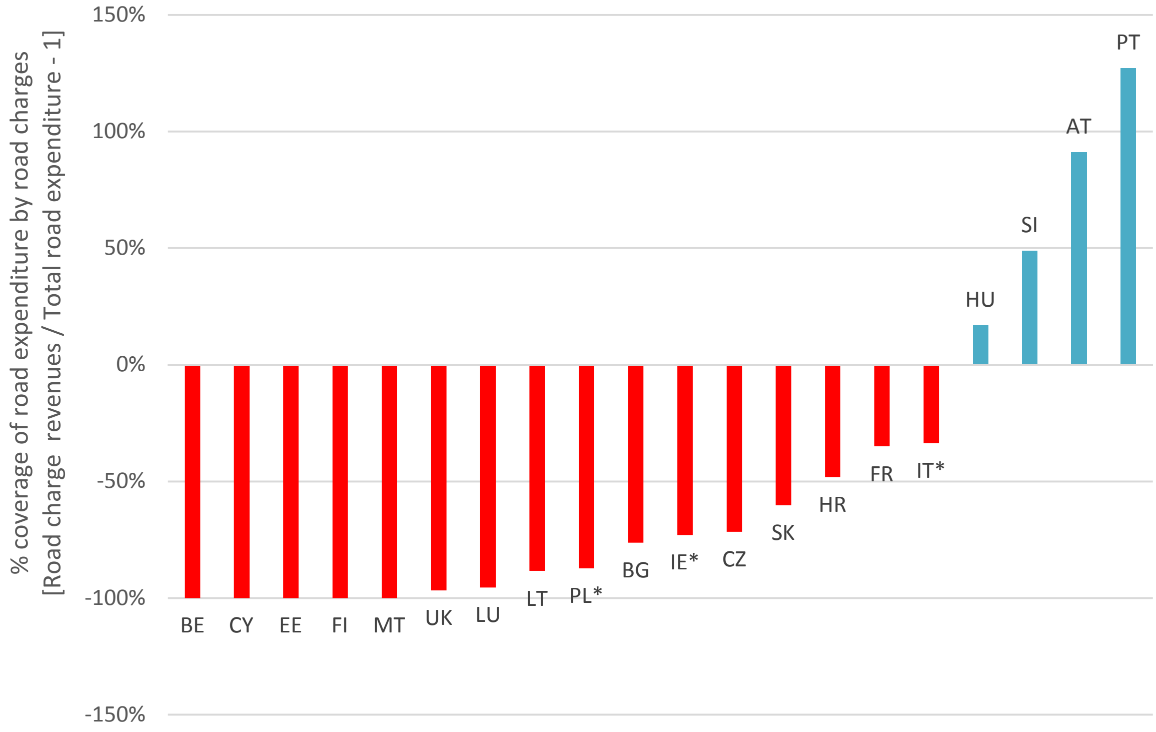
Root cause R3: Lack of rules ensuring adequate infrastructure quality and the right level of investment in infrastructure

The coverage of road expenditure by revenues indicates whether available revenues obtained through infrastructure charges are sufficient to cover countries' expenditures on road maintenance/investment. Figure 1-7 shows that out of the 20 Member States for which sufficient data was available, only four (Portugal, Austria, Slovenia and Hungary) could fully cover expenditures for road maintenance *and* investment over the timeframe (assuming that revenues and expenditures fall into the same timeframe). A further five Member States (Belgium, Cyprus, Estonia, Finland and Malta) did not apply any road charges on the relevant motorway network. Eight countries (UK, Luxemburg, Lithuania, Poland, Bulgaria, Ireland, Czech Republic, Slovakia) had revenues from road charging that were insufficient to meet 50% of the road expenditure for road maintenance and investment.

[7] SWD(2016) 244 final

[8] Ibid 1.

Figure 1-7: Coverage of road expenditure by revenues from road charges over a 3-year timeframe (2012-14)



Sources: Expenditure data for 2012-2014 available from (OECD Stats, 2016b)*; Toll revenue data collected by study team; values identified for 2014 assumed to be applicable to the years 2012 and 2013. Notes: *Assessment over two-year period only, given data availability for the respective countries*

The low coverage of road expenditure by tolls revenues is partly due to the limited scope of vehicles and coverage of the road network, which lead to inefficiencies that impair the capacity to generate sufficient revenues to cover road maintenance expenditure (Section 1.5.2).

Furthermore, the cost coverage analysis does not consider the amounts that *should* be spent on road maintenance/investment to maintain road quality – this was discussed above via the concept of the maintenance gap that has been reported in a number of Member States, although data is insufficient to be able to calculate it at the EU level. The maintenance gap suggests that the cost coverage ratios may underestimate the extent of the problem since <u>the amount being spent currently is insufficient to maintain road quality</u> in an overall good condition.

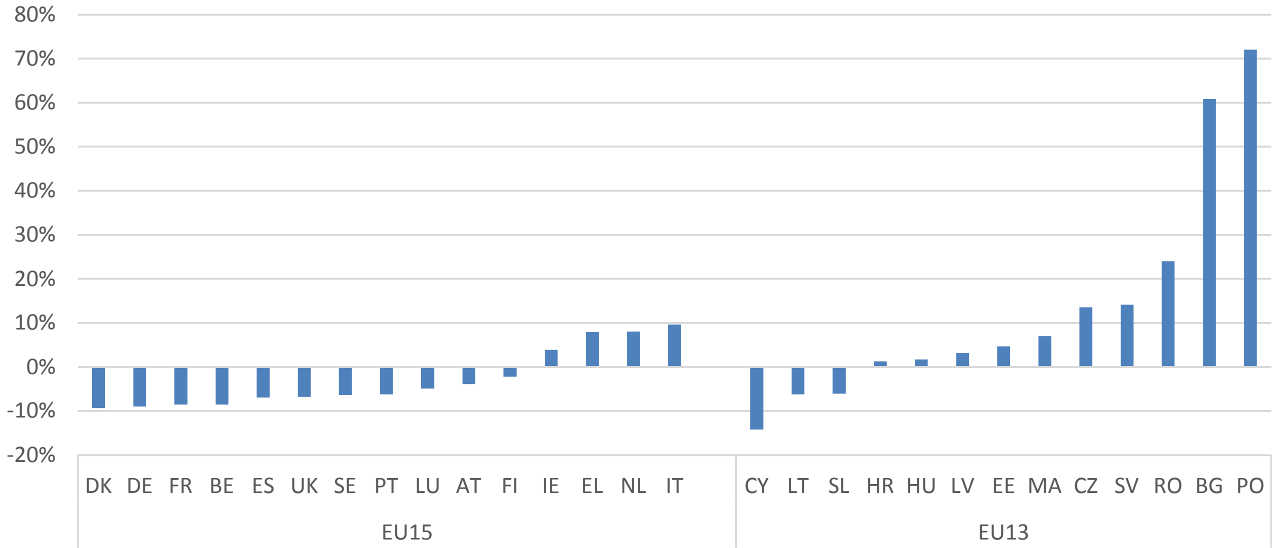
Member States have developed their own approaches to road user charging, including vignettes, tolls, concessions and no charging at all. This leads to varying obligations and expectations to maintain road quality, with a concession typically having a formal obligation to maintain road quality (PWC, 2014), and a toll giving rise to a user expectation of good road quality.

More generally, revenues from all kinds of transport taxes and road charges (e.g. ownership taxes, fuel taxes etc.) at the national level tend to exceed the expenditure on road maintenance and investment by several times. However, since such taxes are generally not earmarked to investment in infrastructure, it is unclear what portion of these taxes, if any, should be treated as an exchange for the service granted by the infrastructure.

1.4.3. How has the problem developed over time

Figure 1-8 shows the trends in (perceived) road quality according to the World Economic Forum (WEF) survey. For the EU-15, on the left of the figure, the changes in the index are minor (with less than 10% change), suggesting a stable situation of relatively high (perceived) road quality in these countries, or a slight deterioration. For the EU-13, the general trend is overwhelmingly positive, especially so for Poland, Bulgaria and Romania, but from a lower level of (perceived) road quality. This suggests a certain level of catching up, although the (perceived) road quality in the EU-13 is still generally lower than the EU-15. Clearly, there are limitations to robustness of the WEF survey results as a measure of road quality, but nonetheless it does provide an indication of the perceived quality of roads.

Figure 1-8 Change in WEF Index between 2011/12 and 2016/17

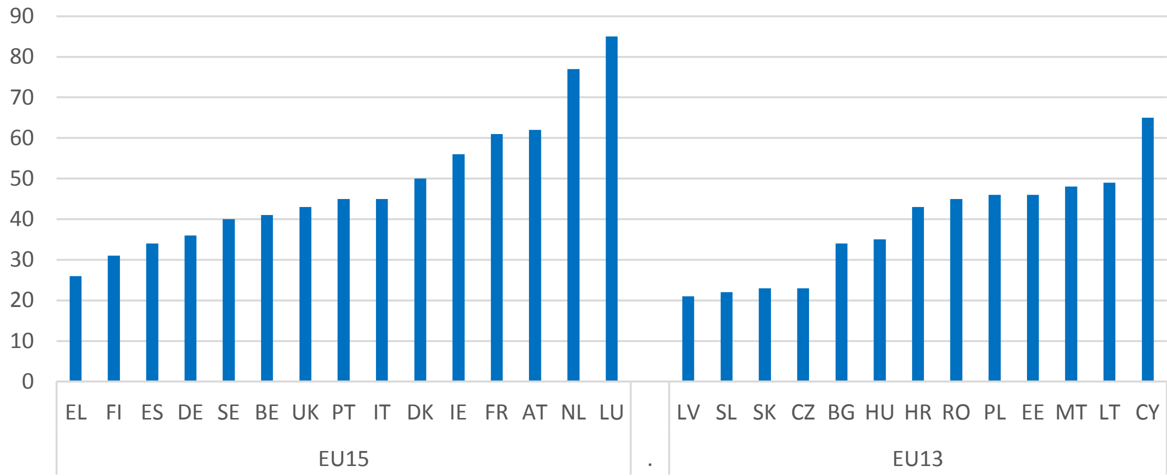


Source; (WEF, 2017)

A separate survey was undertaken by Eurobarometer (Eurobarometer, 2014), which asked European citizens about their views on the priority of improving road quality[9]. These responses are shown in Figure 1-9.

[9] Some 27,868 respondents from different social and demographic groups were interviewed face-to-face at home in their mother tongue

Figure 1-9 Eurobarometer Assessment of Road Quality (2014)

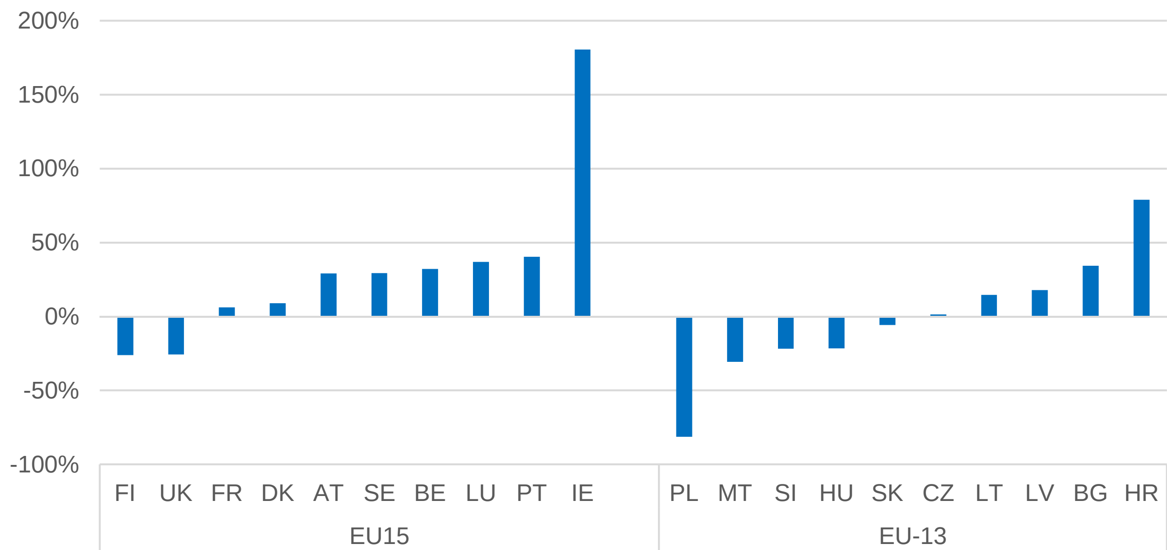


Notes: The answers shown are the complement of the percentage claiming that road quality improvement was a priority as the metric, e.g. if 60% claimed improvement was a priority, this translates into a metric of 40%
Source: (Eurobarometer, 2014)

It can be seen that there is considerable variation in satisfaction with the roads, but the results also suggest a higher level of satisfaction with road quality in the EU-15 compared to the EU-13. Despite the limitations of survey evidence, as discussed previously, the two sources show a high level of correlation between the views of business (WEF) and citizens (Eurobarometer).

Figure 1-10 shows the percentage change in road maintenance expenditure between 2009 and 2014. Although some Member States showed a decrease in maintenance activities following the economic crisis, others showed an increase due to counter-cyclical economic policies (European Parliament, 2014). The impact of the economic crisis on maintenance expenditure has typically been lower in countries where the funding of road infrastructure is not highly dependent on government spending, but rather comes than from other sources such as toll roads.

Figure 1-10: Percentage change in road maintenance expenditure, 2009-2014



Source: (OECD Stats, 2016b)

There is no simple link with the changes in expenditure and the condition of roads – some countries are already suffering from poor road conditions due to historical issues of under-investment or insufficient funds (Bulgaria, Lithuania and Romania). In countries that use concessions to run the major motorways, the concession-run networks are usually of good quality. In Italy the road quality of the tolled network was found to be notably higher than the untolled roads. (Ernst & Young, 2012)

The current profile of annual road maintenance expenditure in Europe has been associated with declining road quality in some (but not all) Member States. Given no action, we can therefore expect a continuation of past trends, of declining road quality and increasing maintenance backlogs, in some Member States. In many cases the 'savings' from delaying maintenance will be false economies, as the roads will degrade to the point where they must be replaced, which is costly compared to ongoing maintenance or repair. These problems will be exacerbated due to expected increases in traffic volumes. For example, Germany is prioritising maintenance over new construction and renewal, partly to account for an expected increase in traffic - distances travelled by road haulage are expected to rise by 18.9% from 2010 to 2030 (GmbH, 2014). The latest plan (2030), which covers the period 2016-2030, allocates €189 billion for infrastructure maintenance (70% of all funds). In contrast, the previous FTIP plan for 2001-2015 earmarked 84 billion euros (56% of funding) (BMVI, 2016).

1.4.4. Potential impacts

Delayed maintenance can also result in several wider costs, as follows:

- **Increased vehicle operating costs:**
    - In Spain, additional vehicle operating costs have been estimated for "moderately deficient road surfaces" as (European Parliament, 2014).
        - Increased fuel consumption of light duty vehicles by 34%, and 12% for heavy duty vehicles
        - Increase in maintenance costs by 185% for light duty vehicles and 129% for heavy duty vehicles
        - Reduction in tyre lifetimes by 66% for light duty vehicles and 10% for heavy duty vehicles
    - In Lithuania, a national study considered that (European Parliament, 2014):
        - Reconstruction of 1 km of urban roads results in 680 thousands litres of fuel saved and 1700 tCO_2 avoided. Similarly, for each kilometre of rural roads, estimates found 300 thousands litres of fuel saved and reductions of 700 tonnes of CO_2 emissions (European Parliament, 2014).
        - The rehabilitation and strengthening of each kilometre of urban roads results in 200 thousands litres of fuel saved and 500 tCO_2 emissions avoided (200 thousands litres of fuel saved and reductions of 500 tonnes CO_2 on rural roads).
    - In Poland, the additional operating cost per km has been estimated for vehicles travelling at 60 km/h as €0.004/km for passenger cars and €0.02km for heavy goods vehicles without trailers (European Parliament, 2014).
- **Risk of accidents:** Poor road surface conditions may increase the risk of accidents due to skidding and also due to road users taking evasive action to

avoid hazards (e.g. potholes), although lower vehicle speeds due to poor conditions may at least partially offset this. For example, an investigation of over 600 truck accidents in seven European countries (France, Germany, Hungary, Italy, the Netherlands, Slovenia and Spain) found that accidents linked to infrastructure conditions represented 5.1% of total accidents. Over 10% of these accidents happened on highways (ETAC, 2007).

- **Emissions of air pollutants**: As roads deteriorate, driving styles and vehicle speeds are likely to change, leading to changes in fuel consumption and levels of emissions – for example, rougher road surfaces and increased start-stop driving may increase emissions (RAC Foundation, 2013). Reduced maintenance may lead to reduced emissions from the maintenance works themselves, as well as fewer vehicles delayed through maintenance sites. The overall impact on air pollution is unclear.
- **Higher noise emissions:** After an initial settling-in period, road surfaces generally generate more road traffic noise as they age. Asphalt pavement noise increases about 3 dBA (this is a doubling of noise levels) after six to seven years of usage and in later years of usage it can increase up to 4 dBA (European Parliament, 2014).
- **Wider economy:** For example, impacts on journey times, productivity and asset value of roads.
    - ADAC (2011) claims that the worsening condition of roads in Germany causes macroeconomic impacts of 4% of German GDP, in the form of increased accidents, vehicle wear and tear and delays due to hampered traffic flow.
    - Calculations for Lithuania indicate net benefits of €2.20 to €2.80 for every Euro invested in road rehabilitation, maintenance and reconstruction (European Parliament, 2014).

1.5. Problem area 3 – Non-level playing field, discrimination of occasional / non-resident road users

1.5.1. Nature of the problem

A key objective of the Eurovignette Directive was to eliminate distortions of competition between transport undertakings in the Member States through a harmonisation of levy systems and the establishment of fair mechanisms for charging infrastructure costs to hauliers[10].

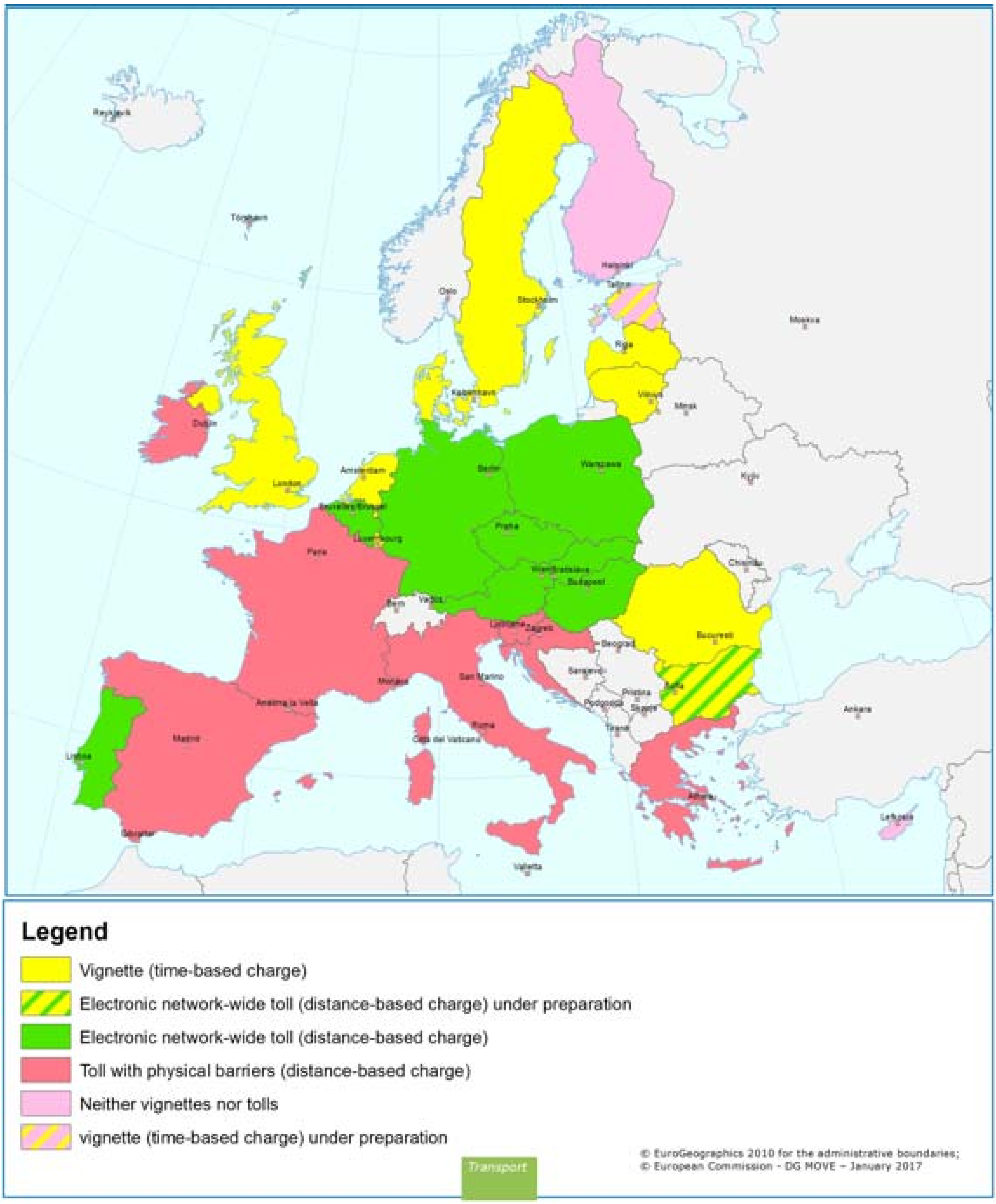
However, there currently exists **a patchwork of charging systems** (see Figure 1-11), which shows that distortions of competition have not yet been eliminated and a level playing field for hauliers across Europe has not been achieved. Out of the 28 EU Member States, four[11] do not have any HGV infrastructure charging systems in place, while time-based charges (vignettes) are applied in nine[12] Member States.

[10] Recital 1 of Directive 1999/62/EC

[11] Cyprus, Estonia, Finland, Malta

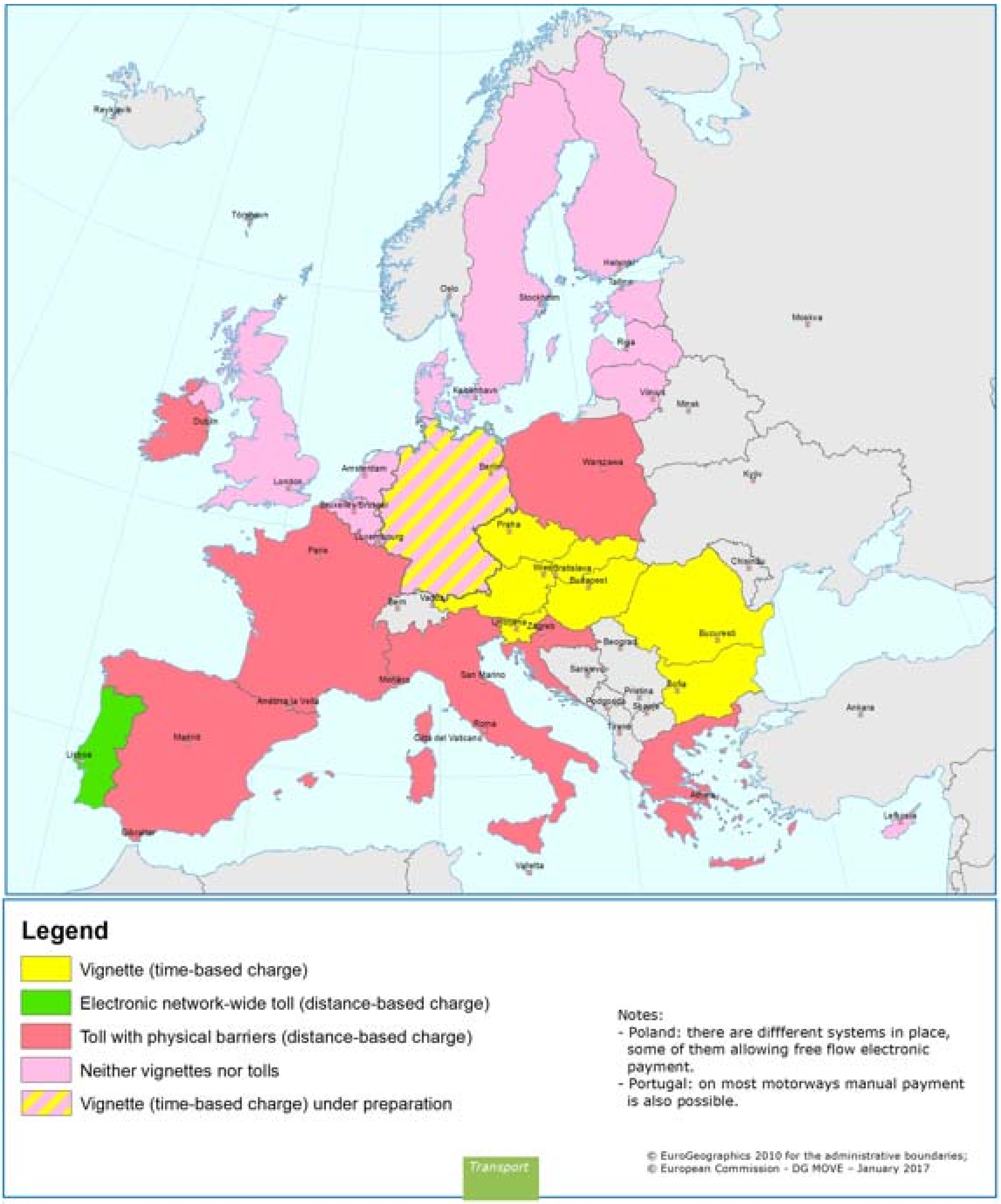
[12] Bulgaria, Denmark, Latvia, Lithuania, Luxembourg, The Netherlands, Romania, Sweden, UK

Figure 1-11: Charging of heavy goods vehicle in the EU in 2017



Similarly for cars, Figure 1-12 shows the un-level playing field in terms of whether or not there is a charging system in place, as well as whether it is a vignette or toll.

Figure 1-12: Charging of passenger cars in the EU in 2017



The Eurovignette Directive also specifies **that tolls and user charges may not discriminate, directly or indirectly, on the grounds of the nationality of the haulier or the origin or destination of the vehicle**[13]. In spite of this, the price of short-term vignettes for light duty vehicles have been found to be disproportionally high compared to long-term (annual) vignettes – i.e. the difference between the daily price of a short-term vignette and an annual vignette cannot be explained by a difference in the relative administrative costs[14] (Booz & Co, 2012a); (European Commission, 2012). This

[13] Article 7(4) of Directive 1999/62/EC

penalises non-resident drivers who are more likely to buy short-term vignettes. As shown in Table 1-1, a sizeable share of users purchase short-term vignettes.

Table 1-1: uptake of annual passes for passenger cars and EPFC for selected vignette countries

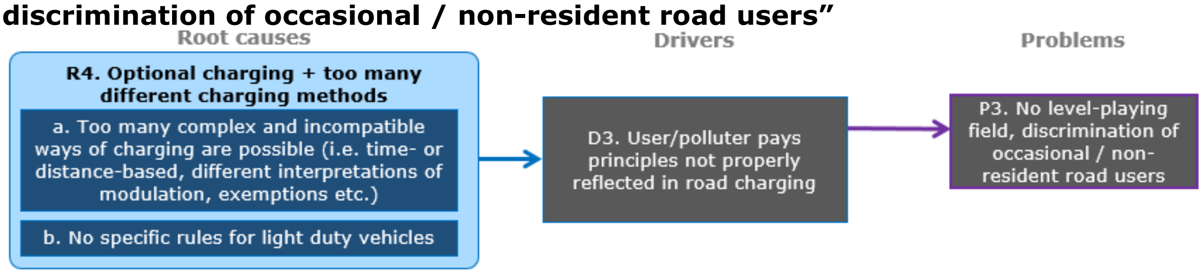
Country	Take-up of annual pass by car owners	Estimated proportion of foreign car journeys on main routes
Austria	70%	26%
Czech Republic	45%	33%
Hungary	7%	19%
Slovenia	87%	39%
Slovakia	49%	27%

Source: (ITC, 2013)

1.5.2. Drivers and root causes of the problem

Figure 1-14 illustrates the drivers and root causes of this problem area.

Figure 1-13: Drivers and root causes of the problem "No level-playing field, discrimination of occasional / non-resident road users"



Driver D3: User/polluter pays principles not properly reflected in road charging

In the context of the problem of an un-level playing field, it is worth reviewing the effective per-km charges levied in different Member States to demonstrate the substantial differences – this illustrates the lack of a level playing field in Europe. Table 1-2 shows the infrastructure charges per kilometre for different reference vehicles across Europe. While a certain price differential can be expected between Member States with different living costs, the variation in infrastructure charges observed might be caused by differences in applying the user pays principle. More significant is the difference between those Member States applying tolls versus vignettes, where it can be seen that the effective per-km charge imposed under vignettes is significantly lower than for tolls, suggesting that vignettes do not sufficiently cover user/polluter pays principles. Furthermore, a number of Member States[15] apply no user charging (European Commission, 2015).

[14] A certain differentiation is justified based on the greater relative importance of administrative costs in the case of short-term vignettes and differences in the level of usage (i.e. short-term vignette holders are likely to use the road network more intensively than annual vignette holders who may not use their vehicles for many days).

[15] Cyprus, Estonia, Finland, Malta

Table 1-2: Road user charges for reference vehicles by Member State and reference routes by Member State, 2016, PPP adjusted

Main type (for HGVs)	Member State	Charges [Euro/km], PPP adjusted				
		Cars	Vans	HGV1 3.5 – 12t	HGV2 >12t	Buses & coaches
Network-wide tolls	Austria*	0.0171	-	0.2235	0.3352	0.3352
	Belgium	-	-	0.0684	0.1146	-
	Czech Republic*	0.0108	0.0132	0.1810	0.2612	0.0602
	Germany	-	-	0.1340	0.1380	-
	Hungary*	0.0279	0.0254	0.2026	0.2951	0.0265
	Poland[16]	-	-	0.0553	0.0746	0.0553
	Slovakia*	0.0100	0.0133	0.1118	0.2624	0.0838
Concession tolls	Croatia	0.1162	0.1718	0.2605	0.3796	0.3796
	France	0.0772	0.1185	0.2270	0.2270	0.2270
	Greece	0.0622	0.0622	0.1565	0.2194	0.2194
	Italy	0.0678	0.0692	0.0935	0.1392	0.0935
	Portugal	0.0960	0.1717	0.2201	0.2446	0.2201
	Slovenia*	0.0220	0.0229	0.1803	0.3016	0.1803
	Spain	0.1073	0.1073	0.1721	0.2176	0.1721
Vignettes	Bulgaria	0.0100	0.0211	0.0122	0.0202	0.0408
	Latvia	-	-	0.0150	0.0231	0.0252
	Lithuania	-	0.0548	0.0151	0.0210	0.0893
	Romania	0.0056	0.0307	0.0114	0.0330	0.0453
	United Kingdom	-	-	-	0.0131	-
	Denmark	-	-	-	0.0276	-
	Luxembourg	-	-	-	0.0232	-
	Netherlands	-	-	-	0.0186	-
	Sweden	-	-	-	0.0299	-

*Notes: * vignettes for LDVs*
Source: Eurostat, AECAP member statistics and national road user charging websites

Furthermore, there is an un-level playing field in terms of the scope of road user charges, both in terms of the coverage of the road network and the vehicles that are charged. Table 1-3 shows the share of the total national motorway network covered by charging systems that apply to HGVs in Europe. Distance-based tolls have been introduced in 18 Member States, and only cover the whole motorway network in eight

[16] Figures based on Warzaw-Lodz route and does not include the A1 route which has different toll rates

countries. Furthermore, there are only a few Member States (e.g. Belgium or Hungary) where national roads, including those parallel to motorways are included in the tolled network.

Table 1-3: Scope of infrastructure charging systems for HGV network – Share of main network that is being tolled

Member State	Total motorway length (km)	Share of motorway that is charged for HGVs*	
		Time OR distance-based	*of which Distance-based (i.e. tolls)*
Austria	2,185	100%	100%
Belgium	1,763	100%	100%
Bulgaria	734	100%	0%
Croatia	1,290	100%	100%
Cyprus	257	0%	0%
Czech Republic	3,404	42%	42%
Denmark	1,216	100%	0%
Estonia	140	0%	0%
Finland	810	0%	0%
France	11,560	79%	79%
Germany	12,949	100%	100%
Greece	1,558	100%	100%
Hungary	1,180	100%	100%
Ireland	897	39%	39%
Italy	6,751	89%	89%
Latvia	1,674	90%	0%
Lithuania	1,948	87%	0%
Luxembourg	152	100%	0%
Malta	163	0%	0%
Netherlands	2,678	100%	1%
Poland	1,552	100%	100%
Portugal	3,065	96%	96%
Romania	683	100%	0%
Slovenia	1,499	40%	40%
Slovakia	1,943	100%	100%
Spain	14,981	23%	23%
Sweden	2,088	100%	1%
United Kingdom	3,760	100%	1%
Total	**82,880**	**76%**	**58%**

*Notes: * some countries may apply exemptions (e.g. for HGVs below 12t) or base their system on vehicle characteristics other than weight (e.g. number of axles or vehicle height);*

Sources: Eurostat, AECAP member statistics and national road user charging websites

Table 1-4 shows that there are also differences in terms of the vehicle types covered. While there are some countries that charge all vehicle types (e.g. Bulgaria, Croatia, Romania), lighter HGVs (those with permissible laden weight below 12t) are exempted from the application of the Eurovignette Directive in other Member States (e.g. Denmark, Germany, Luxembourg, the Netherlands, Sweden and the UK).

Table 1-4: Scope of infrastructure charging systems across Europe – Vehicle categories covered

Type of system (for HGVs >12t)	Member State	Vehicle types				
		Goods vehicles >12t	Goods vehicles >3.5t	Goods vehicles <3.5t	Buses & coaches	Car charges
Vignettes	Bulgaria	✓	✓	✓	✓	vignette
	Denmark	✓	×	×	×	tolls for bridges
	Latvia	✓	✓	×	✓	×
	Lithuania	✓	✓	✓	✓	×
	Luxembourg	✓	×	×	×	×
	Netherlands	✓	×	×	×	tunnel tolls
	Romania	✓	✓	✓	✓	vignette
	Sweden	✓	×	×	×	tunnel tolls
	United Kingdom	✓	×	×	×	Specific m'ways, bridges and tunnels
Network-wide tolls	Austria	✓	✓	vignette	✓	vignette
	Belgium	✓	✓	×	×	tunnel tolls
	Czech Republic	✓	✓	vignette	✓	vignette
	Germany	✓	✓ (>7.5t)	×	×	tunnel and city tolls
	Hungary	✓	✓	vignette	vignette	vignette
	Poland	✓	✓	✓	✓	concession m'ways (excl. national roads)
	Slovakia	✓	✓	vignette	✓	vignette
Concession tolls	Croatia	✓	✓	✓	✓	concession m'ways
	France	✓	✓	✓	✓	concession m'ways
	Greece	✓	✓	✓	✓	concession m'ways
	Ireland	✓	✓	✓	✓	✓
	Italy	✓	✓	✓	✓	concession m'ways & tunnels
	Portugal	✓	✓	✓	✓	concession m'ways
	Spain	✓	✓	✓	✓	concession m'ways
	Slovenia	✓	✓	vignette	✓	vignette

Sources: Eurostat, AECAP member statistics and national road user charging websites

The lack of consistency across Europe in terms of the partial coverage of roads and the inclusion of different vehicle types means that there is not a level playing field as regards road user charging in the Union. Across the EU, only 58% of the motorway network is covered by some type of distance-based charging, whereas this increases to 76% if all types of charging (including vignettes) are considered.

Root cause R4: Optional charging and too many different charging methods

a. Too many complex and incompatible ways of charging are possible

The Eurovignette Directive leaves it to the Member States to decide whether or not a road charging system should be introduced, which has resulted in a patchwork of different systems (as already shown in Figure 1-11). In addition, the Directive leaves a lot of room for different interpretation of charging methods, which has resulted in a wide range of different effective per-km charges across Europe (see Table 1-2). Together, this results in a patchwork of different charging systems.

b. No specific rules for light duty vehicles

For HDVs, the Eurovignette Directive sets maximum charges for daily vignettes, as well as the maximum relative price of daily/weekly/monthly vignettes. However, there are no similar provisions for LDVs and so in 2012, the Commission published a "*Communication on the application of national road infrastructure charges levied on light private vehicles*" (European Commission, 2012). Although the Communication aimed to set out the framework in which a vignette system would guarantee the respect of fundamental principles of EU law, there are no legally binding rules for proportionality of LDV vignette pricing and disproportionate pricing persists.

1.5.3. How the problem has developed over time and how it is expected to develop without further action

In terms of the existing **patchwork of charging systems,** the situation contributes to an un-level playing field despite a gradual evolution from vignette systems towards network-wide distance-based electronic tolling over time. In some cases advanced plans to adopt electronic tolling have for various reasons had to be abandoned or postponed. This was the case in, for example, Denmark, France and the Netherlands. Given the flexibility afforded Member States in the current provisions of the Directive, it can be reasonably expected that the un-level playing field will persist over time without further action.

Regarding **vignettes for LDVs,** there are vignettes for passenger cars are in place in seven Member States (Austria, Czech Republic, Bulgaria, Hungary, Romania, Slovakia, Slovenia) and vignettes for vans are in place in seven Member States with vignettes in place (Austria, Bulgaria, Czech Republic, Lithuania, Romania, Slovakia and Slovenia) (European Commission, 2015).

At the time of writing, a planned vignette in Germany is on hold as the Commission believed the system to be discriminatory and has launched an infringement procedure in 2015 (European Commission, 2016c).[17] A press release published by the EC on 1st December 2016 stated that the European Commission and Germany have reached an agreement on a fair and non-discriminatory road charging scheme. The case, however, will only be formally closed when the amending German legislation taking into account the Commission's legal concerns is adopted and promulgated. (European Commission, 2016d).

Table 1-5 shows that the ratios of short-term vignette prices to long-term vignette prices can range from 2.51 (Hungary) to 8.34 (Bulgaria)[18]. By way of comparison, the limits set

[17] The Commission believes that the German scheme discriminates against drivers from other Member States for two reasons. First, because German users will not effectively pay the road charge, as their vehicle tax bill will be reduced by the exact amount of the road charge. Second, because the price of short-term passes is disproportionally high for certain vehicles.

[18] The limits for HDVs set out in the Eurovignette Directive

out for HDVs in the Eurovignette Directive state that the monthly rate shall be no more than 10 % of the annual rate, the weekly rate shall be no more than 5 % of the annual rate and the daily rate shall be no more than 2 % of the annual rate. Applying the maximum amounts, the ratio between the daily and the annual vignette ranges from 1.80 to 5.04 depending on the EURO class and the number of axles for the vehicle.[19] Out of the seven Member States that apply light-duty private vehicle vignettes, five Member States (Bulgaria, Czech Republic, Romania, Slovakia, Slovenia) show daily/annual price ratios for their passenger car vignettes that are greater than 5:1, which may be considered disproportionate as compared to the limits for HGVs. For vans, five Member States (Bulgaria, Czech Republic, Lithuania, Slovakia, Slovenia) show pricing of short-term vignettes that could be considered disproportionate.

Table 1-5: Vignette prices for light duty vehicles across Member States, 2016, PPP adjusted

Member State	Vignette prices [€/day] PPP adjusted		Ratio of average daily price between shortest term and longest term vignette
	Shortest term vignette (number of days)	Longest term vignette (number of days)	
Passenger cars			
Austria	€8 (10)	€80 (365)	3.75
Bulgaria	€7 (7)	€47 (365)	8.34
Czech Republic	€10 (10)	€50 (365)	7.44
Hungary	€9 (10)	€130 (365)	2.51
Romania	€3 (7)	€26 (365)	5.59
Slovakia	€9 (10)	€47 (365)	7.30
Slovenia	€15 (7)	€110 (365)	7.11
Vans			
Austria	€8 (10)	€80 (365)	3.75
Bulgaria	€7 (7)	€47 (365)	8.34
Czech Republic	€10 (10)	€50 (365)	7.44
Hungary	€9 (10)	€130 (365)	2.51
Lithuania	€6 (1) / €13 (7)	€283 (365)	7.20* / 2.4
Romania	€6 (7)	€89 (365)	3.26
Slovakia	€9 (10)	€47 (365)	7.30
Slovenia	€28 (7)	€205 (365)	7.11

** Ratio of the daily vignette price (in line with the relative price set in the Directive)*
Source: Member State vignette websites

[19] Calculated based on the updated values provided in Directive 2006/38/EC: daily vignette = 11 EUR for all vehicle categories, annual vignette = 797 EUR (EURO IV and less polluting, 3 axles max) to 2233 EUR (EURO 0, four axles and more)

Table 1-6 compares the price ratios in 2012 and 2016, showing that the problem of disproportionate prices has persisted over time (despite the Communication in 2012) – meaning that it can be expected that the problem will not resolve itself without legally binding rules. Price ratios have increased for Bulgaria, Romania and Slovakia between 2012 and 2016, while they have decreased for others (e.g. Austria, Czech Republic, Hungary and Slovenia). Broadly speaking, it is clear that countries that priced short-term vignettes above a proportionate ratio of 3-4 in 2012 still have ratios above this level in 2016 (i.e., pricing remained disproportionate). In addition, the majority of countries shown have disproportionate prices.

Table 1-6: Vignette price ratios for light private vehicles comparison 2012 and 2016

Member State	2012 Assessment Ratio of average daily prices for short-term vignettes compared to long-term vignettes	2016 Assessment Ratio of average daily prices for short-term vignettes compared to long-term vignettes
Austria	3.8	3.8
Bulgaria	7.9	8.3
Czech Republic	7.7	7.4
Hungary	3.7	2.5
Romania	5.4	5.6
Slovakia	7.1	7.3
Slovenia	8.2	7.1

Source: (Booz & Co, 2012a) and Member State vignette pricing websites

1.5.4. Potential impacts

The partial tolling of the network, covering only a share of vehicles, and the wide range of effective per-km prices seen in Table 1-2 shows that there is not a level playing field in terms of road user charges in Europe. To encourage the rational use of scarce resources and to avoid distortions in international trade and investment, the 2011 White Paper on Transport (European Commission, 2011a) advocates that Europe’s transport charges and taxes must be restructured in the direction of a wider application of the ‘polluter-pays’ and ‘user-pays’ principle. Such charges should reflect at least the cost of infrastructure, congestion, air and noise pollution, in order to align market choices with sustainability requirements. Distance-based road pricing is considered to be the single best instrument to internalise the cost of air and noise pollution, congestion or road damage (EEA, 2015). Road user charges in the form of time-based vignettes, on the other hand, are not directly linked to the use of infrastructure and to the generation of externalities

The other potential impact is discrimination against occasional users due to disproportionately costly short-term vignettes. Such pricing policies can amount to a barrier to the free movement to of people, by operating to the detriment of nationals from other Member States. For example, the Austrian Pfändertunnel is often used for transit from Germany to Switzerland and it is reported that many drivers complain about the disproportionate cost of travelling for a few km on this segment, for which they have to pay for a 10-day vignette (the minimum time period available) (ACE Drivers' Association, 2013). For some time a “Korridor vignette” was introduced for a price of €2, which was reportedly considered fair by drivers, but it was abolished in 2013 (ACE Drivers' Association, 2013). German drivers have also complained about the absence of Korridor vignette when coming from Bavaria to Salzburg, situated straight after the border (ACE Drivers' Association, 2013). Complaints have also been registered about Slovenia, where there is no daily vignette and drivers consider it disproportionately costly to pay €15 (weekly vignette) for a single trip (ITC, 2013); (European Parliament, 2016).

1.6. Problem area 4 – Inefficient use of the transport system

1.6.1. Nature of the problem

The introduction of the Eurovignette Directive aimed to improve the efficiency of the transport system – and in particular, the 2011 amendment aimed to help reduce the negative impacts of transport such as congestion, air pollution and noise emissions. However, issues with inefficiencies of the transport system still exist across Europe.

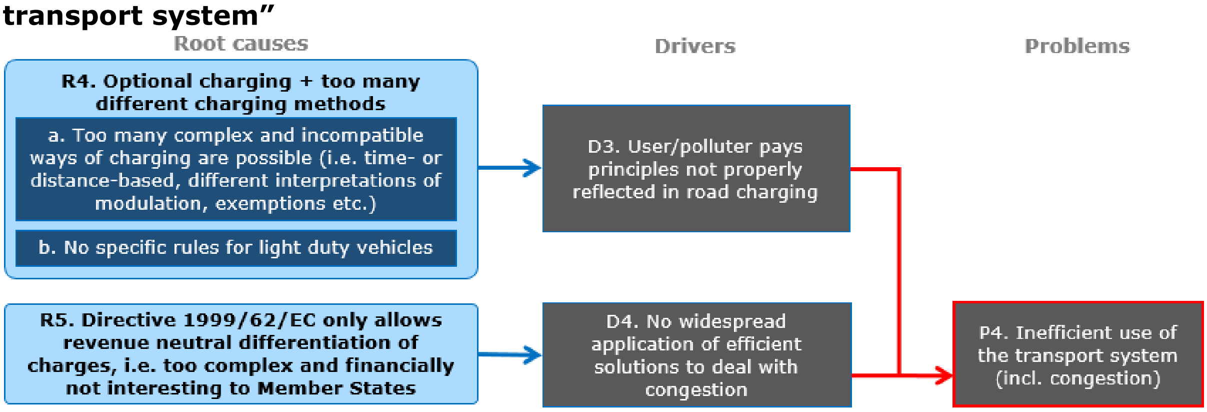
The 2011 Transport White Paper has highlighted congestion as a major concern. Total delay costs from congestion (urban and interurban) in the EU accounted for slightly more than 140 billion €/year in 2015, equivalent to 1% of GDP (Fermi & Fiorello, 2016). Although the phenomenon concentrates around urban areas, because of the length and capacity of the interurban network, including ring roads and urban motorways, a substantial part of the costs (around 20% on average) are attributable to interurban traffic (Fermi & Fiorello, 2016). Congestion outside of urban areas is also becoming more widespread. For example, analysis of TomTom in-vehicle navigation systems carried out by the JRC (2012) confirms that congestion mainly affects urban areas, but that it also extends to a few key bottlenecks in Europe. Yet, despite the significant costs that arise from congestion, the use of time-differentiated charges to help control it is limited in Europe.

Furthermore, existing pricing schemes still show little coherence with the principle of full application of user/polluter pays principles: distance-based infrastructure charges are typically not applied to the full network, and only apply to a subset of vehicle types (as discussed previously in Section 1.5.1). As a result, infrastructure charging is not applied in the most effective way so as to reduce congestion or reflect the real costs of road use. If users are provided with inconsistent price signals, they make decisions based on incorrect incentives leading to welfare losses.

1.6.2. Drivers and root causes of the problem

An extract of the problem tree is shown in Figure 1-14, which illustrates the drivers and root causes of this problem area. These are explained in full below.

Figure 1-14: Drivers and root causes of the problem "Inefficient use of the transport system"



The three drivers stem from the fact that correct price signals cannot be achieved if the charges are not modulated in a way that creates the right incentives for road users – whether this be in terms of congestion reduction or choice of more environmentally efficient vehicles - nor if the charges are applied only to part of the network/vehicle fleet. More precisely, road infrastructure charging systems in order to foster efficient use of transport system should be based on correct price signals adjusted to take into account different vehicle characteristics (e.g. axle load) to adequately reflect the wear and tear of the infrastructure. In order to efficiently tackle congestion, charges should be applied according to the time of day, type of day (i.e. weekday or weekend) and season. Finally, road charges should be differentiated based on the vehicles' environmental performance to create incentives for the purchase and the use of cleaner vehicles.

Driver D3: Road charges do not reflect user/polluter pays principle

The incomplete application of user/polluter pays principles is evidenced by three main issues:

1. **The use of time-based user charges (vignettes),** as already shown in Section 1.5.2 are not directly linked to the use of infrastructure and to the generation of externalities. As a consequence, externalities are in principle adequately reflected only on the sections of the main road network where distance-based charges apply.
2. **Only partial tolling of the network, for only a share of vehicles**
3. **Lack of uptake of external cost charges as permitted in the Directive**

Regarding the second point, as discussed in Section 1.5.2, there is only partial coverage of road user charges in Europe. This not only means that the polluter / user pays principle is not fully applied, but might also result in the diversion of traffic to alternative, un-tolled roads.

The potential negative impacts are twofold: first, users do not pay for the damage they cause (see Driver D4 below for a more extensive discussion of this aspect); second, in cases where HGVs may be diverted to run on secondary roads, which are not always designed for this kind of traffic and therefore this may worsen the effects of congestion, air pollution, noise and infrastructure damage (Baumgarten & Middelkamp, 2015). This also means that less revenue is collected on toll roads specifically designed and built to carry such traffic.

The extent of the above problems depends on the specific country context. For example, in Austria, the traffic diversion is considered by ASFINAG to be 'not excessive' and is estimated at 2% of total traffic at a national level. This low level might also be due to the country's topology and difficulties in taking alternative roads in mountain areas (ITC, 2013). In Latvia, it has shown that the traffic flow on national and regional roads has grown by1.1% and 3.2% respectively. However, a clear link with the Latvian vignette cannot be established (Permanent Representation of the Republic of Latvia to the EU, 2016). Conversely, the effect of route switching/diversion is most pronounced where a dense secondary network of good quality roads adjacent to the motorways exists and where such a secondary network is not already congested (Ricardo-AEA et al, 2014a). In Germany, Baumgarten and Middelkamp (2015) conclude that a shift of accidents to alternative non-tolled roads can be observed in the 1999-2010 timeframe. On the other hand, a study from the German Bundestag (Deutscher Bundestag, 2013) concludes that diversion traffic has not been a comprehensive/nationwide issue (e.g. an increase in toll charges in 2009 is not seen to have had an impact on 95% of the national roads). Overall, the problem of traffic diversion due to the introduction of, or changes to, charging systems appears to be challenging to assess. The available literature suggests that problems may pertain under specific circumstances, for selected parts of the network. However, the available evidence is limited.

Finally, the Directive allows for tolls to comprise both an infrastructure component and an external cost component. An **infrastructure charge** can be levied for the purpose of recovering the costs of infrastructure maintenance, operation and development. The Directive provides a calculation methodology for developing suitable charging levels and sets maximum levels of time-based charges. The provisions however, state that Member States may choose to recover only a percentage of the infrastructure costs[20]. It transpires that in practice, most Member States do not recover the full infrastructure costs from road charging, due to the need to set charges that are politically acceptable (Ricardo-AEA et al, 2014a).

Member States are required to vary infrastructure charges according to vehicle-specific EURO emission classes in a revenue neutral way[21]. Furthermore, Directive 2011/76/EU introduced changes that allowed Member States to apply an additional **external costs charge** for noise and air pollution. This charge is collected for the purpose of recovering the costs incurred in a Member State related to traffic-based air pollution and/or traffic-based noise pollution on top of infrastructure costs.

However, the tolls currently in place do not make full use of these options. Table 1-7 shows that most Member States apply a differentiation by EURO standard as required; however, in the case of concessions, this is not required until the contracts are renewed[22] - the majority of existing contractors will not be renewed until after 2025 (Ricardo-AEA et al, 2014a). Differentiation by time of day to protect sensitive areas from noise is only applied in few countries (e.g. Austria, Slovenia).

Table 1-7: Overview of road charging differentiation according to air and noise pollution in Europe - HGVs

Type	Member State	Differentiation by	
		EURO standard	Noise
Vignettes	Bulgaria	✓ (since 2008)	×
	Denmark	✓ (since 2001)	×
	Latvia	✓	×
	Lithuania	✓	×
	Luxembourg	✓ (since 2001)	×
	Netherlands	✓ (since 2001)	×
	Romania	×	×
	Sweden	✓ (since 2001)	×
	United Kingdom	×	×

[20] Article 7b(2) of Directive 2011/76/EU

[21] Infrastructure charge differentiation according to EURO emission classes is mandatory: although not applicable if an external cost charge is applied. Member States may derogate from the requirement of varying infrastructure charges in the case of existing concession contracts (until the contract is renewed) or in other specific situations covered by Article 7g Paragraph 1

[22] Member States may derogate from the requirement of varying infrastructure charges in the case of existing concession contracts (until the contract is renewed) or in other specific situations covered by Article 7g Paragraph 1

Type	Member State	Differentiation by	
		EURO standard	Noise
Network-wide tolls	Austria*	✓ (since 2010)	✓
	Belgium	✓ (since 2016)	×
	Czech Republic	✓	×
	Germany*	✓ (since 2005)	×
	Hungary	✓ (since 2013)	×
	Slovakia	✓ (since 2010)	×
	Poland	✓ (since 2011)	×
Concession tolls	Croatia	×	×
	France	✓ (selected tunnels)	×
	Greece	×	×
	Italy	×	×
	Ireland	×	×
	Portugal	×	×
	Spain	×	×
	Slovenia	✓ (since 2010)	✓ (day/night)

** Austria and Germany apply external cost charging*
Source: Member States road user charging websites

The Directive sets out maximum charges to recover the cost of air pollution and noise that can be applied, yet this option is hardly taken up in existing systems. Germany is applies such an external cost charge for air pollution (introduced on 1st January 2015). Table 1-8 shows the toll rates used, which match the maximum permissible external cost charge limits for interurban roads (as set out in the 2014 update of Annex IIIb of Directive 2011/76/EU[23]). Only for Euro 0 vehicles the charges are lower than the maximum limit of 12.5 cents/km. Due to the low number of vehicle in the Euro 0 and Euro 1 vehicle categories[24], they are combined in one category are charged 8.3 cents/km (the maximum limit for Euro 1 vehicles). The Federal Ministry of Transport and Digital Infrastructure (BMVI) also highlighted that Germany supports the repeal of any caps on external costs charging.

Table 1-8: HGV external cost charges, covering air pollution costs per kilometre from 1st October 2015, Germany

Emission category	Toll rate [cents], Costs for air pollution
Euro VI	0

[23] Update of Annex II and of Tables 1 and 2 of Annex IIIb with respect to applicable euro values in accordance with Article 10a of Directive 1999/62/EC: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014XC0218(01)

[24] According to the BMVI, only 0.07% of the fleet in 2016 were Euro 0 and Euro I

Emission category	Toll rate [cents], Costs for air pollution
EEV 1, Euro V	2.1
Euro IV, Euro III + with particulate reduction class 2	3.2
Euro III, Euro II + with particulate reduction class 1	6.3
Euro II	7.3
Euro I, Euro 0	8.3

Source: (Toll Collect, 2016). These charges are independent of the number of axles of the vehicle and the type of road (BMJV, 2015).

In addition, Austria introduced a system that takes air pollution and noise into account on 1st January 2017. Table 1-9 provides an overview of the charges for air pollution, which depend on the number of axles for the vehicle. The values for vehicles with 2 axles are multiplied by a factor of 1.4 for vehicles with 3 axles, and 1.6 for vehicles with 4 axles or more. These multiplication factors are based on the average emission factors for axle categories as set out in the EC "Handbook for external costs" (Ricardo AEA, et al., 2014). For 4+ axle vehicles the Austrian charges attain the maximum permissible charge rates.

Table 1-9: HGV external cost charges, covering air pollution costs per kilometre from 1st January 2017, Austria

Emission category	Toll rate [cents], Costs for air pollution 2 axles	Toll rate [cents], Costs for air pollution 3 axles	Toll rate [cents], Costs for air pollution 4+ axles
Euro VI	---	---	---
EEV, Euro V	1.37	1.92	2.19
Euro IV	2.00	2.80	3.20
Euro 0 - III	4.00	5.60	6.40

Source: (BMVIT, 2016b), *Interview input from BMVIT*

The noise pollution charges are presented in Table 1-10, which again vary according to the number of axles. The values for 2 axle vehicles are multiplied by 2.3 for 3 axle vehicles, and 2.0 for 4+ axle vehicles. The multiplication factors reflect the different contribution of axle categories to the average noise level. For the vehicles with 4+ axles, the maximum permissible charges for interurban roads are reached.

Table 1-10: HGV external cost charges, covering noise costs per kilometre from 1st January 2017, Austria

Time	Toll rate [cents], Costs for noise 2 axles	Toll rate [cents], Costs for noise 3 axles	Toll rate [cents], Costs for noise 4+ axles
Day	0.07	0.16	0.20
Night	0.11	0.25	0.32

Source: (BMVIT, 2016b), *Interview input from BMVIT*

Driver D4: No widespread application of efficient solutions to deal with congestion

Differentiation of infrastructure charges offers a tool to manage congestion, provided that the differentiated tolls give a clear and meaningful price signal to road users to modify their behaviour and to avoid congested road sections during peak periods.

Despite the consensus on its positive impact on social welfare, congestion pricing is not widely applied on the interurban network. Due to their time-based nature (i.e. valid for a year, a month, a day or intermediate intervals), vignettes do not allow for a differentiation by time of the day to combat congestion. Even in the case of tolls, examples of time-varying charges are limited. As discussed above the Directive only allows revenue-neutral charging, which might be one of the reasons for the limited use of this option. The Czech Republic introduced time-varying charges to help to control congestion in 2010. Also, some concessionaires in Spain and France have introduced time-varying charges, but this is not generally widespread. Some motorways in France experimented with time-varying charges to control weekend traffic (e.g. A1 motorway); despite success in shifting traffic to off-peak periods, the rates were discontinued. Slovenia has introduced charges that are differentiated according to day and night periods with a difference of 11% between the lower and the higher toll rates (Ricardo-AEA et al, 2014a) (European Commission, 2013).

An analysis of the effectiveness of such measures to deal with congestion has shown that they can be effective. For example in the Czech Republic, increasing the charge by 25% for vehicles with two axles and by 50% for vehicles with three or more axles during peak-hours resulted in a 15% decrease in traffic during peak times. In France, an increase of toll rates during weekend rush hours by 25% and reducing off-peak rates by 25% resulted in a 10% transfer to off-peak times (Ricardo-AEA et al, 2014a) .

Root cause R4: Optional charging and too many different charging methods

a. Too many complex and incompatible ways of charging are possible

The underlying issue that contributes to the inconsistent price signals is the fact that the Directive leaves a lot of flexibility. Furthermore, while the Directive sets some general rules around how a road infrastructure charging system might be designed, Member States are free to choose:

- Whether to apply road infrastructure charging for HGVs or not
- The type of charging: time-based or distance-based
- The price levels, within the constraints of non-discrimination
- Vehicle categories to be tolled
- Share of network to be tolled
- The differentiation parameters: vehicle category, dimensions, axles, Euro standard, time
- The consideration of an external cost charge related to air pollution or noise
- Discounts and exemptions

In addition, there are two competing methods to reflect the level of pollutants emitted by trucks: the differentiation based on the Euro-class and the charging of external costs of pollution. While the modulation of charges according to EURO standards is required without a methodology being prescribed, the charging of external costs is optional.

b. No specific rules for light duty vehicles

A further root cause is the fact that currently the Eurovignette Directive does not specifically include light duty vehicles in its scope. This leads to an even more diverse patchwork of light duty vehicle charging. The lack of rules for light duty vehicles furthermore creates additional issues in the case where light duty vehicle charging is introduced as the pricing is not regulated.

Root cause R5: The Directive only allows for revenue neutral differentiation of congestion charges

While the Directive does allow the differentiation of charging rates by time of day, type of day or season, the provisions define that the tolls should be based on the principle of the recovery of infrastructure costs only and any variations in the tolls that tackle congestion should not be designed to generate additional tolling revenue. The variation should be applied in a revenue-neutral way[25]. In contrast to air and noise pollution, the Directive does not allow the application of charges for congestion as an additional external cost.

A key issue that discourages wider application of congestion charging is the complexity of the current provisions – particularly the requirement for revenue neutrality (Ricardo-AEA et al, 2014a). As such, the process of defining time-based differentiated charges and their enforcement is both time intensive and cost intensive, and generates no additional revenue as an incentive for Member States. Consequently, only a few Member States have developed time-differentiated charging systems.

1.6.3. How the problem has developed over time and how it is expected to develop without further action

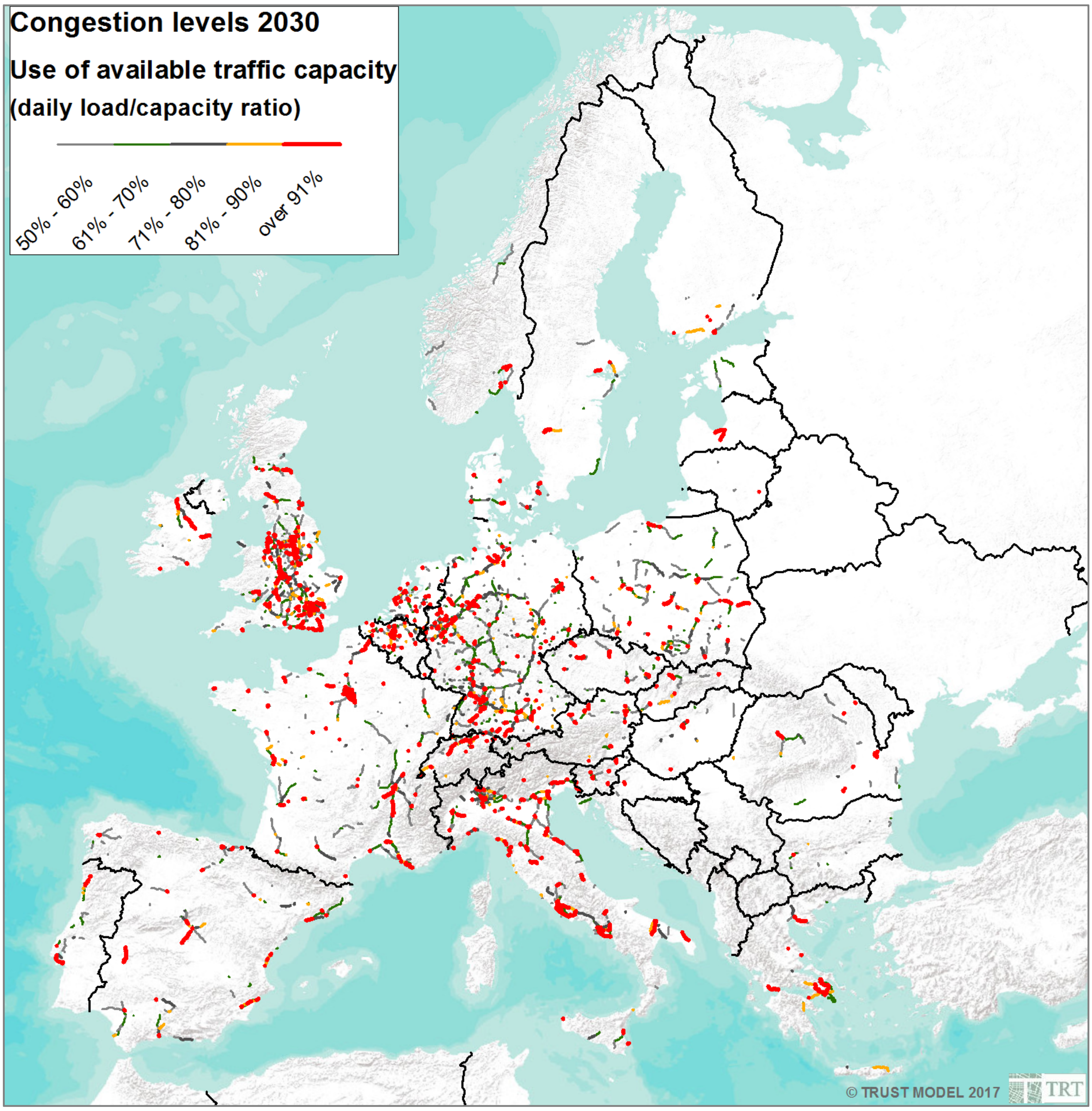
A well-designed road infrastructure charging system should give hauliers the incentive to carry out their transport operations as efficiently as possible, using less polluting vehicles. The reason that so few Member States apply external cost charges is that the methodologies for developing the charges are considered to be complex and increase administrative effort (BMVIT, 2016a).

Road infrastructure charging systems could be an effective measure to reduce congestion. To date, the number of Member States that actually apply congestion charging on inter-urban roads; however, is limited. At the same time, it is generally expected that congestion and its associated costs will increase, linked to the growth of economies, concentration of activities in urban areas and the rise in populations. Under current trends and adopted policies by the end of 2015 congestion costs are projected to increase by about 24% by 2030 and 43% by 2050, relative to 2010.[26] As shown by the TRUST model (see Figure 1-15), congestion on the inter-urban network would be the result of growing freight transport activity along specific corridors, in particular where these corridors cross urban areas with heavy local traffic.

[25] Under Directive 2011/76/EC, Member States have flexibility to charge higher infrastructure charges during peak hours, subject to limitations (a peak period should not exceed five hours per day - in such a way that no infrastructure charge is more than 175% of the maximum level of the weighted average infrastructure charge).

[26] Ibid 1.

Figure 1-15: Congestion levels on the inter-urban network in the Baseline scenario for 2030



Source: TRUST model

1.6.4. Potential impacts

The above-mentioned issues with regard to road infrastructure charging systems in Europe result in inefficiencies of the transport system. Potential impacts include the following:

- While air pollution has decreased over time, other environmental impacts (including CO_2 emissions, noise, and resource depletion) of road freight transport are still increasing: The literature suggests that congestion will further increase over time. Without intervention, congestion will not be tackled sufficiently and this will result in increased emissions of GHG and air pollutants, traffic noise levels and increases in total vehicle-related fuel consumption.
- Economic impacts: congestion is connected to direct costs for households and businesses due to the value of fuel and the time wasted. A 2011 CE Delft study provides figures for European wide costs of road congestion. The aggregate

yearly delay costs reported for passenger cars are in a range between 98.4 and 161.3 billion €/year, while estimated deadweight loss is between 15.9 and 26.0 billion €/year. This data refers to both **urban and inter-urban** congestion. When considering freight road transport, the CE Delft report estimates congestion costs in a range between 26.7 and 42.7 billion €/year for HDVs in terms of delay cost and between 4.3 and 6.9 billion €/year in terms of deadweight loss. (CE Delft, et al., 2011). Congestion costs for road transport in the Baseline scenario are estimated at around 240 billion €/year for 2015[27].

- Loss of competitiveness: congestion, a high proportion of vehicles carrying out empty runs and the use of inappropriate vehicle types to carry out transport operations all result in transport operations not being carried out as efficiently and effectively as might be possible. In a highly competitive sector such as transport, this can have significant negative effects on the competitiveness of the EU.

[27] Ibid 1. Congestion costs in this case cover passenger cars, light and heavy goods vehicles, buses and coaches and powered 2-wheelers.

2. POLICY OBJECTIVES

The **general objective** of the initiative is to promote financially and environmentally sustainable and socially equitable (road) transport through wider application of the 'user pays' and 'polluter pays' principles (fair and efficient pricing).

The **specific objectives** for the revision of Directive 1999/62/EC are the following:

5. Contribute to the reduction of CO_2 emissions in transport (efficiency);
6. Ensure adequate quality of roads in exchange of the user charge (fairness);
7. Ensure that road pricing better reflects the real cost of use, including externalities, and that it treats occasional / non-resident motorists fairly (fairness);
8. Make use of road charging as an effective tool in reducing congestion (efficiency).

3. POLICY OPTIONS

3.1. Retained options

3.1.1. Main policy packages

A long list of policy options was developed on the basis of the previous evaluation study of the Eurovignette Directive (Ricardo-AEA et al, 2014a) and inputs from the open public consultation.

Table 3-1 provides an overview of the retained possible policy measures and the grouping into policy packages. A brief description is given in the table, whereas a full account of all modelling assumptions that are needed to calculate the impacts of the options is given in Annex A. In particular, Directive 1999/62/EC does not oblige Member States to introduce road charging; rather, it sets the framework for road charging should Member States choose to implement it. A similar approach to allowing freedom of choice is retained in the policy options. As a result, assessing the impacts of such optional rules requires that assumptions are made on the uptake of road charging by Member States, as otherwise there could be no quantitative assessment – details of the relevant assumptions are provided in Annex A.

Table 3-1: Overview of main policy packages

Light duty vehicles (LDVs) = LCVs + passenger cars

Light commercial vehicles (LCVs) = passenger vans and freight vans (up to 3.5t)

Heavy duty vehicles (HDVs) = Heavy goods vehicles + buses/coaches

Heavy goods vehicles (HGVs) = freight trucks, with either >3.5t or >12t (as indicated)

Buses/coaches = larger buses and coaches designed to carry more than 16 passengers[28]

Policy options	Description
PO1 - Minimum adjustments and extending the scope of the Directive	
Remove exemptions for HGVs <12t	The present derogation up to 12 tonnes would be phased out over a period of 5 years to ensure fair competition and non-discriminatory treatment of vehicles between 3.5-12 tonnes.
Extend rules on tolls and user charges (Chapter III of the Directive) to include coaches designed to carry at least 16 passengers	Larger buses which are suited or intended to carry more than 16 passengers[29]. These vehicles cause similar damage to the infrastructure and to the environment as HGVs. These buses are typically used for long distance services. It therefore makes sense that these vehicles, similar to rail services, also pay for the use of the infrastructure and for environmental damage and come within the scope of the Eurovignette Directive.
Revision of caps/values for external cost charging	The maximum values of external costs (noise and air pollution) would be reviewed in line with the latest scientific evidence to ensure they better reflect external costs. Simplification of the requirements for external cost charging: • Merging the charging of noise costs with the cost of air pollution; • Using more proportionate values instead of weighted average charges; Member States will no longer be required to notify the Commission where these provisions are respected (i.e. the values set in the Directive are applied).

[28] This limit would correspond to the limit of 3.5 tons for goods vehicles and this is also beyond which a different driving licence is required (D1)

[29] This limit corresponds to the limit of 3.5 tons for goods vehicles and this is also beyond which a different driving licence is required according to Directive 2006/126/EC. Smaller buses designed to carry 8-16 passengers are normally lighter than 3.5 tonnes causing significantly less damage to the infrastructure. While EU legislation on access to the market applies to vehicles above 8 passengers (Regulation 1073/2009) because they may be used for international transport of passengers, it would not be proportionate to apply the same road charging principles to buses carrying between 8 -16 passengers as HGVs

Policy options	Description
Extend mark-ups beyond mountain regions to specific types of motorways	Extend the possibility to use mark-ups (of 15-25%) beyond mountain regions to contribute to the financing of removing bottlenecks on the TEN-T network, while keeping the condition of acute congestion or significant environment damage generated by vehicles. The measure would apply to HGVs and buses/coaches
Introduce non-discrimination requirement and a maximum relative price for short-term vignettes compared to long-term vignettes for LDVs	The provision of the following vignette types and price ratios for all new or substantially amended scheme could be required: • The price of a two-month vignette is max 30% of that of the annual vignette (ratio of 1.8); • The price of a monthly vignette is max 18% of that of the annual vignette (ratio of 2.2); • The price of a 10-day vignette is max 8% of that of the annual vignette (ratio of 2.9); • The price of an (optional) 4-day vignette is max 6% of that of the annual vignette (ratio of 5.5).
Promote zero-emission vehicles through allowing reduced rates (HDVs and LDVs)	As soon as the Directive enters into force, MSs could start rewarding zero-emission vehicles by allowing for reduced rates or even complete exemption from road charges for these vehicles. The Directive could allow the application of reduced toll rates for zero-emission LDVs, similar to those mentioned for HDVs. As for HDVs, this voluntary measure could already have significant positive effects in urban areas at a relatively early stage
PO2 - Measures of PO1 + Address CO_2 emissions of HDVs +Phase out vignettes for HDVs + Adjust circulation taxes for HGVs	
Measures of PO1	
CO_2 differentiation for HDVs (HGVs >3.5t + buses/coaches	Differentiation of infrastructure charges according to CO_2 emissions for HDVs (HGVs + buses/coaches) once vehicle certification data on CO_2 emissions becomes available for new vehicles[30]. Distinction would be made into i) Euro 0-VI vehicles, ii) low-CO_2 (only new) vehicles.
Phase out Euro class-differentiation – more extensive use of external cost charging (optional)	This would be a simplification of tolling rules and avoid potentially contradictory price signals that could be caused by two competing ways of differentiation. Phase out from 2025.
Phase out vignettes for HDVs (HGVs >3.5t + buses/coaches	Phase-out vignettes for HGVs over a period of 5 years. Member States would remain free to decide whether or not to introduce road charging on their territory and which roads to include in the road charging scheme. But once they decide to do so, the method of distance-based tolling would be obligatory on the roads which are charged.
Moderation of circulation	Removing minimum levels of vehicle circulation taxes for HGVs above 12 tonnes, which would allow Member States the

[30] VECTO – Vehicle Energy consumption Calculation Tool developed by DG CLIMA and the JRC – will be ready to provide this information for HGVs above 7.5 t as from 2019.

Policy options	Description
taxes for HGVs (>12t)	reduction or complete abolishing of the tax in case of the application of distance-based charging
PO3a - Measures of PO2 + Allow congestion charging of all vehicles	
Measures of PO2	As for PO2
Allow (optional) genuine congestion charging in distance-based environment for all vehicles (LDVs + HDVs)	Introduce a congestion charge in addition to infrastructure costs. The (optional) congestion charge would apply to all vehicles (LDVs and HDVs) as they are all contributing to congestion. It would be up to the Member State to choose whether to make use of this possibility or not. The Directive would require the revenues generated by congestion charging to be invested in the maintenance/development of the road in question or alternative solutions. This could raise the level of acceptability of an extra charge.
PO3b - Measures of PO3a + Address CO_2 emissions of LDVs +	
Measures of PO3a	As for PO3a, but with an additional CO_2 differentiation option
Address CO_2 emissions of LDVs (LCVs and passenger cars)	Differentiation of tolls and user charges (i.e. both distance- and time-based) for LDVs (LGVs and passenger cars) from 2020: Distinction would be made into 3 or 4 emission classes based on WLTP according to CO_2 and pollutant emissions. In order to provide a coherent price signal and have noticeable impact, Member States would be required to differentiate tolls accordingly
PO4 - Measures of PO3 + Phase out of vignettes for LCVs	
Measures of PO3b	
Phase out vignettes for LCVs (not cars)	Phase out by 2025 so that only distance-based charging is allowed.
Mandatory external cost charging for noise and air pollution for HDVs	Include mandatory external cost charging (for air pollution and noise) for HDVs *where road charging is applied*
Phasing in of distance based charges for passenger cars	Phasing in of distance based charges for passenger cars

3.1.2. Additional policies to target road quality issues

Two policy options were retained that aimed at ensuring fair road quality in return for user charges. These have been examined separately from the main packages, since there are limited interactions between the measures foreseen:

A. **Require Member States to publish regular (annual) infrastructure reports, providing information on toll revenues as well as expenditures on maintenance/operation of toll roads.** This could help Member States identify financing gaps before the problem exacerbates and ensure that the necessary resources are in effect allocated to maintenance.

B. **Quality indicators would be introduced to ensure that the manager of a toll road will maintain the given road section in sufficiently good/safe condition.** Such indicators are already used by most Member States. However, the information is not strictly comparable since different methodologies are used. A harmonised definition based on current national practices in monitoring road characteristics could be adopted by the Commission through an implementing act.

The impact of these additional policies is assessed qualitatively, off-model, and is included in Annex C. This is to ensure clarity between the impact of the main policy packages described in Table 3-1, and these additional packages that could theoretically be combined with any of the main options. Consideration of these additional policies is re-introduced in the main report in the selection of the preferred packages.

3.2. Discarded options

Most of the proposed options in the long list were taken forward in some form within the policy packages described above. Options that were discarded are listed below. These options were discarded in favour of variants that aimed at achieving the same objectives but were more attractive in terms of the selection criteria.

- **Options aimed at contributing to EU goal of transport CO_2 reductions:**
    - *Promotion of vehicles running on low carbon fuels and/or using fuel-saving equipment through rebates.* These options discarded in favour of the more clearly delineated option that foresees rebates for zero emission vehicles. This was in order to avoid complex calculations concerning the production processes of different fuels (e.g. biofuels, hydrogen) in the case of low carbon fuels, or the need to verify that equipment is correctly installed and maintained in the case of fuel-saving equipment (which may need period replacement over the lifetime of the vehicle).
    - *Differentiation or adjustment of taxes (e.g. fuel taxes, circulation taxes) for low carbon vehicles*. Such options were excluded as being outside the scope of the Eurovignette Directive study, and issues of promoting CO_2 reductions were taken into account through policy options that involved differentiation of road user charges instead.
- **Options to avoid discrimination of occasional/non-resident road users and ensure a level playing field**
    - *Make distance-based charging mandatory on the TEN-T network for HGVs or all goods vehicles*. These options were discarded on the grounds of subsidiarity/proportionality, as they would require substantial expansion of user charging in all Member States.
- **Options aimed at ensuring a more efficient transport system**
    - *Make it possible to apply genuine congestion charging (i.e. on top of infrastructure charges) on congested parts of the network in peak hours*

for HGVs only. This was discarded as it would only apply to HGVs, which is not an efficient solution for tackling congestion.

- *Make application of genuine congestion charging mandatory on congested parts of the network in peak hours for all vehicles*. This was discarded on subsidiarity/proportionality grounds, since systems would need to be set up to cover the relevant parts of the network and this would involve substantial costs.

- **Options aimed at improving road quality**
  - *Require Member States to prepare national plans on the maintenance and upgrade of their road networks.* This was discarded in favour of a similar reporting measure that would be less burdensome on member States (i.e. the option to monitor and report toll revenues and expenditures).
  - *Introduction of rules on the liability of the keeper of a toll road to maintain the given road section in sufficiently good/safe condition*. This would effectively introduce a legal obligation to ensure that the objective of achieving fair road quality is met. The option has been discarded as it may either duplicate or conflict with national law and is thus considered to be in conflict with proportionality and subsidiarity requirements. Stakeholders that were interviewed did not support attempting to improve road maintenance by way of rules relating to the potential liabilities. They suggested that liability issues are best dealt with at Member State level and that setting out some general indicators focused on minimum standards at EU level was more appropriate.

4. ANALYSIS OF IMPACTS OF POLICY OPTIONS

The following sections outline the impacts of each policy option in key impact areas. In general, colour coding is used to refer to the direction (positive or negative) and size (small or large) of any expected impacts:

Key: Impacts expected				
××	×	O	✓	✓✓
Strongly negative	Weakly negative	No or negligible impact	Weakly positive	Strongly positive

4.1. Economic impacts

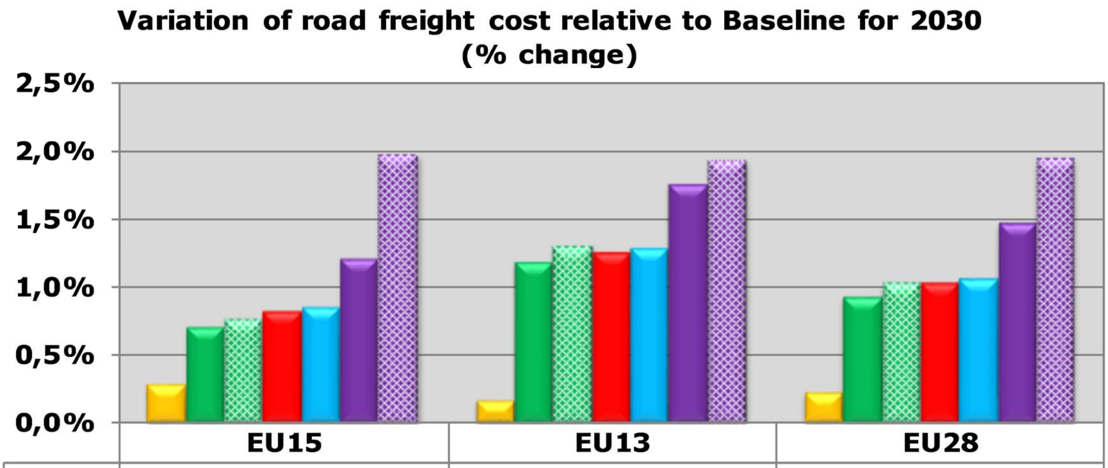
4.1.1. Transport costs for passenger and freight transport and effects on consumer prices

Changes in freight transport costs

All of the policy options imply an increase in transport costs for the road freight sector due to increased road charges. The increases are different in magnitude and depend on the measures implemented in each policy option e.g. increased tariffs for air and noise external costs charging, new distance or time-based tolls, congestion charging, phasing out of EURO class modulation and phasing-in of modulation of infrastructure charges according to CO_2 emissions, extension of mark-ups. Some measures (i.e. rebates for zero-emission vehicles (ZEV) and reduced circulation taxes) moderate the increases in the road freight transport costs.

Figure 4-1 shows the change in road freight costs for different policy options relative to the Baseline in 2030. At EU28 level, the increase in road freight transport costs in PO1 is very limited (0.2% relative to the Baseline), while PO2, PO2s, PO3a, PO3b and PO4 show increases in the range of 0.9% to 1.5%. A more significant increase is projected in the sensitivity case PO4s (i.e. 2%), in which all forms of road charging are applied to almost all Member States.

Figure 4-1: Variation of road freight cost relative to Baseline for 2030 (% change)



	EU15	EU13	EU28
PO1	0,3%	0,2%	0,2%
PO2	0,7%	1,2%	0,9%
PO2s	0,8%	1,3%	1,0%
PO3a	0,8%	1,3%	1,0%
PO3b	0,9%	1,3%	1,1%
PO4	1,2%	1,7%	1,5%
PO4s	2,0%	1,9%	2,0%

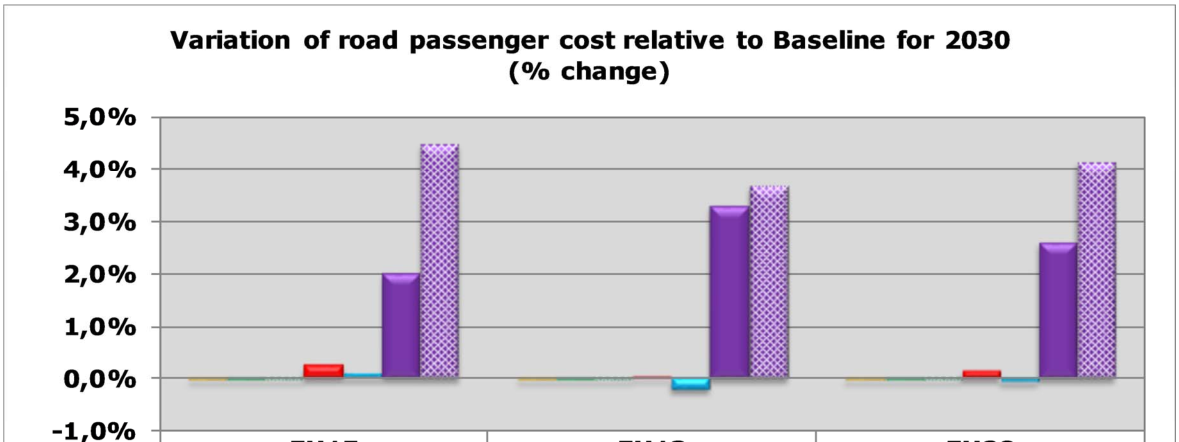
Source: ASTRA model

Impact on passenger transport costs

On the passenger transport side, the main impacts are related to: the assumed implementation of distance-based charges for passenger cars in PO4 and PO4s; to the assumed application of congestion charging to a selection of countries in PO3a, PO3b and PO4 and to its extension to almost all Member States in PO4s.

As shown in Figure 4-2 the impact of PO4s is the most significant with a 4.1% increase in costs relative to the Baseline in 2030, while PO4 shows an increase of 2.6%. PO3a and PO3b show more limited changes.

Figure 4-2: Variation of road passenger cost relative to Baseline for 2030 (% change)



	EU15	EU13	EU28
PO1	0,0%	0,0%	0,0%
PO2	0,0%	0,0%	0,0%
PO2s	0,0%	0,0%	0,0%
PO3a	0,3%	0,0%	0,2%
PO3b	0,1%	-0,2%	-0,1%
PO4	2,0%	3,3%	2,6%
PO4s	4,5%	3,7%	4,1%

Source: ASTRA model

Impact on consumer prices

It is expected that freight transport costs increase slightly compared to the baseline under the policy options, as shown above. The extent to which these cost increases will result in increased consumer prices depends on the extent to which transport costs make up a significant proportion of the final costs, and the extent to which cost increases faced by hauliers are passed through. For the purposes of calculating the potential impact on consumer prices, it is assumed that 100% of cost increases are passed through. This is consistent with studies in Germany, Austria and Switzerland, which suggest that hauliers pass additional costs to their customers (Ruehl et al, 2015). Also, according to experimental design techniques used by Hensher and Puckett (2008), a higher freight rate due to road user charging lowers the marginal disutility of total cost, which implies that any cost increase will be passed on to shippers through higher freight rates.

The impact on consumer prices depends on the specific commodity being considered. A range of commodities are shown in Table 4-1 based on (JRC, 2010), along with the transport costs and average cost increase if 100% of the increase was passed on. As can be seen, the impact on product prices is <0.19% for all policy options.

Table 4-1: Impact on consumer prices for each policy option

Product	Share of transport costs in final price (%)	Average % increase of product price (100% pass through in 2035)						
		PO1	PO2	PO3a	PO3b	PO4	PO2s	PO4s
Biscuit	7.2%	0.01%	0.06%	0.07%	0.08%	0.11%	0.07%	0.14%
Tuna	9.5%	0.02%	0.09%	0.09%	0.10%	0.14%	0.09%	0.19%
Tomato	5.7%	0.01%	0.05%	0.06%	0.06%	0.09%	0.06%	0.11%

Product	Share of transport costs in final price (%)	Average % increase of product price (100% pass through in 2035)						
		PO1	PO2	PO3a	PO3b	PO4	PO2s	PO4s
Blouse	1.2%	0.00%	0.01%	0.01%	0.01%	0.02%	0.01%	0.02%
Jeans	0.9%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%
Suit	2.8%	0.01%	0.03%	0.03%	0.03%	0.04%	0.03%	0.06%
Coffee pack	4.0%	0.01%	0.04%	0.04%	0.04%	0.06%	0.04%	0.08%
Coffee pods	1.5%	0.00%	0.01%	0.02%	0.02%	0.02%	0.02%	0.03%
Passenger car	3.9%	0.01%	0.04%	0.04%	0.04%	0.06%	0.04%	0.08%
Mobile phone	1.0%	0.00%	0.01%	0.01%	0.01%	0.02%	0.01%	0.02%
Pharmaceuticals	0.8%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%

Notes: Transport costs and share of transport costs in final price are taken as the average of seven routes
Source: author calculations

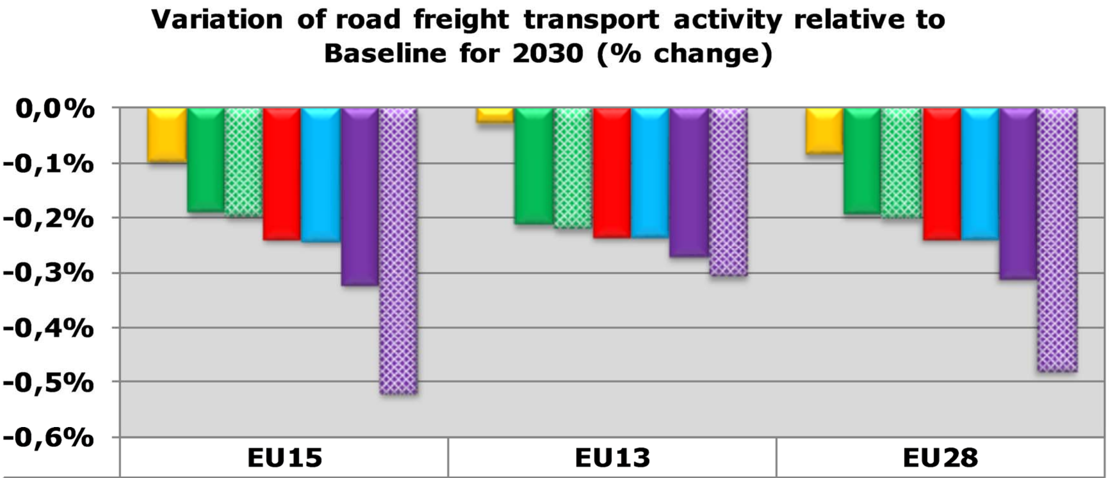
The findings suggest that there will be a negligible impact on consumer prices even under PO4s, where all forms of road charging are applied to almost all Member States. This is supported by practical experience with the road tolls in Germany, Spain, Switzerland and Austria showed no or marginal increases in consumer prices (CEDR, 2009); (Liechti & Renshaw, 2007); (Evangelinos et al, 2012); (Ruehl et al, 2015). The ranges of transport costs in the final price in Table 4-1 are similar to those seen in other industries – for example, transport costs are typically 2-10% of total production costs in the chemicals industry (Mahendra, 2010).

In general, the impact on final product prices is negligible, even if 100% of costs are passed through.

4.1.2. Total transport activity

As far as **total road freight transport activity** is concerned, all scenarios show a limited impact in terms of reduced tonne-km. PO2, PO2s, PO3a and PO3b result in about 0.2% decrease in road freight transport activity at EU28 level. Despite the fact that PO4 is more effective than the other policy options, its impact on road freight transport activity is also rather limited (0.3% decrease relative to the Baseline). Also the sensitivity case PO4s shows a limited impact (0.5% decrease relative to the Baseline).

Figure 4-3: Variation of road freight transport activity relative to Baseline for 2030 (% change)

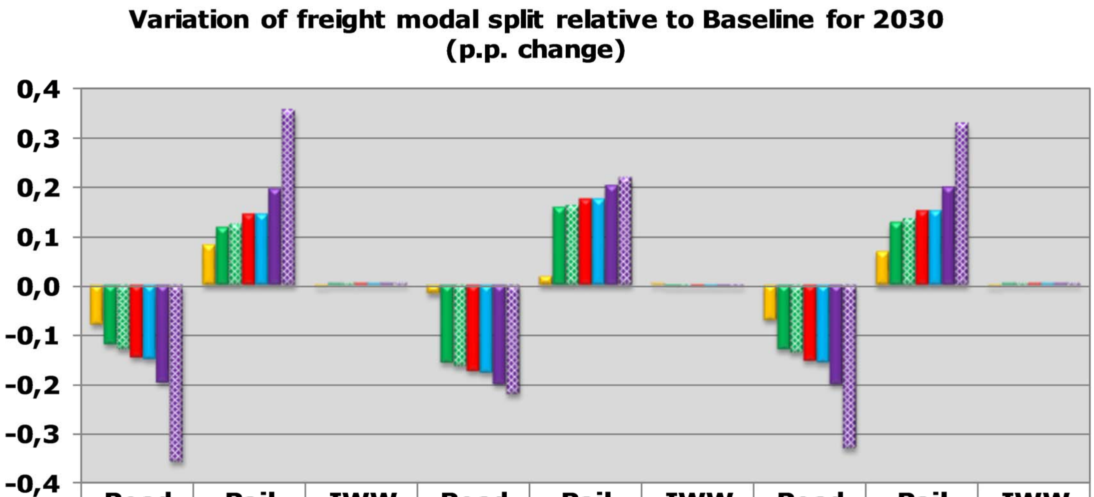


	EU15	EU13	EU28
PO1	-0,1%	0,0%	-0,1%
PO2	-0,2%	-0,2%	-0,2%
PO2s	-0,2%	-0,2%	-0,2%
PO3a	-0,2%	-0,2%	-0,2%
PO3b	-0,2%	-0,2%	-0,2%
PO4	-0,3%	-0,3%	-0,3%
PO4s	-0,5%	-0,3%	-0,5%

Source: ASTRA model

Given the limited change in road freight transport activity, the impacts on freight modal split are also projected to be limited, as shown in Figure 4-4. All scenarios show a modest shift towards rail in comparison with the Baseline scenario, with slightly higher changes in PO4 and its sensitivity case PO4s.

Figure 4-4: Variation of freight modal split relative to Baseline for 2030 (p.p. change)

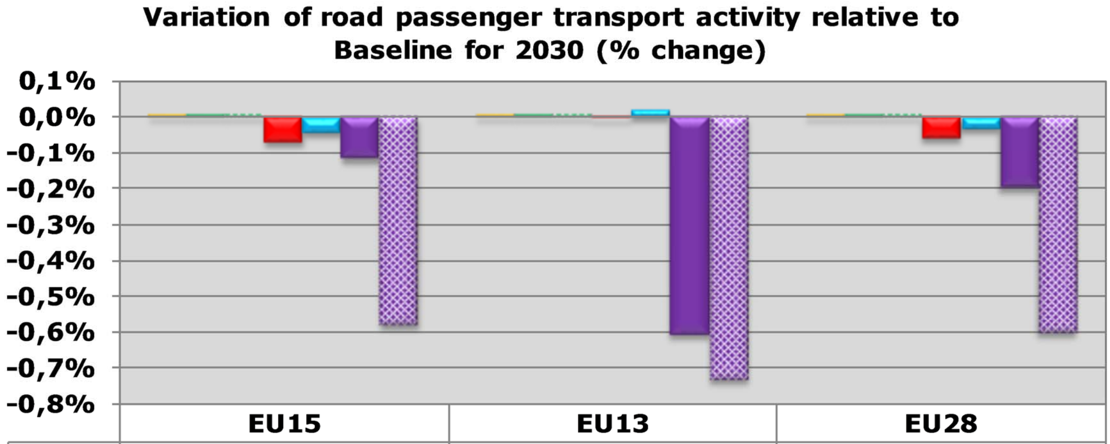


	Road	Rail	IWW	Road	Rail	IWW	Road	Rail	IWW
	EU15			EU13			EU28		
PO1	-0,1	0,1	0,0	0,0	0,0	0,0	-0,1	0,1	0,0
PO2	-0,1	0,1	0,0	-0,2	0,2	0,0	-0,1	0,1	0,0
PO2s	-0,1	0,1	0,0	-0,2	0,2	0,0	-0,1	0,1	0,0
PO3a	-0,1	0,1	0,0	-0,2	0,2	0,0	-0,2	0,2	0,0
PO3b	-0,1	0,1	0,0	-0,2	0,2	0,0	-0,2	0,2	0,0
PO4	-0,2	0,2	0,0	-0,2	0,2	0,0	-0,2	0,2	0,0
PO4s	-0,4	0,4	0,0	-0,2	0,2	0,0	-0,3	0,3	0,0

Source: ASTRA model

For passenger transport, the changes in costs (see Section 4.1.1) drive a decrease in passenger road transport activity of around 0.1% to 0.2% in PO3a and PO4 relative to the Baseline in 2030. The impact in the sensitivity case PO4s is more significant at 0.6% relative to the Baseline (see Figure 4-5).

Figure 4-5: Variation of road passenger transport activity relative to Baseline for 2030 (% change)

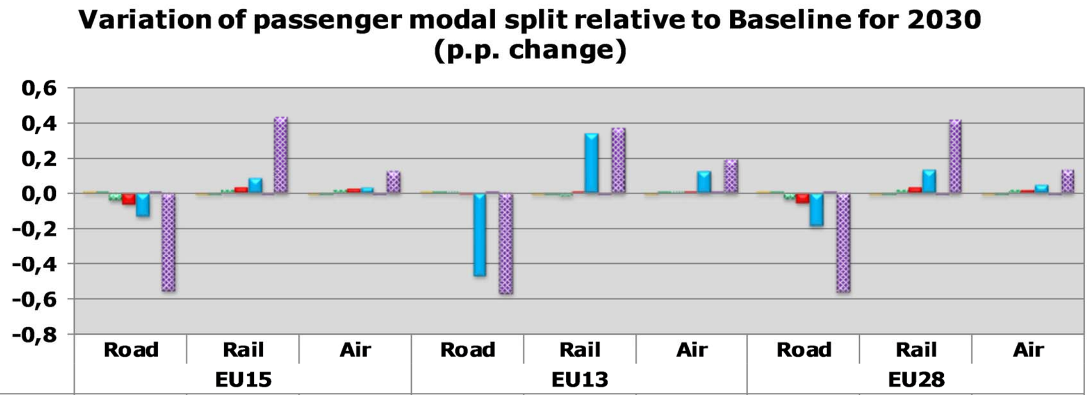


	EU15	EU13	EU28
PO1	0,0%	0,0%	0,0%
PO2	0,0%	0,0%	0,0%
PO2s	0,0%	0,0%	0,0%
PO3a	-0,1%	0,0%	-0,1%
PO3b	0,0%	0,0%	0,0%
PO4	-0,1%	-0,6%	-0,2%
PO4s	-0,6%	-0,7%	-0,6%

Source: ASTRA model

The impacts on passenger modal split are also limited, as shown in Figure 4-6.

Figure 4-6: Variation of passenger modal split relative to Baseline for 2030 (p.p. change)



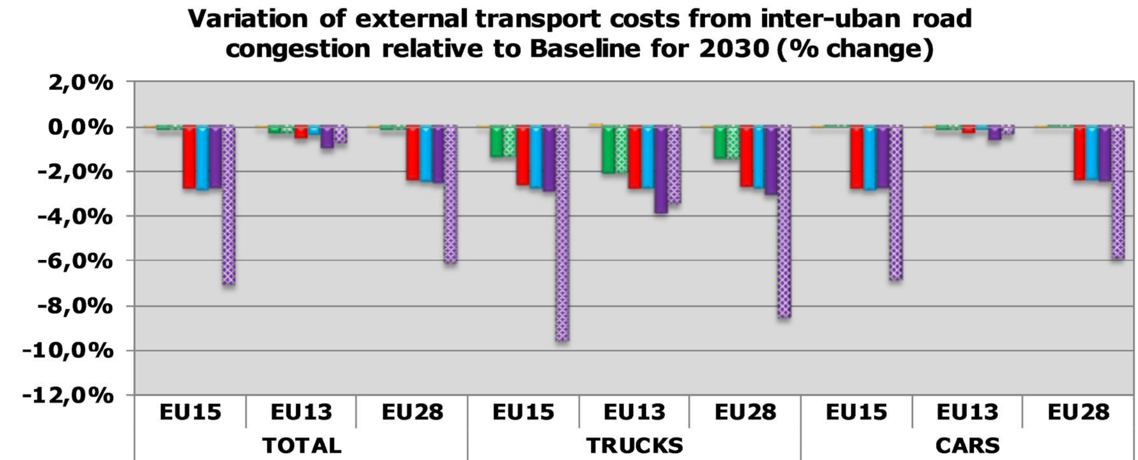
	Road	Rail	Air	Road	Rail	Air	Road	Rail	Air
		EU15			EU13			EU28	
PO1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PO2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PO3b	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PO3a	-0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PO4	-0,1	0,1	0,0	-0,5	0,3	0,1	-0,2	0,1	0,1
PO2s	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
PO4s	-0,6	0,4	0,1	-0,6	0,4	0,2	-0,6	0,4	0,1

Source: ASTRA model

4.1.3. Congestion

When looking at the impacts on external costs from inter-urban road congestion, the more significant reductions can be observed for PO3a and PO3b due to the assumed introduction of congestion charges and in PO4 and PO4s where the application of new charges for road passenger traffic allows its extension to more countries. PO3a, PO3b and PO4 show similar results with a reduction of interurban road congestion costs of about 2.4 to 2.5% at EU28 level. In PO4s the reduction increases to 6.1% relative to the Baseline in 2030.

Figure 4-7: Variation of external transport costs from inter-urban road congestion relative to Baseline for 2030 (% change)



	EU15	EU13	EU28	EU15	EU13	EU28	EU15	EU13	EU28
	TOTAL			TRUCKS			CARS		
PO1	0,0%	0,0%	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,0%	0,0%
PO2	-0,2%	-0,4%	-0,2%	-1,3%	-2,1%	-1,5%	-0,1%	-0,2%	-0,1%
PO2s	-0,2%	-0,4%	-0,2%	-1,3%	-2,1%	-1,5%	-0,1%	-0,2%	-0,1%
PO3a	-2,8%	-0,6%	-2,4%	-2,7%	-2,8%	-2,7%	-2,8%	-0,3%	-2,4%
PO3b	-2,8%	-0,4%	-2,5%	-2,7%	-2,8%	-2,8%	-2,8%	-0,2%	-2,4%
PO4	-2,8%	-1,0%	-2,5%	-2,9%	-3,9%	-3,1%	-2,8%	-0,7%	-2,5%
PO4s	-7,1%	-0,8%	-6,1%	-9,6%	-3,5%	-8,6%	-6,9%	-0,5%	-5,9%

Source: ASTRA model

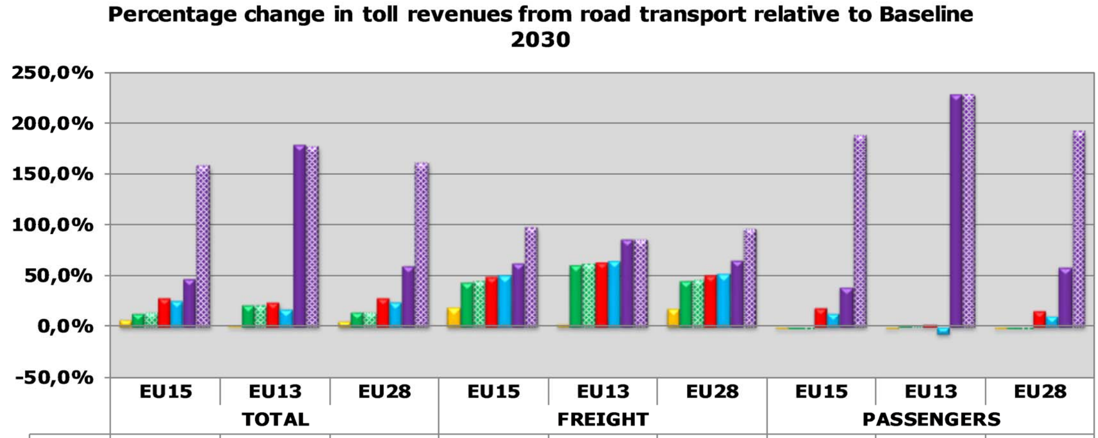
4.1.4. Revenues from tolling

Different impacts arise from increases in the level of charges and from their application to passengers and freight sectors.

The cumulative effect of the modelled measures on toll revenues is clearly visible in Figure 4-8, which shows higher impact at European level on the revenues from both the freight (64.8%) and the passenger sectors (57.9%) under PO4 with a cumulative impact on total revenues of 60.2% in 2030 relative to the Baseline. Higher variations can be observed in the sensitivity case PO4s with revenues from passenger and freight transport reaching respectively 192.8% and 96.4% increase with a cumulative impact on total revenues of +160.5%.

Lower impact is expected under the other policy options, with PO1, PO2 and PO2s showing a small reduction of revenues from road passenger transport sector due to the assumed application of rebates for zero emission vehicles.

Figure 4-8: Percentage change in toll revenues from road transport relative to Baseline for 2030



	TOTAL			FREIGHT			PASSENGERS		
	EU15	EU13	EU28	EU15	EU13	EU28	EU15	EU13	EU28
PO1	5,7%	0,2%	5,2%	19,3%	1,6%	17,5%	-1,1%	-0,6%	-1,1%
PO2	13,8%	20,9%	14,5%	43,3%	59,4%	45,0%	-1,0%	0,2%	-0,9%
PO2s	14,1%	21,6%	14,8%	44,2%	61,2%	46,0%	-1,0%	0,2%	-0,9%
PO3a	28,5%	23,6%	28,0%	49,3%	62,6%	50,8%	18,1%	2,5%	16,5%
PO3b	25,6%	17,3%	24,7%	50,4%	63,8%	51,8%	13,1%	-7,7%	11,1%
PO4	46,9%	178,2%	60,2%	62,3%	86,1%	64,8%	39,2%	227,8%	57,9%
PO4s	158,5%	178,1%	160,5%	97,6%	86,0%	96,4%	189,0%	227,7%	192,8%

Source: ASTRA model

4.1.5. Impact on SMEs

SMEs (companies with fewer than 250 employees) make up the majority of the road freight industry, accounting for 97%-100% of firms depending on the country (Eurostat, 2017). Furthermore, around 90% of enterprises are micro-enterprises that have fewer than 10 employees (Eurostat, 2017).

The proposed policy measures are likely to involve small increases in the costs of transport (see Section 4.1.1) due to the **introduction of new road tolls in certain Member States and the greater use of external cost charges** (and to a lesser extent, mark-ups in mountainous regions).

These cost increases have potential implications for SMEs for several reasons (further details are available in the SME test – see Annex E):

- SMEs may be less able to absorb increased costs of road pricing compared to a larger firm (Mahendra, 2010).
- The ability of SMEs to mitigate cost increases through improvements in the efficiency of their operations[31] may be more limited because they tend to have smaller vehicles and fleets, or a lower density customer network.
- SMEs may have lower bargaining power to pass costs through to their customers (Vega & Eversa, 2016).

That said, experience of road tolls in Germany, Austria and Switzerland showed that cost increases due to road tolls were passed through to customers (BMT Transport Solutions, 2006); (Ruehl et al, 2015). Although these studies did not specify whether the results applied specifically to SMEs, since the haulage industry is made up almost entirely of SMEs it seems reasonable to assume that the outcome of passing through

[31] For example, evidence from Germany and Switzerland suggests that road hauliers were able to offset higher road charges through reducing empty runs and/or increasing loading factors (BMT Transport Solutions, 2006); (CEDR, 2009).

most (if not all) of the additional costs is representative. As such, it is expected that increased transport costs in PO1-4 could have minor negative impacts on SMEs who may be less able to absorb additional costs, but no substantial distortions are expected.

Introducing **congestion charging** will also likely impact SMEs, since they have lower flexibility in their operations (as described above). In particular, small firms may have no choice but to drive in peak hours because they have to maximise utilisation of their vehicles (Mahendra, 2010). At the same time, the same firms would likely benefit from lower congestion, which would result in time savings and an effective increase in the catchment area for the business. Given limited experience with inter-urban congestion charging, it is difficult to say what the net impacts would be – however, evaluations of the London congestion charge found no discernible impact on businesses (TfL, 2008), suggesting that *more limited, targeted interurban congestion charging foreseen in the policy options would not have significant impacts on SMEs (positive or negative).*

The **measures to promote low and zero-emission vehicles** included in all policy options may benefit SMEs less in the short-term compared to larger firms, since SMEs may face more difficulties in making the upfront investment for more expensive low CO_2 vehicles[32]. If SMEs are less able to purchase or lease low CO_2 vehicles, they will *initially* benefit less from the measure compared to a larger firm – both in terms of have less potential to access the lower rates for road user charges, as well as the co-benefits of owning zero emission vehicles in the form of lower fuel costs etc. However, in the longer term it can be expected that the price of electric vehicles will reduce (Wolfram & Lutsey, 2016), making the upfront investment less of a barrier. Furthermore, SMEs typically buy their vehicles on the second-hand market (BCA, 2012). If the measure stimulates additional first-hand purchases of zero-emission vehicles, these will eventually reach the second-hand market and SMEs will benefit from having access to zero-emission vehicles that they would otherwise not have had the opportunity to purchase.

4.1.6. Costs to authorities

Countries that decide to introduce new distance-based charging schemes will need to implement an electronic toll collection system, either based on Dedicated Short-Range Communications (DSRC) or Global Navigation Satellite System (GNSS). This is typically composed of the following elements:

- On-board units (OBUs);
- Central systems and IT infrastructure;
- Tolling stations;
- Enforcement stations;
- OBU distribution network.

The costs were estimated using reference countries for which the system costs are well-understood[33]. It was assumed that larger countries would choose GNSS, whereas smaller ones would opt for DSRC[34]:

[32] For example, Nissan e-NV200 electric van is 47% more expensive to purchase and lease compared to its diesel equivalent, the NV200 (Low Carbon Vehicle Partnership, 2016), and for electric trucks are priced 170-280% higher than a conventional equivalent (CE Delft, 2013).

[33] For GNSS-based schemes the reference country is Belgium, for DSRC-based countries the reference country is Slovenia

[34] In line with the Study on "State of the Art of Electronic Road Tolling" MOVE/D3/2014-259, which reported that GNSS is generally of greater economic interest where the size of the tolled network is larger.

- GNSS: Bulgaria, Netherlands, Romania, United Kingdom
- DSRC: Denmark, Latvia, Lithuania, Luxemburg, Sweden

The CAPEX and OPEX of systems mainly vary with the size of the network and the number of charged vehicles driving in the country (i.e. needing to be equipped with OBUs). Details of the calculations are provided in Annex G.

The additional costs due to Policy Option 1 are considered to be insignificant, since there are not expected to be any impacts in terms of the introduction of new tolls. Although the inclusion of HGVs <12t and buses/coaches will have some impact, this is not considered to be perceptible since the existing distance-based system should have sufficient OBUs and systems in place to support this growth. The costs for Policy Options 2 and 3 are the same - all countries currently with a vignette regime for HGVs above 3.5t (incl. buses) undertake a phase-out of the vignette by 2025 and implement a distance-based charging scheme. Under Policy Option 4, the uptake of tolls is more extensive and includes LGVs (and to a lesser extent also passenger cars), making the investment costs of new and existing schemes slightly higher compared to Policy Option 2/3.

Table 4-2: Impact on costs to authorities

	PO1	PO2	PO3a	PO3b	PO4
CAPEX	0 Insignificant	€1,202 m for the main option (€1,387 m for the sensitivity)			€1,334 m for the main option (€2,193 m for the sensitivity)
OPEX		€168 m/year for the main option (€200 m/year for the sensitivity)			€184 m/year for the main option (€313 m/year for the sensitivity)

4.1.7. Cost to users – administrative/compliance costs

The main costs to road users relate to the OBU procurement costs and related administrative costs. These are calculated based on the findings of the Support study for the Impact Assessment for the Revision of EETS Legislation (Ricardo/TRT/4iCOM, 2017). The overall costs to users in PO4 increase compared to PO2 and PO3 because of the large number of additional vehicles that are under the scope of the toll schemes (due to the relatively large fleet of LDVs compared to HDVs); however, the unit costs per additional user are the same in all scenarios, as follows:

- €104 yearly per OBU, for OBUs provided by the Member States, based on the findings of Ricardo/TRT/4iCOM (2017). This is based on interviews carried out with transport companies and information from Toll Chargers' websites. The cost is composed as follows:
  - Rental or deposit of OBUs: € 10.84 on average
  - Fees for bank guarantee: €6 on average
  - Installation/removal costs: 12.55€ on average
  - Training to the drivers (for the use of OBU, compliance etc): €6.14 on average
  - Time losses (i.e. installation/removal of OBUs, registration at Service Point in Belgium): €13.51 on average
  - Admin. Costs (translated from FTEs): €55.28 on average
- €15 yearly per OBU, for OBUs provided by EETS providers, which corresponds to the extension to a new Member State of the fees payed by users contracting

with EETS providers. The cost of OBUs provided by EETS providers is lower compared to those provided by Member States, since it is assumed that users operating with this type of OBU already have an OBU for other countries by the time of the application of the PO. The impact in terms of additional costs therefore only takes into account the extension to a new Member State of the fees payed by users contracting with EETS providers, namely:

  - 0.5% fees applied on an assumed €250 monthly toll (0.5% x €250 x 12 =€15)

- In order to be consistent with Ricardo/TRT/4iCOM (2017), the penetration rates of EETS providers were assumed to be 0% in BG, RO, UK, LT, LV, CZ, DE, HU, SK, SL and EE; 40% in FI, SE, NL, LU, BE; 50% in AT, DK.

It is assumed that passenger cars are not required to equip with OBUs (but may do so voluntarily, as a matter of convenience, as is the case today in France and Italy etc). In the calculations for PO4, it is assumed that this does not entail a direct cost to users, since it is a convenience element. For GNSS systems, it is assumed that a smartphone-based solution would be available and OBUs would not be mandatory for passenger cars.

Table 4-3: Impact on administrative costs to road users

	PO1	PO2	PO3a	PO3b	PO4
OPEX (€m/year)	0 Insignificant	€8 m/year from 2020 to 2025; €198 m/year from 2025 onward for the main option (€228 m/year sensitivity)			€8 m/year from 2020 to 2025; €240m/year from 2025 onward for the main option (€310 myear sensitivity)

4.1.8. Road quality

The extent to which road quality may be affected by the main policy options is assessed using the changes in revenues from tolling as a proxy indicator. In theory, if Member States have access to additional revenues this will have a positive impact on road quality if the revenues are allocated to maintaining roads (see also interactions with the policies that aim to target road quality, in Annex C). However, road maintenance expenditure is affected by many factors, including the extent of road damage (due to traffic volumes and weather conditions) and economic conditions (cost of labour, materials and capital).

Still, it could be expected that an increase in toll revenues would enable Member States to sustain or increase expenditure on maintenance – and more revenues should be expected to have positive impacts on road quality, all else being equal. Furthermore, Member States tend to use at least a part of the toll revenues to road maintenance – whether or not it is formally earmarked – the following countries use (part of) revenues from road user charges to finance the costs of operation and maintenance of road transport infrastructure: AT, BE, BG, HR, CZ, DK, FR, DE, GR, HU, LV, LT, NL, PL, PT, RO, SL, SK, ES. *As such, the higher the revenues (lowest for PO1, highest for PO4), the more positive the impact on road quality if they were invested in the network, although there is no guarantee that they would be used for this purpose. Since revenues from congestion charging would have to be allocated to investment in transport, the positive impact in PO3 and PO4 would in principle be greatest.* A separate assessment of the additional retained policy options that more explicitly target road quality is provided in **Annex C.**

4.1.9. Regional distribution of impacts

Region/Member State specific impacts can result from the introduction of both road tolls and congestion charges.

Road tolls have the potential to create negative impacts in peripheral regions, which could face a marginal increase in the costs for their imports and exports that in the short run may not be compensated by the increase in welfare from the reduction of externalities. Peripheral regions have lower access to large markets and can have low or falling levels of population density, which can constrain business activity compared to more central regions. Several studies have suggested relatively negative impacts of road pricing on peripheral economies, both in terms of employment and revenue (Gutiérreza et al, 2013). The impacts on each country depend on the international activity (more exports imply greater use of other countries' infrastructure), country size (small countries are usually more export-oriented), level of local fees and location (more peripheral areas have lower revenue from transit traffic and experience greater costs for access to main markets). Positive balances would be experienced by AT, BE, DK, FR, DE and SL, while other countries would pay more to other countries than they receive back in toll revenues (although this depends strongly on the toll fees chosen) (Gutiérreza et al, 2013). The differences in most cases are small, but the most negative balances in absolute terms are expected in IT, PT, ES, GR and PL – countries with little transit traffic that are located peripherally, and have low national fees (Gutiérreza et al, 2013). However, impacts are not expected to be significant in most cases, and only marginally negative in the case of agricultural/raw material industries located in peripheral regions away from agglomerations (JRC, 2010).

In addition, studies on existing tolls across Europe generally find that regional impacts are small, and not necessarily clearly negative. For instance, studies on the German toll suggested a negative impact on economically weak regions, but that this would not be great enough to lead to any companies moving location or any facilities closing down (Gustafsson et al, 2007). Studies in Sweden suggested a negligible regional variation in terms of profitability, productivity and employment, and that overall impacts are small (SIKA, 2007). In Switzerland, it was found that the peripheral and mountainous regions of Switzerland have experienced a greater impact than the more central regions, although again the effect was not significant (Karlsson, 2010). Overall, it can be concluded that greater uptake of road tolls/external cost charges will result in small or negligible negative impacts for peripheral economies in relation to central regions.

Regarding **congestion charges** that are foreseen in **PO3 and PO4**, although there are many studies of impacts of urban schemes, the potential for regional impacts of *interurban charges* is less well-studied. To illustrate the potential impacts, Table 4-4 provides interval estimations for the *regional economic impacts of interurban congestion* charging for 6 representative types of NUTS3 regions[35]. The calculations are based on a parametric analysis on the relationship between accessibility and local/regional impacts quantified according to literature (see Annex D).

[35] It is important to stress that even if some actual NUTS3 regions are used to apply the estimation process, results should not be read with reference to the specific regions. The selected NUTS3 are merely providers of elements for the application of the procedure in different conditions. The outcome of the method is the interval estimation of the impact based on the analysis of all different conditions and not the individual estimations region by region. To get individual results for a specific region one should use detailed data based on local conditions rather than using the parametric approach used here.

Table 4-4: Impact of congestion charge on regional economies (regional GDP)

Zone Type	Description	Effect on regional GDP
Zone type 1	A region located at medium distance from a large economic pole and with a few congestion spots along its connections (e.g. Essex (UK))	Min -0.6% Max 0.5%
Zone type 2	A region located in the middle of a large productive area where congestion is significant especially on short/medium distance (e.g. Milan (IT))	Min -0.7% Max 0.4%
Zone type 3	A region which is the main economic pole in a large area where congestion is significant (e.g. Warsaw (PL))	Min -0.5% Max 1.0%
Zone type 4	A region located in an area where GDP is evenly distributed congestion is limited to some spots (e.g. Oporto (PT))	Min -0.3% Max 0.3%
Zone type 5	A region located at medium/long distance from main economic poles and in an area with widespread congestion (e.g. Harz (DE))	Min -1.1% Max 0.7%
Zone type 6	A region located at medium/long distance from an economic pole and with some congestion along its connections (e.g. Maine et Loire (FR))	Min -0.3% Max 0.2%

Notes: The analysis does not take into account other potentially positive impacts of reduced congestion as lower pollution, GHG emissions, more reliable logistics chains etc. One can therefore expect that the modelled economic effects are fairly conservative. Additionally, it should be considered that the impact of charging on accessibility heavily depends on local conditions such as availability of alternative routes, the length and localisation of the charged links, the availability of alternative modes, the average income in the area and others.

Still, the following key messages can be drawn from the analysis:

- In all region types, the intervals can range from negative to positive values depending on the local conditions.
- The positive effect is most likely where there is more congestion (e.g. zone type 3, illustrated by the region of Warsaw, characterised by significant congestion).

Since congestion charges are optional under PO3 and PO4, *it can be expected that the impacts will tend toward the positive end of the spectrum, since Member States will only deploy congestion charges where conditions are favourable*.

The use of **measures to promote low CO_2 vehicles** foreseen in all policy options may have some regional impacts, although under all options the penetration of electric vehicles in the fleet is expected to remain relatively limited. In general, the dominant markets for zero emission vehicles are expected to be predominantly EU15 countries. It can be expected that the higher uptake of such vehicles in these countries will result in small advantages for hauliers who can benefit from lower road user charges. The overall magnitude of such impacts is expected to be very small, and in addition, hauliers from other countries are likely to deploy their lowest CO_2 vehicles where they can take the most advantage of incentives provided by road user charging. As an analogous example, European hauliers have incentives to use their “cleanest trucks” in the countries that have introduced tolls differentiated by the latest emission class, such as Germany (Centre for Transport Studies Stockholm, 2012).

In **PO1**, the phasing out of exemptions for HGVs <12t will have minor benefits for affected Member States (UK, DK, LU, NL, SE, DE, EE), since they will be compensated by increased revenues due to the increased coverage of HGVs. From 2020, countries that use external cost charging will also benefit from increased compensation for external costs via the reviewed caps and introduction of mark-ups beyond mountainous regions.

In **PO2, PO3 and PO4**, the wider uptake of tolls (introduced following phase-out of vignettes) and more extensive use of external cost charging will increase benefits for central regions with high levels of through-traffic, due to the reduction in externalities and increased toll revenues (JRC, 2010). Conversely, peripheral regions could face an increase in costs of imports/exports that may not be compensated by reductions in externalities in the region. As noted above, these effects should be expected to be small.

Under **PO3a, PO3b and PO4**, it is assumed that the option to implement genuine congestion charges will be taken up by Member States only on those links where they can significantly increase accessibility at low social costs. This will lead to small positive impacts in highly congested regions.

The overall regional impacts are summarised in Table 4-5.

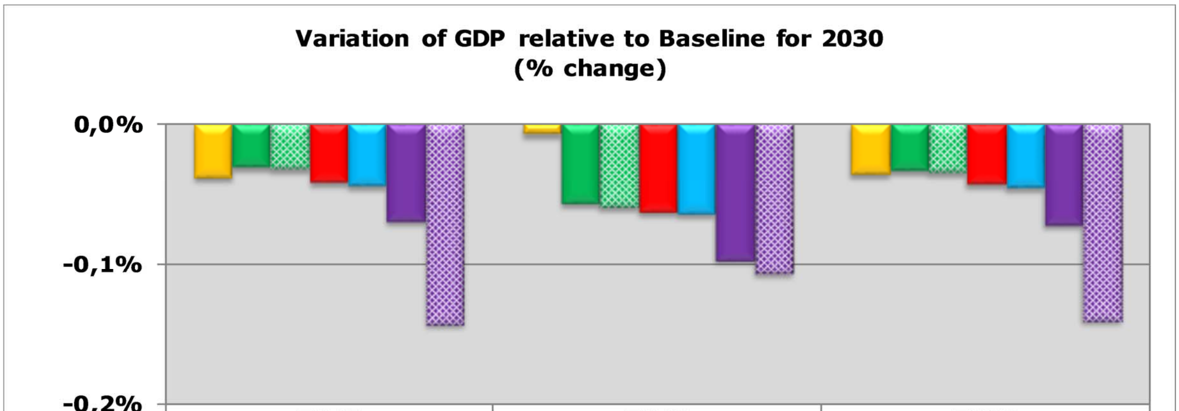
Table 4-5: Impact of road user charging on peripheral regions

Indicator	PO1	PO2	PO3a	PO3b	PO4
Road pricing	0 Negligible	× Peripheral regions could face a marginal increase in the costs for their imports and exports that in the short run may not be compensated by the increase in welfare from the reduction of externalities in the region. Overall, any negative impacts are expected to be small. Regions with a high proportion of through-traffic would benefit from the reduction of externalities and increased toll income			
Congestion charges	0 N/A		✓ Potential positive impact (up to 1% GDP) in some regions with high congestion, due to introduction of congestion charges		
CO_2 measures	0 Negligible				
Overall regional impacts	0 Negligible	0 Negligible	✓/× Small positive impact in regions of high congestion. Small negative impact on peripheral regions.		

4.1.10. Macroeconomic environment (GDP)

All policy options show limited macroeconomic impacts due to the measures assumed to be implemented. Some limited reductions in GDP are projected relative to the Baseline in 2030 (see Figure 4-9).

Figure 4-9: Variation of GDP relative to Baseline for 2030 (% change)



	EU15	EU13	EU28
PO1	0,0%	0,0%	0,0%
PO2	0,0%	-0,1%	0,0%
PO2s	0,0%	-0,1%	0,0%
PO3a	0,0%	-0,1%	0,0%
PO3b	0,0%	-0,1%	0,0%
PO4	-0,1%	-0,1%	-0,1%
PO4s	-0,1%	-0,1%	-0,1%

Source: ASTRA model

4.1.11. Competitiveness of the EU economy

Impact on existing firms

As shown in Section 4.1.1, the policy options will affect transport companies (and own account transport operators) by increasing the unit cost of road transport. *Since the whole road transport sector faces the same increase in charges when driving on tolled roads, competition within the mode would not be directly influenced.*

Indirectly, *operators who chose to adapt their behaviour to improve their efficiency would gain a competitive advantage, as well as contributing to the overall competitiveness of the EU economy*. Operators have a number of options to reduce the impact on operating costs by adapting their operation to the new circumstances through route shift, travel time shift, frequency reduction or modal shift.

In the longer term, substitution to vehicles subject to lower charges (e.g. zero emission vehicles under all Policy Options) could also lead to overall cost savings. Measures aimed to encourage low or zero CO_2 vehicles will involve additional investment costs for hauliers that want to take advantage of the rebates, since the purchase cost for low CO_2 LCVs and HGVs is significantly higher compared to their diesel equivalents (CE Delft, 2013) (Low Carbon Vehicle Partnership, 2016). However, the purchase of such vehicles is not mandatory, and will only be made by companies when it makes financial sense over the lifetime of the vehicle – as such, the measures can be considered as a benefit to competitiveness.

Impact on entry of new firms

None of the policy options should be expected to result in significant impacts or restrictions on the entry of new firms in the transport industry. In terms of any fixed costs imposed by the options, hauliers would need to invest in OBUs. The price depends the type of system (circa €150 per unit for GNSS and €10 for DSRC – see Section 4.1.7 on administrative costs). Although aggregate administrative costs are relatively large due to the large numbers of vehicles in operation, *at the micro level the fixed cost burden relative to the investment cost of a typical vehicle*[36] *is negligible*.

Impacts on upstream and downstream markets

For the most part, industries outside of transport and logistics companies tend to have a low ratio of transport costs to overall revenues (usually less than 5%), and *therefore the effect on the wider economy is likely to be marginal. This is seen numerically in the modelling results, which show a negligible overall changes in GDP as a result of the policy options* (see Section 4.1.10). Studies of the economic impacts of HGV tolls also support this conclusion - in Germany and Spain, significant price increases were found for the transport sector while only marginal impacts on other sectors (Ruehl et al, 2015).

Some sectors – such as food, agriculture and minerals - are more dependent on road transport than others to get their product to markets. As a result, they will be more exposed to changes in the cost of road transport costs seen under the policy options if these costs are passed through. However, as previously noted in Section 4.1.1, the net impacts on consumer prices is expected to be negligible in all options and hence *the impacts on prices of goods even in road-dependent industries is generally expected to be insignificant even in the case of 100% cost pass-through.*

In addition, policy options that encourage the use of congestion charging (PO3 and 4), improvements to delivery reliability due to lower congestion can improve the efficiency of their operations and lead to reductions in costs. For businesses in manufacturing and retail in particular this has implications for inventory costs, especially in sectors that rely on just-in-time delivery.

For example, trucks are a key element in the just-in-time (or lean) manufacturing process. However if their arrival times are missed, production lines can be stopped, at a cost of many times the value of the truck delay times (Hartgen and Fields, 2009). In the retail industry, timing of deliveries is critical because it is related to stocking time – the ability to get products on shelves, or from loading docks to in-store storage. Delays in receiving deliveries contribute to a need to keep more inventory on-hand – both in distribution warehouses and in manufacturing operations (Economic Development Research Group, 2007). These costs imposed by congestion are often unmeasured and unrecognised in traditional modelling or by current cost analysis.

Business sectors in which goods are perishable, costly, or difficult to warehouse; high value; or subject to rapid changes in value are most sensitive to transport reliability (NCHRP, 2001). For example, retail sellers of foods and other perishable items cannot always stockpile goods in case of delays in incoming or outgoing deliveries. Firms that produce high-tech and electronic goods face similar problems; because of rapid changes in the value of inventory, these firms and their suppliers attempt to minimise inventory levels and hence are more sensitive to the cost of delivery delays

Even under scenarios of 100% cost pass-through to customers, any reduction in the competitiveness of European manufacturing products on the global market would be minimal in all Policy Options. In PO3 and PO4, increased uptake of congestion charging will be beneficial the competitiveness of businesses, especially those that make use of just-in-time manufacturing or in which goods are perishable, costly or difficult to warehouse.

Regarding measures designed to encourage the uptake of low and zero CO_2 vehicles, there could be some positive impacts on OEMs. Taking the total cost of ownership into account, low emission LCVs are already close to their diesel equivalent (Low Carbon Vehicle Partnership, 2016); (Energy Saving Trust, 2017) – further cost advantages

[36] Around €30,000 for a LCV and €120,000 for a HGV (NEA, 2010).

through lower road user charges will therefore tip the balance further in favour of low CO_2 vehicles. Differentiation according to real driving emissions (CO_2 and pollutants) will further incentivise the renewal of the vehicle fleet, even based on conventional fuel technologies. For HGVs the total cost of ownership of zero-emission heavy-duty vehicles at present fall somewhere between 140% and 200% of conventional diesel vehicles (CE Delft, 2013). The introduction of zero emission rebates (policy package 1) and a CO_2 differentiation of charges (policy package 2) will add to the benefits of zero emission HGVs, but overall the impact on sales of low emission vehicles is relatively minor. *Overall, it can be said that there will be small positive impacts on the competitiveness of OEMs that manufacture low emission vehicles due to a slight increase in demand.*

4.1.12. Functioning of the internal market

The smooth functioning of the internal market depends on the extent to which price signals are consistent across Member States, and the extent to which these price signals internalise external costs. Tolls and charges reflect a part of real costs that transport users generate in relation to infrastructure and other externalities. Unless these real costs of transport are paid by users, these costs will have to be borne by society through other instruments such as taxes. However, road user charges are more efficient – by sending the correct price signals, user charges can shape more sustainable transport behaviour, e.g. re-directing road users to acquiring and using cleaner vehicles or using the roads outside peak hours.

More consistent price signals based on common principles in all EU countries are expected to reduce competitive distortion between Member States and increase transparency. Moreover, distance-based charges are paid by users independent of their country of establishment (unlike certain types of taxes such as vehicle taxes), and do not discriminate occasional users, or other hauliers on the ground of their nationality or origin.

- **PO1** would contribute to fairer and more consistent price signals by removing exemptions for HGVs <12t and extending the rules on tolls to buses and coaches. Revision of the caps/values for external cost charging will also simplify their application and make the charges more accurate, which could lead to greater use of such charges by Member States. PO1 would not, however, be expected to have a large impact on the number of Member States that choose to introduce distance-based charges.
- **PO2** would likely lead to greater uptake of distance-based charging, although the outcomes are uncertain, due to the phase-out of vignettes for HDVs. Member States with vignettes could choose to replace the lost revenue through raising taxes, or introduce distance-based charges (aided by the option to moderate circulation taxes for HGVs, which would increase public acceptability). More consistent price signals would be achieved by phasing out the EURO class differentiation to allow more extensive use of external cost charging.
- **PO3a and PO3b** would have similar effects as PO2, with the addition of allowing genuine congestion charging that would encourage more Member States to apply such charges on congested links. This would contribute to the functioning of the internal market by allowing freer flow of traffic/trade, and better internalising the external costs of congestion.
- In addition, **PO3b** would introduce variation of LDV charges according to WTLP for emissions classes and CO_2, which would promote more consistent policy messages about the importance of choosing cleaner, more fuel-efficient vehicles and contribute to EU wide goals for CO_2 reduction and clean air.
- **PO4** would have the most beneficial effect on the internal market due to the additional measure to phase out vignettes for LCVs (although as for HGV vignettes, replacement by distance-based tolls is not mandatory). The

mandatory external cost charging for noise and air pollution will ensure the highest level of internalisation.

4.1.13. Impact on third countries

The adoption of proportional rules for vignette pricing for LCVs and cars will predominantly affect occasional or non-resident drivers who are more likely to buy short-term vignettes. This would benefit drivers from third countries in the same way as foreign/occasional road users in general (see Section 4.3.4). By having access to proportionately priced vignettes for shorter time periods, users are more likely to consider single day leisure or business trips across borders encouraging cross border trading, commuting, commercial or social trips (Booz & co., 2012b) – this would have positive impacts on private users and businesses in third countries under PO1-3 (and under PO4 until vignettes are phased out in 2025).

As seen in Section 4.1.1, each of the policy packages is expected to lead to increased transport costs, although these are minor overall. Road users from Russia, Turkey, Ukraine and the Balkans, who are some of the EU's main commercial partners, are most likely to be impacted. HGVs, which are more heavily involved in international transit, will also be more affected compared to LCVs, which only account for a very small share of international transport or cross-trade, more commonly being used in urban or national transport (Ricardo Energy & Environment et al, 2017).

The increase in transport costs for road users from third countries will be in proportion to the extent that they use the road networks in EU countries. The most significant increases will be in the case of drivers in Member States that currently do not have any road charging system, but are expected to adopt new distance-based tolls under the policy packages; however, this holds true for any road user and it is not specific to those from third countries. Road users from third countries could face an increase in costs when they travel in European countries, they would not receive compensation for external costs of European drivers travelling on their own roads if their country did not have a similar road charging policy – again, this would hold true for any user and is not a specific impact for those from third countries.

Table 4-6: Impact on third countries for each policy option

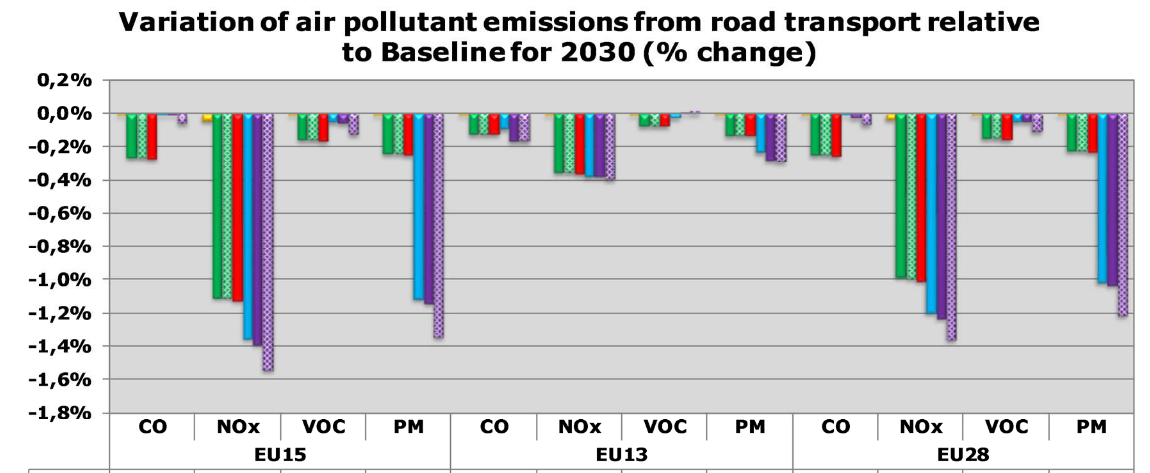
	PO1	PO2	PO3a	PO3b	PO4
Impact on third countries	Minor impacts overall. Positive due to proportionate rules on vignette price. Small increase in costs due to increased transport costs in case of distance-based charges, but not specific to users from third countries as it applies to all road users				

4.2. Environmental impacts

4.2.1. Air quality

The measures analysed have a small impact on air pollutant emissions from road sector. Impacts are slightly higher for PO3b, PO4 and PO4s which include the modulation of infrastructure charges according to CO_2 emissions for passenger cars and drive the uptake of hybrid and electric vehicles (i.e. plug-in hybrids and battery electric).

Figure 4-10: Variation of air pollutant emissions from road sector relative to Baseline for 2030 (% change)



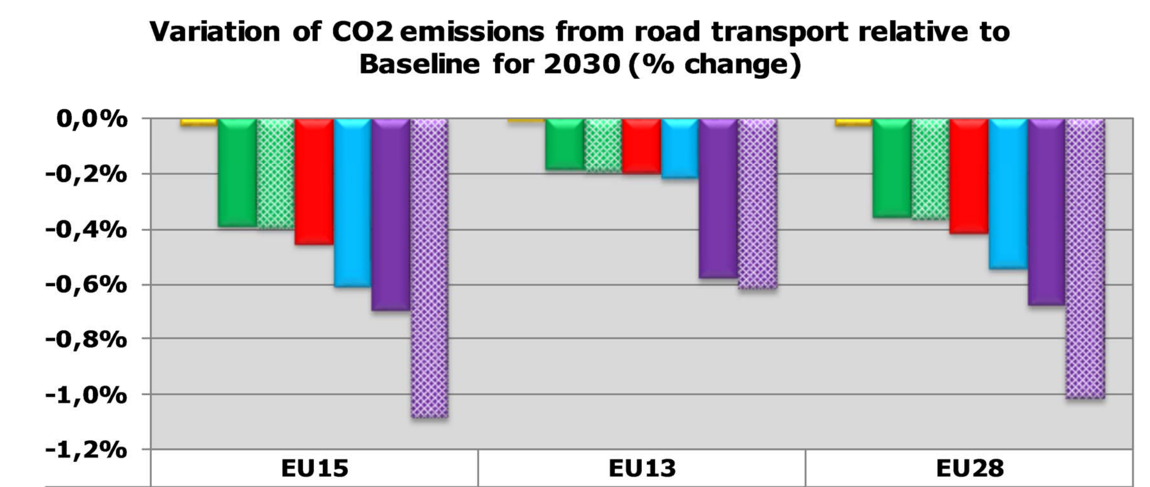
	CO	NOx	VOC	PM	CO	NOx	VOC	PM	CO	NOx	VOC	PM
	EU15				EU13				EU28			
PO1	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PO2	-0,3%	-1,1%	-0,2%	-0,2%	-0,1%	-0,4%	-0,1%	-0,1%	-0,3%	-1,0%	-0,2%	-0,2%
PO2s	-0,3%	-1,1%	-0,2%	-0,2%	-0,1%	-0,4%	-0,1%	-0,1%	-0,3%	-1,0%	-0,2%	-0,2%
PO3a	-0,3%	-1,1%	-0,2%	-0,2%	-0,1%	-0,4%	-0,1%	-0,1%	-0,3%	-1,0%	-0,2%	-0,2%
PO3b	0,0%	-1,4%	-0,1%	-1,1%	-0,1%	-0,4%	0,0%	-0,2%	0,0%	-1,2%	-0,1%	-1,0%
PO4	0,0%	-1,4%	-0,1%	-1,1%	-0,2%	-0,4%	0,0%	-0,3%	0,0%	-1,2%	-0,1%	-1,0%
PO4s	-0,1%	-1,5%	-0,1%	-1,3%	-0,2%	-0,4%	0,0%	-0,3%	-0,1%	-1,4%	-0,1%	-1,2%

Source: ASTRA model

4.2.2. Climate change

The impacts on CO_2 emissions from road transport are also limited (see Figure 4-11), showing more significant impacts in PO4 and PO4s.

Figure 4-11: Variation of CO_2 emissions from road sector relative to Baseline for 2030 (% change)



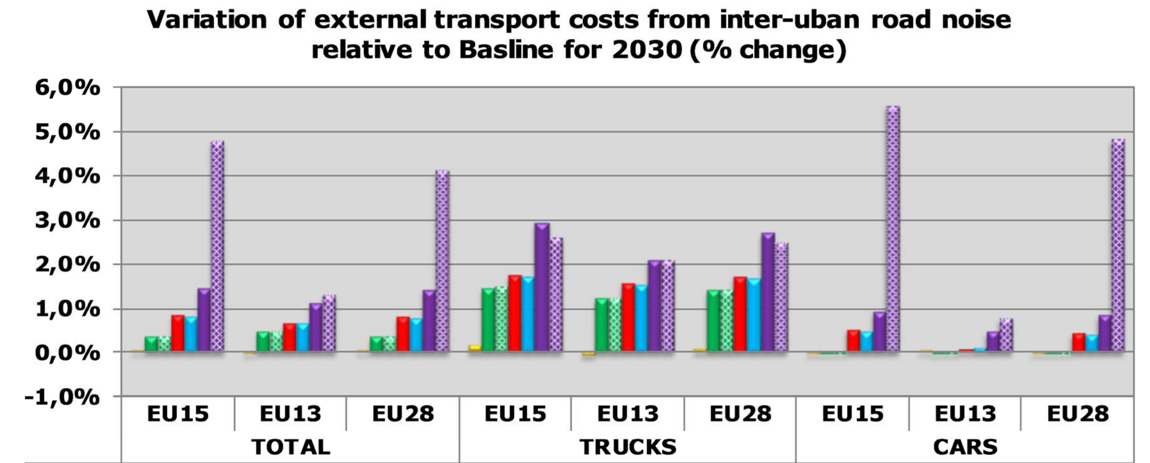
	EU15	EU13	EU28
PO1	0,0%	0,0%	0,0%
PO2	-0,4%	-0,2%	-0,4%
PO2s	-0,4%	-0,2%	-0,4%
PO3a	-0,5%	-0,2%	-0,4%
PO3b	-0,6%	-0,2%	-0,5%
PO4	-0,7%	-0,6%	-0,7%
PO4s	-1,1%	-0,6%	-1,0%

Source: ASTRA model

4.2.3. Noise

Results for external costs from inter-urban road noise show that the diversion to secondary untolled routes increases the externalities from noise, with PO4s showing the biggest increase (4.1% increase relative to the Baseline in 2030 at EU28 level).

Figure 4-12: Variation of external transport costs from inter-urban road noise relative to Baseline for 2030 (% change)



	EU15	EU13	EU28	EU15	EU13	EU28	EU15	EU13	EU28
		TOTAL			TRUCKS			CARS	
PO1	0,0%	0,0%	0,0%	0,1%	-0,1%	0,1%	0,0%	0,0%	0,0%
PO2	0,4%	0,5%	0,4%	1,5%	1,2%	1,4%	-0,1%	0,0%	-0,1%
PO2s	0,4%	0,5%	0,4%	1,5%	1,2%	1,4%	-0,1%	0,0%	-0,1%
PO3a	0,8%	0,7%	0,8%	1,7%	1,5%	1,7%	0,5%	0,1%	0,4%
PO3b	0,8%	0,7%	0,8%	1,7%	1,5%	1,7%	0,5%	0,1%	0,4%
PO4	1,5%	1,1%	1,4%	2,9%	2,1%	2,7%	0,9%	0,5%	0,8%
PO4s	4,8%	1,3%	4,1%	2,6%	2,1%	2,5%	5,6%	0,8%	4,8%

Source: ASTRA model

The transport network model does not take into account possible traffic bans for certain type of vehicles on secondary roads. The diversion to these non-tolled roads is therefore possibly overestimated, suggesting higher noise costs than might occur if Member States adopted complementary policies.

In addition, since congestion charging would be voluntary, it is reasonable to assume that Member States would only implement such schemes after thoroughly assessing local conditions and accompanied them measures to mitigate any undesired traffic diversion (such as improving access to alternative transport modes, limiting transit traffic on secondary roads or charging during peak hours). The impacts on noise levels are therefore considered to be the upper bound in case complementary measures are not taken by the Member States.

4.2.4. Land use

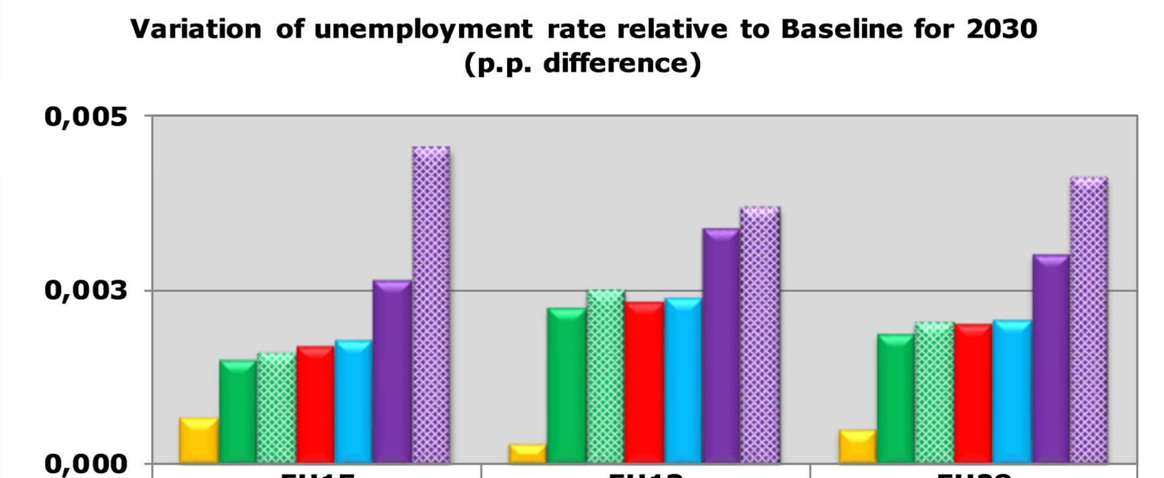
There are extensive motorway networks across Europe, which represents a considerable cost in terms of habitat loss and habitat fragmentation of EUR 49-110 thousand per year for each kilometre of motorway (CE Delft, 2008). To the extent that policy options can reduce transport activity (see Section 4.1.2) and reduce congestion and in order to make more efficient use of the available infrastructure (see Section 4.1.2), it can be expected that they will reduce the need for building new motorways or expanding existing motorways and hence has a positive impact compared to the baseline. PO1 will have no noticeable impact, while *all other policy options have some positive impact with respect to reducing transport demand, and PO3-4 also have an additional benefit in terms of greater deployment of congestion-reducing schemes.*

4.3. Social impacts

4.3.1. Employment

The increase in unemployment rate is not significant (see Figure 4-13).

Figure 4-13: Variation of unemployment rate relative to Baseline 2030 (p.p. difference)



	EU15	EU13	EU28
PO1	0,0	0,0	0,0
PO2	0,0	0,0	0,0
PO2s	0,0	0,0	0,0
PO3a	0,0	0,0	0,0
PO3b	0,0	0,0	0,0
PO4	0,0	0,0	0,0
PO4s	0,0	0,0	0,0

Source: ASTRA model

4.3.2. Public health and safety

The overall impact in this area is due to the aggregation of impacts on factors that influence public health and safety – in particular, emissions of harmful air pollutants and the risk of accidents. The previous sections on the environmental impacts indicate that _PO2-4 are expected to lead to a reduction in air pollutants from road transport – with corresponding benefits for public health_.

Specifically regarding congestion charges (under **PO3 and PO4**), the uptake of such charges has also been associated with a reduction in accidents. For example, in London there was a significant reduction accidents in the charged zone (more than proportional to the reduction in miles driven) (Green et al, 2015). Furthermore, there is no evidence that the congestion charge resulted in a permanent increase in accidents for uncharged times, adjacent geographic regions or uncharged vehicles (Green et al, 2015) - meaning that there were true reductions, rather than a transference of accidents to other areas.

Table 4-7: Impact on public health and safety for each policy option

Indicator	PO1	PO2 and PO2s	PO3a	PO3b	PO4 and PO4s
External cost of air pollution (NOx, PM, CO, VOC) from the road transport sector	Negligible reductions in air pollutants	Small reductions (-0.3%)	Some reductions in air pollutants thanks to modulation of charges (-0.4%)	Small reductions (-0.5%)	Small reductions in external costs (-0.5% to -0.6%)
External cost of accidents	Negligible reductions at EU-28 level. Very Small reductions due to road charging for lighter HGVs	Negligible reductions at EU-28 level. Small reductions due to distance-based road charging for HDVs	Small local reductions due to uptake of congestion charging.	Small local reductions due to road charging and uptake of congestion charging	Small reductions at EU-28 level (-0.2% to -0.5%). Small local reductions due to uptake of congestion charging.
Overall assessment	Negligible	Small positive impact)	Small positive impact	Small positive impact	Small positive impact

4.3.3. Social inclusion and distributional effects

Distributional effects could potentially arise from any of the policy options, since they imply changes to the cost of transport. As seen in Section 4.1.1 the potential for changes in freight costs to affect consumers via cost pass-through to increased product prices is rather limited; hence, the main element of relevance to distributional effects are changes to the costs of passenger transport.

It is relevant to consider different concepts of equity. ***Market equity*** implies that the prices/taxes paid by individuals for transportation should be proportional to the costs imposed. Instruments that are not based on the user and polluter-pays principles discourage travellers from considering how their travel choices impose costs on society (through congestion delays, noise, emissions etc). As such, policy options that imply a greater move toward greater implementation of user- and polluter-pays principles have greater market equity compared to the current situation (i.e. policy options that imply greater moves toward tolls and congestion charging). This is because they place the primary responsibility for payment on those responsible for the use/pollution, and not on those too poor to afford vehicles or who choose to travel by other means (NTPP, 2010). Under this interpretation of equity:

- **PO1** would not impact on market equity, as the options are mainly relevant for freight aspects, but inclusion of buses/coaches in the scope, along with revision of external cost charges, may contribute to better internalisation of external costs for passenger transport.
- **PO2** would phase out vignettes for buses/coaches, and if these were replaced by tolls, it would improve the internalisation of external costs and have positive impacts on market equity (see impacts on external costs in Section 4.2).
- **PO3a and 3b** foresee greater use of congestion charging for all vehicles. This would lead to better internalisation of external costs and therefore improve market equity (see impacts on external costs in Section 4.2).
- **PO4** would introduce mandatory external cost charging that would affect buses/coaches in countries with road tolls, thereby improving internalisation and market equity.

Another concept is of ***outcome equity***, which focusses on equality of access or mobility for individuals regardless of their circumstances. This is a key concern, since transportation is an important link to aspects of quality living (such as education, paid work, recreation, health care, culture etc). At the same time, the equity impacts of road pricing are complex difficult to measure, and few conclusions can be generalised between regions. There are both progressive and regressive impacts that could arise, as follows:

- **Road pricing may disproportionately affect lower-income groups** – for example, it may cause these groups to alter their travel patterns more than wealthier groups[37]. There is also a risk that road-pricing schemes may give less benefit to lower income people, since they tend to have a higher marginal utility of money and lower values of time (Di Commo & Lucas, 2014). This suggests that both the income affordability and time-poverty constraints could lead to greater transport inequity and related social exclusion.
    - However, the magnitude of such impacts is expected to be negligible. For the case of PO1-3, no new tolls are introduced for passenger cars, so the policy measures would only result in very minor, if any, changes in their costs – as reflected in the modelled results of changes in passenger transport costs that are essentially zero.
    - For PO4, the impact depends on the introduction of new tolls to replace vignettes, however, even in this case the impacts are small – annual toll charges typically amount to less than **2% of the total annual ownership cost of a car[38].**
- **Road pricing could also benefit lower-income groups** because higher-income individuals tend to drive the most and thus would pay a higher proportion of the tolls (NTPP, 2010). Also, the negative effects of congestion, traffic safety problems and air pollution often affect lower income groups much more than the higher income groups (van Amelsfort et al, 2015).

Even though there may be distributional effects of general road pricing, the increases in costs of passenger transport are generally negligible for PO1-3(see Section 4.1.1). The cost to consumers of introducing new road tolls (PO4 only) will have some impact (increase in passenger transport costs of 5%); however, this is expected to be

[37] A relatively large body of research suggests that travellers with lower incomes are more sensitive to variations in fares, tolls, and fees than those with higher incomes (NTPP, 2010).

[38] Annual ownership costs are approximately €6,000/yr (Together EU, 2012).

insignificant compared to the average ownership costs of a car (<2% on average) and does not account for possible uses of revenues that may offset distributional effects. Hence, the effect of all POs on general mobility and outcome equity can be expected to be insignificant.

The measures that aim to stimulate uptake of zero emission passenger cars (all options) and low CO_2 passenger cars (PO3b and PO4) have similar distributional effects as road pricing in general. Studies show that total costs of ownership for ultra-low emission vehicles are similar or even lower than comparable diesel or petrol cars (SMMT, 2016), and the additional savings in road user charges will make such vehicles more financially attractive. However, the increased purchase price for low and zero CO_2 vehicles is likely to have a bigger impacts on higher income consumers (as these consumers are more likely to purchase new vehicles). These more fuel efficient vehicles will eventually move into the second-hand car market, where lower income consumers are more likely to purchase them. The rapid depreciation of car values in the first few years is likely to ensure that second-hand owners can reap the fuel savings without the fuel efficiency being fully reflected in the prices they pay for used cars (Ricardo AEA, 2015) – *meaning that in the long term, lower income groups will also benefit from the CO_2 measures.*

Congestion charges frequently raise equity concerns and therefore merit some deeper analysis. Economic theory suggests that there could be disproportionate impacts on workers with lower incomes (particularly if there is no alternative to paying the charge, such as public transport). Moreover, car dependency has rapidly increased amongst low-skilled and lower income people in European cities like London, Paris and Madrid, increasing the exposure of these groups to congestion charges (Di Commo & Lucas, 2014).

The social impacts on congestion charges will depend on location-specific conditions, such as local labour distribution and travel patterns. For example, several studies in Stockholm suggest that there are no regressive effects, and potentially progressive effects overall (Eliasson, 2014). Conversely, studies in the Madrid Metropolitan Area found that the economic burden of urban road pricing particularly affects unskilled and lower income individuals (Di Commo & Lucas, 2014). Kristoffersson & Engelson (2016) demonstrate that even in the same city, the design of a congestion charging scheme can change the outcomes from progressive to regressive. In the longer term, "winners" and "losers" are more difficult to identify as people change jobs or move house (Walker, 2011).

These examples illustrate the dangers of analysing impacts at the EU level. Even so, it can generally be said that the average driver will usually pay more in congestion charges than they gain back in terms of value of time saved, but that the revenues are more than enough to compensate (Eliasson, 2014). Hence, it is possible to design a progressive package by, for example, complementing pricing with investments to improve public transport, cycling and walking and/or by compensating those on lower incomes, e.g. through the welfare system. Whether congestion pricing has progressive or regressive effects depend on the design of the system and on initial travel patterns – and most crucially, on the use of revenues.

Finally, it is important to note that the public acceptability of any new road pricing scheme depends in large part upon the perceived equity of its design, and therefore it is likely that any new schemes will be introduced with such considerations in mind. There are a range of measures that can be taken to mitigate equity concerns, which entail (Taylor et al, 2010):

- Use of revenues: Pricing can be progressive if the revenues are spent to improve transportation services for low-income groups or those with lower mobility;
- Limiting the geographical scope of congestion schemes to the most highly congested zones/corridors;

- Discounts, which reduce the congestion charge paid, and exemptions, which exclude certain persons or vehicles from payment, are a common method of addressing equity concerns[39].

The research shows that one of the main questions that affected the overall equity of tolls and congestion charges is the use of revenues. Member States are likely to face opposition to introduction of congestion charges if the scheme is perceived to be inequitable. The revenues can be used to counteract any regressive impact, which is a key factor in the acceptability of the systems – hence it is likely that any new congestion charge introduced under the policy options will be (perceived as) equitable, otherwise they will be rejected by the public.

Table 4-8 summarises the different aspects of equity and distributional impacts.

Table 4-8: Impact on equity and distributional effects

Indicator	PO1	PO2	PO3a	PO3b	PO4
Market equity (user/ polluter pays principles)	0 Very minor / negligible impact due to extension of scope to include bus/coach	✓ Small positive impact due to phase out vignettes for buses/coaches, assuming these would be replaced by tolls	✓ Greater internalisation of external congestion costs foreseen for all vehicles		✓ Congestion charging of all vehicles and mandatory external cost charges for bus/coach
Outcome equity (access / mobility)	0 Small impact on transport costs. Small positive impact due to uptake of zero CO_2 passenger cars that will eventually benefit lower-income consumers		✓/x Outcome depends on scheme design and use of revenues (esp. for congestion charging), but schemes are likely to be designed to be neutral or progressive in order to ensure public acceptability. Small positive impact due to uptake of zero CO_2 passenger cars that will eventually benefit lower-income consumers		
Overall assessment	0 Very minor / negligible	✓ Small positive impact due to phase out vignettes and slight increase in uptake of zero CO_2 cars	✓ Greater internalisation of external congestion costs (all vehicles). Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance. Small positive impact due to uptake of zero CO_2 passenger cars that will eventually benefit lower-income consumers		✓ Greater internalisation of external congestion costs & air pollution for bus/coach. Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance. Small positive impact due to uptake of zero CO_2 passenger cars

[39] Discounts and exemptions may make congestion pricing more equitable, but they also undermine efficiency, since they reduce incentives to discourage low-value trips or to promote travel at less congested times/routes etc.

4.3.4. Equal treatment of EU citizens

Equal treatment of citizens refers mainly to the principle of non-discrimination. The main policy measure that is relevant is the proposed **change to the rules on pricing of long-term versus short-term vignettes (included in all POs)**. The measure targets the problem of discrimination directly by ensuring that price ratios of short-term versus long-term vignettes are proportionate.

Table 1-5 shows that the average price ratio in 2016 between the 10-day and annual vignette is 6.01 for passenger cars and 5.32 for LCVs. Without policy intervention, it is assumed that existing and newly introduced LDV vignette would apply similar rates to those used in existing systems (since the disproportionate price ratios exist in many Member States and have persisted over time, as established in the problem definition).

As shown in Table 1-5, the new proposed ratio of 2.9 for 10 day vignettes under **PO1-4** would be substantially lower than typical existing ratios (on average, 52% lower for passenger cars and 45% lower for LCVs). For one-month vignettes, the difference is smaller but still significant, with a reduction of 24% and 19% respectively for cars and LCVs. Consequently, drivers using short-term vignettes in any Member State that introduces a new LDV vignette will experience benefits in terms of more equal treatment under PO1-4.

Table 4-9: Vignette prices for light duty vehicles across Member States, 2016

Member State	Ratio between 10 day and annual vignette (new suggested =2.9)	Ratio between 1 month vignette and annual vignette (new suggested =2.2)
Passenger cars		
Austria	3.75	1.80
Bulgaria*	8.34	3.65
Czech Republic	7.44	3.60
Hungary	2.51	1.34
Romania*	5.59	3.04
Slovakia	7.30	3.41
Slovenia*	7.11	3.32
Average of current systems	**6.01**	**2.88**
Proposed ratio	*2.9*	*2.2*
% reduction under the measure	*52%*	*24%*
LCVs (vans)		
Austria	3.75	1.80
Bulgaria*	8.34	3.65
Czech Republic	7.44	3.60
Hungary	2.94	2.69
Lithuania*	2.4	1.12
Romania*	3.26	2.03
Slovakia	7.30	3.41
Slovenia*	7.11	3.32
Average	**5.32**	**2.7**
Proposed ratio	*2.9*	*2.2*
% reduction under the measure	*45%*	*19%*

** Price ratio of 7-day vignette used, as countries do not offer 10 days*
*** Price ratio of 2-month vignette used, as AT does not offer a 1-month vignette*

Further impacts connected to the equal treatment are could potentially arise from the requirement that *at least two* short-term vignette types have to be introduced, once of which should be a 10 day vignette. This will ensure that users have access to appropriate vignettes for their needs. However, the additional benefits are not expected to be major, since all Member States currently already offer at least two short-term vignettes. Nevertheless, the provision does provide an assurance that new schemes will provide sufficient flexibility.

The voluntary introduction of a 4-day vignette will also be beneficial for transit travellers, who are typically only in a country for a very short time. In the current system, such travellers pay a price that is almost nine times greater than that paid by regular users to use the network for that day (Booz & Co, 2012a). Due to the limited availability of vignettes shorter than one week, a positive impact on equal treatment of occasional users can be expected. The magnitude of the impact is however limited by the voluntary nature of the measure.

Estimating the magnitude of such impacts is challenging because data on the share of foreign road users that use short-term vignettes is limited. Available figures for selected Central and Eastern European Member States[40] suggest that the estimated proportion of foreign car journeys on main routes is relatively similar across the countries, with an average share around 30% (ITC, 2013). While this estimate has some caveats (the share will be lower for Member States in the periphery of the EU, the methodology over-estimates the extent of foreign car traffic), it does give an indication of the upper bound of the size of the population potentially discriminated against due to disproportional vignette prices. Data on the exact share of foreign road users out of this estimated 30% who use specific short-term vignettes is also not widely available, but it can be assumed that they would make up a high share of the total. Hence, around 30% of road users in a typical country could benefit from more equal treatment under PO1-4.

[40] AT, CZ, HU, SI, SK

5. COMPARISON OF OPTIONS

The following sections compare the options in terms of:

- Effectiveness;
- Efficiency;
- Main economic, environmental and social impacts.

5.1. Effectiveness

The analysis of the overall effectiveness of the options must consider the extent to which the objectives are achieved. Table 5-1 maps out the general and specific objectives to the key indicators.

Table 5-1: Linking of objectives to key indicators

General objective	Specific objective	Key indicators
Promote financially and environmentally sustainable and socially equitable (road) transport through wider application of the 'user pays' and 'polluter pays' principles (fair and efficient pricing).	Contribute to the reduction of CO_2 emissions from transport	Impact on CO_2 emissions from transport
	Ensure adequate quality of roads in exchange for user charges	Impact on road quality
	Ensure that road pricing better reflects the real cost of use, including externalities, and that it treats occasional / non-resident motorists fairly	Impact on level of internalisation of external costs Impact on equal treatment of occasional / non-resident motorists
	Make use of road charging as an effective tool in reducing congestion	Impact on congestion costs

Notes: The objective to ensure adequate quality of roads is assessed in Annex C

Table 5-2 summarises the effectiveness of each option against the key indicators. In terms of the first specific objective of **contributing to the reduction of CO_2 emissions from transport,** Policy Option 1 allows reduced rates for HDVs and LDVs. However, this measure alone has a negligible impact on CO_2 emissions from road transport in 2030 compared to the baseline.

PO2, PO2s and PO3 strengthen the targeting of CO_2 emissions by requiring CO_2 differentiation of road user charges for HDVs from 2020. The modelling assumptions were that most countries would introduce this from 2025. In PO2 and 3a, reductions in total CO_2 emissions from the road transport sector in 2030 would be 0.4% compared to the baseline at the EU-28 level. However, the effect varies depending on the country, and reductions can reach as much as 1.0-1.2% in specific countries (although the median is 0.2%). **PO3b** extends the CO_2 differentiation also to LDVs (LCVs and passenger cars). This increases the impact on CO_2 reductions (0.5% reduction in CO_2 by 2030 compared to the baseline). Finally, **PO4 and PO4s** show the highest impact on CO_2 emissions, showing a reduction of 0.7 to 1.0%.

The decreases in CO_2 emissions in PO2-4 indicate that differentiation of road user charging can play a supporting role to other CO_2 reduction efforts, and moreover it helps to provide consistent policy messaging to vehicle buyers across the economy regarding the need for CO_2 reduction efforts. As a parallel example, a study of the Bonus-malus scheme in France[41] found that the policy modified consumer preferences

[41] cars are taxed (malus) or credited (bonus) if their CO_2 emissions are above or below certain targets

toward low CO_2 vehicles beyond pure pricing effects (due to the rebates and fuel prices) – such a shift was thought to be due to the information about low CO_2 vehicles provided and the effect of the feebate to introduce a new signal to consumers about how important it is to choose low CO_2 vehicles (D'Haultfoeuille et al, 2015). The proposed differentiation of road user charges by CO_2 would align the Directive with wider CO_2 reduction signals in a similar way.

The objective to **ensure adequate quality of roads in exchange for user charges** is ensured by encouraging greater uptake of tolls that generate additional revenues, which would enable Member States to sustain or increase expenditure on road maintenance. Policy Option 1 has negligible impacts in this area, whereas the objective is gradually met more effectively as the policies progress from package 2 to 3b, 3a and with 4 being the most effective. Furthermore, combining the main policy options with the additional options A and B discussed in Annex C will ensure the most effective achievement of this objective.

In terms of **ensuring that road pricing better reflects the road cost of use**, it can be seen that the measures of **PO1** ensure that road pricing is extended to include HGVs <12t and buses/coaches, ensuring a more uniform inclusion of vehicle types across Europe. The review of caps/values for external cost charging will also enable more accurate and simple charges, which should make it more attractive for Member States to use.

Under **PO2 and PO3,** the achievement of this objective is uncertain, since the key measures allow Member States flexibility over whether to introduce charges or not. Nevertheless, in view of past trends, it is expected that the phase-out of vignettes for HDVs would be expected to lead to more uptake of tolling, since Member States will be motivated to replace the revenue. The phasing out of Euro class differentiation will help to encourage more extensive use of external cost charging (although this is still optional for Member States).

PO4 will have the greatest effectiveness against this objective, particularly due to the mandatory requirement to include external cost charging for noise and air pollution for HDVs in addition to the replacement of vignette systems by distance-based tolling.

With regard to the **fair treatment of occasional / non-resident motorists,** all **POs** contribute equally to this objective due to the introduction of rules on the proportionate pricing of short-term vignettes, which will lead to lower costs for occasional users (52% lower cost for passenger cars using a 10-day vignette on average; 45% for LCVs).

Finally, the objective to **make use of road charging as an effective tool in reducing congestion** is not fully achieved by **PO1 or PO2 (and PO2s)**, since these options do not lead to the deployment of any new congestion charging schemes. Despite this, the increase in the level of tolling in particular through mark-ups in some Member States will have a marginal positive impact in PO2 on reducing congestion (0.2%) due to a small reduction in overall traffic levels.

The impact of **PO3a, PO3b and PO4** as regards congestion is more positive, although somewhat uncertain because the introduction of such charges is voluntary. Nevertheless, by allowing for genuine congestion charging, the complexity of respecting the previous requirement for revenue neutrality is removed, and it can be expected that Member States will be motivated to introduce such charges where needed. If the assumptions made in this impact assessment hold, **PO3/4** will lead to the deployment of fair congestion charging on the most congested links; this will allow the third specific objective to be met with a reasonable degree of effectiveness. Under **PO3a** and **PO3b,** reductions of 2.4% and 2.5% respectively are expected. **PO4 and PO4s** have the greatest effectiveness because the phase-out of vignettes for LCVs is expected to lead to greater introduction of tolls for these vehicles, and consequently could allow easier introduction of congestion charges and the largest expected reduction in congestion (ranging from 2.5% to 6.1% in 2030 compared to the baseline depending on assumptions over which countries introduce distance-based charges).

Table 5-2: Effectiveness of the policy options

Key: Impacts expected

Least effective	Mid-level effectiveness	Most effective

	PO1	PO2 and PO2s	PO3a	PO3b	PO4 and PO4s
Specific Objective 1: Contribute to the reduction of CO_2 emissions from transport					
CO_2 emissions from transport	No significant effects expected	Small effect due to CO_2 differentiation for HGVs (-0.4% in main option and sensitivity	Small effect due to CO_2 differentiation for HGVs (-0.4%)	Most effective due to CO_2 differentiation for HGVs *and* LDVs (-0.5%)	Most effective due to CO_2 differentiation for HGVs *and* LDVs (-0.7% main option; -1.0% sensitivity)
Specific Objective 2: Ensure adequate quality of roads in exchange for user charges					
Impact on road quality	In proportion to additional toll revenues (+5%)	In proportion to additional toll revenues (+15% in main option and sensitivity)	In proportion to additional toll revenues (+28%)	In proportion to additional toll revenues (+25%)	In proportion to additional toll revenues (+60% main option; +160% sensitivity)
Specific Objective 3: Ensure that road pricing better reflects the real cost of use, including externalities, and that it treats occasional / non-resident motorists fairly					
Impact on level of internalisation of external costs	No significant effects expected	Positive outcomes due to replacing vignettes by distance-based charging, but can be limited by the voluntary nature of external cost charging			Most effective due to mandatory external cost charging
Equal treatment of occasional / non-resident motorists	All equally effective due to rule on proportionate pricing				
Specific Objective 4: Make use of road charging as an effective tool in reducing congestion					
Congestion costs	No significant effects expected (0.0%)	No significant effects expected (-0.2%)	Allows genuine congestion charging, although uptake is voluntary (-2.4%)	Allows genuine congestion charging, although uptake is voluntary (-2.5%)	Potentially most effective due to phase out of vignettes for LCVs leading to infrastructure available for congestion charging in more countries (-2.5% main option; -6.1% sensitivity)

In terms of effectiveness, PO1, PO2 and PO3a do not contribute strongly to several of the key objectives around congestion costs, reducing CO_2 emissions and improving road quality. Conversely, PO3b and PO4 show average or good effectiveness against all of the objectives, with PO4 being slightly ahead of PO3 due to the wider scope of road tolls (after phase out of vignettes for LCVs) and mandatory inclusion of external cost charges. The key uncertainty with respect to all POs is that the introduction of tolls remains voluntary, which makes the ultimate outcomes uncertain. The sensitivity analysis (PO4s) shows that the potential impacts are greater if more countries are assumed to introduce distance-based charges.

5.2. *Efficiency (cost-effectiveness)*

Efficiency can be defined as *"the extent to which objectives can be achieved for a given level of resource/at least cost".* The major costs of the policy options come in the form of higher direct transport costs, as well as the implementing and operational costs of the charging schemes. These additional costs can be balanced against the additional revenues generated by user charges, as well as the achievement of the objectives (outlined above).

As can be seen in Table 5-3, higher additional costs are generally associated with higher additional benefits and vice versa.

- **PO1** shows limited effectiveness and limited costs.
- **PO2 and PO3a** perform similarly in terms of cost-effectiveness, since they have similar costs and benefits – although PO3a has slightly better effectiveness and higher revenues.
- **PO3b** shows better cost-effectiveness than PO2 and PO3a, since it has similar costs but slightly higher effectiveness against CO_2 reduction objectives. However, the difference is not significant.
- **PO4** has the highest effectiveness, but also involves higher costs to authorities and users (due to the larger user base that would result from including LDVs in road tolls). There is uncertainty over the possible cost to passenger car users under the schemes, with the lower bound indicating that OBUs are taken up only as a convenience option (and hence no costs are assumed) versus the upper bound, which assumes a level of cost for these users.

Table 5-3: Indicators of efficiency

Key:

Least efficient	Mid-level	Most efficient

	PO1	PO2	PO3a	PO3b	PO4
Additional costs					
CAPEX for authorities	Insignificant	€1,202 m for the main option (€1,387 m for the sensitivity)			€1,334 m for the main option (€2,193 m for the sensitivity)
OPEX for authorities	Insignificant	€168 m/year for the main option (€200 m/year for the sensitivity)			€184 m/year for the main option (€313 m/year for the sensitivity)
Administrative cost to users	Insignificant	€8 m/year from 2020 to 2025; €198 m/year from 2025 onward for the main option (€228 m/year sensitivity)			€8 m/year from 2020 to 2025; €240m/year from 2025 onward for the main option (€310 myear sensitivity)
Benefits					
Revenues	+5%	+15% (+15% in sensitivity)	+28%	+25%	+60% (+160% in sensitivity)

	PO1	PO2	PO3a	PO3b	PO4
Effectiveness in achieving objectives	No significant effects expected	Some contribution to lower CO_2 and wider uptake of tolls	Good contribution to objectives to reduce CO_2 and external costs	Good contribution to objectives to reduce CO_2 and external costs (slightly higher than PO3a in terms of CO_2 reductions)	Potentially most effective due to widest uptake of tolls, congestion charges and external cost charges

5.3. Main economic, environmental and social impacts

The main economic, environmental and social impacts are shown in Table 5-4.

The analysis of **economic impacts** shows the most important differences. The main trade off is between the increased costs for transport users and to authorities, balanced against increased revenues and reductions in congestion costs and other externalities. There are also some potentially negative impacts in terms of distribution and impact on SMEs, as a result of increased costs

The main **environmental impacts** relate to the reductions in CO_2 and air pollutants from road transport. These are highest for PO4 and PO4s (0.7 to 1.0% reduction in CO_2 compared to the baseline in 2030, 1.0 to 1.2% reduction in PM and 1.2 to 1.4% reduction in NOx). The reductions under PO1 are negligible. PO2 and PO3a perform similarly, with reductions of 0.4% for CO_2, 0.2% for PM and 1.0% reduction in NOx. PO3b is between PO3a and PO4, with reductions of 0.5% in CO_2, 1.0% for PM and 1.2% for NOx from road transport.

In terms of **social impacts**, all policies can be expected to make a minor positive contribution by increasing the fairness of road user charges. PO3 and PO4 are expected to have slightly most positive effects due to greater internalisation of external costs (contributing to fairness) and slightly higher benefits for public health and safety.

Table 5-4: Main economic, environmental and social impacts

Key: Impacts expected				
××	×	O	✓	✓✓
Strongly negative	Weakly negative	No or negligible impact	Weakly positive	Strongly positive

	PO1	PO2	PO3a	PO3b	PO4
Economic impacts					
Transport costs Freight transport % change compared to the Baseline)	+0.2%	+0.9% (+1.0% in sensitivity)	+1.0%	+1.1%	+1.5% (+2.0% in sensitivity)
Transport costs Passenger transport (% change compared to the Baseline)	+0.0%	+0.0% (+0.0% in sensitivity)	+0.1%	0.0%	+1.3% (+2.0% in sensitivity)
Congestion costs	0.0%	-0.2% (-0.2% in sensitivity)	-2.4%	-2.5%	-2.5% (-6.1% in sensitivity)
Tolling revenues	+5%	+15% (+15% in sensitivity)	+28%	+25%	+60% (+160% in sensitivity)
Impact on SMEs	0/× Minor negative impacts due to the lower capacity of SMEs to absorb increases in cost, but no significant distortions expected				
CAPEX to authorities	0 Insignificant	€1,202 m for the main option (€1,387 m for the sensitivity)			€1,334 m for the main option (€2,193 m for the sensitivity)
OPEX to authorities	0 Insignificant	€168 m/year for the main option (€200 m/year for the sensitivity)			€184 m/year for the main option (€313 m/year for the sensitivity)

	PO1	PO2	PO3a	PO3b	PO4
Administrative cost to road users	0 Insignificant	€8 m/year from 2020 to 2025; €198 m/year from 2025 onward for the main option (€228 m/year sensitivity)			€8 m/year from 2020 to 2025; €240m/year from 2025 onward for the main option (€310 myear sensitivity)
Road quality	0/✓ Very minor positive impact due to 5% increase in revenues	✓ Small positive impact due to 15% increase in revenues	✓ Small positive impact due to 28% increase in revenues	✓ Small positive impact due to 25% increase in revenues	✓✓ Positive impact due to 60-160% increase in revenues
Regional impacts	0 Negligible	0 Negligible	✓/× Small positive impact in regions of high congestion. Small negative impact on peripheral regions.		
GDP	0.0%	0.0% (0.0% in sensitivity)	0.0%	0.0%	-0.1% (-0.1% in sensitivity)
Competitiveness	0 No impact on competitiveness of European manufacturing products on the global market.	✓ Minor positive impact on competitiveness due to differentiated CO_2 charging for HDVs leading to improved efficiency	✓ Minor positive impact on competitiveness due to differentiated CO_2 charging for HDVs leading to improved efficiency Increased uptake of congestion charging will be beneficial to the competitiveness of businesses, especially those that make use of just-in-time manufacturing or in which goods are perishable, costly or difficult to warehouse		
Internal market	✓ Small positive impact due to removal of exemptions for HGVs<12t and extension to buses/coaches	✓ Small positive impact due to phase out of vignettes and EURO class differentiation – potentially leading to more tolls and external cost charging (voluntary)	✓ As for PO2, plus allowing genuine congestion charging that would encourage more Member States to apply such charges on congested links		✓✓ Highest uptake of tolls likely due to phase out of LCV vignettes. Mandatory external cost charging

	PO1	PO2	PO3a	PO3b	PO4
Third countries	0 Minor impacts overall. Positive due to proportionate rules on vignette price. Small increase in costs due to increased transport costs, but not specific to users from third countries as it applies to all road users				
Environmental impacts					
CO_2 from road transport	0 Negligible	-0.4% (-0.4% in sensitivity)	-0.4%	-0.5%	-0.7% (-1.0% in sensitivity)
Air pollution from road transport (NOx and PM)	0 Negligible	-1.0% NOx; -0.2% PM (-1.0% NOx; -0.2% PM in sensitivity)	-1.0% NOx; -0.2% PM	-1.2% NOx; -1.0% PM	-1.2% NOx; -1.0% PM (-1.4% NOx; -1.2% PM in sensitivity)
Noise[42]	0.0%	+0.4% (+0.4% in sensitivity)	+0.8%	+0.8%	+1.4% (+4.1% in sensitivity)
Land use	0 Negligible	✓ Very minor positive impact due to transport demand reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction	✓ Very minor positive impact due to transport demand reduction and congestion reduction
Social impacts					
Employment	0 Negligible				

[42] Noise: note that the model does not take into account possible accompanying measures that would prevent the diversion of traffic into more sensitive areas, which is the reason for higher noise costs

	PO1	PO2	PO3a	PO3b	PO4
Public health & safety	Negligible	Small reductions in external costs of air pollution from road (-0.3%; -0.3% in sensitivity)	Small reductions in external costs of air pollution from road (-0.4%)	Small reductions in external costs of air pollution (-0.5%)	Negligible impact on external cost of air pollution (-0.5%; -0.6% in sensitivity) and accidents (-0.2%; -0.6% in sensitivity)
Social inclusion	0 Very minor / negligible	✓ Small positive impact due to phase out vignettes	✓✓ Greater internalisation of external congestion costs (all vehicles). Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance		✓✓ Greater internalisation of external congestion costs & air pollution for bus/coach. Congestion charges are likely to be designed to be progressive / equitable to gain public acceptance
Equal treatment of EU citizens	✓ More proportionate charges for occasional users in countries with vignettes (52% lower for passenger cars; 45% for LCVs)				

6. MONITORING AND EVALUATION

The preferred policy option includes many different elements, which require, or provide the opportunity for, Member States to amend their infrastructure charging policy framework. The package of policy measures has been designed to be complementary and consequently should be evaluated in their entirety, along with the other elements of the Directive. It is likely to be the end of 2020 before the Directive has been transposed by Member States, taking account of the need for two years to pass through the co-decision process and a one year transposition period. Furthermore, various elements of the proposed revised Directive would only apply from after 2020. While the evaluation should be undertaken by the Commission in order for it to be independent, the Commission's evaluation should draw upon the experience of Member States as much as possible. Consequently, it would make sense for the Member States to provide information on their experiences with the revised Eurovignette Directive by the end of 2025, which will be used for the Commission's evaluation in 2026. This would ensure that the various elements of the amended Directive have had sufficient time to have had an impact.

While it is recognised that requiring Member States to report upon their experiences with the revised Eurovignette Directive requires administrative resources, information supplied to the Commission is an opportunity to ensure that the subsequent evaluation and review of the Eurovignette Directive meets the needs of Member States. In this respect, Member State reporting contributes to better regulation and enables evidence-based policy making.

The Commission's evaluation should cover *inter alia*, in each case raising any issues or challenges that suggest the need for an amendment to the Directive:

- The extent to which Member States have used the provisions of the amended Directive to incentivise the use of more fuel efficient and zero emission vehicles, their experiences with these, including which have worked and which have not, along with any synergies with other (national) policy measures.
- The experiences of Member States and other stakeholders, including road users, with the reports and indicators introduced to ensure the quality of tolled roads.
- The experience of Member States and other stakeholders, particularly occasional users of vignettes, with the provisions to prevent discrimination as a result of the pricing structure of short-term vignettes.
- The extent to which Member States have used the new provisions that allow for genuine congestion charging in distance-based charging systems, the levels at which charges have been set and Member States experiences with these.
- Any other issues arising that prevent the Directive achieving its objectives.

As a result, it is proposed that:

1. Commission creates and maintains a register of information supplied by Member States.
2. Member States provide the Commission with information on any incentives introduced to promote zero emission vehicles in their territory, including their scope (e.g. types of vehicles covered, roads on which the incentive is applied) and reduced rates applied, as soon as it is implemented.
3. Member States provide the Commission with information on any differentiation by CO_2 emissions introduced for HDVs, as soon as it is implemented.
4. Member States provide the Commission with information on any moderation of circulation taxes for HGVs over 12 tonnes that is introduced to mitigate against the perception of double taxation as a result of the introduction of distance-based charging, as soon as it is implemented.
5. Member States provide the Commission with information on any congestion charge applied, including its level and coverage (e.g. roads and time periods to which it is applied), as soon as it is implemented.

6. Member States provide the Commission with information on any differentiation by real-driving emissions introduced for LDVs, including the level of charges applied and the roads to which the charges are applied, as soon as it is implemented.
7. Member States forward each infrastructure report for tolled roads to the Commission, as soon as it is published.
8. Member States in which quality indicators for monitoring tolled roads already exist should provide information on these indicators to the Commission to support the development of the harmonised set of indicators to be developed by the Commission.
9. Member States provide a report on their experiences with the Directive by the end of 2025 covering the issues noted above that need to be covered in the Commission's evaluation.

7. ANNEX A: MODELLING APPROACH

This annex contains the detailed assumptions of the baseline and policy options. In addition, it provides the modelling results used to support the analysis in the main report.

A model suite has been used for the analytical work, combining the strengths of three different models: **ASTRA, PRIMES-TREMOVE and TRUST.** The model suite covers the entire transport system (e.g. transport activity represented at Member State level, by origin-destination and at link level, technologies and fuels at Member State level, air pollution emissions at Member State and link level and CO_2 emissions at Member State level) and its macro-economic impacts:

- **Geography:** individually all EU Member States.
- **Time horizon:** 2005 to 2050 (5-year time steps) in PRIMES-TREMOVE. ASTRA has been run up to 2030 for this impact assessment.
- **Transport modes covered:** private road passenger (cars, powered 2 wheelers), public road passenger (buses and coaches), road freight (heavy goods vehicles, light commercial vehicles), passenger rail, freight rail, passenger aviation, freight and passenger inland navigation and short sea shipping. Numerous classes of vehicles and transport means with tracking of technology vintages.
- **Regions/road types:** traffic represented at country level in PRIMES-TREMOVE[43]; by origin at NUTS2 level in ASTRA and at link level by NUTS3 region in TRUST.
- **Energy:** all crude oil derived fuels, biofuels, CNG, LNG, LPG, electricity and hydrogen (PRIMES-TREMOVE[44] and ASTRA).
- **Emissions:** greenhouse gas emissions and pollutants emissions (CO, NOx, PM2.5), and VOC (ASTRA).
- **Stock of vehicles:** full dynamics of stock turnover for road (more refined) and non-road transport means.
- **Macro-economic impacts:** GDP and employment (ASTRA).

The **PRIMES-TREMOVE** model is a building block of the modelling framework used for developing the EU Reference scenario 2016 and has been used for the 2011 White Paper on Transport and the 2016 European strategy on low-emission mobility. In this impact assessment PRIMES-TREMOVE has been used to define the **Baseline scenario**, having as a starting point the EU Reference scenario 2016 but additionally including few policy measures that have been adopted after its cut-off date (end of 2014). In addition, it was used to assess the impacts of modulation of infrastructure charges according to CO_2 emissions on vehicle fleet composition (see section 7.2.1).

In order to calculate the full list of indicators needed for **assessment of the policy options**, the **ASTRA** and **TRUST** models were used in combination to maximise the benefits of their individual capabilities. ASTRA has been used to quantify the impacts of policy options and to provide indicators for the direct effects on the transport system (e.g. transport activity, energy use, air pollutant and CO_2 emissions) and for the indirect effects of transport on the economic system (e.g. GDP, employment). The Baseline scenario has been calibrated on PRIMES-TREMOVE projections.

For each policy options, ASTRA provided the TRUST model with the average road charge by country (based on the new vehicle fleet composition) and with updated road

[43] For trip classes distinction between urban areas (distinguished into one metropolitan and other urban areas) and inter-urban areas (distinguished into motorways and other roads).

[44] PRIMES-TREMOVE additionally provides for the linkage to refuelling/recharging infrastructure by trip type.

demand growth rate by mode, country, Origin-Destination and spatial domain. For some policy option, i.e. those including congestion charging, feedback loops from TRUST to ASTRA are implemented, in order to take into account impacts on the transport network[45].

ASTRA and TRUST models have already been successfully used in the Impact Assessment Study of possible measures to revise the Eurovignette Directive carried out between 2012 and 2014. The outputs from these modelling tools are the primary sources of quantitative indicators used for analysing the transport, economic and environmental impacts of the proposed policy options.

TRUST model is a European scale transport network model that allows for the assignment of origin-destination matrices at NUTS3 level for passenger and freight demand and was used for evaluating the impacts of road assignment on link-based indicators.

7.1. Description of the modelling tools

7.1.1. PRIMES-TREMOVE transport model

The PRIMES-TREMOVE transport model projects the evolution of demand for passengers and freight transport by transport mode and transport mean. It is essentially a dynamic system of multi-agent choices under several constraints, which are not necessarily binding simultaneously. The model consists of two main modules, the transport demand allocation module and the technology choice and equipment operation module. The two modules interact with each other and are solved simultaneously.

The projections include details for a large number of transport means, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments for each EU Member State. They also include details about greenhouse gas and air pollution emissions (e.g. NOx, PM, SOx, CO), as well as impacts on external costs of congestion, noise and accidents.

In the transport field, PRIMES-TREMOVE is suitable for modelling *soft measures* (e.g. eco-driving, deployment of Intelligent Transport Systems, labelling), *economic measures* (e.g. subsidies and taxes on fuels, vehicles, emissions; ETS for transport when linked with PRIMES; pricing of congestion and other externalities such as air pollution, accidents and noise; measures supporting R&D), *regulatory measures* (e.g. CO_2 emission performance standards for new passenger cars and new light commercial vehicles; EURO standards on road transport vehicles; technology standards for non-road transport technologies), *infrastructure policies for alternative fuels* (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG). Used as a module which contributes to a broader PRIMES scenario, it can show how policies and trends in the field of transport contribute to economy wide trends in energy use and emissions. Using data disaggregated per Member State, it can show differentiated trends across Member States.

PRIMES-TREMOVE has been used for the 2011 White Paper on Transport, Low Carbon Economy and Energy 2050 Roadmaps, the 2030 policy framework for climate and energy and more recently for the Effort Sharing Regulation, the review of the Energy Efficiency Directive, the recast of the Renewables Energy Directive and for the European strategy on low-emission mobility.

The PRIMES-TREMOVE is a private model that has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[46], based on, but extending

45 See Annex A of Ricardo et al. (2017) Support Study for the Impact Assessment Accompanying the Revision of Directive 1999/62/EC.

46 Source: http://www.e3mlab.National Technical University of Athens.gr/e3mlab/

features of the open source TREMOVE model developed by the TREMOVE[47] modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model[48]. Other parts, like the component on fuel consumption and emissions, follow the COPERT model.

As module of the PRIMES energy system model, PRIMES-TREMOVE[49] has been successfully peer reviewed[50], most recently in 2011[51].

7.1.2. ASTRA model[52]

ASTRA is a strategic model based on the Systems Dynamics Modelling approach simulating the transport system in combination with the economy and the environment. The model is made of different modules linked to each other. The basic structure of ASTRA is depicted in the figure below.

[47] Source: http://www.tmleuven.be/methode/tremove/home.htm

[48] Several model enhancements were made compared to the standard TREMOVE model, as for example: for the number of vintages (allowing representation of the choice of second-hand cars); for the technology categories which include vehicle types using electricity from the grid and fuel cells. The model also incorporates additional fuel types, such as biofuels (when they differ from standard fossil fuel technologies), LPG and LNG. In addition, representation of infrastructure for refuelling and recharging are among the model refinements, influencing fuel choices. A major model enhancement concerns the inclusion of heterogeneity in the distance of stylised trips; the model considers that the trip distances follow a distribution function with different distances and frequencies. The inclusion of heterogeneity was found to be of significant influence in the choice of vehicle-fuels especially for vehicles-fuels with range limitations.

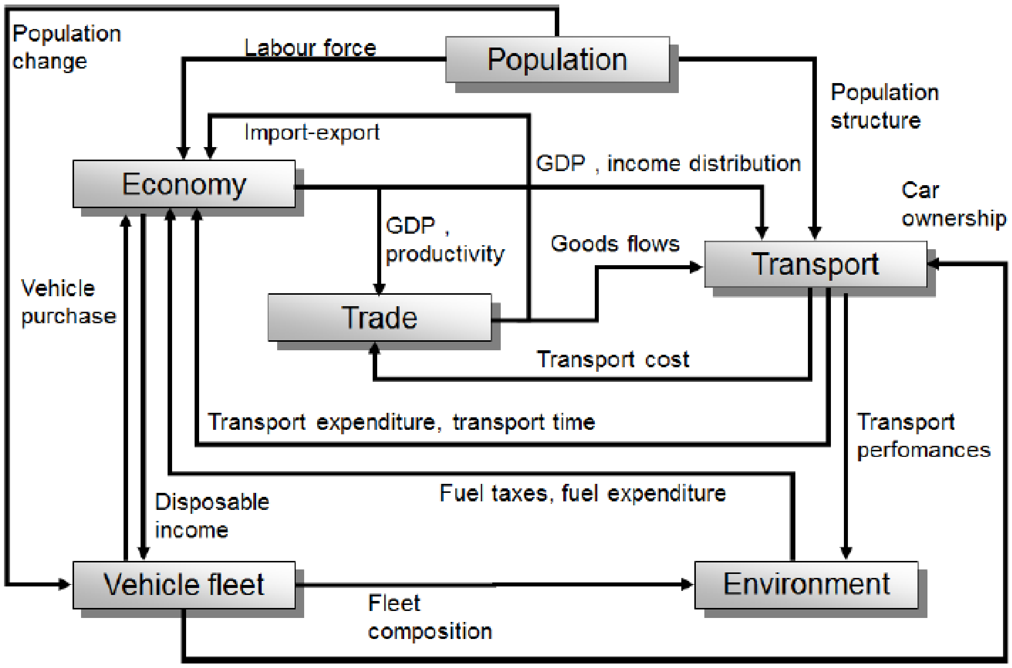
[49] The model can be run either as a stand-alone tool (e.g. for the 2011 White Paper on Transport and for the 2016 Strategy on low-emission mobility) or fully integrated in the rest of the PRIMES energy systems model (e.g. for the Low Carbon Economy and Energy 2050 Roadmaps, for the 2030 policy framework for climate and energy, for the Effort Sharing Regulation, for the review of the Energy Efficiency Directive and for the recast of the Renewables Energy Directive). When coupled with PRIMES, interaction with the energy sector is taken into account in an iterative way.

[50] Source: http://ec.europa.eu/clima/policies/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf.

[51] https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1569_2.pdf

[52] A full description of the ASTRA model is provided in the D4.2 of the ASSIST Project available at http://www.astra-model.eu/doc/ASSIST_D4-2_ASTRA-EC_Model.pdf.

Figure 7-1: Basic structure of the ASTRA model



Five main modules represent the major subsystems and their relationships. The macroeconomic module simulates the fundamental variables of the economic structure. Some of these variables (e.g. GDP) are transferred to the transport generation module, which use the input to generate a distributed transport demand. In the transport module, transport demand is split by mode of transport. The traffic performance by mode is associated to the composition of the fleet computed in the dedicated module and to the emissions factors defined in the environmental module to estimate total emissions.

Several feedback effects take place in the model. For instance, the economic module sends the level of income to the fleet module, in order to estimate vehicle purchase, and receive from the fleet module the information on the total number of purchased vehicles to account for this item of transport consumption and investment. Furthermore, changes in the economic system immediately feed into changes of the transport behaviour and alter origins, destinations and volumes of European transport flows.

The treatment of the linkage between transport and the economy is particularly detailed due to some 'micro-macro bridges'. For instance, transport expenditures in the transport module produce changes in sectoral consumption and GDP at national level: closing the feedback loop therefore implies to establish either macro-micro bridges (e.g. from GDP and sectoral output to goods flows) or vice versa micro-macro bridges (e.g. from transport investments into vehicle fleets to overall investments). This will be important in this study, as ASTRA will allow us to carry out analysis of the macro-economic impacts of the proposed policy options.

The main micro-macro bridges link:

- Passenger transport and sectoral consumption
- Transport and sectoral investment
- Transport and sectoral employment
- Freight transport and total factor productivity
- Transport and intermediate inputs of input-output tables
- Transport and exports.

In addition, government revenues and expenditures are differentiated as far as possible into categories that can be modelled endogenously by ASTRA and one category covering other revenues or other expenditures. Categories that are endogenous comprise, for example, VAT and fuel tax revenues, revenues from transport charges, and transport investments. Intermediate demand is modelled by means of an explicit Input-Output mechanism that describes the technical coefficients between the economic sectors.

The environment module uses input from the transport module (in terms of vehicle-kilometres-travelled per mode and geographical context) and from the vehicle fleet module (in terms of the technical composition of vehicle fleets), in order to compute fuel consumption, greenhouse gas emissions and air pollutant emissions from transport. ASTRA also estimates the upstream emissions (well-to-tank) due to fuel production and vehicles production. Therefore, well-to-wheel emissions can be provided as well.

ASTRA is therefore capable of analysing the long-term impacts of transport policies not only on mobility but also on wider aspects such as economic growth or greenhouse gas emissions. The model runs on an annual basis until the year 2050, covering EU28 countries plus Switzerland and Norway. It is calibrated to reproduce major indicators such as transport performance, fuel consumption, CO_2 emissions and GDP according to the main European reference sources such as Eurostat.

In ASTRA road freight transport demand is segmented by different vehicle types - LDV (below 3.5 tonnes), small HDV (from 3.5 to 12 tonnes) and large HDV (above 12 tonnes) - according to different spatial domains (i.e. local, short, national, international). Assumptions on the composition of vehicle fleet used in each spatial domain are made to reflect the use of each vehicle type (see table below as an example).

Table 7-1: Usage of vehicles in the different spatial domains

	Local [Intra NUTS3]	Short [Extra NUTS3 and intra NUTS2]	National [Extra NUTS2 and intra NUTS0]	International [Extra NUST0]
LDV (< 3.5 t)	100%	27%	-	-
HDV (3.5 t - 12 t)	-	73%	30%	-
HDV (> 12t)	-	-	70%	100%

To simulate road network charging, the model estimates at first an average charge by vehicle type (LDV, HDV below 12 tonnes, HDV above 12 tonnes), weighted where required on the composition of the vehicle fleet by EURO classes and, for LDV, also on fuel engine (gasoline, diesel, battery electric). The assumptions on the type of vehicles (weight) used in each spatial domain is the basis to estimate the average toll by context. This value is contributing to the transport cost of each road mode in each context, where the modal split is simulated. The following table reports the transport modes available for freight transport modal split in each context.

Table 7-2: Transport modes available in the different spatial domains

	Local [Intra NUTS3]	Short [Extra NUTS3 and intra NUTS2]	National [Extra NUTS2 and intra NUTS0]	International [Extra NUST0]
Road	X	X	X	X
Rail		X	X	X
Inland Waterways		X	X	X
Maritime			X	X

The toll cost is applied only to the share of traffic using the tolled network, differentiated by spatial domain and country on domestic network. The share of traffic is estimated on the basis of the share of traffic on the tolled network with respect to the total traffic on main road network in each NUTS1 zone of a country derived from TRUST. In addition, it is expected that the tolled network is used less in the short distance band.

The table below provides an overview of the road freight vehicle fleet segmentation in ASTRA.

Table 7-3: Road freight vehicle fleet segmentation

Truck vehicle	Fuel	Vehicle size	Emission standard
Heavy Duty Trucks	Diesel	3.5 t to 12 t, above 12 t	Pre-Euro, Euro I, Euro II, Euro III, Euro IV, Euro V, Euro VI, post-Euro VI
	Battery electric	3.5 t to 12 t, above 12 t	n.a.
	Hybrid	3.5 t to 12 t, above 12 t	n.a.
	LPG	3.5 t to 12 t, above 12 t	n.a.
	CNG	3.5 t to 12 t, above 12 t	n.a.
Light Duty Trucks	Diesel	Below 3.5 t	Pre-Euro, Euro I, Euro II, Euro III, Euro IV, Euro V, Euro VI, post-Euro VI
	Gasoline		Pre-Euro, Euro I, Euro II, Euro III, Euro IV, Euro V, Euro VI, post-Euro VI
	Battery Electric		n.a.
	Hybrid		n.a.
	LPG		n.a.
	CNG		n.a.

ASTRA has a long record of applications in research projects for the European Commission including the following major studies:

- STEPs (Transport Strategies under the Scarcity of Energy Supply)
- TRIAS (Sustainability Impact Assessment of Strategies Integrating Transport, Technology and Energy Scenarios)
- HOP! (The Macro-economic impacts of high oil prices in Europe)
- ADAM (Adaptation and Mitigation Strategies – Supporting European Climate Policy)
- iTREN-2030 (Integrated Scenario for Energy and Transport in Europe)

In the ASSIST project, a version of ASTRA to be used directly by DG MOVE experts through a user interface was developed. More details on the ASTRA model and its applications can be found at the ASTRA website: http://www.astra-model.eu/.

7.1.3. TRUST model

TRUST (TRansport eUropean Simulation Tool) is a transport network model developed by TRT in the MEPLAN software environment. The model builds on the transport network of TRANS-TOOLS and allows for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight road demand. The whole Europe is covered, including Accession and Neighbouring countries. At Member State level, the Baseline trend of road transport activity has been aligned to the trend of road transport demand in the ASTRA model, which is calibrated according to PRIMES-TREMOVE projections.

Road transport demand is modelled in TRUST by means of origin-destination matrices between NUTS3 zones. Intra-NUTS3 demand is not part of the matrices as it is not assigned to the network, but implicitly considered as pre-load on links.

The matrices of tonnes and passengers are estimated from various sources, including Eurostat, national statistics and ETIS.

TRUST freight matrix includes tonnes transported by vehicles above 3.5 tonnes (i.e. HDVs) and is segmented in four categories according to two dimensions: domestic vs. international and short vs. long distance. This segmentation allows us to apply dedicated parameters and to measure how each segment contribute to link loads.

No differentiation of the freight matrix by HDV type is available. For this reason, the model works with an average charge (currently weighted on the composition of the vehicle fleet and on the charges by vehicle size and EURO classes, where applied). Average charges are applied to the road network as link-based tolls and are differentiated according to link types (e.g. motorway, roads with separate carriageways, two-lane roads) and at country level.

The road network includes all the relevant links between the NUTS3 regions, i.e. motorways, primary roads, but also roads of regional and sub-regional interest. Network links are distinguished in different classes, each with specific features in term of capacity and free-flow speed. Additional corrections to the link characteristics are also applied to take into account of specific conditions, e.g. links in mountain areas are explicitly recognised.

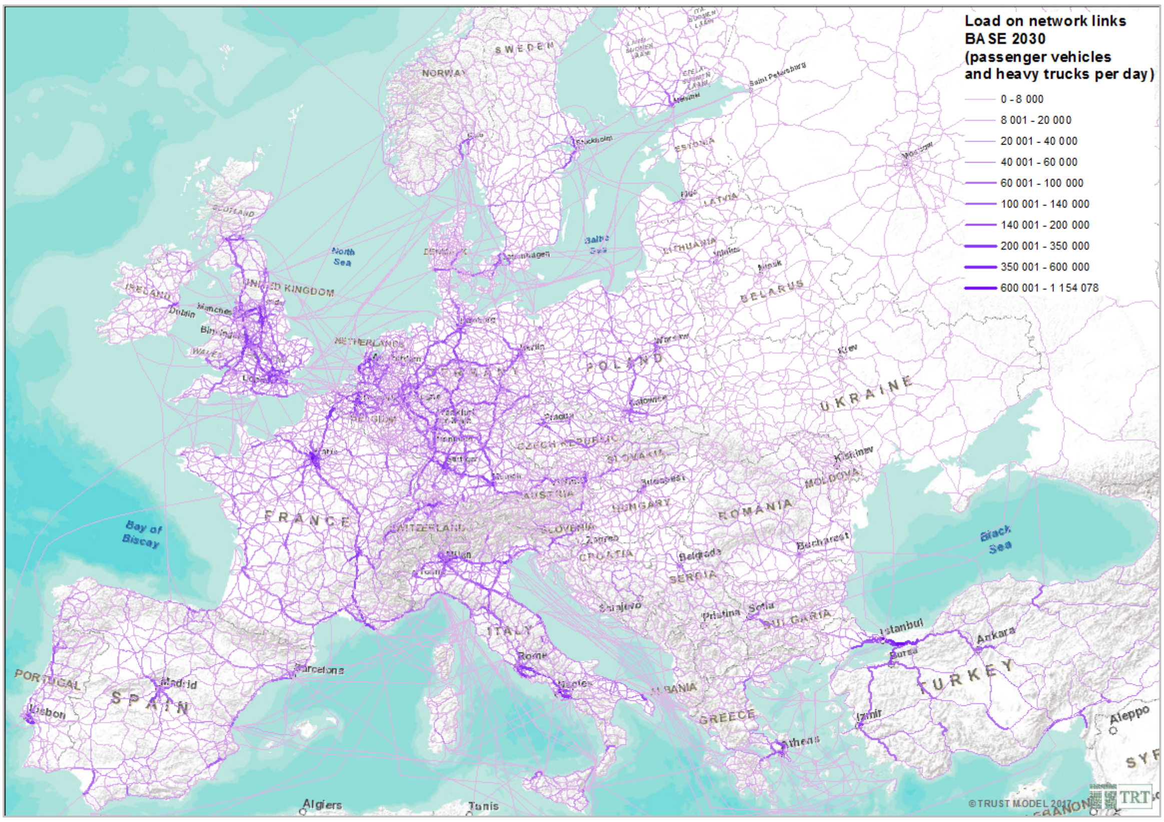
National vignettes are applied as equivalent distance fares (i.e. the fare of the yearly vignette is translated into a distance-base cost as ratio between the cost of the vignette and the average annual travelled mileage on the charged network).

The links where extra-tolls are levied (e.g. tunnels, mark-ups etc.) are modelled case by case. Link tolls, together with other variable operating costs (fuel and, for trucks, driver costs) are relevant for path choice during the assignment step. Revenues from tolls are computed by multiplying v-km travelled on the tolled network with the related link charges.

The assignment algorithm is a SUE (Stochastic User Equilibrium). For each Origin/Destination pair, the model distributes demand among available alternative routes using a logit algorithm. The utility of each path is measured in terms of generalised cost i.e. the sum of monetary costs and monetary equivalent of travel time. Travel time depends on link features and on the level of congestions. Travel cost depends on link-based tolls and on cost parameters representing the variable operating costs (fuel and, for trucks, driver costs) relevant for path choice. Variable operating costs are different across freight demand segment to reflect that lighter vehicles are used on short distances than on long distances. In addition, values of travel time, used to compute the generalised cost, are different among the freight demand segments.

The main output of the model is the load on network links in terms of vehicles per day (see example below).

Figure 7-2: TRUST model link flows



Source: TRUST model

Passenger vehicles are separated from freight vehicles and, as mentioned above, freight vehicles are separated into four different categories. By comparing load and link capacity, more congested links can also be identified (although it should be considered that real congestion is often concentrated in some periods of the day and is hardly recognisable when traffic and capacity are modelled on a daily basis).

Using load as an input parameter, the model also provides emissions by link for NOx, PM and CO2. Emissions factors based on COPERT functions and on the average fleet composition are used in the model to estimate the total emissions. When the model is run for forecasting purposes for future years, the emission factors are updated considering the ASTRA projections regarding the evolution of fleet in the selected year.

7.2. Application of the modelling tools

In carrying out the modelling analysis required for the assignment, the different policy options are translated into three types of input:

- Charge level on the tolled network;
- Extent of the tolled network; and
- Changes in other transport costs (e.g. circulation taxes).

Policy elements such as the charge type (e.g. from time-based to distance-based charging) are simulated as far as they affect one of these three elements.

The **ASTRA model** is used to produce indicators at the national level. Road charges (for cars, vans, buses and trucks) are explicitly implemented in the transport module of ASTRA. However, since the ASTRA model does not include a detailed transport network, tolls that are applied to only part of the network are modelled by assuming that a particular share of total road traffic (using data from TRUST) travels on the tolled network. Tolls are implemented in terms of €/v-km per mode and can change over time. Tolls differentiated by fuel type, Euro emission standard, age of the vehicle, truck load capacity are implemented in the model; than the input is converted to an average value by vehicle type (LDV, HDV <12 t, HDV >12 t) and country, weighted on the basis of vehicle fleet composition by country at each time step.

The ASTRA model estimate modal split by spatial domain (short distance, national, international trips). Therefore, assumptions on the vehicle types used in each spatial domain are made to estimate the average value of truck road charge for the mode split process.

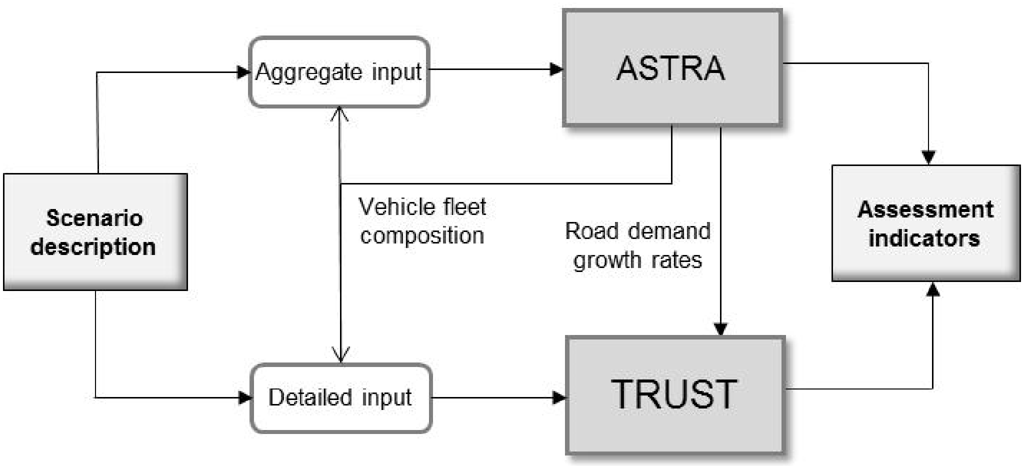
From the output of ASTRA, the aggregate impacts at the national level are extracted, including: average unitary transport cost, modal split, transport energy demand by fuel type, revenues from tolling, CO_2 emissions, pollutant emissions (CO, VOC, NOx and PM) and related external costs, road accidents external cost, macro-economic impact on GDP and employment. ASTRA is run on an annual basis until the year 2030: the impacts of each scenario are observed over time in terms of aggregated indicators.

The **TRUST network model** is used to produce link-based indicators. The inputs are defined on a network basis defining the average level of road toll charge by mode and country (weighted on the basis of vehicle fleet composition by country, using output from ASTRA). Therefore, the three types of input mentioned above were all implemented in the TRUST model, albeit in an aggregated or partial way for some inputs (e.g. vehicle taxes cannot be changed in TRUST since the model deals only with variable costs components). The input variables affect the assignment of road matrices by mode (cars and trucks) to the network, providing link-based output indicators, such as traffic loads and pollutant emissions (CO, NOx, VOC and PM).

TRUST model is run at 2030, simulating both the relevant changes on the supply side and on the demand side (i.e. updated origin-destination matrix). The matrix update is based on the growth rates of demand by mode, country, Origin-Destination and spatial domain provided by ASTRA.

Feedback from TRUST to ASTRA is used to capture the impact of congestion charges also on ASTRA output indicators. Information on the share of traffic (by vehicle type) travelling on links subject to congestion charging is provided from TRUST to ASTRA at NUTS1 level, in order to estimate the average value of congestion charge. The additional charge is applied to calculate travel costs with the related impact on modal split, and revenues from road charging.

Figure 7-3: Use of the modelling tools for scenarios simulation



7.2.1. Modelling of modulation of infrastructure charges by CO2 emissions

One of the policy measures analysed in the impact assessment study envisages the phasing out of the current differentiation of infrastructure charges by Euro emission classes and its replacement with the differentiation by vehicle CO2 emissions performance.

This policy measure might have the following order of impacts:

- Change of total road transport activity;
- Change (i.e. acceleration) of vehicle fleet renewal trend / composition;
- Change of road transport activity by vehicle type.

Both ASTRA and TRUST model present some limitations in the appreciation of the potential impacts of this policy measure, especially in terms of change of vehicle fleet renewal trend and of road transport activity by vehicle type.

To allow for a better simulation of this policy measure, an interaction with PRIMES-TREMOVE model has been established by using the results of this model as input to the modelling with ASTRA and TRUST.

In the first stage the modelling of the modulation of the charges by CO2 emissions has been therefore performed within the PRIMES-TREMOVE model on the basis of its vehicle fleet composition and respecting the revenue neutrality principle.

The PRIMES-TREMOVE model provided the following input to the ASTRA model at country level:

- Detailed road charging scheme by vehicle type (i.e. increase in road charges for vehicles with CO2 emissions above the average[53]);
- Vehicle fleet composition by fuel, euro standard, age group;
- Road transport activity by vehicle type (in terms of v-km)
- Transport activity by mode (in terms of t-km and p-km).

Based on these input, the road charges and the vehicle fleet composition were updated in the ASTRA model (aggregating the information where needed to comply with ASTRA vehicle fleet segmentation).

The impact on total road transport activity was then endogenously estimated by the ASTRA model as a consequence of any impact on the modal split: as far as the average charge in each spatial domain covered by ASTRA (short distance, national, international trips) was changing, an impact on road mode share was observed.

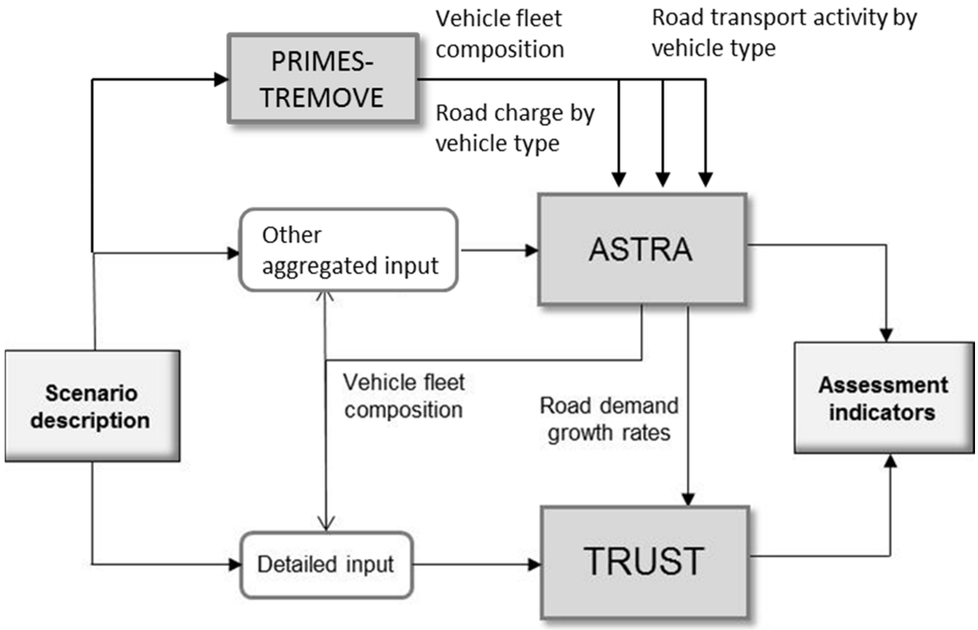
In terms of road transport activity by vehicle type (HDVs above / below 12t in ASTRA), the impact has been modelled thanks to an additional feature implemented in the ASTRA model, which reflects the impact of use of each vehicle type by spatial domain according to the results provided by the PRIMES-TREMOVE model.

The impact of CO2 road charging modulation on freight vehicle fleet composition was taken directly from the output provided by the PRIMES-TREMOVE model.

The ASTRA model then provided the TRUST model with the average road charge by country (based on the new vehicle fleet composition) and with updated road demand growth rate by mode, country, Origin-Destination and spatial domain.

[53] The increase in road charges for the part of the vehicle fleet with CO_2 emissions above the average has been derived while respecting revenue neutrality, i.e. while reducing charges for vehicles with lower than average CO_2 emissions.

Figure 7-4: Use of the modelling tools for scenarios simulation encompassing the interaction with PRIMES-TREMOVE



7.2.2. Modelling of road charging for LDVs and buses

The TRUST model assigns OD matrices of cars and HDVs to the network and doesn't have matrices of LDVs and buses.

Therefore the assessment of the policy measure related to the road charging of LDVs and buses was dealt with in ASTRA in aggregate terms and not at link level.

As already described above, since the ASTRA model does not include a detailed transport network, road charging for LDVs and buses is simulated under the assumption that, depending on the spatial domain, a share of the road traffic flow travels on the charged network. Reference shares are estimated on the basis of data from TRUST.

The description of road charging for LDVs in ASTRA is reported in section 7.1.1. For buses, a similar approach is implemented: an average road charge by country is estimated and applied only to the share of bus traffic using the tolled network in order to estimate the revenues. It is assumed that medium-long distance bus traffic basically uses as much as possible motorways: therefore the shares estimated for HDVs are taken as a reference.

7.2.3. Modelling of genuine congestion charging

Policy measures related to congestion charging on inter-urban links are generally not suitable to be modelled by European scale tools. These typically assign an average daily traffic value to the network and are not therefore able to deal with peak and off-peak transport demand and correct modelling of congestion on links.

Nevertheless, the modelling of congestion charges on some specific links has been performed by the TRUST model under certain assumptions which imply a certain level of approximation in the modelling of the policy measure. This approach has been already used in the IA study of 2012.

The modelling of this policy measure required at first the identification of potential congested links where charges should be phased in. This identification was made on the basis of the TRUST model's output of road traffic assignment at 2030 by assuming a load/capacity ratio computed on daily traffic as representative of congestion during peak time.

Congestion charges have been modelled by adding a daily average charge on the identified congested links. The level of additional charges was set according to the estimation of marginal congestion cost available from the 'Updated Handbook of external costs', by considering specific country values for traffic conditions near to road capacity detailed by road type and vehicle type.

A feedback of the results obtained from TRUST into the ASTRA model (as an exogenous input) allowed for ASTRA indicators to include the impact of congestion charging. Specifically, TRUST provided the share of traffic (by vehicle type) travelling on links subject to congestion charging with respect to the total traffic on tolled road network in each NUTS1 zone of a country. These shares were used to calculate the average value of congestion charge (applied on top of the infrastructure charge) at the NUTS1 level, which was introduced in ASTRA as an input to calculate travel costs, affecting modal split and revenues from road charging.

7.2.4. Modelling of phasing-out vignettes (phasing-in of distance-based charges)

In the models the fares of yearly vignettes are converted into distance-based charges on the basis of an average annual vehicle mileage. A differentiation between daily and yearly vignettes is not available in the models. Also, the converted distance-based charges are applied in the same way to national and foreign vehicles (no discrimination can be simulated in the models).

The modelling of the phasing-out of vignettes is approached by assuming that the phasing-out is accompanied by the phasing-in of distance-based charges. It is assumed that an increase of charge per km will occur, as distance-based charges are generally higher than the charges per km derived for vignettes.

7.2.5. Modelling of external costs charging

The modelling of external costs charging is simulated both in the TRUST and ASTRA models by applying additional charges on top of the existing infrastructure charges.

The increase of tolls with the purpose to recovery of the costs of noise and air pollution is implemented by assuming additional charges for air pollution and noise costs as available from the 'Updated Handbook of external costs'. For air pollution, EU average values by road type (interurban and motorway) in constant prices have been considered. For heavy good vehicles, charges have been applied at country level by weighting them on the vehicle fleet composition of each country.

For noise, the charges related to the night period in suburban environment and for thin traffic have been considered.

7.3. Baseline scenario

7.3.1. Scenario design, consultation process and quality assurance

The Baseline scenario used in this impact assessment builds on the EU Reference scenario 2016[54,55] but additionally includes some updates in the technology costs assumptions for light duty vehicles and few policy measures adopted after its cut-off date (end of 2014). It has been developed with the PRIMES-TREMOVE transport

[54] ICCS-E3MLab et al. (2016), EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050

[55] The EU Reference scenario 2016 projects EU and Member States energy, transport and GHG emission-related developments up to 2050, given current global and EU market trends and adopted EU and Member States' energy, transport, climate and related relevant policies by the end of 2014. The EU Reference scenario 2016 provides projections, not forecasts. Unlike forecasts, projections do not make predictions about what the future will be. They rather indicate what would happen if the assumptions which underpin the projection actually occur.

model, which is one of the core models of the modelling framework used for developing the EU Reference scenario 2016. The model was calibrated on transport and energy data up to year 2013 from Eurostat and other sources. The report "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"[56] describes the inputs and results in detail.

The ASTRA Baseline scenario has been calibrated on PRIMES-TREMOVE projections, while in TRUST the trend of road transport activity at Member State level has been estimated on the trend of road transport demand in the ASTRA model.

7.3.2. Main assumptions of the Baseline scenario

The main assumptions of the Baseline scenario, including on population growth, macroeconomic and oil price developments, technology improvements, and policies are described below.

7.3.2.1. Macroeconomic assumptions

The Baseline scenario uses the same macroeconomic assumptions as the EU Reference scenario 2016. The population projections draw on the European Population Projections (EUROPOP 2013) by Eurostat. The EU28 population is expected to grow by 0.2% per year during 2010-2030 (0.1% for 2010-2050), to 516 million in 2030 (522 million by 2050).

GDP projections mirror the joint work of DG ECFIN and the Economic Policy Committee, presented in the 2015 Ageing Report[57]. The average EU GDP growth rate is projected to remain relatively low at 1.2% per year for 2010-2020, down from 1.9% per year during 1995-2010. In the medium to long term, higher expected growth rates (1.4% per year for 2020-2030 and 1.5% per year for 2030-2050) are taking account of the catching up potential of countries with relatively low GDP per capita, assuming convergence to a total factor productivity growth rate of 1% in the long run.

7.3.2.2. Fossil fuel price assumptions

Oil prices used in the Baseline scenario are the same with those of the EU Reference scenario 2016. Following a gradual adjustment process with reduced investments in upstream productive capacities by non-OPEC[58] countries, the quota discipline is assumed to gradually improve among OPEC members and thus the oil price is projected to reach 87 $/barrel in 2020 (in year 2013-prices). Beyond 2020, as a result of persistent demand growth in non-OECD countries driven by economic growth and the increasing number of passenger cars, oil price would rise to 113 $/barrel by 2030 and 130 $/barrel by 2050.

7.3.2.3. Techno-economic assumptions

For all transport means, except for light duty vehicles (i.e. passenger cars and light commercial vehicles), the Baseline scenario uses the same technology costs assumptions as the EU Reference scenario 2016.

For light duty vehicles, the data for technology costs and emissions savings has been updated based on a recent study commissioned by DG CLIMA[59]. Battery costs for electric vehicles are assumed to go down to 205 euro/kWh by 2030 and 160 euro/kWh

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56 ICCS-E3MLab et al. (2016), EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050

57 European Commission/DG ECFIN (2014), The 2015 Ageing Report: Underlying Assumptions and Projection Methodologies, European Economy 8/2014.

58 OPEC stands for Organization of Petroleum Exporting Countries.

59 Source: https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/technology_results_web.xlsx

by 2050; further reduction in the cost of both spark ignition gasoline and compression ignition diesel are assumed to take place. Technology cost assumptions are based on extensive literature review, modelling and simulation, consultation with relevant stakeholders, and further assessment by the Joint Research Centre (JRC) of the European Commission.

7.3.2.4. Specific policy assumptions

Similarly to the EU Reference scenario 2016, the key policies included in the Baseline scenario are[60]:

- CO_2 standards for cars and vans regulations (Regulation (EC) No 443/2009, amended by Regulation (EU) No 333/2014 and Regulation (EU) No 510/2011, amended by Regulation (EU) No 253/2014); CO_2 standards for cars are assumed to be 95gCO_2/km as of 2021 and for vans 147gCO_2/km as of 2020, based on the NEDC test cycle, in line with current legislation. No policy action to strengthen the stringency of the target is assumed after 2020/2021.
- The Renewable Energy Directive (Directive 2009/28/EC) and Fuel Quality Directive (Directive 2009/30/EC) including ILUC amendment (Directive 2015/1513/EU): achievement of the legally binding RES target for 2020 (10% RES in transport target) for each Member State, taking into account the use of flexibility mechanisms when relevant as well as of the cap on the amount of food or feed based biofuels (7%). Member States' specific renewable energy policies for the heating and cooling sector are also reflected where relevant.
- Directive on the deployment of alternative fuels infrastructure (Directive 2009/30/EC).
- Directive on the charging of heavy goods vehicles for the use of certain infrastructures (Directive 2011/76/EU amending Directive 1999/62/EC).
- Relevant national policies, for instance on the promotion of renewable energy, on fuel and vehicle taxation, are taken into account.
- In addition, few policy measures adopted after the cut-off date of the EU Reference scenario 2016 at both EU and Member State level, have been included in the Baseline scenario:
- Directive on weights & dimensions (Directive 2015/719/EU);
- Directive as regards the opening of the market for domestic passenger transport services by rail and the governance of the railway infrastructure (Directive 2016/2370/EU);
- Directive on technical requirements for inland waterway vessels (Directive 2016/1629/EU), part of the Naiades II package;
- Regulation establishing a framework on market access to port services and financial transparency of ports[61];
- The replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonized Light-vehicles Test Procedure (WLTP) has been implemented in the Baseline scenario, drawing on work by JRC.

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60 For a comprehensive discussion see the Reference scenario report: "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"

61 Awaiting signature of act (Source : http://www.europarl.europa.eu/oeil/popups/ficheprocedure.do?reference=2013/0157(COD)&l=en)

- For Germany, an extension of the toll network by roughly 40,000 kilometres of federal trunk road from 2018 onwards for all heavy goods vehicles over 7.5t.[62]
- For Austria, the incorporation of exhaust emissions and noise pollution in the distance based charges. All federal highways and motorways, totalling around 2,200 km, are subject to distance based charges.
- For Belgium, a distance based system replaced the former Eurovignette for heavy goods vehicles over 3.5t from April 2016. The system applies to all inter-urban motorways, main (national) roads[63] and all urban roads in Brussels.
- For Latvia, the introduction of a vignette system applied for goods vehicles below 3.5t on the motorways, starting with 1 January 2017. In addition, for all heavy goods vehicles over 3.5t the vignette rates applied on motorways for the EURO 0, EURO I, EURO II are increased by 10% starting with 1 January 2017.

[62] Currently, 15,000 kilometres of federal trunk road and motorways are subject to tolls.
[63] E.g. http://www.viapass.be/fileadmin/viapass/documents/download/VlaanderenE.JPG

Table 4: Summary of road charging systems applied by Member States in the Baseline

Current Situation			AT	BE	BG	CY	CZ	DE[64]	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	Vignette	HGV <12t			■														■		■					■				
		HGV >12 t			■				■										■	■	■		■			■	■			■
		Buses			■											■			■		■					■				
		LGV	■		■		■									■			■		■					■		■	■	
		Cars	■		■		■									■										■		■	■	
	Toll	HGV <12t	■	■			■	▒			■	■		■	■	■	■	■						■	■			■	■	
		HGV >12 t	■	■			■	■			■	■		■	■	■	■	■						■	■			■	■	
		Buses	■				■				■	■		■	■		■	■						■	■			■	■	
		LGV									■	■		■	■		■	■						■	■					
		Cars									■	■		■	■		■	■						■	■					
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV		■	■		■		■							■			■	■	■		■	■			■	■	■	
		Buses			■		■												■		■			■				■	■	
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV	■					■																						
		Buses	■																											
Congestion charging		All																												
Mark-ups		HGV	■																											
		Buses	■																											
Reduced circulation taxes		HGV																												
		LGV																												

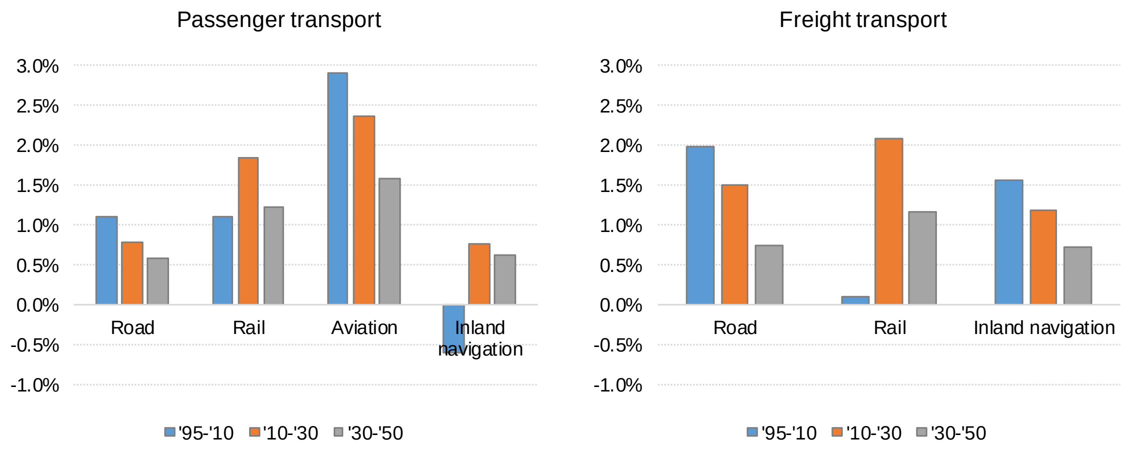
[64] In the Baseline only tolls for HGVs above 7.5 t apply.

7.3.3. Summary of main results of the Baseline scenario

EU transport activity is expected to continue growing under current trends and adopted policies beyond 2015, albeit at a slower pace than in the past. Freight transport activity for inland modes is projected to increase by 36% between 2010 and 2030 (1.5% per year) and 60% for 2010-2050 (1.2% per year). Passenger traffic growth would be slightly lower than for freight at 23% by 2030 (1% per year) and 42% by 2050 (0.9% per year for 2010-2050). The annual growth rates by mode, for passenger and freight transport, are provided in **Figure 7-5**[65].

Road transport would maintain its dominant role within the EU. The share of road transport in inland freight is expected to slightly decrease at 70% by 2030 and 69% by 2050. The activity of heavy goods vehicles expressed in tonnes kilometres is projected to grow by 35% between 2010 and 2030 (56% for 2010-2050) in the Baseline scenario, while light goods vehicles activity would go up by 27% during 2010-2030 (50% for 2010-2050). For passenger transport, road modal share is projected to decrease by 4 percentage points by 2030 and by additional 3 percentage points by 2050. Passenger cars and vans would still contribute 70% of passenger traffic by 2030 and about two thirds by 2050, despite growing at lower pace (17% for 2010-2030 and 31% during 2010-2050) relative to other modes, due to slowdown in car ownership increase which is close to saturation levels in many EU15 Member States and shifts towards rail.

Figure 7-5: Passenger and freight transport projections (average growth rate per year)



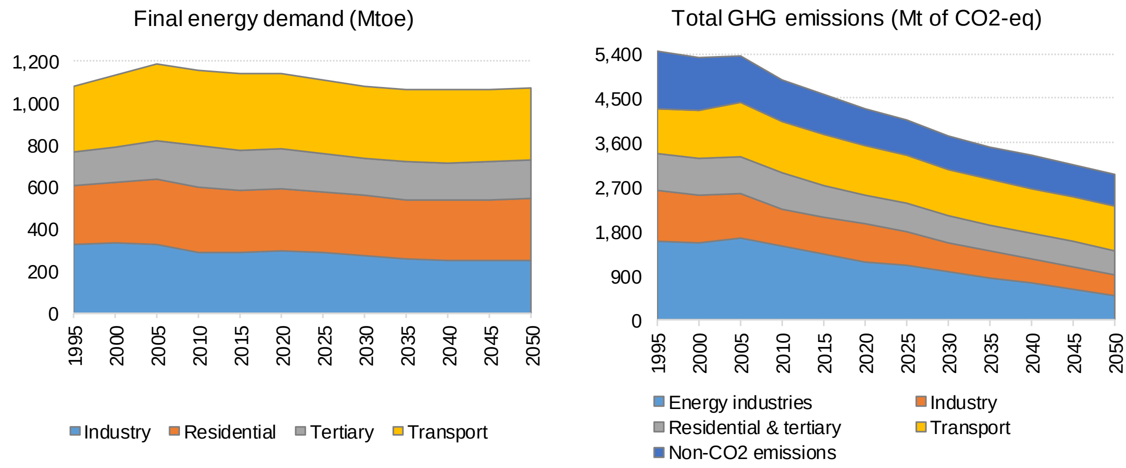
Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)
Note: For aviation, domestic and international intra-EU activity is reported, to maintain the comparability with reported statistics.

Transport accounts today for about one third of final energy consumption. In the context of growing activity, energy use in transport is projected to decrease by 5% between 2010 and 2030 and to stabilise post-2030 (see **Figure 7-6**). These developments are mainly driven by the implementation of the Regulations setting emission performance standards for new light duty vehicles. Light duty vehicles are currently responsible for around 60% of total energy demand in transport but this share is projected to significantly decline over time, to 53% by 2030 and 49% by 2050. Energy use in passenger cars and passenger vans is projected to go down by 19% during 2010-2030 (-24% for 2010-2050). Heavy goods vehicles are projected to increase their share in final energy demand from 2010 onwards, continuing the

65 Projections for international maritime and international extra-EU aviation are not included in the total passenger and freight transport activity to preserve comparability with statistics for the historical period.

historic trend from 1995. Energy demand by heavy goods vehicles would grow by 14% between 2010 and 2030 (23% for 2010-2050).

Figure 7-6: Evolution of total final energy consumption and GHG emissions for 1995-2050



Source: Baseline scenario, PRIMES model (ICCS-E3MLab)

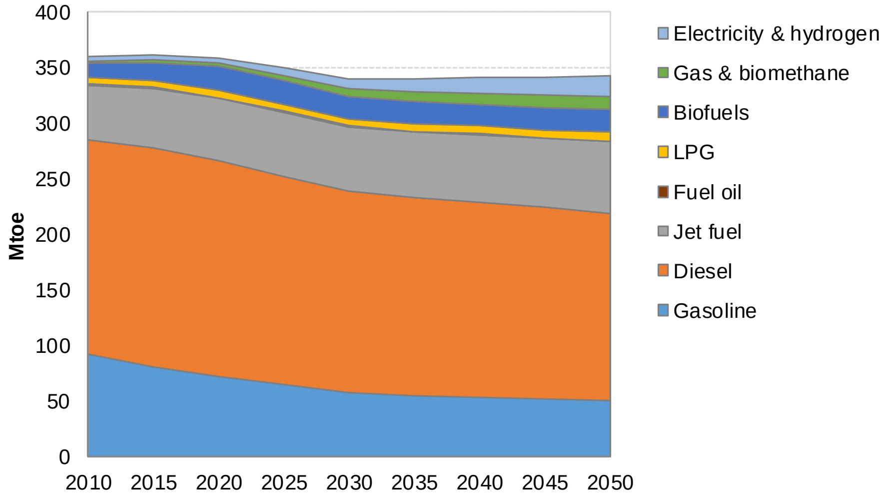
Electricity use in transport is expected to increase steadily as a result of further rail electrification and the uptake of alternative powertrains in road transport; its share increases from 1% currently to 3% in 2030 and 4% in 2050. Battery electric and plug-in hybrid electric vehicles are expected to see faster growth beyond 2020, in particular in the segment of light duty vehicles, driven by EU and national policies offering various incentives and the decrease in battery costs. The share of battery electric and plug-in hybrid electric vehicles in the total light duty vehicle stock would reach about 6% by 2030 and 15% by 2050. The uptake of hydrogen would be facilitated by the increased availability of refuelling infrastructure, but its use would remain limited in lack of additional policies beyond those assumed in the Baseline scenario. Fuel cells would represent about 3% of the light duty vehicle stock by 2050.

LNG becomes a candidate energy carrier for road freight, especially in the medium to long term, driven by the implementation of the Directive on the deployment of alternative fuels infrastructure and the revised TEN-T guidelines which represent important drivers for the higher penetration of alternative fuels in the transport mix. In the Baseline scenario, the share of LNG is projected to go up to 3% by 2030 (8% by 2050) for road freight.

Biofuels uptake is driven by the legally binding target of 10% renewable energy in transport (Renewables Directive), as amended by the ILUC Directive, and by the requirement for fuel suppliers to reduce the GHG intensity of road transport fuel by 6% (Fuel Quality Directive). Beyond 2020, biofuel levels would remain relatively stable at around 6% in the Baseline scenario. The Baseline scenario does not take into account the recent proposal by the Commission for a recast of the Renewables Energy Directive.

In the Baseline scenario, **oil products would still represent about 90% of the EU transport sector needs in 2030** and 85% in 2050, despite the renewables policies and the deployment of alternative fuels infrastructure which support some substitution effects towards biofuels, electricity, hydrogen and natural gas (see **Figure 7-7**).

Figure 7-7: Evolution of final energy use in transport by type of fuel



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

The **declining trend in transport emissions is expected to continue**, leading to 13% lower emissions by 2030 compared to 2005, and 15% by 2050.[66] However, relative to 1990 levels, emissions would still be 13% higher by 2030 and 10% by 2050, owing to the fast rise in the transport emissions during the 1990s. The share of transport in total GHG emissions would continue increasing, going up from 23% currently (excluding international maritime) to 25% in 2030 and 31% in 2050, following a relatively lower decline of emissions from transport compared to power generation and other sectors (see **Figure 7-6**).

CO_2 emissions from road freight transport (heavy goods and light goods vehicles) are projected to increase by 6% between 2010 and 2030 (11% for 2010-2050) in the Baseline scenario. For heavy goods vehicles, the increase would be somewhat higher (10% for 2010-2030 and 17% for 2010-2050), in lack of specific measures in place. At the same time, emissions from passenger cars and passenger vans are projected to decrease by 22% between 2010 and 2030 (32% for 2010-2050) thanks to the CO_2 standards in place and the uptake of electromobility. CO_2 emissions from buses and coaches are projected to remain relatively unchanged by 2030 compared to their 2010 levels, and to slightly increase post-2030 (3% increase for 2010-2050).

NOx emissions would drop by about 56% by 2030 (64% by 2050) with respect to 2010 levels. The decline in **particulate matter** (PM2.5) would be less pronounced by 2030 at 51% (65% by 2050). By 2030, over 75% of heavy goods vehicle stock is projected to be Euro VI in the Baseline scenario and more than 80% of the passenger cars stock is projected to be Euro 6. Overall, external costs related to air pollutants would decrease by about 56% by 2030 (65% by 2050).[67]

High congestion levels are expected to seriously affect road transport in several Member States by 2030 in the absence of effective countervailing measures such as road pricing. While urban congestion will mainly depend on car ownership levels, urban sprawl and the availability of public transport alternatives, congestion on the inter-urban network would be the result of growing freight transport activity along specific corridors, in particular where these corridors cross urban areas with heavy local traffic.

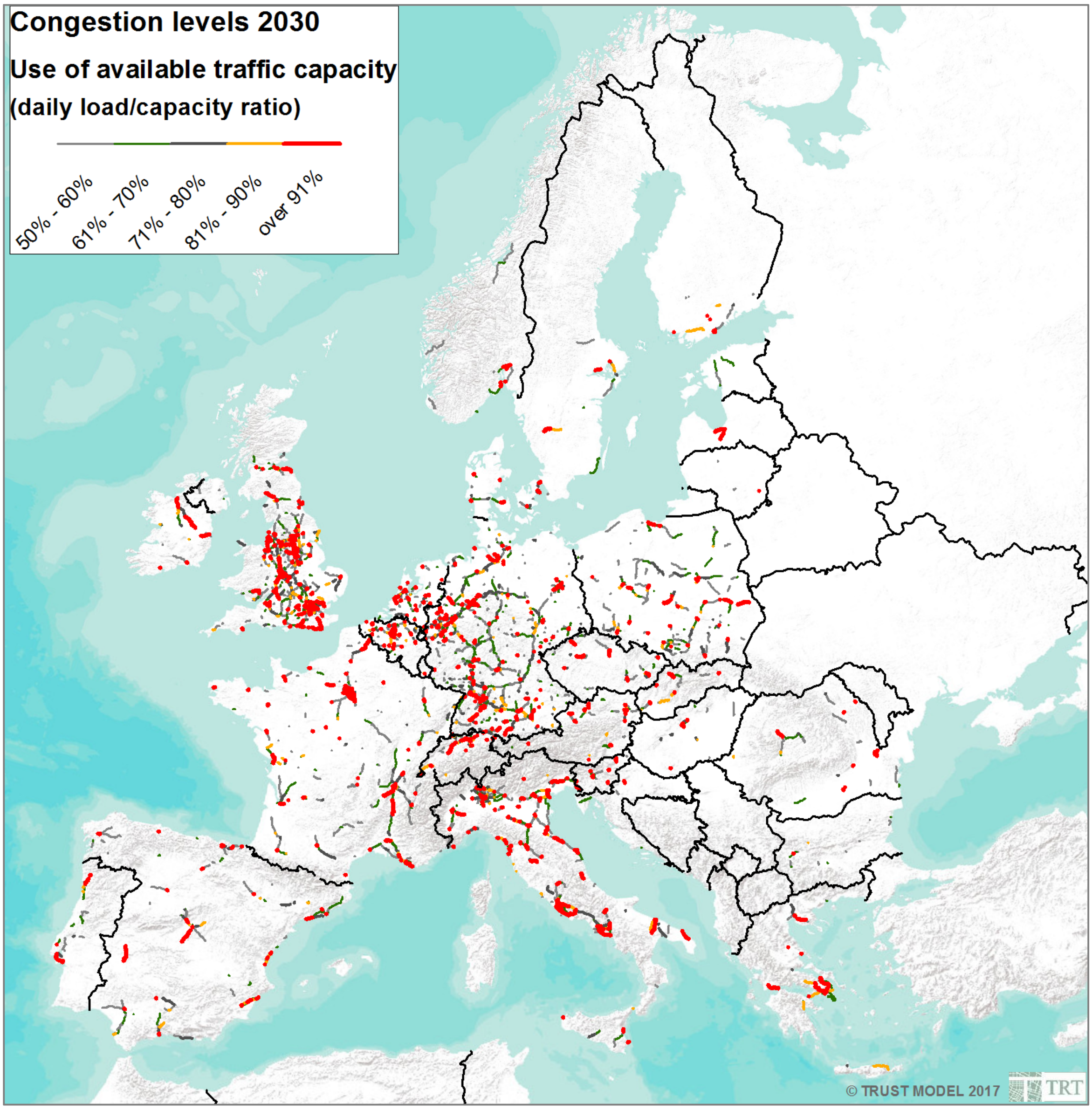
Detailed results at link level provided by the **TRUST** model show that the largest part of inter-urban congestion will be concentrated near densely populated zones with high

66 Including international aviation but excluding international maritime and other transportation.

67 External costs are expressed in 2013 prices. They cover NOx, PM2.5 and SOx emissions.

economic activity such as Belgium and the Netherlands – to a certain extent as a result of port and transhipment operations – and in large parts of Germany, the United Kingdom and northern Italy. Congestion patterns differ significantly among Member States though, since their hourly, daily and seasonal variation depends on local conditions (see **Figure 7-8**).

Figure 7-8: Congestion levels on the inter-urban network in the Baseline scenario for 2030



Source: TRUST model

Estimating the costs of congestion is not straightforward, because it occurs mostly during certain times of the day, often caused by specific bottlenecks in the network. In the PRIMES-TREMOVE Baseline scenario, total **congestion costs for urban and inter-urban network are projected to increase** by about 24% by 2030 and 43% by 2050, relative to 2010.

Noise related external costs of transport would continue to increase, by about 17% during 2010-2030 (24% for 2010-2050), driven by the rise in traffic. Thanks to policies in place, external **costs of accidents** are projected to go down by about 46%

by 2030 (-42% for 2010-2050) – but still remain high at over €100 billion in 2050. Overall, external costs[68] are projected to decrease by about 10% by 2030 and to increase post-2030; by 2050 they stabilise around levels observed in 2010.

7.4. Policy Option 1

7.4.1. Modelling assumptions

Policy Option 1 builds upon the Baseline scenario and includes the following modelling assumptions:

- **Remove exemptions for HGVs below 12 tonnes:** it is assumed that **time-based charges** for HGVs below 12 tonnes are introduced in **DK, LU, NL, SE and UK** starting from 2025. The rates for HGVs below 12 tonnes are set at 65% of those already existing for HGVs above 12 tonnes. For **Germany,** an extension of the tolling system to **HGVs below 7.5 tonnes** is assumed from 2020 onwards**.**
- **Promote zero-emission vehicles through allowing reduced rates:** it is assumed that starting with 2020 zero-emission **HGVs and buses** are **exempt from charging** and that zero-emission **LGVs and cars** have a **50% reduction**[69].
- **Extension of mark-ups beyond mountain regions:** this is simulated through the introduction of mark-ups on some roads in France and in Slovenia. Even though these are plans for mark-ups mainly in mountain regions, they are the only real examples available to test the introduction of possible future schemes. These examples can also show the possible differences in effect on larger and smaller Member States.
- Reviewing of maximum values for external cost charging to better reflect external costs: in **Germany and Austria**[70] from 2020 **external costs** for HGVs and buses (the latter only for Austria) are increased according to values in the 2014 Handbook on external costs of transport[71].

Table 7-5 below provides with a summary of the measures simulated in the various Member States.

[68] External costs cover here air pollution, congestion, noise and accidents.

[69] Reduced rates are implemented only in Member States where road charging systems are currently in place.

[70] Currently these are the only Member States making use of this possibility offered by Directive 1999/62/EC

[71] Ricardo-AEA et al (2014), Update of the Handbook on External Costs of Transport: http://ec.europa.eu/transport/themes/sustainable/studies/sustainable_en

Table 7-5: Summary of policy measures introduced in PO1 on top of the Baseline

			AT	BE	BG	CY	CZ	DE[72]	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing out EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs[73]		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

72 In PO1 tolls for HGVs also apply below 7.5 t.

73 In the context of reviewing the maximum values for external cost charging to better reflect external costs, the charges for HGVs and buses for AT and for HGVs for DE are increased in line with the values in the 2014 Handbook on external costs of transport.

Table 7-6: Summary of policy measures introduced in PO1 relative to the Baseline

			AT	BE	BG	CY	CZ	DE[74]	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs[75]		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Note: measures included in PO1 relative to the Baseline are reported in green.

[74] In PO1 tolls for HGVs also apply below 7.5 t.

[75] In the context of reviewing the maximum values for external cost charging to better reflect external costs, the charges for HGVs and buses for AT and for HGVs for DE are increased in line with the values in the 2014 Handbook on external costs of transport.

7.4.2. Modelling results – ASTRA

The measures introduced in PO1 are expected to increase transportation costs in those countries where a variation of the existing charging system is envisaged.

Generally, the increase in transport cost varies at the country level depending on several factors: on the level of charges (differences between existing and new charges), on the extension of the tolled network, on the share of trips on the tolled network, on load factors and on operating costs.

Moreover, it should be noted that the increase in road freight cost reflects both the increase in the level of charges within the country as well as the increase in the level of charges in the other countries where trade relationships exist. For countries where no variation of charges is assumed, the increase in transportation costs reflect only the increase in charges of partner countries.

The measures simulated under PO1 affect road freight transport costs at a very marginal level (see Table 7-7).

The most significant variation in road freight costs, as expected, can be observed in **Germany**, where the distance based charging system is extended to HGVs below 7.5 tonnes and charges are increased to cover external costs for air and noise pollution from all HGVs according to the Handbook values. In this case the observed increase in road freight cost is of **2,3%** in 2030 relative to the Baseline.

Less significant increases in road freight costs in 2030 relative to the Baseline are observed in those countries where a time based charge is applied to HGVs below 12 tonnes, and specifically: DK (0,3%), LU (0,5%), NL (0,3%), SE (0,2%). No change is observed in UK given the possibility to deduct the vignette from taxes.

The application of **mark-ups beyond mountain** regions is expected to determine a small increase in road freight transportation costs in **Slovenia (0,5%)** and to have a limited impact in **France (0,1%).** The differences in the magnitude of impact in the two countries can be justified by the lower share that the network charged for mark-ups in France has on the total country tolled network.

In **Austria** the application of **external costs on HGVs** based on Handbook values is projected to increase road freight transport cost by **0,8%.**

Table 7-7: Variation of road freight cost (including VAT Euro2010/t-km) in Policy Option 1 relative to the Baseline for 2030 – by Member State (% change)

Country	PO1 vs Baseline Variation (% change)
AT	0,8%
BE	0,2%
BG	0,0%
CY	0,0%
CZ	0,2%
DE	2,3%
DK	0,3%
EE	0,1%
EL	0,0%
ES	0,1%
FI	0,0%
FR	0,1%
HR	0,3%
HU	0,2%
IE	0,0%
IT	0,0%
LT	0,2%
LU	0,5%
LV	0,3%
MT	0,0%

Country	PO1 vs Baseline Variation (% change)
NL	0,3%
PL	0,1%
PT	0,0%
RO	0,1%
SE	0,2%
SI	0,5%
SK	0,2%
UK	0,0%

Source: ASTRA model

The increased costs have a negligible impact on the road freight transport activity at country level, as shown in Table 7-8.

It must be considered that the variation in total transport activity depends on the impact of new charges both at national and international level, the latter being particularly relevant where strong trade relationships exist between countries. This second component may lead to a reduction in transport activity in one country as a consequence of the tolls introduced in neighbouring countries.

Table 7-8: Variation of freight transport activity in Mio t-km in Policy Option 1 relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,2%	0,7%	0,0%	0,0%
BE	-0,1%	0,2%	0,0%	0,0%
BG	0,0%	0,0%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	0,0%	0,1%	0,0%	0,0%
DE	-0,3%	1,0%	0,0%	0,0%
DK	-0,1%	0,2%	-	-0,1%
EE	0,0%	0,0%	-	0,0%
EL	0,0%	0,1%	-	0,0%
ES	0,0%	0,1%	-	0,0%
FI	0,0%	0,0%	0,0%	0,0%
FR	0,0%	0,2%	0,0%	0,0%
HR	0,0%	0,1%	0,0%	0,0%
HU	0,0%	0,1%	0,0%	0,0%
IE	0,0%	0,0%	-	0,0%
IT	0,0%	0,2%	0,0%	0,0%
LT	-0,1%	0,1%	0,0%	0,0%
LU	-0,1%	0,4%	0,0%	0,0%
LV	-0,1%	0,1%	-	0,0%
MT	0,0%	-	-	0,0%
NL	-0,1%	0,5%	0,0%	0,0%
PL	0,0%	0,0%	0,0%	0,0%
PT	0,0%	0,0%	-	0,0%
RO	0,0%	0,0%	0,0%	0,0%
SE	0,0%	0,1%	-	0,0%
SI	-0,1%	0,2%	-	0,0%
SK	0,0%	0,1%	0,0%	0,0%
UK	0,0%	0,1%	0,0%	0,0%
EU15	-0,1%	0,6%	0,0%	0,0%
EU13	0,0%	0,1%	0,0%	0,0%
EU28	-0,1%	0,4%	0,0%	0,0%

Source: ASTRA model

Given the negligible variation in total transport activity, no significant impacts can be expected on freight modal split. The comparison between the Policy Option 1 and the Baseline shows substantially no variation at country level.

Table 7-9: Variation of freight modal split in Policy Option 1 relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,2	0,2	0,0
BE	0,0	0,0	0,0
BG	0,0	0,0	0,0
CY	0,0	0,0	0,0
CZ	0,0	0,0	0,0
DE	-0,2	0,2	0,0
DK	0,0	0,0	0,0
EE	0,0	0,0	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	0,0	0,0	0,0
FR	0,0	0,0	0,0
HR	0,0	0,0	0,0
HU	0,0	0,0	0,0
IE	0,0	0,0	0,0
IT	0,0	0,0	0,0
LT	0,0	0,0	0,0
LU	0,0	0,0	0,0
LV	0,0	0,0	0,0
MT	0,0	0,0	0,0
NL	0,0	0,0	0,0
PL	0,0	0,0	0,0
PT	0,0	0,0	0,0
RO	0,0	0,0	0,0
SE	0,0	0,0	0,0
SI	-0,1	0,1	0,0
SK	0,0	0,0	0,0
UK	0,0	0,0	0,0
EU15	-0,1	0,1	0,0
EU13	0,0	0,0	0,0
EU28	-0,1	0,1	0,0

Source: ASTRA model

Negligible impacts can be expected on **fuel consumption**. The comparison between the Policy Option 1 and the Baseline shows virtually no variation at Member State level (Table 7-10).

Table 7-10: Variation of fuel consumption from road sector in Mtoe in Policy Option 1 relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	0,0%	-0,1%	0,0%	0,0%	-0,1%	0,0%	0,0%
BE	0,0%	0,0%	0,0%	-0,1%	0,0%	0,0%	0,0%
BG	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
DE	0,0%	-0,1%	0,0%	-0,1%	-0,1%	0,0%	0,0%
DK	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,0%	0,0%
EE	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
EL	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
ES	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
FI	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
FR	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
HR	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
HU	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
IE	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
IT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
LT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
LU	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
LV	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PL	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
RO	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
SE	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
SI	0,0%	0,0%	0,0%	-0,1%	0,0%	0,0%	0,0%
SK	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
UK	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
EU15	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
EU13	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
EU28	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Source: ASTRA model

As a consequence of the trends shown above, substantially no variation in air pollutant and CO2 emissions from the road sector may also be expected at country and European level (Table 7-11).

Table 7-11: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 1 relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	0,0%	-0,1%	0,0%	0,0%	-0,1%
BE	0,0%	0,0%	0,0%	0,0%	0,0%
BG	0,0%	0,0%	0,0%	0,0%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,0%	0,0%	0,0%	0,0%	0,0%
DE	0,0%	-0,2%	0,0%	-0,1%	-0,1%
DK	0,0%	-0,1%	0,0%	0,0%	0,0%
EE	0,0%	0,0%	0,0%	0,0%	0,0%
EL	0,0%	0,0%	0,0%	0,0%	0,0%
ES	0,0%	0,0%	0,0%	0,0%	0,0%
FI	0,0%	0,0%	0,0%	0,0%	0,0%
FR	0,0%	0,0%	0,0%	0,0%	0,0%
HR	0,0%	0,0%	0,0%	0,0%	0,0%
HU	0,0%	0,0%	0,0%	0,0%	0,0%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	0,0%	0,0%	0,0%	0,0%	0,0%
LT	0,0%	0,0%	0,0%	0,0%	0,0%
LU	0,0%	0,0%	0,0%	0,0%	0,0%
LV	0,0%	0,0%	0,0%	0,0%	0,0%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	0,0%	0,0%	0,0%	0,0%
PL	0,0%	0,0%	0,0%	0,0%	0,0%
PT	0,0%	0,0%	0,0%	0,0%	0,0%
RO	0,0%	0,0%	0,0%	0,0%	0,0%
SE	0,0%	0,0%	0,0%	0,0%	0,0%
SI	0,0%	0,0%	0,0%	0,0%	0,0%
SK	0,0%	0,0%	0,0%	0,0%	0,0%
UK	0,0%	0,0%	0,0%	0,0%	0,0%
EU15	0,0%	0,0%	0,0%	0,0%	0,0%
EU13	0,0%	0,0%	0,0%	0,0%	0,0%
EU28	0,0%	0,0%	0,0%	0,0%	0,0%

Source: ASTRA model

The absence of change in road sector air pollution and CO2 emissions is also reflected in the negligible impacts on the amount of external costs (

Table 7-12).

Table 7-12: Variation of external costs for road transport sector in Mio Euro in Policy Option 1 relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	0,0%	-0,1%	0,0%	0,0%	0,0%
EU13	0,0%	0,0%	0,0%	0,0%	0,0%
EU28	0,0%	-0,1%	0,0%	0,0%	0,0%

Source: ASTRA model

The main impact arising from the measures applied in the PO1 scenario is on revenues from road transport. Percentage changes in toll revenues from road transport in Policy Option 1 relative to the Baseline for 2030 are shown in Table 7-13. Road revenues are very marginally affected by promotional rates for zero emission vehicles (ZEV) as generally these represent a relatively small share of vehicle fleet in 2030.

The main increases in revenues from the freight sector can be observed in those countries where an extension of the tolling system for HGVs was introduced.

In Austria the increase in external cost charges for buses and HGVs according to the Handbook values drives an increase in revenues from these vehicle categories of 9,3% and 6,3% respectively in 2030 relative to the Baseline. Overall the total increase of toll revenues is 2,6% in Policy Option 1 relative to the Baseline for 2030.

In Germany the extension of the tolling system to HGVs below 7.5 tonnes and the increase in external cost charges for HGVs is expected to increase revenues by 50,6% in 2030 relative to the Baseline.

The introduction of vignettes for HGVs below 12 t is projected to produce increases in revenues varying from 155% in LU (where the most of domestic traffic is performed by vehicles below 12 tonnes) to 16,8% in SE in 2030 relative to the Baseline.

In Slovenia the application of mark-ups beyond mountain regions is projected to increase revenues from HGVs and buses by around 13% with an overall increase of total revenues of 4,5% in 2030 relative to the Baseline.

In France the effect of mark-ups on revenues increases from HGVs and buses is of around 2%; overall these increases have a negligible effect on total revenues which are marginally reduced by the rebates applied to ZEV.

Table 7-13: Percentage change in toll revenues from road transport in Policy Option 1 relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	2,6%	6,3%	-0,1%	9,3%	-0,8%
BE	-0,1%	-0,1%	-	-	-
BG	-0,2%	0,0%	-0,2%	0,0%	-0,3%
CY	-	-	-	-	-
CZ	-0,3%	-0,1%	-0,3%	0,0%	-0,3%
DE	50,6%	50,6%	-	-	-
DK	20,1%	20,1%	-	-	-
EE	-	-	-	-	-
EL	-1,1%	0,0%	-0,1%	0,0%	-1,3%
ES	-0,4%	0,0%	-0,5%	0,0%	-0,4%
FI	-	-	-	-	-
FR	-1,0%	2,0%	-1,2%	4,3%	-1,8%

Country	TOTAL	HGV	LGV	BUS	CAR
HR	-1,1%	-0,1%	0,0%	0,0%	-1,2%
HU	-0,2%	0,0%	0,0%	0,0%	-0,5%
IE	-0,7%	0,0%	-0,1%	0,0%	-0,7%
IT	-0,4%	0,0%	-0,9%	0,0%	-0,4%
LT	-0,2%	-0,2%	0,0%	0,0%	-
LU	155,2%	155,2%	-	-	-
LV	-0,1%	-0,1%	-0,1%	0,0%	-
MT	-	-	-	-	-
NL	31,1%	31,1%	-	-	-
PL	-0,1%	0,0%	0,0%	0,0%	-0,2%
PT	-0,4%	0,0%	-0,2%	0,0%	-0,4%
RO	-0,3%	0,0%	-0,3%	0,0%	-0,3%
SE	16,8%	16,8%	-	-	-
SI	4,5%	12,7%	-0,3%	23,4%	-1,6%
SK	-0,4%	0,0%	0,0%	0,0%	-0,5%
UK	25,6%	25,6%	-	-	-
EU15	5,7%	21,2%	-1,0%	2,5%	-1,1%
EU13	0,2%	1,8%	-0,2%	2,9%	-0,6%
EU28	5,2%	19,2%	-0,9%	2,6%	-1,1%

Source: ASTRA model

Overall, European revenues from tolls in the freight sector (HGV) are expected to increase by 19,2% and total revenues from road transport are expected to increase by 5,2% in Policy Option 1 relative to the Baseline for 2030.

ASTRA results in terms of macroeconomic impact show that the effect of Policy Option 1 on the economic sector is not significant.

Table 7-14: Variation of GDP and Unemployment in Policy Option 1 relative to the Baseline for 2030 – EU average

	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	0,0%	0,0
EU13	0,0%	0,0
EU28	0,0%	0,0

Source: ASTRA model

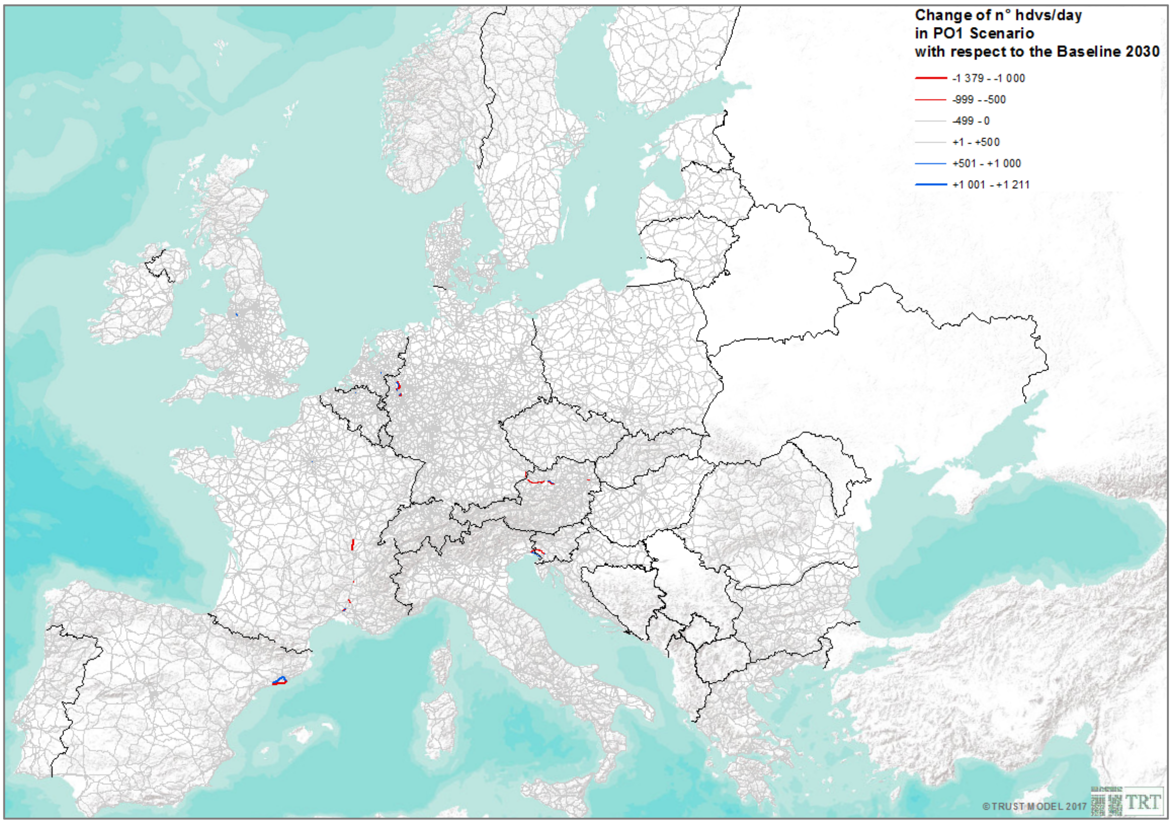
7.4.3. Modelling results – TRUST

In this section, the link-based indicators of road assignment performed with the TRUST model are presented.

Specifically the figures below show the reduction (in red) and the increase (in blue) of daily link flows for HGVs (Figure 7-9) and passengers car (Figure 7-10). Modelled variations are in the range of -1.500/+1.200 vehicles for HGVs and of -2.000/+2.000 vehicles for cars.

Results of traffic assignment suggest that the extension of the tolling system on German roads to cover also trucks below 7.5 t determines an almost negligible rerouting of some long distance trips towards countries with lower charging rates. This effect is very marginal as modelled variations on 97% of the European network are in the range -100/+100 vehicles per day.

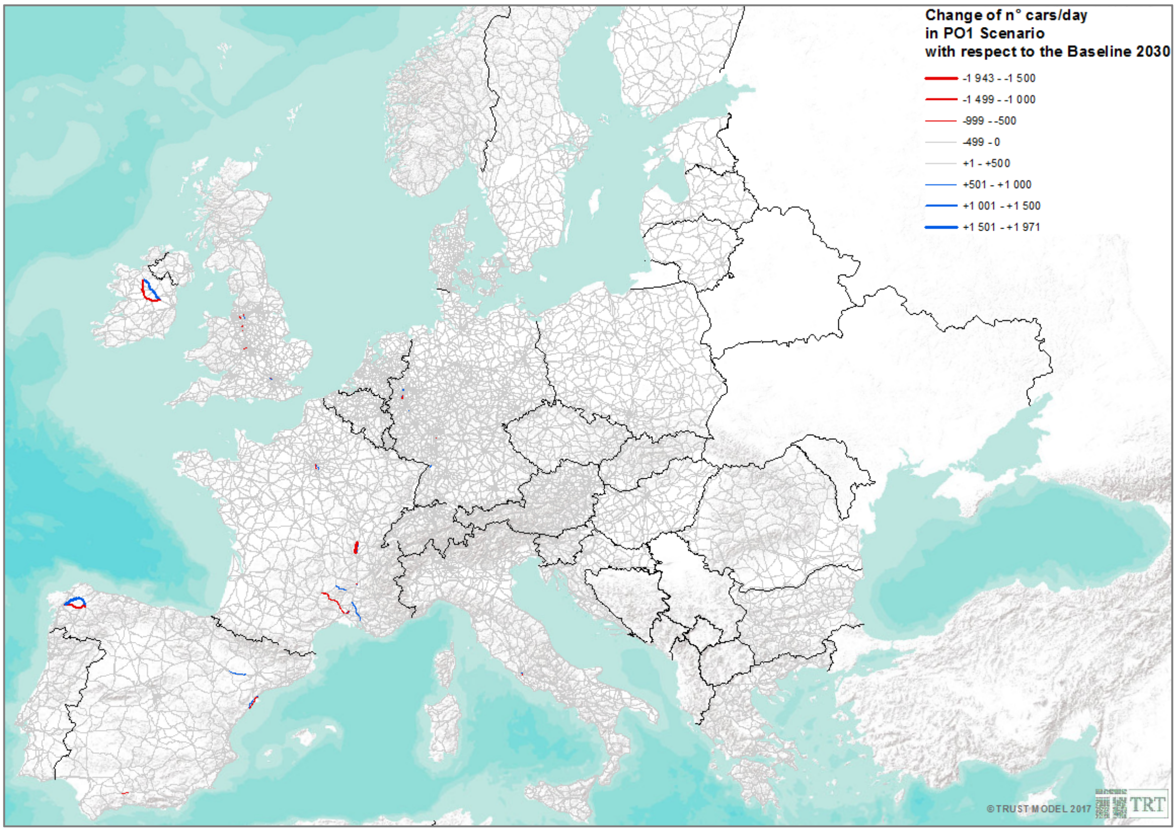
Figure 7-9: PO1 Scenario – Difference on link flows, comparison with Baseline for 2030, HGV traffic



Source: TRUST model

On the other hand, results of car traffic assignment suggest that some very marginal rerouting of trips occur locally due to the increased capacity of some links as a consequence of reduced trucks loads. Overall the change of car transport activity is negligible.

Figure 7-10: PO1 Scenario – Difference on link flows, comparison with Baseline for 2030, Car traffic



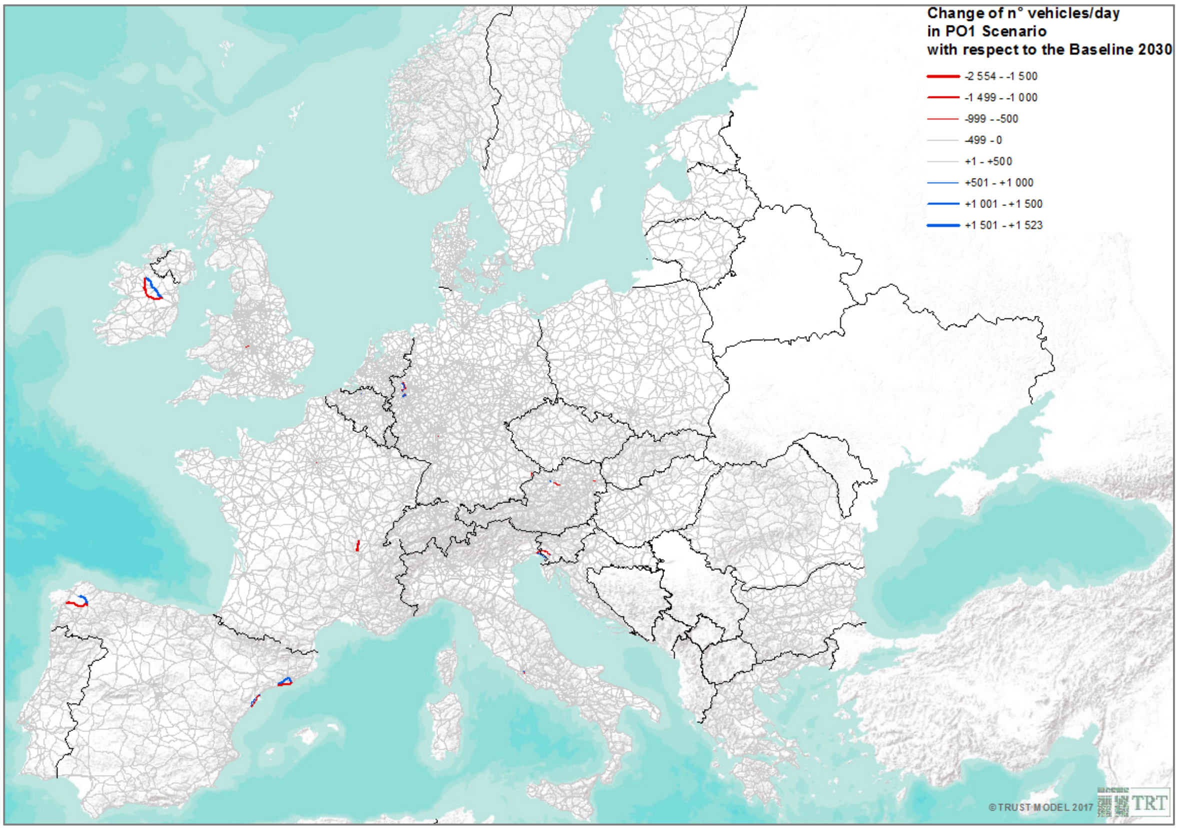
Source: TRUST model

The impacts on total traffic flows are shown in Figure 7-11 while the change in distribution of pollutants on the network determined by traffic diversion is shown in Figure 7-12. In the picture the overall impacts on NOx emissions are illustrated: green lines identify the links where a reduction of NOx occurs in comparison with the Baseline, while the orange lines show an increase of pollution due to increased traffic loads. It should be noted that NOx variations are in the range of -17,5/+20,9 tons per year, therefore negligible.

The level of emissions depends also on the mix of traffic (car and trucks). The local impacts on NOx are more visible where links are relieved from a share of HGV traffic; nevertheless, in this case pollution is only shifted from one link to another, but without any significant effect on global pollution which remains substantially unchanged.

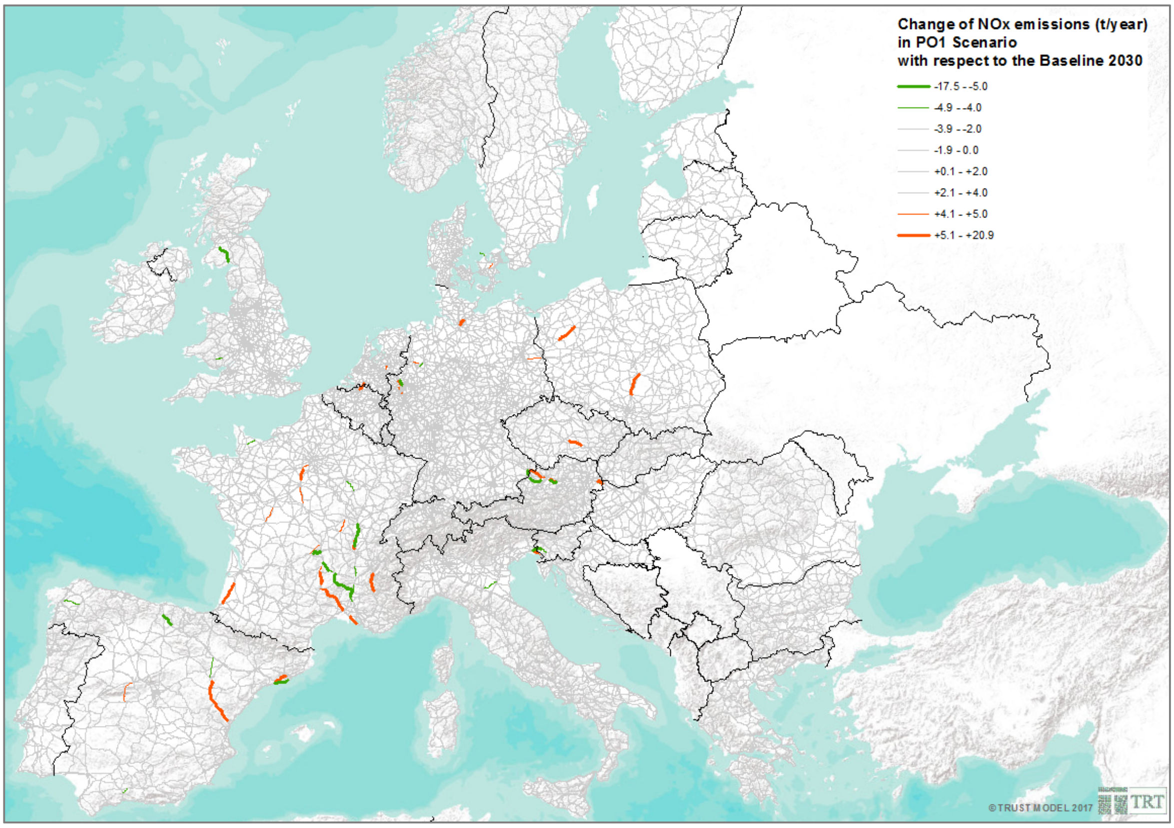
Similar impacts can be observed for other pollutants.

Figure 7-11: PO1 Scenario – Difference on link flows, comparison with Baseline for 2030, Total traffic (cars and trucks)



Source: TRUST model

Figure 7-12: PO1 Scenario – NOx emissions, comparison with Baseline for 2030



Source: TRUST model

Results for external costs from interurban road congestion of PO1 relative to the Baseline for 2030 are provided in Table 7-15.

It is worth mentioning that the calculation of interurban congestion cost is highly dependent on the specific local network conditions modelled at county level: any shift of traffic from one link to another might induce reduction of congestion cost on that link and increase the congestion cost on the other link (if the latter reaches a specific threshold of load capacity ratio assumed as representative of congestion during peak hours). When this route shift involves links of different nature (i.e. shift from primary to secondary roads) the impact on overall congestion costs is amplified due to the rerouting of traffic from primary roads to secondary roads with lower capacity and leading to higher delay time.

When looking at the external costs of interurban road congestion for PO1 it can be observed that the impacts relative to the Baseline for 2030 are not significant at both Member State and European level (Table 7-15).

Table 7-15: External transport costs of interurban road congestion in Policy Option 1 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-0,1%	-1,0%	0,0%
BE	0,0%	0,2%	-0,1%
BG	0,0%	0,0%	0,0%
CY	-	-	-
CZ	-0,1%	0,0%	-0,1%
DE	-0,2%	-0,4%	-0,1%
DK	0,2%	0,7%	0,2%
EE	0,0%	0,0%	0,0%
EL	0,0%	-0,1%	0,0%
ES	0,0%	-0,2%	0,0%
FI	0,0%	0,1%	0,0%
FR	0,0%	-0,2%	0,0%
HR	0,0%	0,1%	0,0%
HU	0,1%	-0,4%	0,1%
IE	0,2%	-0,3%	0,2%
IT	0,0%	0,0%	0,0%
LT	-0,1%	-0,4%	-0,1%
LU	-0,3%	-1,2%	-0,2%
LV	-0,2%	-0,5%	-0,1%
MT	-	-	-
NL	0,0%	0,5%	0,0%
PL	0,0%	0,1%	0,0%
PT	-0,1%	-0,8%	0,0%
RO	0,0%	0,0%	0,0%
SE	0,0%	0,1%	0,0%
SI	0,0%	-1,0%	0,0%
SK	-0,1%	-0,5%	-0,1%
UK	-0,1%	0,1%	-0,1%
EU15	0,0%	-0,1%	0,0%
EU13	0,0%	0,0%	0,0%
EU28	-0,1%	-1,0%	0,0%

Source: TRUST model

Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Similar results can be observed for the external costs related to noise: the low increase of external costs is related to the shift of traffic from main roads to secondary roads (where costs for noise are higher). However the global effect is low.

Table 7-16: External transport costs of noise from interurban road transport in Policy Option 1 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,7%	2,7%	0,0%
BE	-0,2%	-0,8%	0,0%
BG	-0,1%	-0,2%	0,0%
CY	-	-	-
CZ	0,0%	-0,1%	0,0%
DE	0,4%	1,4%	0,0%
DK	-0,3%	-0,7%	0,0%
EE	-0,2%	-0,9%	0,1%
EL	0,0%	-0,1%	0,0%
ES	-0,3%	-0,6%	0,0%
FI	0,0%	-0,1%	0,0%
FR	-0,1%	-0,3%	0,0%
HR	0,0%	-0,1%	0,0%
HU	0,0%	0,0%	0,0%
IE	0,0%	-0,1%	0,0%
IT	-0,1%	-0,4%	0,0%
LT	-0,2%	-0,7%	0,0%
LU	0,1%	0,3%	0,0%
LV	-0,2%	-0,5%	0,0%
MT	-	-	-
NL	-0,1%	-0,3%	0,0%
PL	0,0%	0,0%	0,0%
PT	-0,1%	-0,5%	0,0%
RO	-0,1%	-0,4%	0,0%
SE	0,0%	0,0%	0,0%
SI	0,2%	1,2%	0,0%
SK	0,1%	0,2%	0,0%
UK	-0,2%	-0,7%	0,0%
EU15	0,0%	0,1%	0,0%
EU13	0,0%	-0,1%	0,0%
EU28	0,0%	0,1%	0,0%

Source: TRUST model

Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.5. Policy Option 2

7.5.1. Modelling assumptions

Policy Option 2 builds upon Policy Option 1 and additionally includes the following modelling assumptions:

- **Phase out vignettes for HGVs >3.5t and buses** starting in 2025[76] with the introduction of new distance based charging systems in **DK, LT, LU, LV, NL, RO, SE** and **UK** and the extension of the existing ones to cover also buses in **BE, DE** and **HU. Additionally,** for **BG** the phasing out of vignette for HGVs is assumed starting with 2020[77]. Assumed average charges are summarised in Table 7-17.

[76] Conservative estimate linked to the uncertainty of precise possible adoption of the measures. Assumptions about changes in charging systems were made in 5-year steps for easier follow-up.

[77] In line with Government plans even though not yet adopted in law and thus not considered in the Baseline.

Table 7-17: Assumed average distance-base infrastructure charges replacing existing vignettes (€cent/km)

Country	HGV 3.5t - 12t	HGV> 12 t	Buses
BE	Unchanged	Unchanged	13,5
BG	8,18	14,49	8,18
DE	13,5	Unchanged	13,5
DK	13,5	16,3	13,5
HU	Unchanged	Unchanged	11,7
LT	8,18	14,49	8,18
LU	13,5	16,3	13,5
LV	8,18	14,49	8,18
NL	13,5	16,3	13,5
RO	8,18	14,49	8,18
SE	13,5	16,3	13,5
UK	13,5	16,3	13,5

- **Phase out Euro class-differentiation and more extensive use of external cost charging** starting in 2025. The measure is simulated through the elimination of modulation of infrastructure charges by Euro classes in all Member States where it is applied and the assumed introduction of **external cost charging** for air and noise pollution based on 2014 Handbook on external costs of transport[78] in those Member States. More concretely, external costs charging for HGVs would be additionally applied in PO2 in BE, BG, CZ, DK, HU, LT, LV, LU, NL, PL, SE, SI, SK and for buses in BG, CZ, LT, LV, PL, SI and SK.
- **Phasing in of revenue neutral modulation of infrastructure charges by CO2 emissions for HGVs >3.5t and buses** starting in 2025 in all MSs except CY, EE, FI and MT (where no charging system is applied). The revised charges are based on the results of the PRIMES-TREMOVE model (ICCS-E3MLab)[79]. The assumptions used for the modulation of infrastructure charges according to CO_2 emissions are provided in Table 7-18.

Table 7-18: Assumptions used for the modulation of infrastructure charges by CO2 emissions for HGVs and buses/coaches

Environmental performance	Euro 0-VI	New low CO_2-emission vehicles[80]
Heavy goods vehicles between 3.5t and 7.5t plus buses/coaches	Charge above average rate	Assume 25% reduction in charges versus Euro 0-VI
Heavy goods vehicles above 7.5t	Charge above average rate	Assume 25% reduction in charges versus Euro 0-VI

- **Rebates for all Zero Emission vehicles (ZEV)** starting with 2020 in almost all MSs (except CY, EE, FI and MT). Rebates imply the full exemption from tolls for ZEV HGVs and buses and 50% reduction for ZEV LGV and passenger cars. Exemption for HGVs < 12t is phased in starting with 2025 in DK, LU, LV, LT**,** NL, RO, SE and UK and from 2020 onwards for BG[81].

[78] http://ec.europa.eu/transport/themes/sustainable/internalisation_en
[79] This measure has been modelled in two steps. In the first step, the PRIMES-TREMOVE model has been run. In the second step, PRIMES-TREMOVE results (i.e. the structure of the vehicle fleet by type of powertrain, age and its evolution; increase in road charges for vehicles with CO_2 emissions above the average) have been used in defining the integrated policy package in ASTRA.
[80] 'Low emission' vehicles are defined as below the average (VECTO baseline).
[81] Differences in the timing of introduction are linked to the introduction of distance-based systems in these Member States.

- **Reduction of circulation taxes** for HGVs > 12t and HGVs < 12t according to Table 7-19, where a 50% reduction is assumed for distance-based systems already in place and exemption for new distance-based systems.

Table 7-19: Implementation of reduced circulation taxes

Country	HGVs > 12 t and HGVs < 12t
AT	2020 (50% reduction)
BE	2020 (50% reduction)
BG	2020 (Exemption)
CY	-
CZ	2020 (50% reduction)
DE	2020 (50% reduction)
DK	2025 (Exemption)
EL	2020 (50% reduction)
ES	2020 (50% reduction)
FR	2020 (50% reduction)
HR	2020 (50% reduction)
HU	2020 (50% reduction)
IE	2020 (50% reduction)
IT	2020 (50% reduction)
LT	2025 (Exemption)
LU	2025 (Exemption)
LV	2025 (Exemption)
MT	-
NL	2025 (Exemption)
PL	2020 (50% reduction)
PT	2020 (50% reduction)
RO	2025 (Exemption)
SE	2025 (Exemption)
SI	2020 (50% reduction)
SK	2020 (50% reduction)
UK	2025 (Exemption)

Table 7-20 and Table 7-22 below provide with a summary of the measures simulated in the various Member States in PO2.

Table 7-20: Summary of policy measures introduced in PO2 on top of the Baseline and PO1

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Table 7-21: Summary of policy measures introduced in PO2 relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Note: measures included in PO1 and PO2 are reported in green; additional measures included in PO2 are reported in blue.

7.5.2. Modelling results – ASTRA

The measures introduced in PO2 (i.e. new tolling systems and application of external costs charging in some countries) increase road freight transportation costs to a more visible extent in those countries where the introduction of a distance based charge is applied i.e. **BG (3,9%), DE (1,9%), DK (2,6%), LT (2,3%), LU (2,4%), LV (2,6%), NL (1,4%), RO (2,7%), SE (2,9%)** and **UK (1,3%).**

Variation in other countries reflect the cumulated effect of modulation of charges by CO2 emissions, external costs charging, reduction of circulation taxes and variation of road charges in the trading partner countries. In some countries (i.e. FR, IT and PT) the modulation of charges by CO2 emissions and the reduced circulation taxes determine a reduction of transportation costs relative to the Baseline.

Table 7-22: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 2 relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	0,9%
BE	1,1%
BG	3,9%
CY	0,1%
CZ	0,6%
DE	1,9%
DK	2,6%
EE	0,6%
EL	-0,1%
ES	-0,6%
FI	0,3%
FR	-1,3%
HR	0,4%
HU	0,8%
IE	-0,1%
IT	-0,6%
LT	2,3%
LU	2,4%
LV	2,6%
MT	0,2%
NL	1,4%
PL	0,5%
PT	-0,6%
RO	2,7%
SE	2,9%
SI	0,9%
SK	0,3%
UK	1,3%

Source: ASTRA model

Also in PO2, the increased road freight transportation costs have a low impact on the road freight transport activity at country level, as shown in Table 7-23, although variations are slightly higher than in PO1.

Table 7-23: Variation of freight transport activity in Mio tkm in Policy Option 2 relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,3%	0,9%	0,0%	0,1%
BE	-0,3%	1,0%	0,0%	-0,1%
BG	-0,5%	2,2%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,1%	0,3%	0,0%	0,0%
DE	-0,3%	1,0%	0,0%	0,0%
DK	-0,8%	2,9%	-	-0,3%

Country	Road	Rail	IWW	TOTAL
EE	-0,2%	0,3%	-	-0,1%
EL	0,0%	0,2%	-	0,0%
ES	0,0%	-0,5%	-	-0,1%
FI	-0,1%	0,1%	0,0%	-0,1%
FR	-0,1%	-0,1%	0,0%	-0,1%
HR	-0,1%	0,1%	0,0%	0,0%
HU	-0,3%	0,7%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	0,1%	-0,6%	0,0%	0,0%
LT	-0,7%	0,6%	0,0%	-0,1%
LU	-0,2%	1,4%	0,0%	-0,1%
LV	-0,6%	0,9%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,3%	1,6%	0,0%	-0,1%
PL	-0,1%	0,6%	0,0%	0,0%
PT	0,0%	-0,5%	-	0,0%
RO	-0,6%	0,8%	0,0%	0,0%
SE	-0,8%	1,7%	-	-0,1%
SI	-0,2%	0,5%	-	0,0%
SK	-0,1%	0,2%	0,0%	0,0%
UK	-0,3%	2,2%	0,0%	0,0%
EU15	-0,2%	0,8%	0,0%	0,0%
EU13	-0,2%	0,6%	0,0%	0,0%
EU28	-0,2%	0,7%	0,0%	0,0%

Source: ASTRA model

Given the relatively low changes in total transport activity by mode, no significant impacts can be expected on freight modal split. The comparison with the values of the Baseline shows low variation at country level.

Table 7-24: Variation of freight modal split in Policy Option 2 relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,2	0,2	0,0
BE	-0,2	0,1	0,0
BG	-0,3	0,3	0,0
CY	0,0	0,0	0,0
CZ	-0,1	0,1	0,0
DE	-0,2	0,2	0,0
DK	-0,4	0,4	0,0
EE	-0,1	0,1	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,1	0,1	0,0
FR	0,0	0,0	0,0
HR	0,0	0,0	0,0
HU	-0,2	0,2	0,0
IE	0,0	0,0	0,0
IT	0,1	-0,1	0,0
LT	-0,3	0,3	0,0
LU	-0,1	0,1	0,0
LV	-0,3	0,3	0,0
MT	0,0	0,0	0,0
NL	-0,1	0,1	0,0
PL	-0,1	0,1	0,0
PT	0,1	-0,1	0,0
RO	-0,3	0,3	0,0
SE	-0,5	0,5	0,0
SI	-0,1	0,1	0,0
SK	-0,1	0,1	0,0
UK	-0,2	0,2	0,0

Country	Road	Rail	IWW
EU15	-0,1	0,1	0,0
EU13	-0,2	0,2	0,0
EU28	-0,1	0,1	0,0

Source: ASTRA model

Variation of vehicle fleet composition is provided by PRIMES-TREMOVE model results. As it can be observed, the modulation by CO2 emissions is expected to slightly increase the share of hybrid and LNG HGV at European level as shown in Table 7-25.

Table 7-25: Variation of HGV vehicle fleet composition in Policy Option 2 at EU level (p.p. difference relative to the Baseline for 2030)

	HGV below 12t	HGV above 12t
Diesel conventional	-4,6	-2,8
Diesel hybrid	3,6	2,2
LPG	0,0	0,0
LNG	0,9	0,6
Electric	0,0	0,0

Source: ASTRA model based on PRIMES-TREMOVE results

Given the low impact on road freight transport activity, the impacts on **fuel consumption** – although rather limited - are substantially driven by the variation of the vehicle fleet composition due to the modulation of infrastructure charging by CO2 emission simulated by the PRIMES-TREMOVE model.

The comparison with the Baseline shows a reduction in diesel consumption due to the uptake of hybrid vehicles and some increase in LNG and LPG, although starting from a low base at country level in all MSs (Table 7-26). The more visible increase of gas consumption in France (i.e. reaching only 0.6 Mtoe in Policy Option 2), is due to the increased share of LNG fuelled heavy good vehicles in the vehicle stock (from 0,6% to 4,2% for HGVs below 12t and from 0,7% to 1,9% for HGVs above 12t).

Table 7-26: Variation of fuel consumption from road sector in Mtoe in Policy Option 2 relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	0,0%	-0,4%	0,1%	5,3%	-0,7%	0,0%	0,0%
BE	0,0%	-0,3%	0,1%	12,0%	-0,3%	0,0%	0,0%
BG	0,0%	-0,3%	0,0%	1,3%	-0,3%	0,0%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,0%	-0,2%	0,1%	2,8%	-0,2%	0,0%	0,0%
DE	0,0%	-1,2%	0,2%	31,7%	-1,6%	0,0%	0,0%
DK	0,0%	-0,5%	0,2%	4,8%	-0,5%	0,0%	0,0%
EE	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,0%	0,0%
EL	0,0%	-0,2%	0,0%	7,0%	-0,1%	0,0%	0,0%
ES	0,0%	-0,5%	0,9%	25,7%	-1,2%	0,0%	0,0%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
FR	0,0%	-2,2%	4,9%	116,8%	-3,7%	0,0%	0,0%
HR	0,0%	-0,2%	0,0%	2,4%	-0,4%	0,0%	0,0%
HU	0,0%	-0,7%	0,2%	31,6%	-0,7%	0,0%	0,0%
IE	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%
IT	0,0%	-0,8%	0,0%	4,6%	-0,7%	0,0%	0,0%
LT	0,0%	-0,5%	0,0%	0,4%	-0,5%	0,0%	0,0%
LU	0,0%	-0,2%	0,2%	0,5%	-0,2%	0,0%	0,0%
LV	0,1%	-0,3%	0,0%	4,6%	-0,3%	0,0%	0,0%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,1%	17,3%	-0,8%	0,1%	0,0%
PL	0,0%	-0,3%	0,1%	13,0%	-0,5%	0,0%	0,0%
PT	0,0%	-0,3%	0,2%	19,8%	-0,5%	0,0%	0,0%
RO	0,0%	-0,3%	0,1%	15,2%	-0,3%	0,0%	0,0%
SE	0,0%	-0,6%	0,2%	4,8%	-0,7%	0,0%	0,0%
SI	0,0%	-1,0%	0,0%	21,7%	-0,7%	0,0%	0,0%
SK	0,0%	-0,5%	0,1%	16,5%	-0,7%	0,0%	0,0%
UK	0,0%	-0,4%	0,1%	16,9%	-0,7%	0,0%	0,0%

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
EU15	0,0%	-1,0%	0,2%	13,7%	-1,3%	0,0%	0,0%
EU13	0,0%	-0,4%	0,1%	12,0%	-0,4%	0,0%	0,0%
EU28	0,0%	-0,9%	0,1%	13,6%	-1,2%	0,0%	0,0%

Source: ASTRA model

As a consequence of the trends shown above, small reductions in emissions from the road sector are observed at country and European level (Table 7-27). At EU level, CO2 emissions from HGVs decrease by about 1,3% relative to the Baseline in 2030. However, as the HGVs and buses emissions represent about 25% of CO2 emissions from road transport, this translates into a 0,4% decrease in CO2 emissions from road transport relative to the Baseline in 2030.

Table 7-27: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 2 relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	-0,2%	-0,4%	-0,1%	-0,1%	-0,3%
BE	-0,1%	-0,2%	0,0%	0,0%	-0,2%
BG	-0,1%	-0,2%	0,0%	-0,1%	-0,2%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	-0,1%	-0,2%	0,0%	-0,1%	-0,1%
DE	-0,3%	-1,3%	-0,2%	-0,4%	-0,5%
DK	-0,1%	-0,6%	-0,1%	-0,3%	-0,3%
EE	0,0%	-0,1%	0,0%	0,0%	-0,1%
EL	0,0%	-0,1%	0,0%	0,0%	0,0%
ES	-0,4%	-0,6%	-0,2%	-0,2%	-0,3%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%
FR	-0,8%	-2,9%	-0,4%	-0,6%	-1,0%
HR	-0,1%	-0,3%	0,0%	-0,1%	-0,1%
HU	-0,2%	-0,7%	-0,1%	-0,3%	-0,3%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	-0,1%	-0,4%	-0,1%	-0,1%	0,1%
LT	-0,1%	-0,3%	-0,1%	-0,1%	-0,3%
LU	-0,1%	-0,1%	0,0%	0,0%	-0,1%
LV	0,0%	-0,2%	0,0%	0,0%	-0,2%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,0%	0,0%	-0,2%
PL	-0,2%	-0,4%	-0,1%	-0,1%	-0,2%
PT	-0,1%	-0,3%	-0,1%	0,0%	-0,1%
RO	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
SE	-0,1%	-0,6%	0,0%	-0,1%	-0,3%
SI	-0,1%	-0,6%	-0,1%	-0,2%	-0,1%
SK	-0,2%	-0,6%	-0,2%	-0,2%	-0,3%
UK	0,0%	-0,4%	0,0%	-0,1%	-0,2%
EU15	-0,3%	-1,1%	-0,2%	-0,2%	-0,4%
EU13	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
EU28	-0,3%	-1,0%	-0,2%	-0,2%	-0,4%

Source: ASTRA model

The observed variations on road sector emissions are reflected in changes in the amount of external costs (Table 7-28).

Table 7-28: Variation of external costs for road transport sector in Mio Euro in Policy Option 2 relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
			Road Sector		
EU15	-0,1%	-0,6%	-0,1%	0,0%	-0,3%
EU13	0,0%	-0,2%	-0,1%	0,0%	-0,2%
EU28	-0,1%	-0,5%	-0,1%	0,0%	-0,3%

Source: ASTRA model

The main impact arising from the PO2 measures is on revenues from road transport. Percentage changes in toll revenues from road transport in Policy Option 2 relative to the Baseline for 2030 are shown in Table 7-29 at country and at EU level. It should be noted that percentage changes for those countries where there are no charges in the baseline are not computed.

As already seen in PO1, road revenues are very marginally affected by promotional rates for zero emission vehicles (ZEV) given their small share on vehicle fleet.

The main increases in revenues can be observed in those countries where an extension of the tolling system to HGVs and buses is introduced or where external costs charging is phased in. The impact on revenues depends also on the charge level existing in the baseline, i.e. larger impacts in terms of percentage change could be observed where the baseline charge is low and this is typically the case of countries that currently apply vignettes such as Luxembourg, United Kingdom, Netherlands etc.

It is important to underline that the set of measures is not the same in all MSs, as it is evident from Table 7-20.

Revenues for cars and LGVs are reduced with respect to the baseline due to the implementation of rebates for zero emission vehicles and the size of such impact is related to the share of ZEV vehicles in the domestic fleet.

Table 7-29: Percentage change in toll revenues from road transport in Policy Option 2 relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	5,3%	11,8%	-0,6%	24,6%	-0,8%
BE	22,9%	22,7%	-	n.c.	-
BG	95,5%	825,5%	-0,3%	249,8%	-0,3%
CY	-	-	-	-	-
CZ	8,9%	36,1%	-0,3%	105,7%	-0,3%
DE	57,7%	57,7%	-	n.c.	-
DK	568,3%	560,8%	-	n.c.	-
EE	-	-	-	-	-
EL	-1,3%	-2,0%	-0,1%	4,8%	-1,3%
ES	-0,8%	-3,7%	-1,0%	12,3%	-0,4%
FI	-	-	-	-	-
FR	2,5%	18,3%	-1,3%	57,7%	-1,8%
HR	-0,9%	3,3%	0,6%	17,2%	-1,2%
HU	12,7%	21,5%	-0,2%	388,3%	-0,5%
IE	-0,7%	-1,7%	-0,1%	5,9%	-0,7%
IT	-0,9%	-4,1%	-0,4%	14,4%	-0,4%
LT	722,6%	793,0%	0,0%	38,4%	-
LU	1835,1%	1829,6%	-	n.c.	-
LV	323,7%	745,4%	0,3%	497,4%	-
MT	-	-	-	-	-
NL	1115,8%	1115,8%	-	n.c.	-
PL	26,5%	51,2%	-0,2%	87,0%	-0,2%
PT	-0,5%	-2,3%	-0,2%	14,0%	-0,4%
RO	32,2%	435,4%	-0,2%	109,1%	-0,3%
SE	521,6%	519,0%	-	n.c.	-
SI	11,8%	29,5%	-0,3%	60,3%	-1,6%
SK	6,2%	24,3%	-0,3%	83,9%	-0,5%
UK	861,7%	854,7%	-	n.c.	-
EU15	13,8%	47,3%	-0,8%	69,5%	-1,1%
EU13	20,9%	66,0%	-0,2%	139,6%	-0,6%
EU28	14,5%	49,3%	-0,7%	92,2%	-1,1%

Source: ASTRA model
n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are null. The % variation at EU level however include the overall impacts on revenues including also the changes in respect to values that are null in the Baseline.

Overall, EU revenues from tolls in the freight sector (HGV) are expected to increase by 49,3% and total revenues from road transport are expected to increase by 14,5%. Revenues from circulation taxes are reduced at EU level by 30%.

ASTRA results in terms of macroeconomic impact confirms also that the effect of Policy Option 2 on the economic sector is limited.

Table 7-30: Variation of GDP and Unemployment in Policy Option 2 relative to the Baseline for 2030

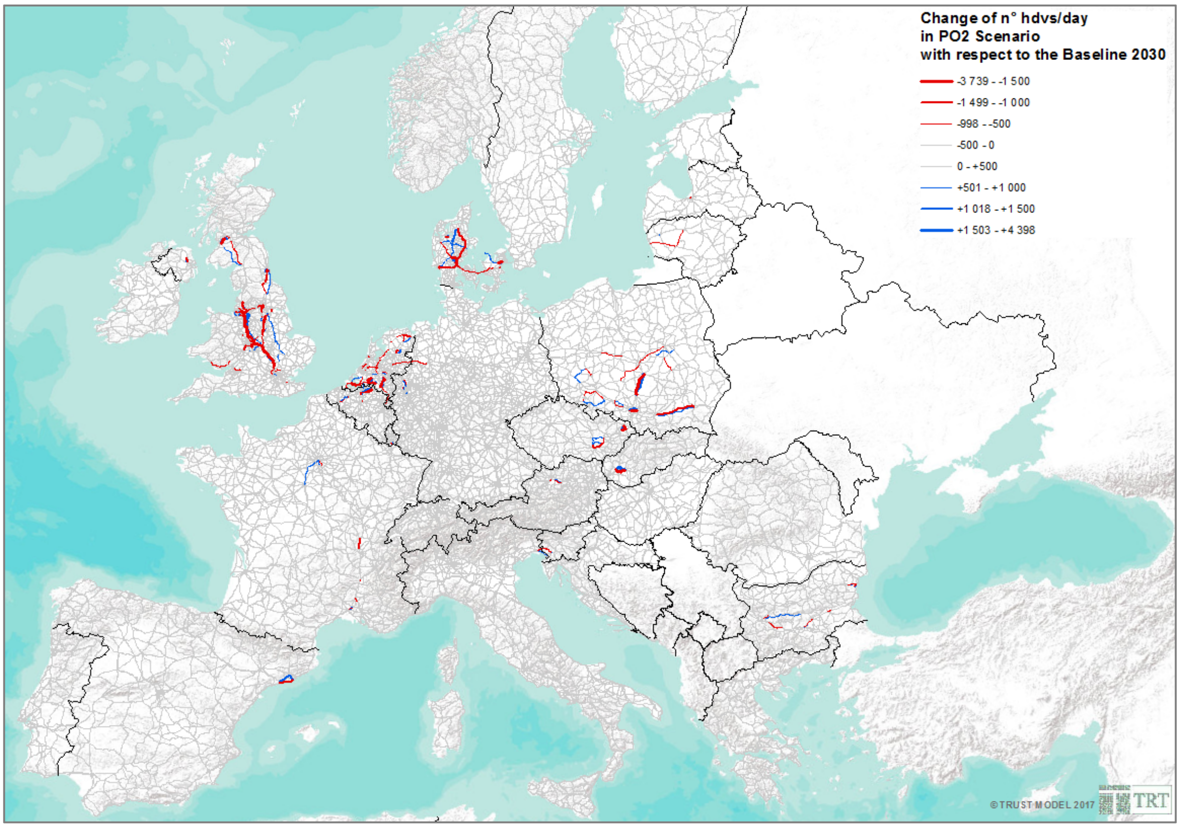
	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	0,0%	0,0
EU13	-0,1%	0,0
EU28	0,0%	0,0

Source: ASTRA model

7.5.3. Modelling results – TRUST

In this section, the link-based indicators of road assignment performed with the TRUST model are presented. Figure 7-13 shows that the effect of charges variation, mainly driven by the introduction of external cost charging, induces some shift of HGVs to uncharged routes. On 98,15% of the European road network length variations are in the range of -500/+500 vehicles per day and in the range of -1.000/+1.000 vehicles per day on 99% of the network length.

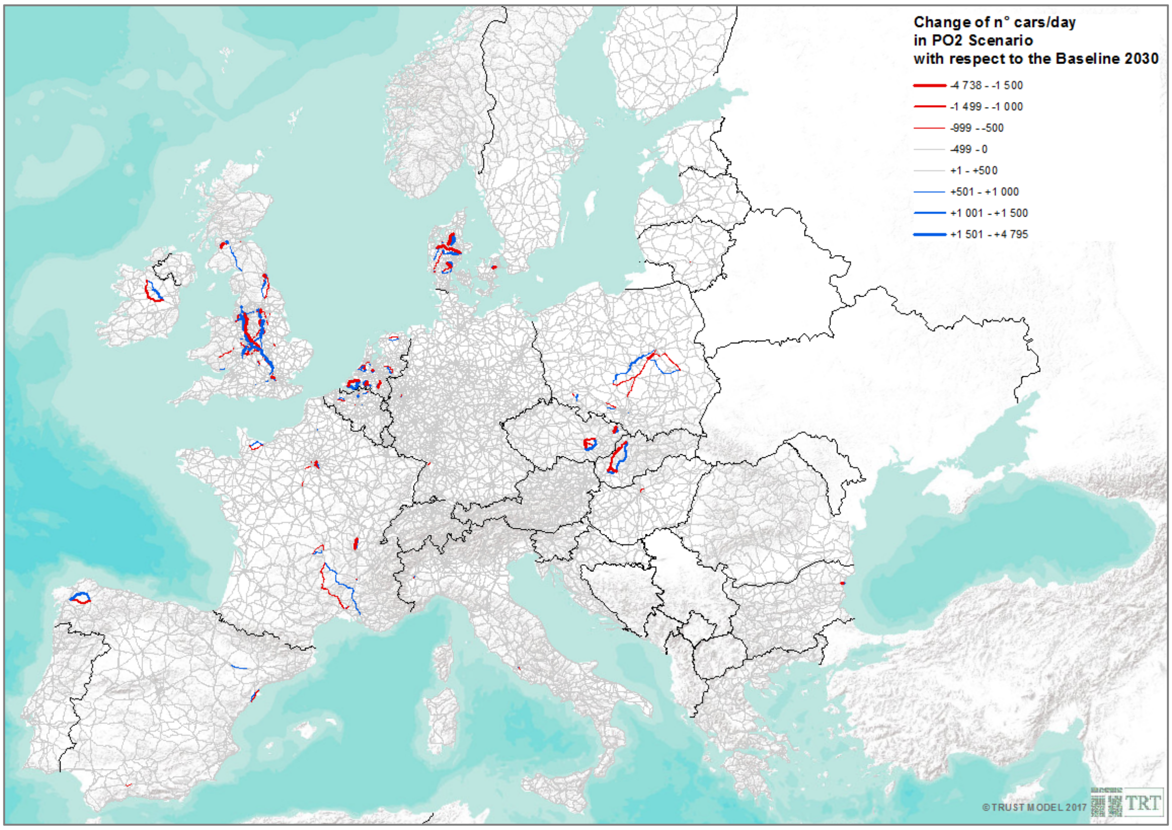
Figure 7-13: PO2 Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

Similarly to PO1, also in this scenario some route shift occurs for passenger cars as more capacity on tolled roads is left free from the diversion of HGV traffic (see Figure 7-14).

Figure 7-14: PO2 Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

Results on interurban road congestion suggests that HGV traffic generally gets some benefits from the impact of policy measures applied in PO2. Variation at country level however shows that the diversion of traffic might increase congestion on un-tolled routes (by nature less suitable to HGV traffic) and, as a consequence, increase overall congestion costs. Overall interurban congestion costs at European level are marginally affected by measures implemented in PO2.

Table 7-31: External transport costs of interurban road congestion in Policy Option 2 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-0,1%	-1,1%	0,0%
BE	-0,8%	-4,1%	-0,5%
BG	0,1%	0,4%	0,1%
CY	n.a.	n.a.	n.a.
CZ	-0,9%	-1,9%	-0,8%
DE	-0,2%	-0,5%	-0,2%
DK	-1,7%	-6,3%	-1,2%
EE	-0,1%	-0,5%	-0,1%
EL	0,0%	-0,1%	0,0%
ES	0,0%	-0,2%	0,0%
FI	0,0%	0,0%	0,0%
FR	0,0%	-0,2%	0,0%
HR	0,0%	0,1%	0,0%
HU	-0,1%	-1,1%	0,0%
IE	0,3%	-0,1%	0,3%
IT	0,0%	0,0%	0,0%
LT	0,1%	0,7%	0,0%
LU	-0,4%	-1,6%	-0,3%
LV	-0,6%	-1,5%	-0,5%

Country	TOTAL (cars + trucks)	Trucks	Car
MT	n.a.	n.a.	n.a.
NL	-0,7%	-3,0%	-0,5%
PL	-0,3%	-2,0%	-0,1%
PT	-0,1%	-0,8%	0,0%
RO	0,0%	-0,1%	0,0%
SE	-0,6%	-1,5%	-0,4%
SI	0,0%	-1,3%	0,0%
SK	-0,8%	-7,1%	-0,4%
UK	-0,2%	-3,4%	0,1%
EU15	-0,2%	-1,3%	-0,1%
EU13	-0,4%	-2,1%	-0,2%
EU28	-0,2%	-1,5%	-0,1%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries.

Results for external costs related to noise confirms the trend already observed in PO1 with a general small increase of external costs related to the shift of traffic from main roads to secondary roads (where costs for noise are higher).

Table 7-32: External transport costs of noise from interurban road transport in Policy Option 2 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,7%	2,8%	0,0%
BE	1,6%	6,6%	-0,1%
BG	0,4%	1,5%	-0,1%
CY	n.a.	n.a.	n.a.
CZ	0,2%	0,3%	0,1%
DE	0,3%	1,2%	0,0%
DK	2,0%	5,7%	-0,2%
EE	-0,4%	-1,6%	0,2%
EL	0,0%	-0,2%	0,0%
ES	-0,3%	-0,7%	0,0%
FI	0,0%	-0,1%	0,0%
FR	-0,1%	-0,7%	0,1%
HR	0,0%	0,1%	0,0%
HU	0,0%	0,2%	0,0%
IE	-0,1%	-0,6%	0,1%
IT	-0,1%	-0,4%	0,0%
LT	1,8%	5,9%	-0,1%
LU	0,6%	2,3%	-0,1%
LV	3,5%	9,0%	0,0%
MT	n.a.	n.a.	n.a.
NL	1,3%	6,4%	-0,3%
PL	0,5%	1,1%	0,0%
PT	-0,1%	-0,6%	0,0%
RO	0,0%	0,3%	-0,1%
SE	0,5%	1,2%	0,0%
SI	0,3%	1,8%	0,0%
SK	2,3%	7,5%	-0,3%
UK	0,6%	2,9%	-0,1%
EU15	0,4%	1,5%	-0,1%
EU13	0,5%	1,2%	0,0%
EU28	0,4%	1,4%	-0,1%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.6. Policy Option 3a

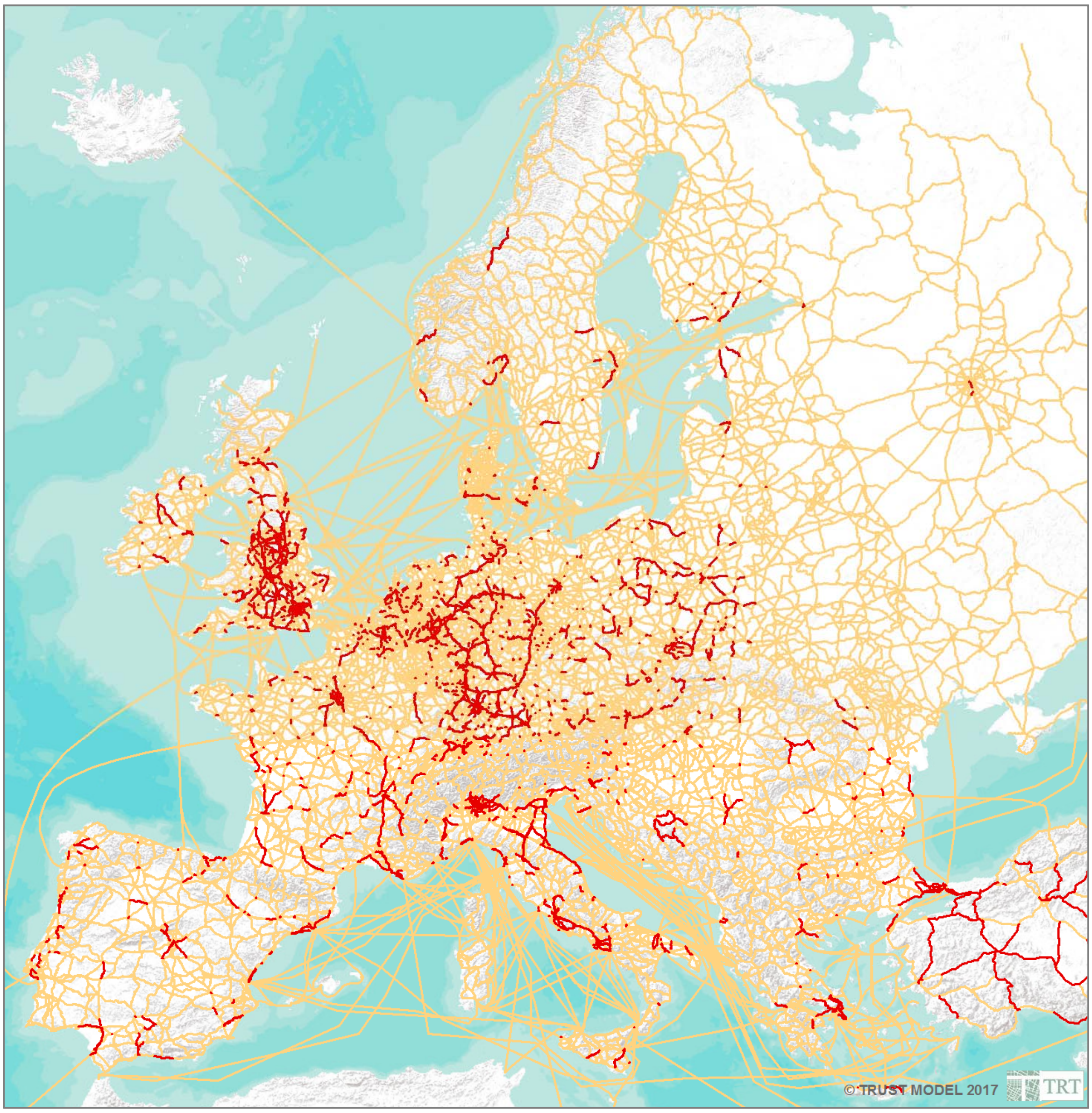
7.6.1. Modelling assumptions

Policy Option 3b has the same assumptions as for PO2 and adds on top of these:

- **Genuine congestion charging in distance-based environment for all vehicles** in **EL, ES, FR, HR, IE, IT, PL and PT** starting in 2025.

The modelling of congestion charging required the identification of potential congested links where charges should be phased in. The identification of the most congested links is made on the basis of the TRUST model's output of road traffic assignment in 2030 by assuming a load/capacity ratio of 0.5 computed on daily traffic as representative of congestion during peak time.

Figure 7-15: Congested links in TRUST 2030 network (Daily load/capacity ratio >= 0.5)



Source: TRUST model

The level of additional charges is based on the specific country values for traffic conditions close to road capacity detailed by road type (motorways and main roads) and vehicle type available from the Handbook.

The daily average charges are expressed in 2015 prices. To translate peak charges into average daily charges the share of cars and HDV traffic in the peak periods (from

7:00 to 11:00 and from 16:00 to 20:00) has been used, considering an available set of real traffic data for motorways and main roads in EU countries.

Average daily congestion charges modelled in the scenario are summarised in Table 7-33.

Table 7-33: Average daily efficient marginal congestion costs, € per vkm

	Car		Rigid truck		Articulated truck		Bus	
Country	**Motor-way**	**Main Roads**	**Motor-way**	**Main Roads**	**Motor-way**	**Main Roads**	**Motor-way**	**Main Roads**
EL	0,074	0,093	0,108	0,163	0,165	0,249	0,142	0,215
ES	0,082	0,104	0,121	0,182	0,184	0,278	0,159	0,24
FR	0,089	0,112	0,13	0,196	0,198	0,3	0,171	0,258
HR	0,049	0,062	0,072	0,108	0,109	0,165	0,094	0,142
IE	0,105	0,132	0,154	0,232	0,235	0,354	0,202	0,305
IT	0,083	0,105	0,122	0,184	0,186	0,28	0,16	0,242
PL	0,052	0,065	0,076	0,114	0,115	0,174	0,099	0,15
PT	0,066	0,083	0,096	0,146	0,147	0,222	0,127	0,191

Source: TRT elaborations based on Updated Handbook of external costs

Additional assumptions on maximum congestion charges are made considering the specific length of the congested links in the TRUST model network. Given the strategic level of the network implemented in European models such as TRUST, links are generally characterized by a certain length (e.g. 20–30 km) and the increase of charges due to congestion should consider only a portion of the link, to reflect the real situation where, if congestion occurs, it is generally localised a on shorter portion of the links. In this respect, a threshold of 10 kilometres is imposed.

A feedback of the results obtained from TRUST into the ASTRA model (as an exogenous input) allowed for ASTRA indicators to include the impact of congestion charging. Specifically, TRUST provided the share of traffic (by vehicle type) travelling on links subject to congestion charging with respect to the total traffic on tolled road network in each NUTS1 zone of a country. These shares were used to calculate the average value of congestion charge (applied on top of the infrastructure charge) at the NUTS1 level, which was introduced in ASTRA as an input to calculate travel costs, affecting modal split and revenues from road charging.

Table 7-34 and Table 7-35 below provide with a summary of the measures simulated in the various Member States in PO3a.

Table 7-34: Summary of policy measures introduced in PO3a on top of the Baseline, PO1 and PO2

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Table 7-35: Summary of policy measures introduced in PO3a relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	Vignette	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t			blue			hatched	blue										blue	blue	blue		blue			blue	blue			blue
		HGV >12t			blue				blue										blue	blue	blue		blue			blue	blue			blue
		Buses		blue	blue			blue	blue							blue			blue	blue	blue		blue			blue	blue			blue
		LGV																												
		Cars																												
Phasing out vignette		HGV			blue				blue										blue	blue	blue		blue			blue	blue			blue
		Buses			blue											blue			blue		blue					blue				
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV		blue	blue		blue		blue							blue			blue	blue	blue		blue	blue			blue	blue	blue	
		Buses			blue		blue												blue		blue			blue				blue	blue	
Phasing in CO2/pollutant modulation		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		Buses	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV	green	green	green		green	green	green		green	green		green	green	green	green	green	green	green	green		green	green	green	green	green	green	green	green
		Buses	green	blue	green		green	blue	blue		green	green		green	green	green	green	green	green	blue	green		blue	green	green	green	blue	green	green	blue
		LGV	green		green		green				green	green		green	green	green	green	green	green		green			green	green	green		green	green	
		Cars	green		green		green				green	green		green	green	green	green	green						green	green	green		green	green	
External costs		HGV	hatched	blue	blue		blue	hatched	blue							blue			blue	blue	blue		blue	blue			blue	blue	blue	
		Buses	hatched		blue		blue												blue		blue			blue				blue	blue	
Congestion charging		All									purple	purple		purple	purple		purple	purple						purple	purple					
Mark-ups		HGV												green														green		
		Buses												green														green		
Reduced circulation taxes		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV																												

Note: measures included in PO1, PO2 and PO3a are reported in green; measures included in PO2 and PO3a are reported in blue; measures additionally included in PO3a are provided in purple.

7.6.2. Modelling results – ASTRA

The variations of road freight cost in Policy Option 3a relative to the Baseline for 2030 are reported in Table 7-36.

As mentioned above, Policy Option 3a is built on Policy Option 2 with the sole addition of genuine congestion charging (all the other elements being the same).

The comparison with impacts observed in PO2 shows that the introduction of congestion charges on the congested road tolled sections in the concerned countries (i.e. EL, ES, FR, HR, IE, IT, PL and PT) has a low impact on the costs of the domestic road freight sector as a whole.

Table 7-36: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	1,0%
BE	1,2%
BG	3,9%
CY	0,1%
CZ	0,6%
DE	2,0%
DK	2,6%
EE	0,6%
EL	0,1%
ES	-0,4%
FI	0,3%
FR	-1,0%
HR	0,5%
HU	1,0%
IE	-0,1%
IT	0,1%
LT	2,3%
LU	2,5%
LV	2,8%
MT	0,4%
NL	1,4%
PL	0,6%
PT	-0,5%
RO	2,7%
SE	2,9%
SI	1,0%
SK	0,3%
UK	1,3%

Source: ASTRA model

Given the similarity with road freight costs observed in PO2 in many Member States, similar low impact on the road freight transport activity at country level can be observed in PO3a, as shown in Table 7-37.

Table 7-37: Variation of freight transport activity in Mio tkm in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,3%	1,0%	0,0%	0,1%
BE	-0,4%	1,1%	0,0%	-0,1%
BG	-0,5%	2,2%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,1%	0,3%	0,0%	0,0%
DE	-0,3%	1,0%	0,0%	0,0%
DK	-0,8%	2,9%	-	-0,4%
EE	-0,2%	0,3%	-	-0,1%

Country	Road	Rail	IWW	TOTAL
EL	-0,1%	0,5%	-	-0,1%
ES	-0,1%	-0,2%	-	-0,1%
FI	-0,1%	0,1%	0,0%	-0,1%
FR	-0,1%	0,4%	0,0%	-0,1%
HR	-0,1%	0,2%	0,0%	0,0%
HU	-0,3%	0,7%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	-0,1%	0,6%	0,0%	0,0%
LT	-0,8%	0,6%	0,0%	-0,1%
LU	-0,2%	1,5%	0,0%	-0,1%
LV	-0,6%	0,9%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,3%	1,6%	0,0%	-0,1%
PL	-0,2%	0,7%	0,0%	0,0%
PT	0,0%	-0,5%	-	0,0%
RO	-0,6%	0,8%	0,0%	0,0%
SE	-0,8%	1,7%	-	-0,1%
SI	-0,2%	0,6%	-	0,0%
SK	-0,1%	0,3%	0,0%	0,0%
UK	-0,3%	2,3%	0,0%	0,0%
EU15	-0,2%	1,0%	0,0%	-0,1%
EU13	-0,2%	0,7%	0,0%	0,0%
EU28	-0,2%	0,9%	0,0%	0,0%

Source: ASTRA model

Freight modal split does not change significantly compared to PO2. The comparison with the values of the Baseline shows low variation at country level.

Table 7-38: Variation of freight modal split in Policy Option 3a relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,3	0,3	0,0
BE	-0,2	0,2	0,0
BG	-0,3	0,3	0,0
CY	0,0	0,0	0,0
CZ	-0,1	0,1	0,0
DE	-0,2	0,2	0,0
DK	-0,4	0,4	0,0
EE	-0,1	0,1	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,1	0,1	0,0
FR	0,0	0,0	0,0
HR	-0,1	0,0	0,0
HU	-0,2	0,2	0,0
IE	0,0	0,0	0,0
IT	-0,1	0,1	0,0
LT	-0,3	0,3	0,0
LU	-0,1	0,1	0,0
LV	-0,3	0,3	0,0
MT	0,0	0,0	0,0
NL	-0,1	0,1	0,0
PL	-0,2	0,2	0,0
PT	0,0	0,0	0,0
RO	-0,3	0,3	0,0
SE	-0,5	0,5	0,0
SI	-0,2	0,2	0,0
SK	-0,1	0,1	0,0
UK	-0,2	0,2	0,0
EU15	-0,1	0,1	0,0
EU13	-0,2	0,2	0,0

Country	Road	Rail	IWW
EU28	-0,2	0,2	0,0

Source: ASTRA model

Congestion charging has also a small impact on road passenger transport costs, as shown in Table 7-39. Variations are generally dependent on the level of congestion on the tolled network (influencing the portion of network on which congestion charge is applied) as well as on ratio between congestion charges and the toll applied on the network. The variation is slightly more visible in Greece (+1,3%) since in this case the value of congestion charges is similar to the value of infrastructure charges, especially in one zone of the country.

Table 7-39: Variation of road passenger transport cost (car+bus, including VAT Euro2010/pkm) in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	0,1%
BE	0,0%
BG	0,1%
CY	0,0%
CZ	0,0%
DE	0,0%
DK	0,0%
EE	0,0%
EL	1,3%
ES	0,4%
FI	0,0%
FR	0,9%
HR	0,0%
HU	0,0%
IE	0,0%
IT	0,8%
LT	0,0%
LU	0,1%
LV	0,0%
MT	0,1%
NL	0,0%
PL	0,1%
PT	0,1%
RO	0,0%
SE	0,0%
SI	0,0%
SK	0,0%
UK	0,0%

Source: ASTRA model

As a consequence of the low variations of road passenger transport costs, the impacts on passenger transport activity (Table 7-40) and modal split (Table 7-41) are limited at country and European level.

Table 7-40: Variation of passenger transport activity in Mio pkm in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	Air	Total
AT	0.0%	0.0%	0.1%	0.0%
BE	0.0%	0.0%	0.2%	0.0%
BG	0.0%	0.0%	0.1%	0.0%
CY	0.0%	0.0%	0.0%	0.0%
CZ	0.0%	0.0%	0.0%	0.0%
DE	0.0%	0.0%	0.0%	0.0%

Country	Road	Rail	Air	Total
DK	0.0%	0.0%	0.0%	0.0%
EE	0.0%	0.0%	0.0%	0.0%
EL	-0.2%	1.9%	0.1%	-0.1%
ES	-0.1%	0.4%	0.2%	0.0%
FI	0.0%	0.0%	0.0%	0.0%
FR	-0.2%	0.8%	0.5%	0.0%
HR	0.0%	0.0%	0.3%	0.0%
HU	0.0%	0.0%	0.1%	0.0%
IE	0.0%	0.0%	0.0%	0.0%
IT	-0.1%	1.1%	0.5%	0.0%
LT	0.0%	0.0%	0.0%	0.0%
LU	0.0%	0.1%	0.2%	0.0%
LV	0.0%	0.0%	0.0%	0.0%
MT	-0.1%	0.0%	0.0%	0.0%
NL	0.0%	0.0%	0.0%	0.0%
PL	0.0%	0.1%	0.0%	0.0%
PT	0.0%	0.0%	0.2%	0.0%
RO	0.0%	0.0%	0.1%	0.0%
SE	0.0%	0.0%	0.0%	0.0%
SI	0.0%	0.2%	0.6%	0.0%
SK	0.0%	0.0%	0.0%	0.0%
UK	0.0%	0.0%	0.0%	0.0%
EU15	-0.1%	0.4%	0.2%	0.0%
EU13	0.0%	0.0%	0.1%	0.0%
EU28	-0.1%	0.3%	0.2%	0.0%

Source: ASTRA model

Table 7-41: Variation of passenger modal split in Policy Option 3a relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	Air
AT	0.0	0.0	0.0
BE	0.0	0.0	0.0
BG	0.0	0.0	0.0
CY	0.0	0.0	0.0
CZ	0.0	0.0	0.0
DE	0.0	0.0	0.0
DK	0.0	0.0	0.0
EE	0.0	0.0	0.0
EL	-0.1	0.0	0.0
ES	-0.1	0.0	0.0
FI	0.0	0.0	0.0
FR	-0.1	0.1	0.0
HR	0.0	0.0	0.0
HU	0.0	0.0	0.0
IE	0.0	0.0	0.0
IT	-0.1	0.1	0.0
LT	0.0	0.0	0.0
LU	0.0	0.0	0.0
LV	0.0	0.0	0.0
MT	0.0	0.0	0.0
NL	0.0	0.0	0.0

Country	Road	Rail	Air
PL	0.0	0.0	0.0
PT	0.0	0.0	0.0
RO	0.0	0.0	0.0
SE	0.0	0.0	0.0
SI	0.0	0.0	0.0
SK	0.0	0.0	0.0
UK	0.0	0.0	0.0
EU15	-0.1	0.0	0.0
EU13	0.0	0.0	0.0
EU28	0.0	0.0	0.0

Source: ASTRA model

Given the limited impact on passenger and freight road transport activity, the impacts on **fuel consumption** – although limited - are substantially driven by the changes in the vehicle fleet composition due to the modulation of infrastructure charges by CO2 emission for HGVs and buses, simulated by the PRIMES-TREMOVE model (already discussed within PO2).

The comparison with the Baseline shows a decrease in the diesel use due to the uptake of hybrid HGVs and some increase in LNG and LPG at country level in all MSs (Table 7-42). Similar consideration already given in PO2 apply for the increase in the gas consumption in France.

Table 7-42: Variation of fuel consumption from road sector in Mtoe in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	0,0%	-0,4%	0,1%	5,2%	-0,8%	0,0%	0,0%
BE	0,0%	-0,3%	0,1%	12,0%	-0,4%	0,0%	0,0%
BG	0,0%	-0,3%	0,0%	1,3%	-0,3%	0,0%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,0%	-0,2%	0,0%	2,8%	-0,2%	0,0%	0,0%
DE	0,0%	-1,3%	0,2%	31,7%	-1,6%	0,0%	0,0%
DK	0,0%	-0,5%	0,2%	4,8%	-0,5%	0,0%	0,0%
EE	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,0%	0,0%
EL	-0,3%	-0,2%	-0,2%	6,9%	-0,3%	-0,2%	-0,3%
ES	-0,1%	-0,6%	0,8%	25,6%	-1,3%	-0,1%	-0,1%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
FR	-0,2%	-2,4%	4,7%	116,5%	-3,9%	-0,1%	-0,2%
HR	0,0%	-0,2%	0,0%	2,4%	-0,4%	0,0%	0,0%
HU	0,0%	-0,7%	0,2%	31,6%	-0,7%	0,0%	0,0%
IE	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%
IT	-0,2%	-1,0%	-0,1%	4,4%	-0,9%	-0,1%	-0,2%
LT	0,0%	-0,5%	0,0%	0,4%	-0,5%	0,0%	0,0%
LU	0,0%	-0,2%	0,2%	0,5%	-0,3%	0,0%	0,0%
LV	0,1%	-0,3%	0,0%	4,6%	-0,3%	0,0%	0,0%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,1%	17,3%	-0,8%	0,1%	0,0%
PL	0,0%	-0,4%	0,1%	13,0%	-0,5%	0,0%	0,0%
PT	0,0%	-0,3%	0,1%	19,8%	-0,5%	0,0%	0,0%
RO	0,0%	-0,3%	0,1%	15,2%	-0,3%	0,0%	0,0%
SE	0,0%	-0,6%	0,2%	4,8%	-0,7%	0,0%	0,0%
SI	0,0%	-1,0%	0,0%	21,7%	-0,7%	0,0%	0,0%
SK	0,0%	-0,5%	0,1%	16,5%	-0,7%	0,0%	0,0%
UK	0,0%	-0,4%	0,1%	16,9%	-0,7%	0,0%	0,0%
EU15	-0,1%	-1,1%	0,1%	13,6%	-1,4%	-0,1%	-0,1%
EU13	0,0%	-0,4%	0,1%	11,9%	-0,5%	0,0%	0,0%
EU28	-0,1%	-1,0%	0,1%	13,5%	-1,2%	0,0%	-0,1%

Source: ASTRA model

Some decreases in air pollutant and CO2 emissions from the road sector are observed at country and EU level as a consequence of the trends shown above (**Table 7-43**).

Table 7-43: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 3a relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	-0,2%	-0,5%	-0,1%	-0,1%	-0,3%
BE	-0,1%	-0,2%	0,0%	-0,1%	-0,2%
BG	-0,1%	-0,2%	0,0%	-0,1%	-0,2%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	-0,1%	-0,2%	0,0%	-0,1%	-0,1%
DE	-0,3%	-1,4%	-0,2%	-0,4%	-0,5%
DK	-0,1%	-0,6%	-0,1%	-0,3%	-0,3%
EE	0,0%	-0,1%	0,0%	0,0%	-0,1%
EL	0,0%	-0,1%	0,0%	-0,1%	-0,2%
ES	-0,4%	-0,6%	-0,2%	-0,2%	-0,4%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%
FR	-0,8%	-2,9%	-0,5%	-0,6%	-1,2%
HR	-0,1%	-0,3%	0,0%	-0,1%	-0,1%
HU	-0,2%	-0,7%	-0,1%	-0,3%	-0,3%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	-0,1%	-0,5%	-0,1%	-0,1%	-0,1%
LT	-0,1%	-0,3%	-0,1%	-0,1%	-0,3%
LU	-0,1%	-0,1%	0,0%	0,0%	-0,2%
LV	0,0%	-0,2%	0,0%	0,0%	-0,2%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,0%	0,0%	-0,2%
PL	-0,2%	-0,4%	-0,1%	-0,2%	-0,2%
PT	-0,1%	-0,3%	-0,1%	0,0%	-0,1%
RO	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
SE	-0,1%	-0,6%	0,0%	-0,1%	-0,3%
SI	-0,1%	-0,6%	-0,1%	-0,2%	-0,1%
SK	-0,2%	-0,6%	-0,2%	-0,3%	-0,3%
UK	0,0%	-0,4%	0,0%	-0,1%	-0,2%
EU15	-0,3%	-1,1%	-0,2%	-0,2%	-0,5%
EU13	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
EU28	-0,3%	-1,0%	-0,2%	-0,2%	-0,4%

Source: ASTRA model

The limited variation of road sector emissions is also reflected in the decreases in the amount of external costs (Table 7-44).

Table 7-44: Variation of external costs for road transport sector in Mio Euro in Policy Option 3a relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	-0,1%	-0,6%	-0,1%	-0,1%	-0,4%
EU13	0,0%	-0,2%	-0,1%	0,0%	-0,2%
EU28	-0,1%	-0,5%	-0,1%	-0,1%	-0,3%

Source: ASTRA model

The impact arising from the measures applied in PO3a scenario on revenues from road transport is shown in Table 7-45 where the comparison with the Baseline scenario in 2030 is given in the form of % changes. Overall, EU revenues from tolls in the freight sector (HGV) are expected to increase by 54,2% and total revenues from road transport are expected to increase by 28%.

Given the high similarity of PO2 and PO3a (the difference being the application of congestion charges in EL, ES, FR, HR, IE, IT, PL and PT) the comparison with analogous results of PO2 for these countries shows the impact on total revenues from the sole application of congestion charges. Revenues from circulation taxes are reduced at EU level by 30% relative to the Baseline in 2030.

Table 7-45: Percentage change in toll revenues from road transport in Policy Option 3a relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	5,2%	11,8%	-0,6%	24,6%	-0,8%
BE	22,8%	22,6%	-	n.c.	-
BG	95,5%	825,5%	-0,3%	249,9%	-0,3%
CY	-	-	-	-	-
CZ	8,9%	36,1%	-0,3%	105,7%	-0,3%
DE	57,7%	57,7%	-	n.c.	-
DK	568,2%	560,7%	-	n.c.	-
EE	-	-	-	-	-
EL	39,8%	6,3%	36,4%	45,4%	42,9%
ES	14,0%	5,5%	18,0%	37,3%	15,2%
FI	-	-	-	-	-
FR	18,3%	26,6%	10,3%	74,5%	16,3%
HR	1,4%	3,5%	2,1%	17,9%	1,3%
HU	12,7%	21,5%	-0,2%	388,3%	-0,5%
IE	-0,7%	-1,7%	-0,1%	5,9%	-0,7%
IT	22,2%	17,4%	20,8%	46,9%	23,1%
LT	722,3%	792,7%	0,0%	38,4%	-
LU	1834,6%	1829,1%	-	n.c.	-
LV	323,7%	745,2%	0,3%	497,4%	-
MT	-	-	-	-	-
NL	1115,7%	1115,7%	-	n.c.	-
PL	38,6%	62,5%	3,4%	112,4%	12,7%
PT	15,7%	3,0%	9,9%	22,7%	16,5%
RO	32,2%	435,3%	-0,2%	109,1%	-0,3%
SE	521,6%	519,0%	-	n.c.	-
SI	11,8%	29,4%	-0,3%	60,5%	-1,7%
SK	6,2%	24,2%	-0,3%	83,9%	-0,5%
UK	861,6%	854,6%	-	n.c.	-
EU15	28,5%	52,4%	15,1%	91,6%	18,0%
EU13	23,6%	69,5%	0,0%	142,5%	1,7%
EU28	28,0%	54,2%	13,2%	108,1%	16,4%

Source: ASTRA model

n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are null. The % variation at EU level however include the overall impacts on revenues including also the changes in respect to values that are null in the Baseline.

ASTRA results in terms of macroeconomic impact confirms that also the effect of Policy Option 3a on the economic sector is substantially limited.

Table 7-46: Variation of GDP and Unemployment in Policy Option 3a relative to the Baseline for 2030 – EU average

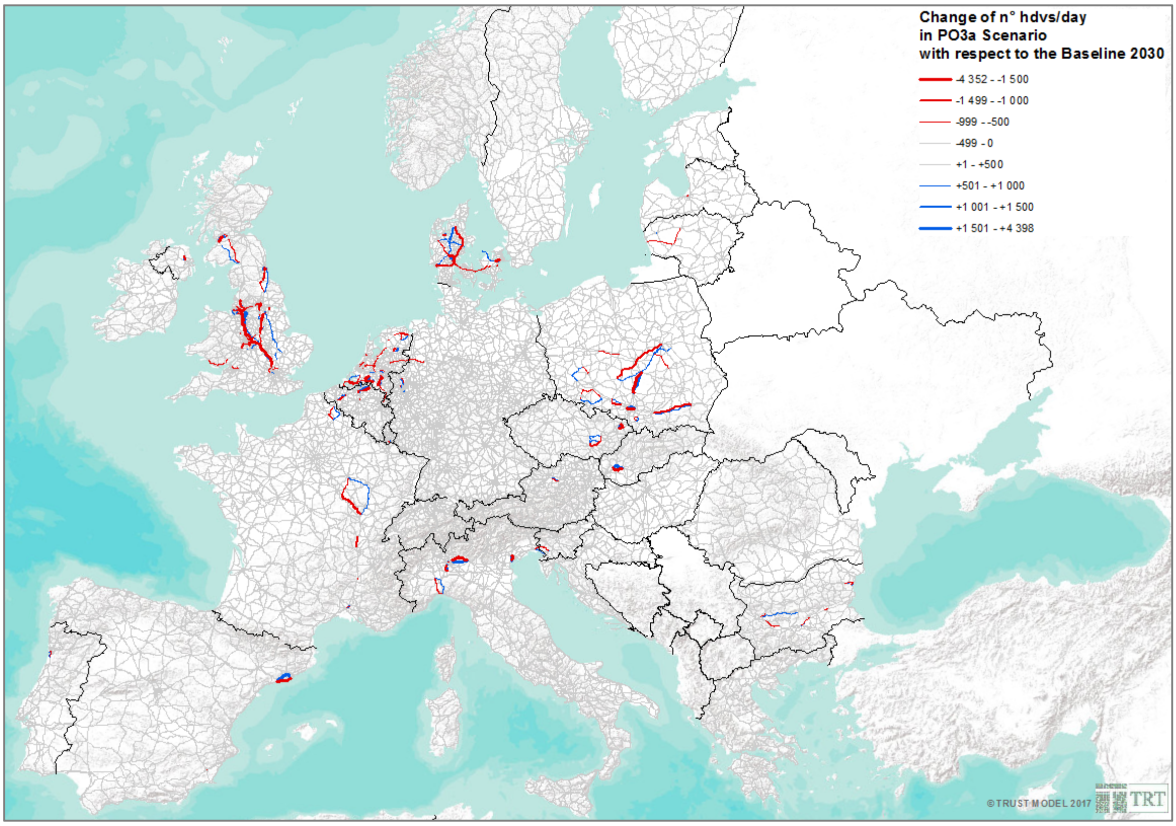
	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	0,0%	0,0
EU13	-0,1%	0,0
EU28	0,0%	0,0

Source: ASTRA model

7.6.3. Modelling results – TRUST

In this section, the link-based indicators of road assignment performed with the TRUST model are presented. As it can be noted from Figure 7-16, results for road traffic assignment of heavy good vehicles are in line with those observed in PO2.

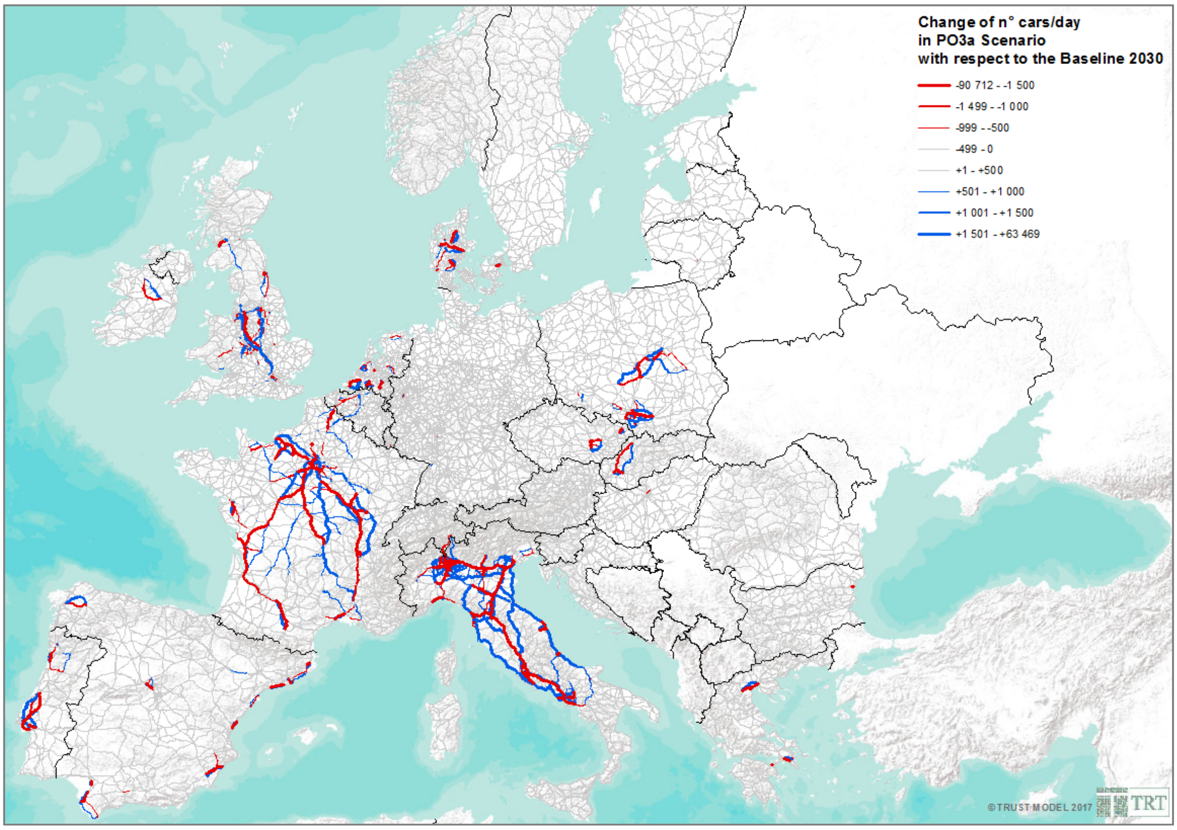
Figure 7-16: PO3a Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

A different picture is provided by the results of car traffic assignment available in Figure 7-17 which is mainly driven by the introduction of congestion cost charges in the selected countries.

Figure 7-17: PO3a Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

Results on the impacts of PO3a on external costs from interurban road congestion and noise are provided in Table 7-47 and in Table 7-48 respectively. Similar considerations already provided for PO1 and PO2 apply also to this case.

Table 7-47: External transport costs of interurban road congestion in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-0,1%	-1,2%	0,0%
BE	-0,9%	-4,5%	-0,6%
BG	0,1%	0,4%	0,1%
CY	n.a.	n.a.	n.a.
CZ	-0,9%	-1,9%	-0,8%
DE	-0,2%	-0,5%	-0,1%
DK	-1,7%	-6,3%	-1,2%
EE	-0,1%	-0,5%	-0,1%
EL	-6,9%	-5,5%	-7,0%
ES	0,2%	-1,7%	0,5%
FI	0,0%	0,0%	0,0%
FR	-1,2%	-2,3%	-1,1%
HR	0,0%	0,1%	0,0%
HU	-0,1%	-1,1%	0,0%
IE	0,3%	-0,1%	0,3%
IT	-11,5%	-8,7%	-11,5%
LT	0,1%	0,7%	0,0%
LU	-0,4%	-1,6%	-0,4%
LV	-0,5%	-1,5%	-0,4%
MT	n.a.	n.a.	n.a.
NL	-0,7%	-3,0%	-0,5%

Country	TOTAL (cars + trucks)	Trucks	Car
PL	-0,7%	-2,9%	-0,4%
PT	-13,0%	-1,1%	-13,4%
RO	0,0%	-0,1%	0,0%
SE	-0,6%	-1,5%	-0,4%
SI	-0,1%	-1,3%	-0,1%
SK	-0,7%	-7,0%	-0,4%
UK	-0,2%	-3,4%	0,1%
EU15	-2,8%	-2,7%	-2,8%
EU13	-0,6%	-2,8%	-0,3%
EU28	-2,4%	-2,7%	-2,4%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Table 7-48: External transport costs of noise from interurban road transport in Policy Option 3a relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,7%	2,8%	0,0%
BE	1,6%	6,6%	-0,1%
BG	0,4%	1,5%	-0,1%
CY	n.a.	n.a.	n.a.
CZ	0,2%	0,3%	0,1%
DE	0,3%	1,2%	0,0%
DK	2,0%	5,7%	-0,2%
EE	-0,4%	-1,6%	0,2%
EL	1,7%	0,0%	2,0%
ES	0,0%	-0,5%	0,4%
FI	0,0%	-0,1%	0,0%
FR	0,6%	-0,2%	0,9%
HR	0,0%	0,1%	0,0%
HU	0,1%	0,2%	0,0%
IE	-0,2%	-0,6%	0,1%
IT	2,5%	2,1%	2,6%
LT	1,8%	5,9%	-0,1%
LU	0,5%	2,3%	-0,1%
LV	3,5%	9,0%	0,0%
MT	n.a.	n.a.	n.a.
NL	1,3%	6,4%	-0,3%
PL	0,9%	1,6%	0,2%
PT	0,4%	0,1%	0,4%
RO	0,0%	0,3%	-0,1%
SE	0,5%	1,2%	0,0%
SI	0,2%	1,7%	0,0%
SK	2,3%	7,6%	-0,3%
UK	0,6%	2,9%	-0,1%
EU15	0,8%	1,7%	0,5%
EU13	0,7%	1,5%	0,1%
EU28	0,8%	1,7%	0,4%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.7. Policy Option 3b

7.7.1. Modelling assumptions

On top of Policy Option 2, Policy Option 3b adds the following modelling assumptions:

- **Phasing in of modulation of infrastructure charges according to CO2 and pollutant emission for LGV and passenger cars** by 2025 as shown in Table 7-49. The revised charges are based on the results of the PRIMES-TREMOVE model (ICCS-E3MLab)[82].

Table 7-49: Assumptions used for the modulation of infrastructure charges according to CO2 and air pollutant emissions for LGVs and passenger cars

Environmental performance	Conformity factor above 2.1	Maximum 168 mg NOx and maximum 95 gCO2/km for passenger cars (147 gCO2/km for LGVs) in 2020	Maximum 80 mg NOx and maximum 95 gCO2/km for passenger cars (147 gCO2/km for LGVs) from 2021
Charge per km	Above average rate	-15% versus highest rate	-30% versus highest rate

- **Phase in genuine congestion charging in distance-based environment for all vehicles**, i.e. in **EL, ES, FR, HR, IE, IT, PL and PT**[83] from 2025. Assumptions concerning congestion charges are the same as in PO3a

Table 7-50 and Table 7-51 below provide with a summary of the measures simulated in the various Member States in PO3b.

[82] This measure has been modelled in two steps. In the first step, the PRIMES-TREMOVE model has been run. In the second step, PRIMES-TREMOVE results (i.e. the structure of the vehicle fleet by type of powertrain, age and its evolution; the increase in road charges for vehicles with CO_2 emissions above the average) have been used in defining the integrated policy package in ASTRA model.

[83] These are the Member States currently applying distance-based charging for all vehicle categories, therefore the only ones that can make use of the instrument.

Table 7-50: Summary of policy measures introduced in PO3b on top of the Baseline, PO1, PO2 and PO3a

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	Vignette	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV	grey		grey		grey									grey			grey		grey					grey		grey	grey	
		Cars	grey		grey		grey									grey										grey		grey	grey	
	Toll	HGV <12t	grey	grey	blue		grey	hatched	blue		grey	grey		grey	grey	grey	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		HGV >12 t	grey	grey	blue		grey	grey	blue		grey	grey		grey	grey	grey	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		Buses	grey	blue	blue		grey	blue	blue		grey	grey		grey	grey	blue	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		LGV									grey	grey		grey	grey		grey	grey						grey	grey					
		Cars									grey	grey		grey	grey		grey	grey						grey	grey					
Phasing out vignette		HGV			blue				blue										blue	blue	blue		blue			blue	blue			blue
		Buses			blue											blue			blue		blue					blue				
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		Buses	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV	orange		orange		orange				orange	orange		orange	orange	orange	orange	orange	orange		orange			orange	orange	orange		orange	orange	
		Cars	orange		orange		orange				orange	orange		orange	orange	orange	orange	orange						orange	orange	orange		orange	orange	
Rebates for zero emission vehicles		HGV	green	green	green		green	green	green		green	green		green	green	green	green	green	green	green	green		green	green	green	green	green	green	green	green
		Buses	green	blue	green		green	blue	blue		green	green		green	green	green	green	green	green	blue	green		blue	green	green	green	blue	green	green	blue
		LGV	green		green		green				green	green		green	green	green	green	green	green		green			green	green	green		green	green	
		Cars	green		green		green				green	green		green	green	green	green	green						green	green	green		green	green	
External costs		HGV	hatched	blue	blue		blue	hatched	blue							blue			blue	blue	blue		blue	blue			blue	blue	blue	
		Buses	hatched		blue		blue												blue		blue			blue				blue	blue	
Congestion charging		All									purple	purple		purple	purple		purple	purple						purple	purple					
Mark-ups		HGV	grey											green														green		
		Buses	grey											green														green		
Reduced circulation taxes		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV																												

Table 7-51: Summary of policy measures introduced in PO3b relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

7.7.2. Modelling results – ASTRA

The measures implemented in Policy Option 3b impact on road freight transportation costs as shown in Table 7-52. As it can be noted from the comparison with PO2 results, the possible application of **congestion charging** on the inter-urban network in those Member States where this is allowed (i.e. EL, ES, FR, HR, IE, IT, PL and PT[84]) counterbalances the reduction induced by reduced circulation taxes.

Table 7-52: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	1,0%
BE	1,2%
BG	4,0%
CY	0,1%
CZ	0,6%
DE	2,0%
DK	2,6%
EE	0,6%
EL	0,1%
ES	-0,4%
FI	0,3%
FR	-1,0%
HR	0,5%
HU	1,1%
IE	0,0%
IT	0,3%
LT	2,3%
LU	2,5%
LV	2,7%
MT	0,4%
NL	1,4%
PL	0,6%
PT	-0,5%
RO	2,8%
SE	2,9%
SI	1,0%
SK	0,3%
UK	1,3%

Source: ASTRA model

The changes in freight transport activity and freight modal split driven by the change in the road freight costs are shown in Table 7-53 and Table 7-54

Table 7-53: Variation of freight transport activity in Mio t-km in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,3%	1,0%	0,0%	0,1%
BE	-0,4%	1,1%	0,0%	-0,1%
BG	-0,5%	2,2%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,1%	0,3%	0,0%	0,0%
DE	-0,3%	1,0%	0,0%	0,0%
DK	-0,8%	2,9%	-	-0,4%
EE	-0,2%	0,3%	-	-0,1%
EL	-0,1%	0,5%	-	-0,1%
ES	-0,1%	-0,2%	-	-0,1%

[84] Member States which apply distance-based charges to all vehicles.

Country	Road	Rail	IWW	TOTAL
FI	-0,1%	0,1%	0,0%	-0,1%
FR	-0,1%	0,4%	0,0%	-0,1%
HR	-0,1%	0,2%	0,0%	0,0%
HU	-0,3%	0,7%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	-0,1%	0,6%	0,0%	0,0%
LT	-0,8%	0,6%	0,0%	-0,1%
LU	-0,2%	1,5%	0,0%	-0,1%
LV	-0,6%	0,9%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,3%	1,6%	0,0%	-0,1%
PL	-0,2%	0,7%	0,0%	0,0%
PT	0,0%	-0,5%	-	0,0%
RO	-0,6%	0,8%	0,0%	0,0%
SE	-0,8%	1,7%	-	-0,1%
SI	-0,2%	0,6%	-	0,0%
SK	-0,1%	0,3%	0,0%	0,0%
UK	-0,3%	2,3%	0,0%	0,0%
EU15	-0,2%	1,0%	0,0%	-0,1%
EU13	-0,2%	0,7%	0,0%	0,0%
EU28	-0,2%	0,9%	0,0%	0,0%

Source: ASTRA model

Table 7-54: Variation of freight modal split in Policy Option 3b relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,3	0,3	0,0
BE	-0,2	0,2	0,0
BG	-0,3	0,4	0,0
CY	0,0	0,0	0,0
CZ	-0,1	0,1	0,0
DE	-0,2	0,2	0,0
DK	-0,4	0,4	0,0
EE	-0,1	0,1	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,1	0,1	0,0
FR	-0,1	0,0	0,0
HR	-0,1	0,0	0,0
HU	-0,2	0,2	0,0
IE	0,0	0,0	0,0
IT	-0,1	0,1	0,0
LT	-0,3	0,3	0,0
LU	-0,1	0,1	0,0
LV	-0,3	0,3	0,0
MT	0,0	0,0	0,0
NL	-0,1	0,1	0,0
PL	-0,2	0,2	0,0
PT	0,0	0,0	0,0
RO	-0,3	0,3	0,0
SE	-0,5	0,5	0,0
SI	-0,2	0,2	0,0
SK	-0,1	0,1	0,0
UK	-0,2	0,2	0,0
EU15	-0,1	0,1	0,0
EU13	-0,2	0,2	0,0
EU28	-0,2	0,2	0,0

Source: ASTRA model

Changes in road passenger transport costs at country level are dependent on a combination of measures (i.e. modulation of infrastructure charges by CO2/pollutant emissions, rebates for zero emission vehicles and congestion charging) which are applied differently by Member States.

Changes can be observed also in other countries due to the increase of road cost on international routes, especially where closest trade relationships exist between countries.

Table 7-55: Variation of road passenger transport cost (car+bus, including VAT Euro2010/p-km) in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	-0,3%
BE	0,0%
BG	-0,1%
CY	0,0%
CZ	-0,3%
DE	0,0%
DK	0,0%
EE	0,0%
EL	0,6%
ES	0,3%
FI	0,0%
FR	0,2%
HR	-0,8%
HU	-0,3%
IE	-0,2%
IT	0,6%
LT	0,0%
LU	0,0%
LV	0,0%
MT	0,1%
NL	0,0%
PL	0,0%
PT	-0,2%
RO	-0,2%
SE	0,0%
SI	-0,6%
SK	-0,4%
UK	0,0%

Source: ASTRA model

As a consequence of changed road passenger transport costs, small variations in passenger transport activity can be observed (Table 7-56). When slight reduction of road passenger costs occurs, a small increase in road transport activity can be observed with consequent small reduction in other transport modes.

Table 7-56: Variation of passenger transport activity in Mio p-km in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	Air	Total
AT	0.0%	-0.3%	0.0%	0.0%
BE	0.0%	0.0%	0.2%	0.0%
BG	0.0%	0.2%	0.1%	0.0%
CY	0.0%	0.0%	0.0%	0.0%
CZ	0.0%	-0.2%	0.0%	0.0%
DE	0.0%	0.0%	0.0%	0.0%
DK	0.0%	0.0%	0.0%	0.0%
EE	0.0%	0.0%	0.0%	0.0%

Country	Road	Rail	Air	Total
EL	-0.1%	0.8%	0.1%	0.0%
ES	-0.1%	0.4%	0.2%	0.0%
FI	0.0%	0.0%	0.0%	0.0%
FR	-0.1%	0.3%	0.3%	0.0%
HR	0.1%	-0.8%	0.0%	0.0%
HU	0.0%	-0.2%	0.0%	0.0%
IE	0.0%	-0.4%	0.2%	0.1%
IT	-0.1%	0.9%	0.5%	0.0%
LT	0.0%	0.1%	0.0%	0.0%
LU	0.0%	0.0%	0.1%	0.0%
LV	0.0%	0.0%	0.0%	0.0%
MT	-0.1%	0.0%	0.0%	0.0%
NL	0.0%	0.0%	0.0%	0.0%
PL	0.0%	0.0%	0.0%	0.0%
PT	0.0%	-0.5%	0.1%	0.0%
RO	0.1%	-0.2%	0.0%	0.0%
SE	0.0%	0.0%	0.0%	0.0%
SI	0.0%	-0.8%	0.1%	0.0%
SK	0.0%	-0.4%	-0.1%	0.0%
UK	0.0%	0.0%	0.0%	0.0%
EU15	0.0%	0.2%	0.1%	0.0%
EU13	0.0%	-0.1%	0.0%	0.0%
EU28	0.0%	0.2%	0.1%	0.0%

Source: ASTRA model

Nonetheless, the impact on modal shift at EU28 level not significant, as shown in Table 7-57

Table 7-57: Variation of passenger modal split in Policy Option 3b relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	Air
AT	0.0	0.0	0.0
BE	0.0	0.0	0.0
BG	0.0	0.0	0.0
CY	0.0	0.0	0.0
CZ	0.0	0.0	0.0
DE	0.0	0.0	0.0
DK	0.0	0.0	0.0
EE	0.0	0.0	0.0
EL	0.0	0.0	0.0
ES	-0.1	0.0	0.0
FI	0.0	0.0	0.0
FR	-0.1	0.0	0.0
HR	0.0	0.0	0.0
HU	0.0	0.0	0.0
IE	0.0	0.0	0.0
IT	-0.1	0.1	0.0
LT	0.0	0.0	0.0
LU	0.0	0.0	0.0
LV	0.0	0.0	0.0
MT	0.0	0.0	0.0
NL	0.0	0.0	0.0

Country	Road	Rail	Air
PL	0.0	0.0	0.0
PT	0.0	0.0	0.0
RO	0.0	0.0	0.0
SE	0.0	0.0	0.0
SI	0.0	0.0	0.0
SK	0.0	0.0	0.0
UK	0.0	0.0	0.0
EU15	0.0	0.0	0.0
EU13	0.0	0.0	0.0
EU28	0.0	0.0	0.0

Source: ASTRA model

The modulation of infrastructure charges according to CO2 emissions is expected to slightly increase the share of hybrid and electric car and LGV at European level as shown in Table 7-58

Table 7-58: Variation of passenger cars and LGV vehicle fleet composition in Policy Option 3b at EU level (p.p. difference relative to the Baseline for 2030)

	Passenger cars	LGVs
Diesel conventional	-0.4	-0.3
Petrol conventional	0.0	0.05
Diesel and petrol hybrids	0.2	0.03
Electric	0.2	0.2
LPG	0.0	0.0
CNG	0.0	0.0
Hydrogen	0.0	0.0

Source: ASTRA based on the PRIMES-TREMOVE model results

Also in this policy option the impacts on **fuel consumption** (Table 7-59) are mainly driven by the changes in the vehicle fleet composition due to the modulation of infrastructure charging by CO_2 emission simulated by the PRIMES-TREMOVE model (already discussed within PO2) which in this case is phased in also for LGVs and passenger cars. The comparison with the Baseline shows a general decrease in diesel use together with some limited increase in gas used for HGVs and electricity used for passenger cars. Small increases in gasoline consumption in some Member State is driven by the switch from diesel to petrol hybrids cars.

Table 7-59: Variation of fuel consumption from road sector in Mtoe in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	0,4%	-0,5%	0,4%	7,1%	-0,8%	2,2%	0,2%
BE	0,0%	-0,3%	0,1%	12,0%	-0,4%	0,0%	0,0%
BG	-0,2%	-0,2%	-0,1%	1,7%	-0,3%	1,6%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,3%	-0,4%	0,8%	3,9%	-0,2%	1,8%	0,1%
DE	0,0%	-1,3%	0,2%	31,7%	-1,6%	0,0%	0,0%
DK	0,0%	-0,5%	0,2%	4,8%	-0,5%	0,0%	0,0%
EE	0,0%	-0,1%	0,0%	-0,1%	0,0%	0,0%	0,0%
EL	0,0%	-0,6%	0,3%	7,1%	-0,3%	2,3%	-0,2%
ES	2,9%	-1,5%	7,6%	29,6%	-1,7%	8,4%	0,2%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
FR	-0,2%	-3,0%	12,5%	120,4%	-4,1%	8,7%	0,3%
HR	-0,9%	0,2%	0,2%	3,4%	-0,4%	3,0%	0,2%
HU	-0,9%	-0,4%	1,6%	32,3%	-0,9%	3,3%	0,2%
IE	0,0%	0,0%	0,2%	0,4%	0,0%	0,4%	0,1%
IT	1,9%	-2,3%	0,1%	4,4%	-1,3%	6,8%	0,0%
LT	0,1%	-0,5%	-0,1%	0,6%	-0,5%	0,7%	0,3%
LU	0,0%	-0,2%	0,2%	0,5%	-0,3%	0,0%	0,0%
LV	0,1%	-0,3%	0,0%	4,6%	-0,3%	0,0%	0,0%

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,1%	17,3%	-0,8%	0,1%	0,0%
PL	0,0%	-0,4%	0,0%	13,0%	-0,5%	0,4%	0,0%
PT	0,7%	-0,8%	5,0%	21,9%	-0,8%	8,3%	0,5%
RO	0,3%	-0,5%	0,3%	15,4%	-0,2%	1,7%	0,1%
SE	0,0%	-0,6%	0,3%	4,8%	-0,7%	0,0%	0,0%
SI	0,1%	-1,3%	1,1%	21,9%	-0,8%	2,8%	0,0%
SK	-0,2%	-0,5%	0,2%	17,2%	-0,8%	1,6%	0,2%
UK	0,1%	-0,5%	0,5%	17,0%	-0,7%	0,6%	0,0%
EU15	0,4%	-1,5%	0,5%	13,9%	-1,5%	3,6%	0,1%
EU13	-0,1%	-0,4%	0,0%	12,2%	-0,5%	1,7%	0,0%
EU28	0,4%	-1,3%	0,3%	13,8%	-1,4%	3,4%	0,1%

Source: ASTRA model

As a result of the changes above, some limited decreases in emissions from the road sector take place at country and EU level (**Table 7-60**).

Table 7-60: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 3b relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	0,0%	-0,5%	-0,1%	-0,5%	-0,4%
BE	-0,1%	-0,2%	0,0%	-0,1%	-0,2%
BG	0,0%	-0,2%	0,1%	-0,1%	-0,2%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,2%	-0,3%	0,1%	-0,6%	-0,2%
DE	-0,3%	-1,4%	-0,2%	-0,4%	-0,5%
DK	-0,1%	-0,6%	-0,1%	-0,3%	-0,3%
EE	0,0%	-0,1%	0,0%	0,0%	-0,1%
EL	0,0%	-0,3%	-0,1%	-0,7%	-0,2%
ES	0,7%	-1,1%	0,1%	-1,8%	-0,7%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%
FR	-0,6%	-3,4%	-0,3%	-1,9%	-1,6%
HR	-0,3%	-0,1%	0,3%	0,3%	-0,1%
HU	-0,4%	-0,6%	0,0%	-0,1%	-0,4%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	1,1%	-1,0%	0,2%	-2,2%	-0,3%
LT	-0,1%	-0,4%	0,0%	-0,1%	-0,3%
LU	-0,1%	-0,1%	0,0%	0,0%	-0,2%
LV	0,0%	-0,2%	0,0%	0,0%	-0,2%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,0%	0,0%	-0,2%
PL	-0,2%	-0,4%	-0,1%	-0,2%	-0,2%
PT	0,6%	-0,4%	0,4%	-1,0%	-0,3%
RO	0,0%	-0,5%	0,0%	-0,4%	-0,2%
SE	-0,1%	-0,6%	0,0%	-0,1%	-0,3%
SI	-0,1%	-0,8%	0,0%	-0,8%	-0,3%
SK	-0,2%	-0,6%	-0,1%	-0,3%	-0,3%
UK	0,0%	-0,4%	0,0%	-0,2%	-0,2%
EU15	0,0%	-1,4%	-0,1%	-1,1%	-0,6%
EU13	-0,1%	-0,4%	0,0%	-0,2%	-0,2%
EU28	0,0%	-1,2%	-0,1%	-1,0%	-0,5%

Source: ASTRA model

The changes in road sector emissions are also reflected in external costs, which decrease relative to the Baseline for 2030 (Table 7-61).

Table 7-61: Variation of external costs for road transport sector in Mio Euro in Policy Option 3b relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	0,0%	-0,6%	0,0%	-0,4%	-0,4%
EU13	0,0%	-0,2%	0,0%	-0,1%	-0,2%
EU28	0,0%	-0,5%	0,0%	-0,4%	-0,4%

Source: ASTRA model

The impact arising from the measures applied in PO3b scenario on toll revenues from road transport is shown in Table 7-62, where the comparison with the Baseline scenario in 2030 is given in the form of percentage changes.

Overall revenues at EU level are expected to increase by 24,7% relative to the Baseline for 2030.

Table 7-62: Percentage change in toll revenues from road transport in Policy Option 3b relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	2,6%	11,8%	9,3%	24,3%	-6,1%
BE	22,8%	22,6%	-	n.c.	-
BG	94,5%	825,4%	10,1%	250,0%	-4,0%
CY	-	-	-	-	-
CZ	-0,3%	36,1%	-0,4%	104,6%	-12,8%
DE	57,7%	57,7%	-	n.c.	-
DK	568,2%	560,7%	-	n.c.	-
EE	-	-	-	-	-
EL	20,0%	6,3%	47,7%	44,2%	20,1%
ES	15,2%	5,5%	25,3%	37,6%	16,5%
FI	-	-	-	-	-
FR	13,7%	26,6%	17,7%	74,4%	9,9%
HR	-8,5%	3,5%	14,5%	17,9%	-9,1%
HU	9,2%	21,5%	18,6%	380,9%	-10,9%
IE	-7,2%	-1,7%	20,7%	6,5%	-10,2%
IT	20,9%	17,4%	40,9%	46,9%	20,3%
LT	722,8%	792,7%	9,9%	38,4%	-
LU	1834,6%	1829,1%	-	n.c.	-
LV	318,7%	745,2%	-8,5%	497,4%	-
MT	-	-	-	-	-
NL	1115,7%	1115,7%	-	n.c.	-
PL	35,6%	62,5%	16,8%	112,0%	6,1%
PT	11,6%	3,0%	13,7%	21,7%	11,9%
RO	26,8%	435,3%	10,4%	108,6%	-8,9%
SE	521,6%	519,0%	-	n.c.	-
SI	3,7%	29,4%	9,1%	60,4%	-15,8%
SK	-4,2%	24,2%	8,6%	82,4%	-14,5%
UK	861,6%	854,6%	-	n.c.	-
EU15	25,6%	52,4%	28,2%	91,4%	13,0%
EU13	17,3%	69,5%	11,7%	141,1%	-8,7%
EU28	24,7%	54,2%	26,2%	107,4%	10,9%

Source: ASTRA model

n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are zero. The % variation at EU level however includes the overall impacts on revenues including also the changes in respect to values that are zero in the Baseline.

ASTRA results in terms of macroeconomic impact confirms that the effect of Policy Option 3b on GDP is limited.

Table 7-63: Variation of GDP and Unemployment in Policy Option 3b relative to the Baseline for 2030 – EU average

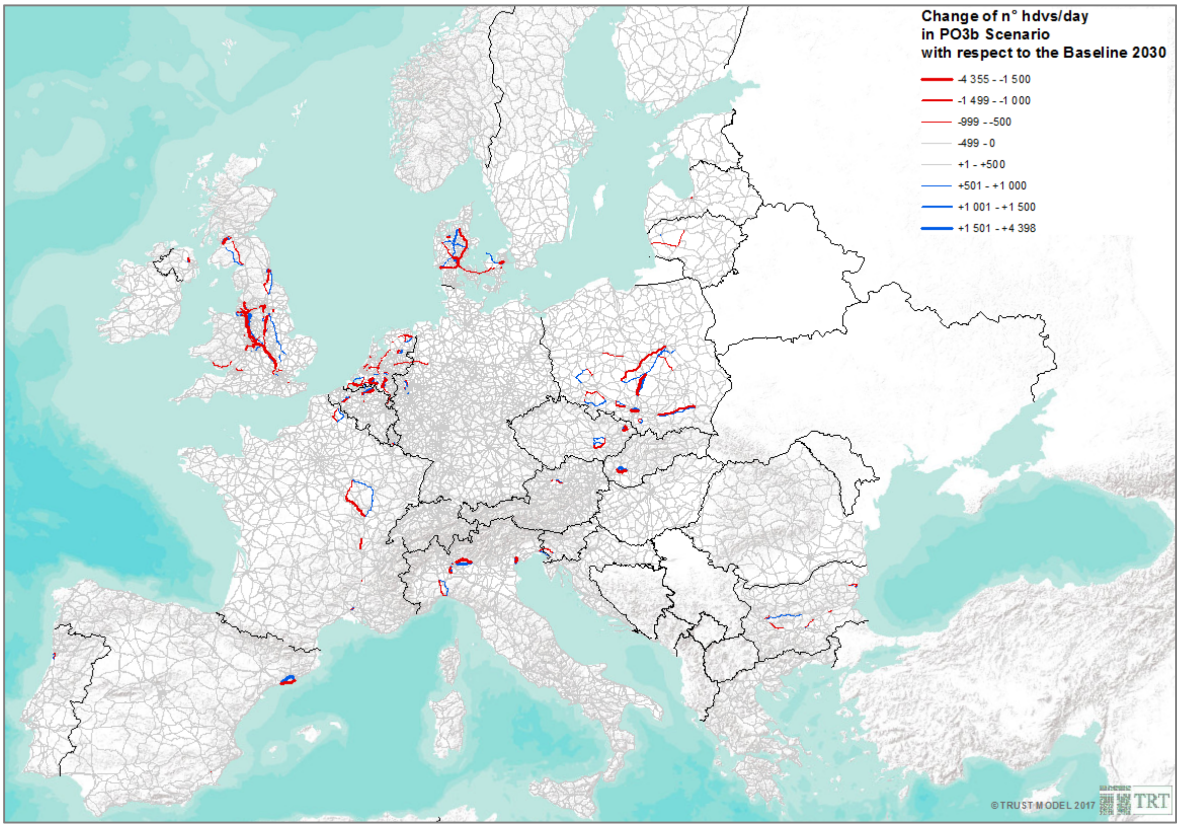
	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	0,0%	0,0
EU13	-0,1%	0,0
EU28	0,0%	0,0

Source: ASTRA model

7.7.3. Modelling results – TRUST

Considerations already provided in the description of PO2 and PO3a concerning the results of HDV traffic assignment on the road network, and the related differences with the Baseline results, apply also to this scenario, as results are driven by similar type of measures.

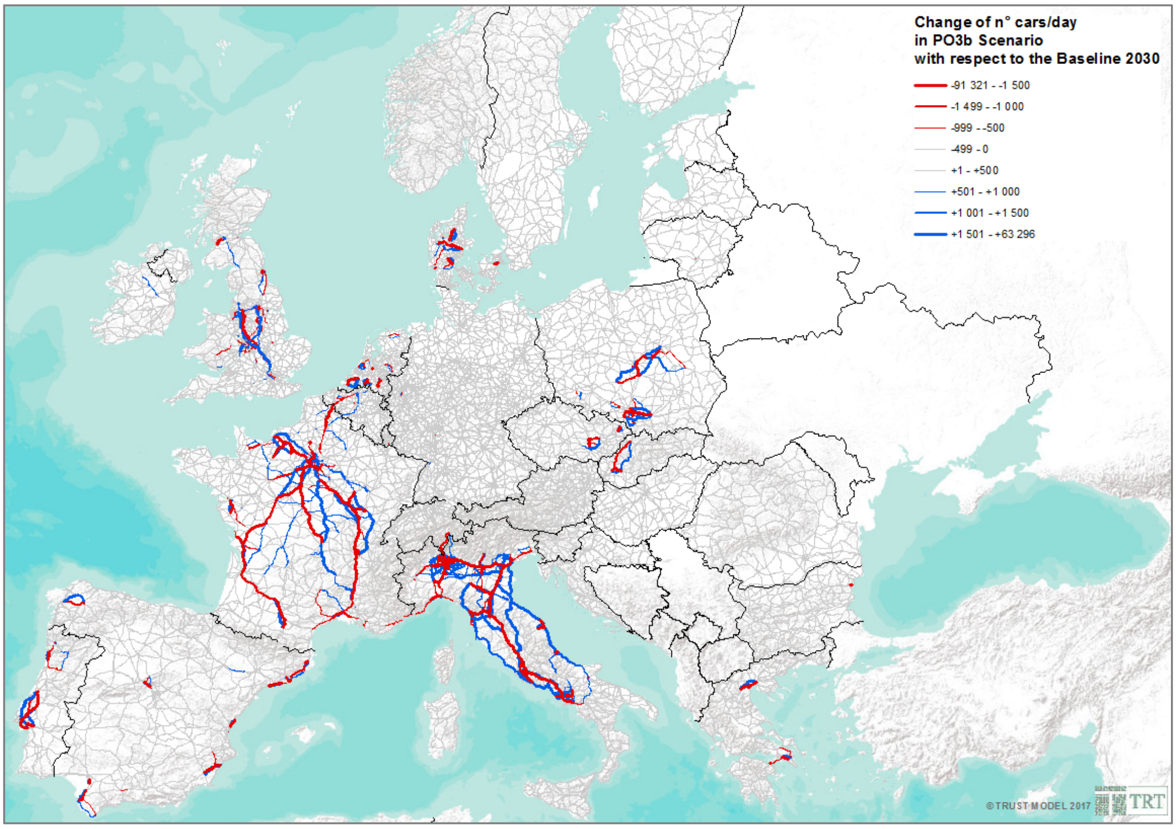
Figure 7-18: PO3b Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

More visible impacts can be noted when analysing the differences between PO3b and the Baseline scenario for car passenger traffic. It can be observed that impacts are more visible in those countries phasing in congestion charges (for cars the effect is higher than for HGVs as they represent a larger share of road traffic).

Figure 7-19: PO3b Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

The effect on external costs from interurban road congestion and on noise deriving from the package of measures implemented in PO3b are illustrated in Table 7-64 and Table 7-65 below. Congestion costs at EU level are reduced by about 2,5% relative to the Baseline in 2030. On the other side, the diversion of traffic to un-tolled routes determines a small increase in external costs from noise (about 0,8% relative to the Baseline in 2030).

Table 7-64: External transport costs of interurban road congestion in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,1%	-1,0%	0,2%
BE	-1,0%	-4,6%	-0,6%
BG	0,1%	0,4%	0,1%
CY	n.a.	n.a.	n.a.
CZ	-0,7%	-1,8%	-0,6%
DE	-0,2%	-0,5%	-0,1%
DK	-1,7%	-6,3%	-1,2%
EE	-0,1%	-0,4%	-0,1%
EL	-7,5%	-6,0%	-7,5%
ES	-0,2%	-2,1%	0,1%
FI	0,0%	0,0%	0,0%
FR	-1,0%	-2,3%	-0,9%
HR	0,2%	0,2%	0,2%
HU	0,1%	-1,0%	0,3%
IE	0,7%	0,4%	0,7%
IT	-11,9%	-9,2%	-12,0%
LT	0,0%	0,7%	0,0%
LU	-0,5%	-1,6%	-0,4%
LV	-0,5%	-1,5%	-0,4%
MT	n.a.	n.a.	n.a.

Country	TOTAL (cars + trucks)	Trucks	Car
NL	-0,7%	-3,0%	-0,6%
PL	-0,7%	-3,0%	-0,4%
PT	-13,1%	-1,2%	-13,5%
RO	0,7%	0,1%	0,7%
SE	-0,6%	-1,5%	-0,4%
SI	0,1%	-1,2%	0,2%
SK	-0,4%	-6,9%	0,0%
UK	-0,2%	-3,4%	0,1%
EU15	-2,8%	-2,7%	-2,8%
EU13	-0,4%	-2,8%	-0,2%
EU28	-2,5%	-2,8%	-2,4%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Table 7-65: External transport costs of noise from interurban road transport in Policy Option 3b relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,7%	2,8%	0,0%
BE	1,6%	6,6%	-0,1%
BG	0,4%	1,5%	-0,1%
CY	n.a.	n.a.	n.a.
CZ	0,2%	0,3%	0,2%
DE	0,3%	1,2%	0,0%
DK	2,0%	5,7%	-0,2%
EE	-0,4%	-1,6%	0,2%
EL	1,6%	-0,1%	1,9%
ES	0,0%	-0,6%	0,3%
FI	0,0%	-0,1%	0,0%
FR	0,5%	-0,3%	0,8%
HR	0,2%	0,1%	0,2%
HU	0,1%	0,2%	0,0%
IE	-0,1%	-0,6%	0,2%
IT	2,4%	2,0%	2,4%
LT	1,8%	5,9%	-0,1%
LU	0,5%	2,3%	-0,1%
LV	3,5%	9,0%	0,0%
MT	n.a.	n.a.	n.a.
NL	1,3%	6,4%	-0,3%
PL	0,9%	1,6%	0,2%
PT	0,4%	0,1%	0,4%
RO	0,1%	0,3%	0,0%
SE	0,5%	1,2%	0,0%
SI	0,3%	1,7%	0,0%
SK	2,4%	7,5%	-0,2%
UK	0,6%	2,9%	-0,1%
EU15	0,8%	1,7%	0,5%
EU13	0,7%	1,5%	0,1%
EU28	0,8%	1,7%	0,4%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.8. Policy Option 4

7.8.1. Modelling assumptions

Policy Option 4 builds upon Policy Option 3b and includes:

- **Mandatory external cost charging** for air pollution and noise for HGVs and buses on the TEN-T network in all countries where road charging is applied.
- **Phase out vignettes for LGVs** by 2025 and phase-in of distance-based charging for these vehicles in **AT, BG, CZ, HU, LT, LV, RO, SI, SK.**
- **Phase out vignettes for cars and phase in of distance based charges for passenger cars** in **AT, BG, CZ, HU, RO, SI** and **SK.**
- **Extension of genuine congestion charging** also to **AT, BG, CZ, HU, RO, SI** and **SK**. Modelled average daily congestion charges (for all countries), based on Handbook values, are summarised in Table 7-66.
- **Exemption from circulation taxes** for LGVs in **AT, BG, CZ, HU, LT, LV, RO, SI, SK** from 2025 onwards. Assume a 50% reduction for LGVs for the distance-based systems already in place in EL, ES, FR, HR, IE, IT, PL and PT from 2020 onwards.

Table 7-66: Average daily efficient marginal congestion costs, € per vkm

	Car		Rigid truck		Articulated truck		Bus	
Country	Motor-way	Main Roads	Motor-way	Main Roads	Motor-way	Main Roads	Motor-way	Main Roads
AT	0,104	0,131	0,152	0,23	0,232	0,351	0,2	0,302
BG	0,036	0,046	0,053	0,080	0,081	0,122	0,070	0,105
CZ	0,066	0,083	0,096	0,145	0,146	0,221	0,126	0,19
EL	0,074	0,093	0,108	0,163	0,165	0,249	0,142	0,215
ES	0,082	0,104	0,121	0,182	0,184	0,278	0,159	0,24
FR	0,089	0,112	0,13	0,196	0,198	0,3	0,171	0,258
HR	0,049	0,062	0,072	0,108	0,109	0,165	0,094	0,142
HU	0,053	0,067	0,078	0,118	0,119	0,18	0,103	0,155
IE	0,105	0,132	0,154	0,232	0,235	0,354	0,202	0,305
IT	0,083	0,105	0,122	0,184	0,186	0,28	0,16	0,242
PL	0,052	0,065	0,076	0,114	0,115	0,174	0,099	0,15
PT	0,066	0,083	0,096	0,146	0,147	0,222	0,127	0,191
RO	0,039	0,049	0,056	0,085	0,086	0,130	0,074	0,112
SI	0,07	0,088	0,102	0,154	0,156	0,236	0,135	0,203
SK	0,06	0,076	0,088	0,134	0,135	0,204	0,116	0,176

Source: TRT elaborations based on Updated Handbook of external costs

Table 7-67 and Table 7-68 below provide with a summary of the measures simulated in the various Member States in PO4.

Table 7-67: Summary of policy measures introduced in PO4 on top of the Baseline, PO1, PO2, PO3a and PO3b

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	Vignette	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t	grey	grey	blue		grey	hatched	blue		grey	grey		grey	grey	grey	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		HGV >12 t	grey	grey	blue		grey	grey	blue		grey	grey		grey	grey	grey	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		Buses	grey	blue	blue		grey	blue	blue		grey	grey		grey	grey	blue	grey	grey	blue	blue	blue		blue	grey	grey	blue	blue	grey	grey	blue
		LGV	red		red		red				grey	grey		grey	grey	red	grey	grey	red		red			grey	grey	red		red	red	
		Cars	red		red		red				grey	grey		grey	grey	red	grey	grey						grey	grey	red		red	red	
Phasing out vignette		HGV			blue				blue										blue	blue	blue		blue			blue	blue			blue
		Buses			blue											blue			blue		blue					blue				
		LGV	red		red		red									red			red		red					red		red	red	
		Cars	red		red		red									red										red		red	red	
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		Buses	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV	orange		orange		orange				orange	orange		orange	orange	orange	orange	orange	orange		orange			orange	orange	orange		orange	orange	
		Cars	orange		orange		orange				orange	orange		orange	orange	orange	orange	orange						orange	orange	orange		orange	orange	
Rebates for zero emission vehicles		HGV	green	green	green		green	green	green		green	green		green	green	green	green	green	green	green	green		green	green	green	green	green	green	green	green
		Buses	green	blue	green		green	blue	blue		green	green		green	green	green	green	green	green	blue	green		blue	green	green	green	blue	green	green	blue
		LGV	green		green		green				green	green		green	green	green	green	green	green		green			green	green	green		green	green	
		Cars	green		green		green				green	green		green	green	green	green	green						green	green	green		green	green	
External costs		HGV	hatched	blue	blue		blue	hatched	blue		red	red		red	red	blue	red	red	blue	blue	blue		blue	blue	red	red	blue	blue	blue	red
		Buses	hatched	red	blue		blue	red	red		red	red		red	red	red	red	red	blue	red	blue		red	blue	red	red	red	blue	blue	red
Congestion charging		All	red		red		red				purple	purple		purple	purple	red	purple	purple						purple	purple	red		red	red	
Mark-ups		HGV	grey											green														green		
		Buses	grey											green														green		
Reduced circulation taxes		HGV	blue	blue	blue		blue	blue	blue		blue	blue		blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV	red		red		red				red	red		red	red	red	red	red	red		red			red	red	red		red	red	

Table 7-68: Summary of policy measures introduced in PO4 relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t			Blue			Hatched	Blue										Blue	Blue	Blue		Blue			Blue	Blue			Blue
		HGV >12t			Blue				Blue										Blue	Blue	Blue		Blue			Blue	Blue			Blue
		Buses		Blue	Blue			Blue	Blue							Blue			Blue	Blue	Blue		Blue			Blue	Blue			Blue
		LGV	Red		Red		Red									Red			Red		Red					Red		Red	Red	
		Cars	Red		Red		Red									Red										Red		Red	Red	
Phasing out vignette		HGV			Blue				Blue										Blue	Blue	Blue		Blue			Blue	Blue			Blue
		Buses			Blue											Blue			Blue		Blue					Blue				
		LGV	Red		Red		Red									Red			Red		Red					Red		Red	Red	
		Cars	Red		Red		Red									Red										Red		Red	Red	
Phasing out EURO Class modulation		HGV		Blue	Blue		Blue		Blue							Blue			Blue	Blue	Blue		Blue	Blue			Blue	Blue	Blue	
		Buses			Blue		Blue												Blue		Blue			Blue				Blue	Blue	
Phasing in CO2/pollutant modulation		HGV	Blue	Blue	Blue		Blue	Blue	Blue		Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
		Buses	Blue	Blue	Blue		Blue	Blue	Blue		Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
		LGV	Orange		Orange		Orange				Orange	Orange		Orange	Orange	Orange	Orange	Orange	Orange		Orange			Orange	Orange	Orange		Orange	Orange	
		Cars	Orange		Orange		Orange				Orange	Orange		Orange	Orange	Orange	Orange	Orange						Orange	Orange	Orange		Orange	Orange	
Rebates for zero emission vehicles		HGV	Green	Green	Green		Green	Green	Green		Green	Green		Green	Green	Green	Green	Green	Green	Green	Green		Green	Green	Green	Green	Green	Green	Green	Green
		Buses	Green	Blue	Green		Green	Blue	Blue		Green	Green		Green	Green	Green	Green	Green	Green	Blue	Green		Blue	Green	Green	Green	Blue	Green	Green	Blue
		LGV	Green		Green		Green				Green	Green		Green	Green	Green	Green	Green	Green		Green			Green	Green	Green		Green	Green	
		Cars	Green		Green		Green				Green	Green		Green	Green	Green	Green	Green						Green	Green	Green		Green	Green	
External costs		HGV	Hatched	Blue	Blue		Blue	Hatched	Blue		Red	Red		Red	Red	Blue	Red	Red	Blue	Blue	Blue		Blue	Blue	Red	Red	Blue	Blue	Blue	Red
		Buses	Hatched	Red	Blue		Blue	Red	Red		Red	Red		Red	Red	Red	Red	Red	Blue	Red	Blue		Red	Blue	Red	Red	Red	Blue	Blue	Red
Congestion charging		All	Red		Red		Red				Purple	Purple		Purple	Purple	Red	Purple	Purple						Purple	Purple	Red		Red	Red	
Mark-ups		HGV												Green														Green		
		Buses												Green														Green		
Reduced circulation taxes		HGV	Blue	Blue	Blue		Blue	Blue	Blue		Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
		LGV	Red		Red		Red				Red	Red		Red	Red	Red	Red	Red	Red		Red		Red	Red	Red		Red	Red		

Note: measures included in PO1, PO2, PO3a, PO3b and PO4 are reported in green; measures included in PO2, PO3a, PO3b and PO4 are reported in blue; measures included in PO3a, PO3b and PO4 are provided in purple; measures included in PO3b and PO4 are reported in orange; measures additionally included in PO4 are reported in red.

7.8.2. Modelling results – ASTRA

The measures introduced in PO4 (i.e. related to HGVs but also LGVs) increase road freight transportation costs to a more visible extent with respect to the other policy options. In particular, the introduction of distance-based charging for LGVs and the congestion charging are the drivers of additional increase in several countries, i.e. **AT (3,9%), BG (5,1%), RO (4,9%)** and **HU (2,8%)**; in other countries the changes mainly reflect the cumulated effect of the introduction of distance-based charging for LGVs and external costs charging for HGVs, e.g. **LT (2,4%),** and **LV (3,0%).** In **DK (2,6%), SE (2,9%)** and **UK (1,7%)**, **LU (2,7%)** and **NL (1,5%)** the mandatory external cost charging for HGVs is mainly responsible for the additional increase.

Table 7-69: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	3,9%
BE	1,3%
BG	5,1%
CY	0,4%
CZ	0,7%
DE	2,1%
DK	2,6%
EE	0,7%
EL	0,4%
ES	-0,1%
FI	0,3%
FR	-0,5%
HR	0,8%
HU	2,8%
IE	0,0%
IT	1,0%
LT	2,4%
LU	2,7%
LV	3,0%
MT	0,7%
NL	1,5%
PL	0,5%
PT	-0,3%
RO	4,9%
SE	2,9%
SI	1,0%
SK	0,3%
UK	1,7%

Source: ASTRA model

The increased road freight transportation costs have an impact on the road freight transport activity at country level, resulting in an overall increase of rail transport activity (see Table 7-70). The size of the change depends on the increase in the road freight transport cost within the country, but also on the increase in road freight cost on international routes; the latter is particularly relevant where strong trade relationships exist between countries.

Table 7-70: Variation of freight transport activity in Mio tkm in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,6%	1,7%	0,0%	0,1%
BE	-0,4%	1,3%	0,0%	-0,1%
BG	-0,6%	2,4%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,2%	0,4%	0,0%	0,0%

Country	Road	Rail	IWW	TOTAL
DE	-0,3%	1,1%	0,0%	0,0%
DK	-0,8%	2,9%	-	-0,4%
EE	-0,2%	0,3%	-	-0,1%
EL	-0,2%	1,5%	-	-0,1%
ES	-0,2%	0,1%	-	-0,1%
FI	-0,1%	0,1%	0,0%	-0,1%
FR	-0,3%	1,1%	0,0%	-0,1%
HR	-0,2%	0,3%	0,0%	-0,1%
HU	-0,4%	1,1%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	-0,3%	1,9%	0,0%	-0,1%
LT	-0,8%	0,6%	0,0%	-0,1%
LU	-0,3%	1,7%	0,0%	-0,1%
LV	-0,6%	0,9%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,4%	1,7%	0,0%	-0,1%
PL	-0,2%	0,8%	0,0%	0,0%
PT	0,0%	-0,2%	-	-0,1%
RO	-0,8%	1,1%	0,0%	0,1%
SE	-0,8%	1,7%	-	-0,2%
SI	-0,3%	0,7%	-	0,0%
SK	-0,1%	0,3%	0,0%	0,0%
UK	-0,4%	3,0%	0,0%	0,0%
EU15	-0,3%	1,3%	0,0%	-0,1%
EU13	-0,3%	0,8%	0,0%	0,0%
EU28	-0,3%	1,1%	0,0%	-0,1%

Source: ASTRA model

Moderate impacts take place in terms of mode split at country level, resulting in 0.2 p.p. decrease in road transport modal share at EU28 level in 2030 relative to the Baseline.

Table 7-71: Variation of freight modal split in Policy Option 4 relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,5	0,5	0,0
BE	-0,2	0,2	0,0
BG	-0,4	0,4	0,0
CY	0,0	0,0	0,0
CZ	-0,1	0,1	0,0
DE	-0,2	0,2	0,0
DK	-0,4	0,4	0,0
EE	-0,1	0,1	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,1	0,1	0,0
FR	-0,1	0,1	0,0
HR	-0,1	0,1	0,0
HU	-0,3	0,3	0,0
IE	0,0	0,0	0,0
IT	-0,2	0,2	0,0
LT	-0,3	0,3	0,0
LU	-0,2	0,2	0,0
LV	-0,3	0,3	0,0
MT	0,0	0,0	0,0
NL	-0,1	0,1	0,0
PL	-0,2	0,2	0,0
PT	0,0	0,0	0,0
RO	-0,4	0,4	0,0
SE	-0,5	0,5	0,0

Country	Road	Rail	IWW
SI	-0,2	0,2	0,0
SK	-0,1	0,1	0,0
UK	-0,3	0,3	0,0
EU15	-0,2	0,2	0,0
EU13	-0,2	0,2	0,0
EU28	-0,2	0,2	0,0

Source: ASTRA model

The introduction of distance-based charging for cars and of congestion charging in several Member States, results in a visible increase of road passenger transport cost in the respective countries, i.e. **AT (27,4%), CZ (6,3%), RO (12,6%), SI (5,8%)** and **SK (9,9%)** and in a smaller increase in **HU (3,4%)** and **BG (3,8%).**

Table 7-72: Variation of road passenger transport cost (car+bus, including VAT Euro2010/p-km) in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	27,4%
BE	0,0%
BG	3,8%
CY	0,8%
CZ	6,3%
DE	0,1%
DK	0,0%
EE	0,1%
EL	0,7%
ES	0,3%
FI	0,0%
FR	0,2%
HR	1,0%
HU	3,4%
IE	-0,2%
IT	0,8%
LT	0,2%
LU	0,2%
LV	0,3%
MT	0,1%
NL	0,0%
PL	0,2%
PT	-0,2%
RO	12,6%
SE	0,0%
SI	5,8%
SK	9,9%
UK	0,0%

Source: ASTRA model

As a consequence of increased road passenger transport cost, road passenger activity is reduced, while rail activity is increased (Table 7-73). In some countries air transport activity increases relative to the Baseline for medium and long distance origin-destination relationships.

Table 7-73: Variation of passenger transport activity in Mio p-km in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	Air	Total
AT	-3.1%	23.4%	4.5%	1.6%
BE	0.0%	0.0%	0.1%	0.0%
BG	-1.5%	9.7%	1.5%	-0.9%
CY	-0.7%	0.0%	0.3%	-0.1%

Country	Road	Rail	Air	Total
CZ	-0.7%	4.1%	1.5%	0.2%
DE	0.0%	0.1%	0.5%	0.0%
DK	0.0%	0.1%	0.1%	0.0%
EE	0.0%	0.0%	0.1%	0.0%
EL	-0.2%	0.9%	0.3%	0.0%
ES	-0.1%	0.3%	0.2%	0.0%
FI	0.0%	0.0%	0.0%	0.0%
FR	-0.1%	0.2%	0.3%	0.0%
HR	-0.1%	0.9%	1.8%	0.1%
HU	-0.5%	1.9%	2.5%	0.0%
IE	0.0%	-0.3%	0.2%	0.1%
IT	-0.2%	1.0%	0.8%	0.0%
LT	-0.2%	-0.9%	1.5%	-0.1%
LU	0.0%	0.1%	0.2%	0.0%
LV	-0.6%	2.3%	0.9%	-0.2%
MT	-0.1%	0.0%	0.1%	0.0%
NL	0.0%	0.0%	0.1%	0.0%
PL	0.0%	0.1%	0.5%	0.0%
PT	0.0%	-0.8%	0.0%	0.0%
RO	-2.0%	8.4%	3.0%	-0.2%
SE	0.0%	0.0%	0.0%	0.0%
SI	-0.4%	18.1%	1.8%	0.1%
SK	-1.2%	8.2%	4.3%	0.2%
UK	0.0%	0.0%	0.0%	0.0%
EU15	-0.1%	0.9%	0.3%	0.0%
EU13	-0.6%	3.4%	1.4%	0.0%
EU28	-0.2%	1.3%	0.5%	0.0%

Source: ASTRA model

The impacts in terms of mode split are provided in Table 7-74, showing a shift from road to rail passenger transport.

Table 7-74: Variation of passenger modal split in Policy Option 4 relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	Air
AT	-3.5	3.2	0.3
BE	0.0	0.0	0.0
BG	-0.5	0.2	0.3
CY	-0.2	0.0	0.2
CZ	-0.7	0.5	0.1
DE	0.0	0.0	0.0
DK	0.0	0.0	0.0
EE	0.0	0.0	0.0
EL	-0.1	0.0	0.1
ES	-0.1	0.0	0.0
FI	0.0	0.0	0.0
FR	-0.1	0.0	0.0
HR	-0.2	0.0	0.1
HU	-0.4	0.3	0.2
IE	0.0	0.0	0.0
IT	-0.1	0.1	0.1
LT	-0.1	0.0	0.1

Country	Road	Rail	Air
LU	0.0	0.0	0.0
LV	-0.3	0.1	0.2
MT	0.0	0.0	0.0
NL	0.0	0.0	0.0
PL	0.0	0.0	0.0
PT	0.0	0.0	0.0
RO	-1.4	1.2	0.3
SE	0.0	0.0	0.0
SI	-0.5	0.4	0.0
SK	-1.1	0.9	0.2
UK	0.0	0.0	0.0
EU15	-0.1	0.1	0.0
EU13	-0.5	0.3	0.1
EU28	-0.2	0.1	0.1

Source: ASTRA model

The impacts on **fuel consumption** by the road sector (Table 7-75) are driven on one hand by the changes in the vehicle fleet composition due to the modulation of infrastructure charges according to CO2 emission, simulated by the PRIMES-TREMOVE model (already discussed within PO2 and PO3b), and on the other hand by the changes in road transport activity.

The comparison with the Baseline shows a general decrease in diesel use, combined with some limited increase in gas used by HGVs and electricity used by passenger cars (i.e. particularly in Spain, France, Italy and Portugal).

Table 7-75: Variation of fuel consumption from road sector in Mtoe in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	-3,8%	-2,7%	-3,0%	3,6%	-3,3%	-1,0%	-3,7%
BE	0,0%	-0,3%	0,1%	11,9%	-0,4%	0,0%	0,0%
BG	-1,2%	-0,7%	-1,1%	0,8%	-1,0%	0,9%	-1,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	-0,8%	-0,9%	-0,2%	2,9%	-1,0%	0,9%	-1,1%
DE	-0,1%	-1,3%	0,1%	31,6%	-1,6%	-0,1%	-0,1%
DK	0,0%	-0,5%	0,2%	4,8%	-0,5%	0,0%	0,0%
EE	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%
EL	0,0%	-0,6%	0,3%	7,0%	-0,4%	2,3%	-0,2%
ES	2,9%	-1,5%	7,6%	29,5%	-1,7%	8,4%	0,2%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
FR	-0,2%	-3,0%	12,5%	120,3%	-4,2%	8,7%	0,3%
HR	-1,1%	0,1%	0,0%	3,2%	-0,6%	2,8%	-0,1%
HU	-1,8%	-0,7%	1,1%	31,9%	-1,5%	3,1%	-0,4%
IE	0,0%	0,0%	0,2%	0,4%	0,0%	0,4%	0,1%
IT	1,8%	-2,4%	0,1%	4,3%	-1,3%	6,8%	-0,1%
LT	0,0%	-0,5%	-0,1%	0,5%	-0,5%	0,7%	0,2%
LU	0,0%	-0,2%	0,2%	0,5%	-0,3%	0,0%	0,0%
LV	0,0%	-0,3%	-0,1%	4,6%	-0,3%	0,0%	-0,1%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,1%	17,3%	-0,8%	0,1%	0,0%
PL	0,0%	-0,4%	-0,1%	13,0%	-0,5%	0,3%	0,0%
PT	0,8%	-0,8%	5,1%	21,8%	-0,8%	8,3%	0,6%
RO	-2,0%	-1,6%	-1,8%	14,9%	-1,9%	0,0%	-2,2%
SE	0,0%	-0,6%	0,3%	4,8%	-0,7%	0,0%	0,0%
SI	-0,7%	-1,7%	0,4%	21,7%	-1,4%	2,7%	-0,6%
SK	-2,1%	-0,9%	-1,7%	16,4%	-1,9%	0,1%	-1,6%
UK	0,1%	-0,5%	0,5%	17,0%	-0,7%	0,6%	0,0%
EU15	0,4%	-1,6%	0,5%	13,8%	-1,6%	3,5%	0,0%
EU13	-0,9%	-0,7%	-0,2%	11,9%	-1,0%	1,2%	-0,4%

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
EU28	0,2%	-1,4%	0,2%	13,7%	-1,5%	3,3%	0,0%

Source: ASTRA model

The measures implemented in PO4 results in a reduction of road transport emissions relative to the Baseline for 2030 (i.e. 0,7% decrease for CO_2 emissions, 1,2% decrease for NOx and 1% decrease for PM emissions).

Table 7-76: Variation of air pollutant and CO_2 emissions from road sector in 1000 t in Policy Option 4 relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	-0,4%	-0,8%	-0,3%	-1,0%	-2,8%
BE	-0,1%	-0,3%	0,0%	-0,1%	-0,2%
BG	-0,1%	-0,3%	0,0%	-0,2%	-0,8%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,1%	-0,3%	0,1%	-0,6%	-0,8%
DE	-0,3%	-1,4%	-0,2%	-0,4%	-0,6%
DK	-0,1%	-0,6%	-0,1%	-0,3%	-0,3%
EE	0,0%	-0,1%	0,0%	0,0%	-0,1%
EL	0,0%	-0,3%	-0,1%	-0,7%	-0,2%
ES	0,7%	-1,1%	0,1%	-1,8%	-0,7%
FI	0,0%	-0,1%	0,0%	0,0%	0,0%
FR	-0,6%	-3,4%	-0,3%	-1,9%	-1,6%
HR	-0,3%	-0,2%	0,3%	0,3%	-0,3%
HU	-0,5%	-0,6%	0,1%	-0,1%	-0,8%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	1,1%	-1,1%	0,2%	-2,2%	-0,4%
LT	-0,1%	-0,4%	0,0%	-0,2%	-0,4%
LU	-0,1%	-0,2%	0,0%	0,0%	-0,2%
LV	0,0%	-0,2%	0,0%	0,0%	-0,3%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,0%	0,0%	-0,2%
PL	-0,2%	-0,4%	-0,1%	-0,2%	-0,2%
PT	0,6%	-0,5%	0,4%	-1,0%	-0,3%
RO	-0,3%	-0,5%	0,1%	-0,6%	-1,7%
SE	-0,1%	-0,6%	0,0%	-0,1%	-0,3%
SI	-0,2%	-0,9%	-0,1%	-1,1%	-0,8%
SK	-0,5%	-0,5%	0,0%	-0,5%	-1,1%
UK	0,0%	-0,5%	0,0%	-0,2%	-0,3%
EU15	0,0%	-1,4%	-0,1%	-1,1%	-0,7%
EU13	-0,2%	-0,4%	0,0%	-0,3%	-0,6%
EU28	0,0%	-1,2%	-0,1%	-1,0%	-0,7%

Source: ASTRA model

The observed variations on road sector emissions are also reflected in the external costs of road transport.

Table 7-77: Variation of external costs for road transport sector in Mio Euro in Policy Option 4 relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	0,0%	-0,7%	0,0%	-0,4%	-0,5%
EU13	-0,1%	-0,3%	-0,1%	-0,1%	-0,5%
EU28	0,0%	-0,6%	0,0%	-0,4%	-0,5%

Source: ASTRA model

Table 7-78 shows the impact arising from the measures implemented in PO4 on toll revenues from road transport (in comparison with the Baseline scenario in 2030 in the form of percentage changes).

Large variations are observed in total revenues, related in many cases to the new distance-based charges for LGV and car in combination with congestion charging (e.g. AT, CZ, HU, SI and SK).

Overall, revenues at European level are expected to increase by 60,2% in comparison with the Baseline for 2030. Revenues from circulation taxes are reduced at EU level by 46% (respectively -63% for HGVs and -30% for LGVs).

Table 7-78: Percentage change in toll revenues from road transport in Policy Option 4 relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	289,6%	16,5%	1325,4%	73,5%	525,6%
BE	22,8%	22,5%	-	n.c.	-
BG	324,7%	827,7%	163,5%	255,5%	280,7%
CY	-	-	-	-	-
CZ	295,5%	51,5%	647,0%	220,9%	375,4%
DE	57,7%	57,6%	-	n.c.	-
DK	570,0%	560,6%	-	n.c.	-
EE	-	-	-	-	-
EL	22,8%	39,8%	47,7%	85,2%	20,1%
ES	17,2%	20,4%	25,3%	54,7%	16,5%
FI	-	-	-	-	-
FR	16,6%	40,2%	17,7%	90,5%	9,9%
HR	-7,7%	20,7%	14,5%	42,4%	-9,2%
HU	76,3%	23,4%	327,9%	510,6%	114,6%
IE	-4,2%	14,6%	20,7%	28,5%	-8,0%
IT	24,8%	45,0%	40,9%	71,8%	20,2%
LT	722,0%	792,3%	0,3%	38,4%	-
LU	1835,2%	1828,3%	-	n.c.	-
LV	372,2%	745,0%	86,9%	497,4%	-
MT	-	-	-	-	-
NL	1115,5%	1115,5%	-	n.c.	-
PL	35,6%	62,5%	16,8%	112,0%	6,1%
PT	10,5%	21,9%	13,7%	40,2%	9,8%
RO	475,2%	611,1%	80,5%	203,2%	533,4%
SE	522,3%	518,9%	-	n.c.	-
SI	115,7%	33,2%	376,0%	81,6%	176,4%
SK	321,4%	35,2%	555,7%	170,5%	422,0%
UK	1092,2%	1083,9%	-	n.c.	-
EU15	46,9%	63,2%	52,3%	131,2%	39,1%
EU13	178,2%	78,9%	151,0%	202,7%	227,9%
EU28	60,2%	64,8%	64,6%	154,3%	57,7%

Source: ASTRA model
n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are null. The % variation at EU level however include the overall impacts on revenues including also the changes in respect to values that are null in the Baseline.

ASTRA results in terms of macroeconomic impact suggest that the effect of Policy Option 4 on GDP is limited.

Table 7-79: Variation of GDP and Unemployment in Policy Option 4 relative to the Baseline for 2030 – EU average

	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	-0,1%	0,0
EU13	-0,1%	0,0
EU28	-0,1%	0,0

Source: ASTRA model

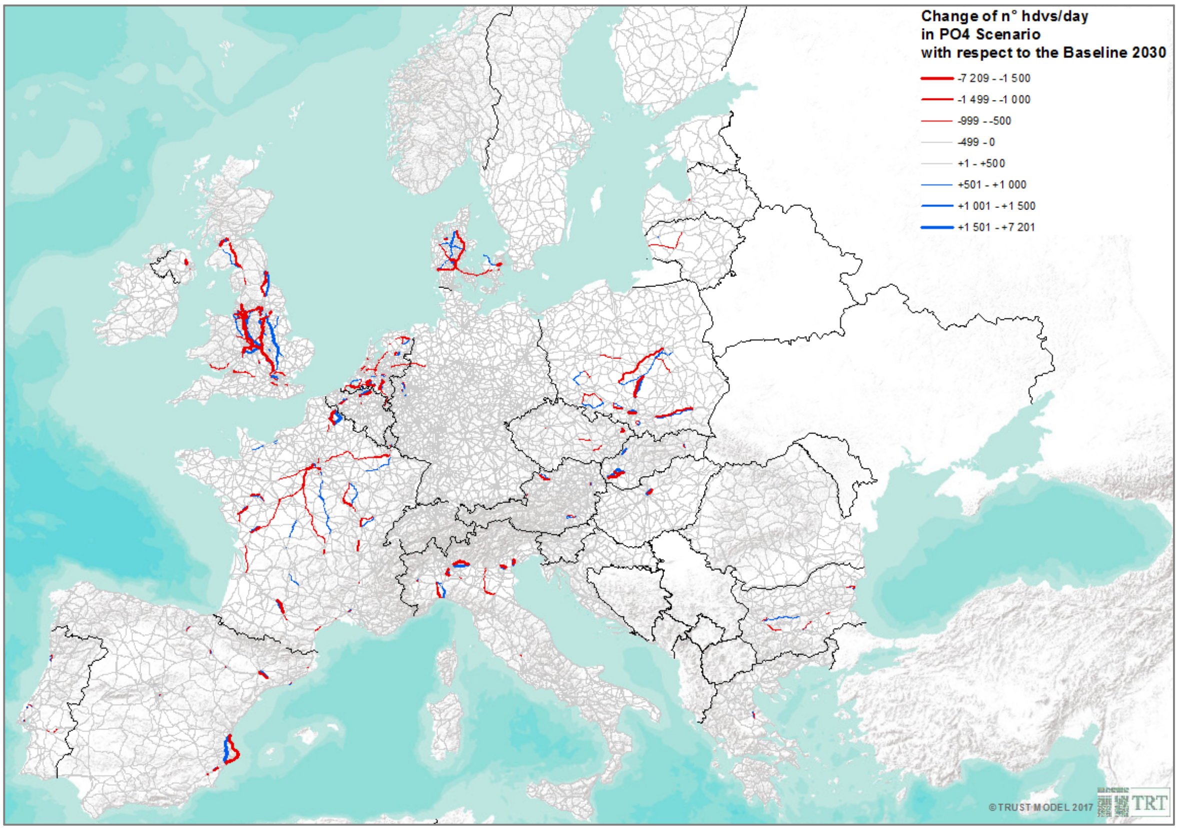
7.8.3. Modelling results – TRUST

Results of road traffic assignment of PO4 are illustrated in Figure 7-20 and Figure 7-21 respectively for HGVs and passenger cars.

Results for HGVs suggest that the extended application of congestion charging, coupled with the application of external costs in several Member States, determine a decrease in road freight traffic on some international routes (e.g. FR-BE and FR-NL).

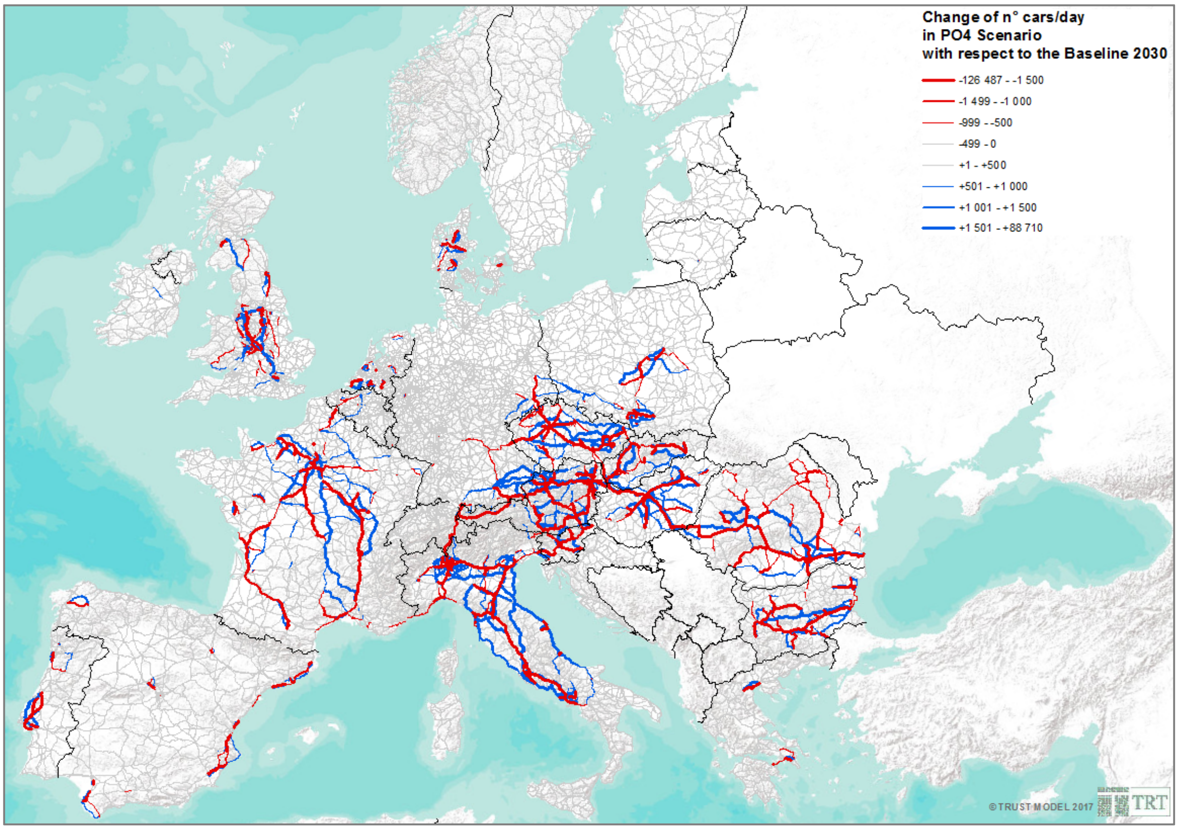
Passenger car traffic assignment shows some diversion to untolled routes; this is more visible in those countries phasing in distance-based charges and congestion charges and less visible in those countries introducing only congestion charging. Effects are more visible for cars than for HGVs as passenger traffic represents a larger share of total road traffic. The effect of congestion charging is especially significant for those origin-destination relations where congestion charges are applied to several links of their connecting road routes.

Figure 7-20: PO4 Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

Figure 7-21: PO4 Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

Table 7-80 and Table 7-81 report the variations of external transport cost for interurban congestion and noise relative to the Baseline in 2030.

Results for interurban congestion costs show that decreases at country level are dependent on the modelled local transport network conditions. In some cases, the application of congestion charging might increase overall congestion costs due to the rerouting of traffic from tolled routes towards secondary roads with lower capacity (therefore leading to higher delay time). For SK, despite the high impacts in percentage terms the effects in absolute terms are limited.

Results for noise confirm also in this case an increase due to traffic diversion towards secondary roads.

Table 7-80: External transport costs of interurban road congestion in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-15,9%	-37,7%	-13,8%
BE	-0,5%	-3,3%	-0,2%
BG	-5,2%	-5,6%	-5,1%
CY	n.a.	n.a.	n.a.
CZ	-11,0%	-12,4%	-10,9%
DE	-0,2%	-0,7%	-0,2%
DK	-1,6%	-3,8%	-1,3%
EE	0,2%	-0,6%	0,3%
EL	-7,4%	-5,4%	-7,4%
ES	0,2%	-0,6%	0,3%
FI	-0,2%	-0,3%	-0,1%
FR	-0,9%	-2,4%	-0,8%
HR	-0,1%	-0,3%	0,0%
HU	0,5%	-5,1%	1,3%
IE	0,7%	0,4%	0,7%

Country	TOTAL (cars + trucks)	Trucks	Car
IT	-11,5%	-7,3%	-11,6%
LT	1,7%	3,9%	1,6%
LU	1,7%	8,9%	1,2%
LV	-0,6%	-1,7%	-0,5%
MT	n.a.	n.a.	n.a.
NL	-0,6%	-2,6%	-0,4%
PL	-0,2%	-2,4%	0,1%
PT	-11,7%	2,5%	-12,3%
RO	-12,7%	-11,1%	-12,8%
SE	-0,6%	-1,6%	-0,4%
SI	-4,0%	-0,5%	-4,0%
SK	17,0%	-8,6%	18,5%
UK	-0,2%	-4,6%	0,2%
EU15	-2,8%	-2,9%	-2,8%
EU13	-1,0%	-3,9%	-0,7%
EU28	-2,5%	-3,1%	-2,5%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Table 7-81: External transport costs of noise from interurban road transport in Policy Option 4 relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	15,6%	-0,5%	20,8%
BE	1,6%	6,6%	-0,1%
BG	0,3%	1,1%	0,0%
CY	n.a.	n.a.	n.a.
CZ	1,7%	1,6%	1,7%
DE	0,4%	1,2%	0,0%
DK	2,0%	5,7%	-0,2%
EE	-0,3%	-1,6%	0,3%
EL	1,8%	1,3%	1,8%
ES	0,7%	1,4%	0,3%
FI	0,0%	-0,1%	0,0%
FR	1,1%	2,3%	0,7%
HR	0,7%	1,9%	0,1%
HU	3,7%	5,6%	2,7%
IE	0,0%	-0,4%	0,1%
IT	2,7%	4,3%	2,4%
LT	1,8%	5,9%	-0,1%
LU	0,8%	3,1%	-0,1%
LV	3,5%	8,9%	0,0%
MT	n.a.	n.a.	n.a.
NL	1,3%	6,4%	-0,3%
PL	0,9%	1,6%	0,2%
PT	1,4%	5,2%	0,4%
RO	-0,2%	-0,3%	-0,2%
SE	0,5%	1,2%	0,0%
SI	2,7%	-0,1%	3,3%
SK	0,7%	8,5%	-3,3%
UK	1,1%	5,5%	-0,3%
EU15	1,5%	2,9%	0,9%
EU13	1,1%	2,1%	0,5%
EU28	1,4%	2,7%	0,8%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.9. Policy Option 2s – Sensitivity case

7.9.1. Modelling assumptions

PO2s builds on PO2 but includes the following modelling assumptions:

- Phase in distance-based charges for all HGVs and buses to EE and FI starting with 2025.
- Phase in of revenue neutral modulation of infrastructure charges by CO2 emissions for HGVs >3.5t and buses starting in 2025 for EE and FI. The revised charges are based on the results of the PRIMES-TREMOVE model (ICCS-E3MLab), similarly to PO2.
- Rebates for all Zero Emission vehicles (ZEV) starting with 2025 in EE and FI.
- Exemption of circulation taxes for HGVs from 2025 onwards in EE and FI.

Table 7-82 and Table 7-83 below provides with a summary of the measures simulated in the various Member States in PO2s.

Table 7-82: Summary of policy measures introduced in PO2 sensitivity case (PO2s) on top of the Baseline, PO1 and PO2

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Table 7-83: Summary of policy measures introduced in PO2 sensitivity case (PO2s) relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t			blue			checkered	blue	hatched			hatched						blue	blue	blue		blue			blue	blue			blue
		HGV >12t			blue				blue	hatched			hatched						blue	blue	blue		blue			blue	blue			blue
		Buses		blue	blue			blue	blue	hatched			hatched			blue			blue	blue	blue		blue			blue	blue			blue
		LGV																												
		Cars																												
Phasing out vignette		HGV			blue				blue										blue	blue	blue		blue			blue	blue			blue
		Buses			blue											blue			blue		blue					blue				
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV		blue	blue		blue		blue							blue			blue	blue	blue		blue	blue			blue	blue	blue	
		Buses			blue		blue												blue		blue			blue				blue	blue	
Phasing in CO2/pollutant modulation		HGV	blue	blue	blue		blue	blue	blue	hatched	blue	blue	hatched	blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		Buses	blue	blue	blue		blue	blue	blue	hatched	blue	blue	hatched	blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV	green	green	green		green	green	green	hatched	green	green	hatched	green	green	green	green	green	green	green	green		green	green	green	green	green	green	green	green
		Buses	green	blue	green		green	blue	blue	hatched	green	green	hatched	green	green	green	green	green	green	blue	green		blue	green	green	green	blue	green	green	blue
		LGV	green		green		green				green	green		green	green	green	green	green	green		green			green	green	green		green	green	
		Cars	green		green		green				green	green		green	green	green	green	green						green	green	green		green	green	
External costs		HGV	checkered	blue	blue		blue	checkered	blue							blue			blue	blue	blue		blue	blue			blue	blue	blue	
		Buses	checkered		blue		blue												blue		blue			blue				blue	blue	
Congestion charging		All																												
Mark-ups		HGV												green														green		
		Buses												green														green		
Reduced circulation taxes		HGV	blue	blue	blue		blue	blue	blue	hatched	blue	blue	hatched	blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue	blue
		LGV																												

Note: measures included in PO1 and PO2 are reported in green; measures included in PO2 and PO2s are reported in blue; additional measures included in PO2s are reported in light blue.

7.9.2. Modelling results – ASTRA

PO2s is a sensitivity case differing from PO2 for the sole introduction of measures for EE and FI. Road freight transportation costs for these countries are increased respectively by 2,0% for Estonia and by 1,1% for Finland relative to the Baseline in 2030. Slight increases of road costs in comparison with PO2 can be observed for those countries having strong trade relations with them.

Table 7-84: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 2s relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	0,9%
BE	1,1%
BG	3,9%
CY	0,1%
CZ	0,6%
DE	2,0%
DK	2,6%
EE	2,0%
EL	-0,1%
ES	-0,6%
FI	1,1%
FR	-1,3%
HR	0,4%
HU	0,9%
IE	-0,1%
IT	-0,6%
LT	2,3%
LU	2,4%
LV	2,9%
MT	0,2%
NL	1,4%
PL	0,5%
PT	-0,6%
RO	2,7%
SE	3,0%
SI	0,9%
SK	0,3%
UK	1,3%

Source: ASTRA model

Variations of road freight transport activity (Table 7-85), freight modal split (Table 7-86), fuel consumption (Table 7-87) and pollutant emissions (Table 7-88) are substantially in line with those already observed in PO2, with slightly more visible changes for EE and FI.

Table 7-85: Variation of freight transport activity in Mio tkm in Policy Option 2s relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,3%	0,9%	0,0%	0,1%
BE	-0,3%	1,0%	0,0%	-0,1%
BG	-0,5%	2,2%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,1%	0,3%	0,0%	0,0%
DE	-0,3%	1,0%	0,0%	0,0%
DK	-0,8%	2,9%	-	-0,3%
EE	-0,6%	0,7%	-	-0,2%
EL	0,0%	0,2%	-	0,0%
ES	0,0%	-0,5%	-	-0,1%
FI	-0,4%	1,6%	0,0%	0,1%

Country	Road	Rail	IWW	TOTAL
FR	-0,1%	-0,1%	0,0%	-0,1%
HR	-0,1%	0,1%	0,0%	0,0%
HU	-0,3%	0,7%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	0,1%	-0,6%	0,0%	0,0%
LT	-0,8%	0,6%	0,0%	-0,1%
LU	-0,2%	1,4%	0,0%	-0,1%
LV	-0,7%	1,1%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,3%	1,6%	0,0%	-0,1%
PL	-0,1%	0,6%	0,0%	0,0%
PT	0,0%	-0,5%	-	0,0%
RO	-0,6%	0,8%	0,0%	0,0%
SE	-0,9%	1,7%	-	-0,2%
SI	-0,2%	0,5%	-	0,0%
SK	-0,1%	0,2%	0,0%	0,0%
UK	-0,3%	2,2%	0,0%	0,0%
EU15	-0,2%	0,8%	0,0%	0,0%
EU13	-0,2%	0,6%	0,0%	0,0%
EU28	-0,2%	0,8%	0,0%	0,0%

Source: ASTRA model

Table 7-86: Variation of freight modal split in Policy Option 2s relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,2	0,2	0,0
BE	-0,2	0,1	0,0
BG	-0,3	0,3	0,0
CY	0,0	0,0	0,0
CZ	-0,1	0,1	0,0
DE	-0,2	0,2	0,0
DK	-0,4	0,4	0,0
EE	-0,3	0,3	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,4	0,4	0,0
FR	0,0	0,0	0,0
HR	0,0	0,0	0,0
HU	-0,2	0,2	0,0
IE	0,0	0,0	0,0
IT	0,1	-0,1	0,0
LT	-0,3	0,3	0,0
LU	-0,1	0,1	0,0
LV	-0,4	0,4	0,0
MT	0,0	0,0	0,0
NL	-0,1	0,1	0,0
PL	-0,1	0,1	0,0
PT	0,1	-0,1	0,0
RO	-0,3	0,3	0,0
SE	-0,5	0,5	0,0
SI	-0,1	0,1	0,0
SK	-0,1	0,1	0,0
UK	-0,2	0,2	0,0
EU15	-0,1	0,1	0,0
EU13	-0,2	0,2	0,0
EU28	-0,1	0,1	0,0

Source: ASTRA model

Table 7-87: Variation of fuel consumption from road sector in Mtoe in Policy Option 2s relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	0,0%	-0,4%	0,1%	5,3%	-0,7%	0,0%	0,0%
BE	0,0%	-0,3%	0,1%	12,0%	-0,3%	0,0%	0,0%
BG	0,0%	-0,3%	0,0%	1,3%	-0,3%	0,0%	0,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,0%	-0,2%	0,1%	2,8%	-0,2%	0,0%	0,0%
DE	0,0%	-1,2%	0,2%	31,7%	-1,6%	0,0%	0,0%
DK	0,0%	-0,5%	0,2%	4,8%	-0,5%	0,0%	0,0%
EE	0,0%	-0,3%	0,0%	4,3%	-0,2%	0,0%	0,0%
EL	0,0%	-0,2%	0,0%	7,0%	-0,1%	0,0%	0,0%
ES	0,0%	-0,5%	0,9%	25,7%	-1,2%	0,0%	0,0%
FI	0,0%	-0,2%	0,1%	0,0%	-0,1%	0,0%	0,0%
FR	0,0%	-2,2%	4,9%	116,8%	-3,7%	0,0%	0,0%
HR	0,0%	-0,2%	0,0%	2,4%	-0,4%	0,0%	0,0%
HU	0,0%	-0,7%	0,2%	31,6%	-0,7%	0,0%	0,0%
IE	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%
IT	0,0%	-0,8%	0,0%	4,6%	-0,7%	0,0%	0,0%
LT	0,0%	-0,5%	0,0%	0,4%	-0,5%	0,0%	0,0%
LU	0,0%	-0,2%	0,2%	0,5%	-0,2%	0,0%	0,0%
LV	0,1%	-0,3%	0,0%	4,6%	-0,3%	0,0%	0,0%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,1%	17,3%	-0,8%	0,1%	0,0%
PL	0,0%	-0,3%	0,1%	13,0%	-0,5%	0,0%	0,0%
PT	0,0%	-0,3%	0,2%	19,8%	-0,5%	0,0%	0,0%
RO	0,0%	-0,3%	0,1%	15,2%	-0,3%	0,0%	0,0%
SE	0,0%	-0,6%	0,2%	4,8%	-0,7%	0,0%	0,0%
SI	0,0%	-1,0%	0,0%	21,7%	-0,7%	0,0%	0,0%
SK	0,0%	-0,5%	0,1%	16,5%	-0,7%	0,0%	0,0%
UK	0,0%	-0,4%	0,1%	16,9%	-0,7%	0,0%	0,0%
EU15	0,0%	-1,0%	0,2%	13,7%	-1,3%	0,0%	0,0%
EU13	0,0%	-0,4%	0,1%	12,0%	-0,4%	0,0%	0,0%
EU28	0,0%	-0,9%	0,1%	13,6%	-1,2%	0,0%	0,0%

Source: ASTRA model

Table 7-88: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 2s relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	-0,2%	-0,4%	-0,1%	-0,1%	-0,3%
BE	-0,1%	-0,2%	0,0%	0,0%	-0,2%
BG	-0,1%	-0,2%	0,0%	-0,1%	-0,2%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	-0,1%	-0,2%	0,0%	-0,1%	-0,1%
DE	-0,3%	-1,3%	-0,2%	-0,4%	-0,5%
DK	-0,1%	-0,6%	-0,1%	-0,3%	-0,3%
EE	-0,1%	-0,3%	0,0%	-0,1%	-0,2%
EL	0,0%	-0,1%	0,0%	0,0%	0,0%
ES	-0,4%	-0,6%	-0,2%	-0,2%	-0,3%
FI	0,0%	-0,2%	0,0%	-0,1%	-0,1%
FR	-0,8%	-2,9%	-0,4%	-0,6%	-1,0%
HR	-0,1%	-0,3%	0,0%	-0,1%	-0,1%
HU	-0,2%	-0,7%	-0,1%	-0,3%	-0,3%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	-0,1%	-0,4%	-0,1%	-0,1%	0,1%
LT	-0,1%	-0,3%	-0,1%	-0,1%	-0,3%
LU	-0,1%	-0,1%	0,0%	0,0%	-0,1%
LV	0,0%	-0,3%	0,0%	-0,1%	-0,3%

Country	CO	NOx	VOC	PM	CO2
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	0,0%	-0,7%	0,0%	0,0%	-0,2%
PL	-0,2%	-0,4%	-0,1%	-0,1%	-0,2%
PT	-0,1%	-0,3%	-0,1%	0,0%	-0,1%
RO	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
SE	-0,1%	-0,6%	0,0%	-0,1%	-0,3%
SI	-0,1%	-0,6%	-0,1%	-0,2%	-0,1%
SK	-0,2%	-0,6%	-0,2%	-0,2%	-0,3%
UK	0,0%	-0,4%	0,0%	-0,1%	-0,2%
EU15	-0,3%	-1,1%	-0,2%	-0,2%	-0,4%
EU13	-0,1%	-0,4%	-0,1%	-0,1%	-0,2%
EU28	-0,3%	-1,0%	-0,2%	-0,2%	-0,4%

Source: ASTRA model

Table 7-89: Variation of external costs for road transport sector in Mio Euro in Policy Option 2s relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	-0,1%	-0,6%	-0,1%	0,0%	-0,3%
EU13	0,0%	-0,2%	-0,1%	0,0%	-0,2%
EU28	-0,1%	-0,5%	-0,1%	0,0%	-0,3%

Source: ASTRA model

Overall, EU revenues from tolls in the freight sector (HGV) are expected to increase by 50,3% and total revenues from road transport are expected to increase by 14,8% relative to Baseline 2030. The comparison with analogous results for PO2 shows that revenues from road transport at European level are only marginally increased by the introduction of charges for FI and EE. Revenues from circulation taxes are reduced at EU level by 32%.

Table 7-90: Percentage change in toll revenues from road transport in Policy Option 2s relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	5,3%	11,8%	-0,6%	24,6%	-0,8%
BE	22,9%	22,7%	-	n.c.	-
BG	95,5%	825,5%	-0,3%	249,8%	-0,3%
CY	-	-	-	-	-
CZ	8,9%	36,1%	-0,3%	105,7%	-0,3%
DE	57,7%	57,7%	-	n.c.	-
DK	568,3%	560,8%	-	n.c.	-
EE	n.c.	n.c.	-	n.c.	-
EL	-1,3%	-2,0%	-0,1%	4,8%	-1,3%
ES	-0,8%	-3,7%	-1,0%	12,3%	-0,4%
FI	n.c.	n.c.	-	n.c.	-
FR	2,5%	18,3%	-1,3%	57,7%	-1,8%
HR	-0,9%	3,3%	0,6%	17,2%	-1,2%
HU	12,7%	21,5%	-0,2%	388,3%	-0,5%
IE	-0,7%	-1,7%	-0,1%	5,9%	-0,7%
IT	-0,9%	-4,1%	-0,4%	14,4%	-0,4%
LT	722,3%	792,7%	-0,1%	38,4%	-
LU	1835,1%	1829,6%	-	n.c.	-
LV	322,8%	743,2%	0,3%	497,4%	-
MT	-	-	-	-	-
NL	1115,8%	1115,8%	-	n.c.	-
PL	26,5%	51,2%	-0,2%	87,0%	-0,2%
PT	-0,5%	-2,3%	-0,2%	14,0%	-0,4%
RO	32,2%	435,4%	-0,2%	109,1%	-0,3%
SE	521,4%	518,7%	-	n.c.	-
SI	11,8%	29,5%	-0,3%	60,3%	-1,6%

Country	TOTAL	HGV	LGV	BUS	CAR
SK	6,2%	24,3%	-0,3%	83,9%	-0,5%
UK	861,7%	854,7%	-	n.c.	-
EU15	14,1%	48,2%	-0,8%	76,0%	-1,1%
EU13	21,6%	67,9%	-0,2%	142,8%	-0,6%
EU28	14,8%	50,3%	-0,7%	97,6%	-1,1%

Source: ASTRA model
n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are null. The % variation at EU level however include the overall impacts on revenues including also the changes in respect to values that are null in the Baseline.

Results in terms of macroeconomic impact are in line with those observed for PO2.

Table 7-91: Variation of GDP and Unemployment in Policy Option 2s relative to the Baseline for 2030 – EU average

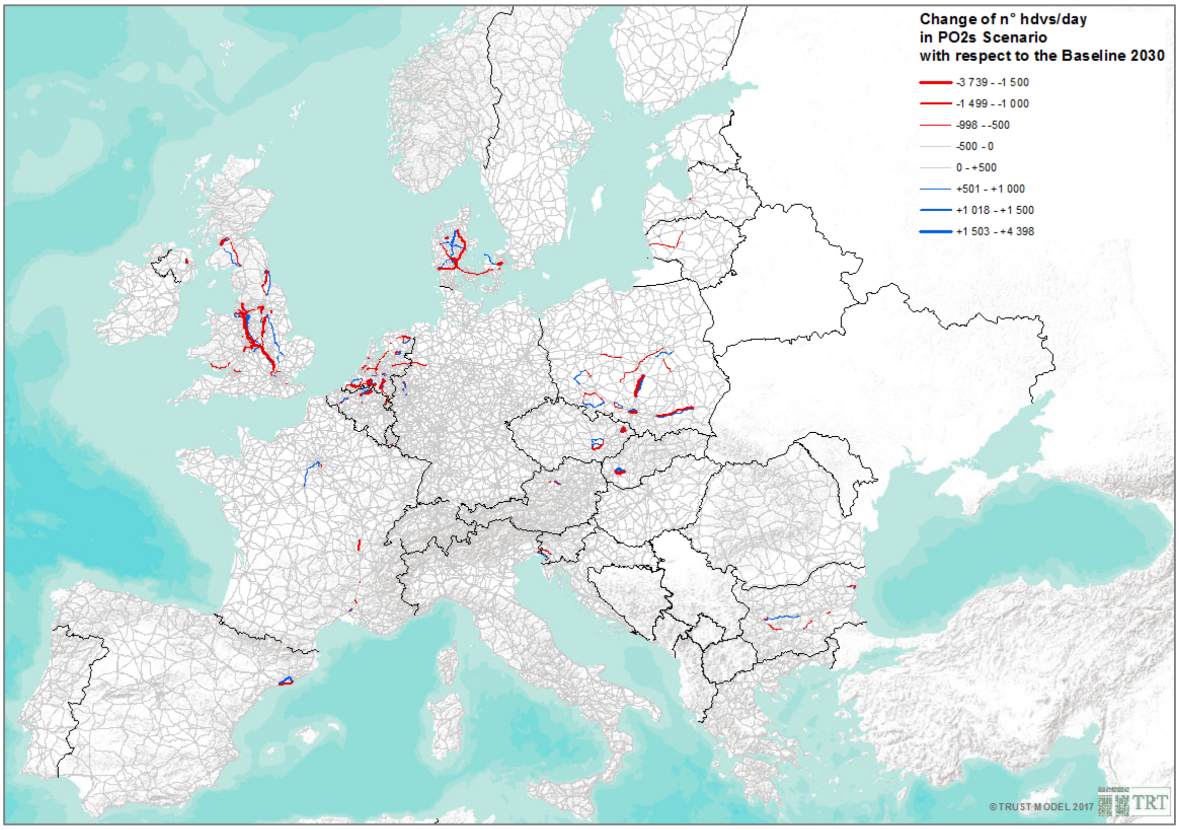
	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	0,0%	0,0
EU13	-0,1%	0,0
EU28	0,0%	0,0

Source: ASTRA model

7.9.3. Modelling results – TRUST

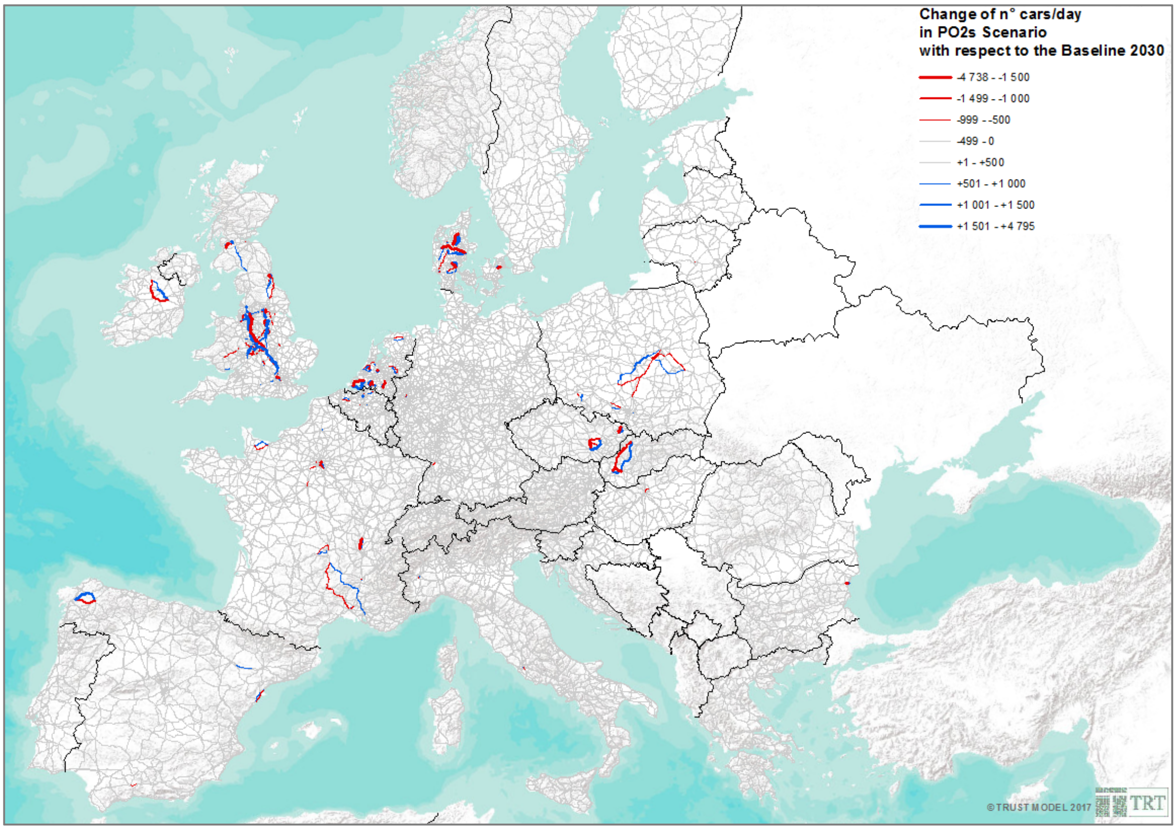
Modelling results from the TRUST model confirm the very small difference of this sensitivity case with the PO2.

Figure 7-22: PO2s Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

Figure 7-23: PO2s Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

Table 7-92: External transport costs of interurban road congestion in Policy Option 2s relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-0,1%	-1,1%	0,0%
BE	-0,8%	-4,1%	-0,5%
BG	0,1%	0,4%	0,1%
CY	n.a.	n.a.	n.a.
CZ	-0,9%	-1,9%	-0,8%
DE	-0,2%	-0,5%	-0,2%
DK	-1,7%	-6,3%	-1,2%
EE	-0,2%	-1,3%	-0,2%
EL	0,0%	-0,1%	0,0%
ES	0,0%	-0,2%	0,0%
FI	-0,1%	-0,1%	-0,2%
FR	0,0%	-0,2%	0,0%
HR	0,0%	0,1%	0,0%
HU	-0,1%	-1,1%	0,0%
IE	0,3%	-0,1%	0,3%
IT	0,0%	0,0%	0,0%
LT	0,0%	0,5%	0,0%
LU	-0,4%	-1,6%	-0,3%
LV	-0,6%	-1,8%	-0,5%
MT	n.a.	n.a.	n.a.
NL	-0,7%	-3,0%	-0,5%
PL	-0,3%	-2,0%	-0,1%
PT	-0,1%	-0,8%	0,0%
RO	0,0%	-0,1%	0,0%
SE	-0,6%	-1,5%	-0,4%
SI	0,0%	-1,3%	0,0%
SK	-0,8%	-7,1%	-0,4%

Country	TOTAL (cars + trucks)	Trucks	Car
UK	-0,2%	-3,4%	0,1%
EU15	-0,2%	-1,3%	-0,1%
EU13	-0,4%	-2,1%	-0,2%
EU28	-0,2%	-1,5%	-0,1%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Table 7-93: External transport costs of noise from interurban road transport in Policy Option 2s relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	0,7%	2,8%	0,0%
BE	1,6%	6,6%	-0,1%
BG	0,4%	1,5%	-0,1%
CY	n.a.	n.a.	n.a.
CZ	0,2%	0,3%	0,1%
DE	0,3%	1,2%	0,0%
DK	2,0%	5,7%	-0,2%
EE	-0,6%	-1,7%	-0,1%
EL	0,0%	-0,2%	0,0%
ES	-0,3%	-0,7%	0,0%
FI	0,4%	1,0%	0,1%
FR	-0,1%	-0,7%	0,1%
HR	0,0%	0,1%	0,0%
HU	0,0%	0,2%	0,0%
IE	-0,1%	-0,6%	0,1%
IT	-0,1%	-0,4%	0,0%
LT	1,7%	5,7%	-0,1%
LU	0,6%	2,3%	-0,1%
LV	3,3%	8,5%	0,0%
MT	n.a.	n.a.	n.a.
NL	1,3%	6,4%	-0,3%
PL	0,5%	1,1%	0,0%
PT	-0,1%	-0,6%	0,0%
RO	0,0%	0,3%	-0,1%
SE	0,5%	1,3%	0,0%
SI	0,3%	1,8%	0,0%
SK	2,3%	7,5%	-0,3%
UK	0,6%	2,9%	-0,1%
EU15	0,4%	1,5%	-0,1%
EU13	0,5%	1,2%	0,0%
EU28	0,4%	1,4%	-0,1%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

7.10. Policy Option 4s – Sensitivity case

7.10.1. Modelling assumptions

PO4s builds upon the PO4 and includes the following modelling assumptions:

- Phase in distance based charges for LGVs and passenger cars in BE, DE, LU and NL from 2025 onwards.
- Phase in of revenue neutral modulation of infrastructure charges by CO2/air pollutant emissions for passenger cars and LGVs starting in 2025 for BE, DE, LU and NL.
- Rebates for all Zero Emission LGVs and passenger cars starting with 2025 in BE, DE, LU and NL.
- Extension of genuine congestion charging also to BE, DE, LU and NL.
- Exemption from circulation taxes for LGVs in BE, DE, LU and NL from 2025 onwards.

Table 7-94 and Note: measures included in PO1, PO2, PO3a, PO3b, PO4 and PO4s are reported in green; measures included in PO2, PO3a, PO3b, PO4 and PO4s are reported in blue; measures included in PO3a, PO3b, PO4 and PO4s are provided in purple; measures included in PO3b, PO4 and PO4s are reported in orange; measures included in PO4 and PO4s are reported in red; measures additionally included in PO4s are reported in light red.

Table 7-95 below provide with a summary of the measures simulated in the various Member States in PO4s.

Table 7-94: Summary of policy measures introduced in PO4 sensitivity case (PO4s) on top of the Baseline, PO1, PO2, PO3b, PO3a and PO4

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge	**Vignette**	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12 t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

Note: measures included in PO1, PO2, PO3a, PO3b, PO4 and PO4s are reported in green; measures included in PO2, PO3a, PO3b, PO4 and PO4s are reported in blue; measures included in PO3a, PO3b, PO4 and PO4s are provided in purple; measures included in PO3b, PO4 and PO4s are reported in orange; measures included in PO4 and PO4s are reported in red; measures additionally included in PO4s are reported in light red.

Table 7-95: Summary of policy measures introduced in PO4 sensitivity case (PO4s) relative to the Baseline

			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Road infrastructure charge variations	**Vignette**	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
	Toll	HGV <12t																												
		HGV >12t																												
		Buses																												
		LGV																												
		Cars																												
Phasing out vignette		HGV																												
		Buses																												
		LGV																												
		Cars																												
Phasing out EURO Class modulation		HGV																												
		Buses																												
Phasing in CO2/pollutant modulation		HGV																												
		Buses																												
		LGV																												
		Cars																												
Rebates for zero emission vehicles		HGV																												
		Buses																												
		LGV																												
		Cars																												
External costs		HGV																												
		Buses																												
Congestion charging		All																												
Mark-ups		HGV																												
		Buses																												
Reduced circulation taxes		HGV																												
		LGV																												

7.10.2. Modelling results – ASTRA

The bundle of measures envisaged in PO4s is expected to increase road freight transportation costs in **BE (3,7%), DE (6,0%), LU (5,1%)** and **NL (3,9%)** relative to Baseline for 2030. The comparison with analogous results for PO4 shows that road freight costs increase by about 2,4% for BE, LU and NL and by about 3,9% in DE. Slight variations can be observed also in some other countries as a consequence of increased costs of transport on international routes.

Table 7-96: Variation of road freight cost (including VAT Euro2010/tkm) in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	4,4%
BE	3,7%
BG	5,1%
CY	0,4%
CZ	0,9%
DE	6,0%
DK	2,9%
EE	0,7%
EL	0,4%
ES	0,0%
FI	0,3%
FR	-0,5%
HR	1,2%
HU	3,1%
IE	0,0%
IT	1,1%
LT	2,7%
LU	5,1%
LV	3,5%
MT	0,7%
NL	3,9%
PL	0,7%
PT	-0,3%
RO	5,0%
SE	3,1%
SI	1,3%
SK	0,6%
UK	1,8%

Source: ASTRA model

The variation of road freight transport activity at country level is shown in Table 7-97; the increased rail transport activity in BE, DE, LU and NL reflects the reduction of road transport activity as a consequence of increased road freight costs.

Table 7-97: Variation of freight transport activity in Mio tkm in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	IWW	TOTAL
AT	-0,8%	2,3%	0,0%	0,1%
BE	-0,9%	3,2%	0,0%	-0,2%
BG	-0,6%	2,4%	0,0%	0,0%
CY	0,0%	-	-	0,0%
CZ	-0,2%	0,5%	0,0%	0,0%
DE	-0,9%	3,1%	0,0%	0,1%
DK	-1,0%	3,2%	-	-0,5%
EE	-0,2%	0,3%	-	-0,1%
EL	-0,2%	1,6%	-	-0,1%
ES	-0,2%	0,2%	-	-0,2%
FI	-0,2%	0,1%	0,0%	-0,1%

Country	Road	Rail	IWW	TOTAL
FR	-0,3%	1,3%	0,0%	-0,1%
HR	-0,2%	0,4%	0,0%	-0,1%
HU	-0,4%	1,2%	0,0%	0,0%
IE	0,0%	0,2%	-	0,0%
IT	-0,3%	2,1%	0,0%	-0,1%
LT	-1,0%	0,7%	0,0%	-0,2%
LU	-0,5%	3,5%	0,0%	-0,1%
LV	-0,7%	1,0%	-	-0,1%
MT	0,0%	-	-	0,0%
NL	-0,7%	4,0%	0,0%	-0,2%
PL	-0,2%	0,8%	0,0%	0,0%
PT	-0,1%	-0,2%	-	-0,1%
RO	-0,8%	1,2%	0,0%	0,1%
SE	-0,9%	1,8%	-	-0,2%
SI	-0,3%	0,8%	-	0,0%
SK	-0,2%	0,4%	0,0%	0,0%
UK	-0,4%	3,1%	0,0%	-0,1%
EU15	-0,5%	2,4%	0,0%	-0,1%
EU13	-0,3%	0,8%	0,0%	0,0%
EU28	-0,5%	1,9%	0,0%	-0,1%

Source: ASTRA model

Moderate impacts take place in terms of mode split at country level, as shown in Table 7-98.

Table 7-98: Variation of freight modal split in Policy Option 4s relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	IWW
AT	-0,6	0,7	0,0
BE	-0,5	0,4	0,0
BG	-0,4	0,4	0,0
CY	0,0	0,0	0,0
CZ	-0,2	0,2	0,0
DE	-0,6	0,6	0,0
DK	-0,5	0,5	0,0
EE	-0,1	0,1	0,0
EL	0,0	0,0	0,0
ES	0,0	0,0	0,0
FI	-0,1	0,1	0,0
FR	-0,1	0,1	0,0
HR	-0,1	0,1	0,0
HU	-0,3	0,3	0,0
IE	0,0	0,0	0,0
IT	-0,2	0,2	0,0
LT	-0,4	0,4	0,0
LU	-0,3	0,3	0,0
LV	-0,4	0,4	0,0
MT	0,0	0,0	0,0
NL	-0,3	0,2	0,1
PL	-0,2	0,2	0,0
PT	0,0	0,0	0,0
RO	-0,4	0,4	0,0
SE	-0,5	0,5	0,0
SI	-0,2	0,2	0,0
SK	-0,1	0,1	0,0
UK	-0,3	0,3	0,0
EU15	-0,4	0,4	0,0
EU13	-0,2	0,2	0,0
EU28	-0,3	0,3	0,0

Source: ASTRA model

As already seen in PO4, the introduction of distance-based charging for cars and of congestion charging in several Member States results in a visible increase of road passenger transport cost in the respective countries (see Table 7-99). Variations of road passenger costs for the Member States not already covered in PO4 are **BE (9,0%), DE (14,9%), LU (6,8%)** and **NL (7,0%).**

Table 7-99: Variation of road passenger transport cost (car+bus, including VAT Euro2010/pkm) in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	Variation (% change)
AT	28,2%
BE	9,0%
BG	3,8%
CY	1,1%
CZ	7,1%
DE	14,9%
DK	0,8%
EE	0,8%
EL	0,7%
ES	0,3%
FI	0,1%
FR	0,4%
HR	1,6%
HU	3,6%
IE	-0,1%
IT	0,8%
LT	0,8%
LU	6,8%
LV	0,6%
MT	0,1%
NL	7,0%
PL	0,6%
PT	-0,2%
RO	12,7%
SE	0,2%
SI	6,5%
SK	10,1%
UK	0,0%

Source: ASTRA model

Similarly to results of PO4, road passenger activity is reduced, while rail activity is increased (Table 7-100) as a consequence of increased road passenger costs. In some countries air transport activity increases relative to the Baseline for medium and long distance origin-destination relationships.

Table 7-100: Variation of passenger transport activity in Mio pkm in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	Road	Rail	Air	Total
AT	-3.1%	23.9%	5.6%	1.7%
BE	-1.3%	12.0%	1.9%	0.2%
BG	-1.5%	9.7%	1.7%	-0.9%
CY	-1.0%	0.0%	0.5%	-0.1%
CZ	-0.9%	4.9%	2.6%	0.2%
DE	-1.9%	11.4%	5.3%	0.4%
DK	-0.3%	0.5%	1.2%	0.1%
EE	-0.4%	0.2%	1.6%	-0.2%
EL	-0.2%	0.9%	0.4%	0.0%

Country	Road	Rail	Air	Total
ES	-0.1%	0.3%	0.2%	0.0%
FI	-0.1%	0.0%	0.4%	0.0%
FR	-0.1%	0.3%	0.9%	0.0%
HR	-0.2%	1.1%	3.4%	0.1%
HU	-0.6%	2.0%	3.5%	0.0%
IE	0.0%	-0.3%	0.2%	0.0%
IT	-0.2%	1.0%	0.9%	0.0%
LT	-0.3%	0.7%	1.9%	-0.1%
LU	-1.6%	12.6%	0.5%	-0.3%
LV	-0.8%	3.2%	1.1%	-0.3%
MT	-0.1%	0.0%	0.1%	0.0%
NL	-1.0%	8.1%	1.9%	0.1%
PL	-0.2%	0.4%	2.1%	0.0%
PT	0.0%	-0.8%	0.1%	0.0%
RO	-2.0%	8.4%	3.4%	-0.2%
SE	-0.1%	0.0%	0.4%	0.0%
SI	-0.5%	19.1%	3.2%	0.0%
SK	-1.2%	8.5%	4.8%	0.2%
UK	0.0%	0.0%	0.1%	0.0%
EU15	-0.6%	4.5%	1.2%	0.1%
EU13	-0.7%	3.7%	2.3%	0.0%
EU28	-0.6%	4.4%	1.3%	0.1%

Source: ASTRA model

Impacts in terms of mode split provided in Table 7-101 show a shift from road to rail passenger transport.

Table 7-101: Variation of passenger modal split in Policy Option 4s relative to the Baseline for 2030, by Member State (p.p. difference to the Baseline)

Country	Road	Rail	Air
AT	-3.6	3.2	0.4
BE	-1.2	1.1	0.1
BG	-0.6	0.2	0.3
CY	-0.3	0.0	0.3
CZ	-0.9	0.6	0.2
DE	-1.8	1.5	0.4
DK	-0.2	0.0	0.2
EE	-0.2	0.0	0.2
EL	-0.1	0.0	0.1
ES	-0.1	0.0	0.1
FI	-0.1	0.0	0.1
FR	-0.1	0.0	0.1
HR	-0.3	0.1	0.2
HU	-0.5	0.3	0.2
IE	0.0	0.0	0.0
IT	-0.2	0.1	0.1
LT	-0.2	0.0	0.2
LU	-1.1	1.1	0.1
LV	-0.4	0.2	0.2
MT	0.0	0.0	0.0
NL	-0.9	0.7	0.2

Country	Road	Rail	Air
PL	-0.2	0.0	0.1
PT	0.0	0.0	0.0
RO	-1.4	1.2	0.3
SE	-0.1	0.0	0.1
SI	-0.5	0.5	0.1
SK	-1.2	1.0	0.2
UK	0.0	0.0	0.0
EU15	-0.6	0.4	0.1
EU13	-0.6	0.4	0.2
EU28	-0.6	0.4	0.1

Source: ASTRA model

The impacts on **fuel consumption** by the road sector are reported in Table 7-102. More visible variations can be observed in PO4s for BE, DE, LU, and NL than those in PO4.

Table 7-102: Variation of fuel consumption from road sector in Mtoe in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	Gasoline	Diesel	LPG	Gas	Biofuels	Electricity	Hydrogen
AT	-3,9%	-2,8%	-3,1%	3,5%	-3,5%	-1,1%	-3,8%
BE	-1,3%	-1,3%	0,0%	11,5%	-1,4%	0,1%	-0,9%
BG	-1,2%	-0,7%	-1,1%	0,8%	-1,0%	0,9%	-1,0%
CY	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	-1,0%	-1,0%	-0,4%	2,8%	-1,1%	0,7%	-1,3%
DE	-1,6%	-2,8%	-0,4%	30,9%	-3,1%	0,4%	-1,4%
DK	-0,2%	-0,7%	0,0%	4,6%	-0,7%	-0,2%	-0,2%
EE	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%
EL	0,0%	-0,6%	0,3%	7,0%	-0,4%	2,3%	-0,2%
ES	2,9%	-1,5%	7,6%	29,5%	-1,7%	8,4%	0,2%
FI	0,0%	-0,1%	0,0%	0,0%	-0,1%	0,0%	0,0%
FR	-0,2%	-3,1%	12,5%	120,2%	-4,2%	8,7%	0,3%
HR	-1,1%	0,1%	0,0%	3,2%	-0,6%	2,8%	0,0%
HU	-1,9%	-0,7%	1,0%	31,9%	-1,5%	3,0%	-0,4%
IE	0,0%	0,0%	0,2%	0,4%	0,0%	0,4%	0,1%
IT	1,8%	-2,4%	0,0%	4,3%	-1,3%	6,8%	-0,1%
LT	-0,1%	-0,6%	-0,2%	0,5%	-0,6%	0,6%	0,2%
LU	-0,5%	-0,5%	0,0%	0,1%	-0,6%	0,0%	-0,5%
LV	0,0%	-0,4%	-0,1%	4,6%	-0,3%	-0,1%	-0,1%
MT	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
NL	-0,7%	-1,6%	0,2%	17,2%	-1,7%	1,1%	-0,4%
PL	-0,1%	-0,4%	-0,2%	12,9%	-0,6%	0,3%	-0,1%
PT	0,8%	-0,8%	5,1%	21,8%	-0,8%	8,3%	0,6%
RO	-2,1%	-1,6%	-1,8%	14,9%	-1,9%	0,0%	-2,2%
SE	0,0%	-0,6%	0,2%	4,7%	-0,7%	0,0%	0,0%
SI	-0,7%	-1,8%	0,4%	21,7%	-1,4%	2,7%	-0,6%
SK	-2,1%	-0,9%	-1,8%	16,4%	-1,9%	0,1%	-1,6%
UK	0,1%	-0,5%	0,5%	16,9%	-0,7%	0,6%	0,0%
EU15	-0,1%	-2,0%	0,3%	13,7%	-2,0%	3,6%	-0,6%
EU13	-0,9%	-0,7%	-0,3%	11,9%	-1,0%	1,1%	-0,5%
EU28	-0,2%	-1,8%	0,1%	13,6%	-1,8%	3,4%	-0,6%

Source: ASTRA model

PO4s results in 1% decrease for CO2 emissions at EU level relative to the Baseline in 2030, 1,4% decrease for NOx and 1,2% decrease for PM emissions.

Table 7-103: Variation of air pollutant and CO2 emissions from road sector in 1000 t in Policy Option 4s relative to the Baseline, by Member State (% change)

Country	CO	NOx	VOC	PM	CO2
AT	-0,4%	-0,9%	-0,3%	-1,0%	-3,0%
BE	-0,2%	-0,6%	-0,1%	-0,6%	-1,2%
BG	-0,1%	-0,3%	0,0%	-0,2%	-0,8%
CY	0,0%	0,0%	0,0%	0,0%	0,0%
CZ	0,1%	-0,3%	0,1%	-0,6%	-1,0%
DE	-0,5%	-1,9%	-0,5%	-1,4%	-2,0%
DK	-0,1%	-0,7%	-0,1%	-0,3%	-0,5%
EE	0,0%	-0,1%	0,0%	0,0%	-0,1%
EL	0,0%	-0,3%	-0,1%	-0,7%	-0,3%
ES	0,7%	-1,2%	0,1%	-1,8%	-0,7%
FI	0,0%	-0,1%	0,0%	0,0%	-0,1%
FR	-0,6%	-3,4%	-0,3%	-1,9%	-1,7%
HR	-0,3%	-0,2%	0,3%	0,3%	-0,2%
HU	-0,5%	-0,6%	0,1%	-0,1%	-0,8%
IE	0,0%	0,0%	0,0%	0,0%	0,0%
IT	1,1%	-1,1%	0,2%	-2,2%	-0,4%
LT	-0,1%	-0,4%	-0,1%	-0,2%	-0,5%
LU	-0,2%	-0,3%	-0,1%	-0,2%	-0,5%
LV	0,0%	-0,2%	0,0%	0,0%	-0,3%
MT	0,0%	0,0%	0,0%	0,0%	0,0%
NL	-0,1%	-1,1%	-0,2%	-1,1%	-1,0%
PL	-0,2%	-0,4%	-0,1%	-0,2%	-0,3%
PT	0,6%	-0,5%	0,4%	-1,0%	-0,3%
RO	-0,3%	-0,5%	0,1%	-0,6%	-1,7%
SE	-0,1%	-0,6%	-0,1%	-0,1%	-0,4%
SI	-0,2%	-0,9%	-0,1%	-1,1%	-0,8%
SK	-0,5%	-0,5%	0,0%	-0,5%	-1,1%
UK	0,0%	-0,5%	0,0%	-0,2%	-0,3%
EU15	-0,1%	-1,5%	-0,1%	-1,3%	-1,1%
EU13	-0,2%	-0,4%	0,0%	-0,3%	-0,6%
EU28	-0,1%	-1,4%	-0,1%	-1,2%	-1,0%

Source: ASTRA model

The observed variations on road sector emissions are also reflected in the external costs of road transport.

Table 7-104: Variation of external costs for road transport sector in Mio Euro in Policy Option 4s relative to the Baseline for 2030 (% change)

	CO	NOx	VOC	PM	CO2
Road Sector					
EU15	0,0%	-0,8%	-0,1%	-0,6%	-0,9%
EU13	-0,1%	-0,3%	-0,1%	-0,1%	-0,6%
EU28	0,0%	-0,7%	-0,1%	-0,5%	-0,8%

Source: ASTRA model

The impact on toll revenues from road transport (in comparison with the Baseline scenario in 2030 in the form of percentage changes) is provided in Table 7-105.

Overall, revenues at European level are expected to increase by 160,5% in comparison with the Baseline for 2030. Revenues from circulation taxes are reduced at EU level by 59% (respectively -63% for HGVs and -56% for LGVs).

Table 7-105: Percentage change in toll revenues from road transport in Policy Option 4s relative to the Baseline for 2030, by Member State

Country	TOTAL	HGV	LGV	BUS	CAR
AT	289,1%	16,2%	1325,4%	74,2%	524,8%

Country	TOTAL	HGV	LGV	BUS	CAR
BE	518,8%	57,5%	n.c.	n.c.	n.c.
BG	324,7%	827,6%	163,5%	255,6%	280,7%
CY	-	-	-	-	-
CZ	294,9%	51,4%	647,0%	221,4%	374,7%
DE	856,8%	112,3%	n.c.	n.c.	n.c.
DK	568,3%	558,9%	-	n.c.	-
EE	-	-	-	-	-
EL	22,8%	39,8%	47,7%	85,2%	20,1%
ES	17,1%	20,4%	25,3%	54,7%	16,5%
FI	-	-	-	-	-
FR	16,5%	40,1%	17,7%	90,4%	9,9%
HR	-7,7%	20,6%	14,5%	42,4%	-9,2%
HU	76,3%	23,4%	327,9%	510,7%	114,5%
IE	-4,2%	14,6%	20,7%	28,5%	-8,0%
IT	24,8%	44,9%	40,9%	71,8%	20,2%
LT	719,5%	789,7%	0,3%	38,4%	-
LU	4592,5%	1823,5%	n.c.	n.c.	n.c.
LV	371,7%	743,8%	86,9%	497,4%	-
MT	-	-	-	-	-
NL	13037,4%	1427,5%	n.c.	n.c.	n.c.
PL	35,5%	62,5%	16,8%	112,0%	6,0%
PT	10,5%	21,8%	13,7%	40,2%	9,8%
RO	475,1%	610,9%	80,5%	203,3%	533,4%
SE	522,0%	518,6%	-	n.c.	-
SI	115,6%	33,1%	376,0%	81,6%	176,4%
SK	321,3%	35,1%	555,7%	170,6%	421,9%
UK	1091,8%	1083,6%	-	n.c.	-
EU15	158,5%	86,8%	217,5%	158,8%	189,0%
EU13	178,1%	78,8%	151,0%	202,8%	227,8%
EU28	160,5%	86,0%	209,3%	173,0%	192,9%

Source: ASTRA model

n.c.= not computable. It is not possible to compute % variation when reference values in the Baseline are null. The % variation at EU level however include the overall impacts on revenues including also the changes in respect to values that are null in the Baseline.

ASTRA results in terms of macroeconomic impact suggest that the effect of Policy Option 4s on GDP is limited.

Table 7-106: Variation of GDP and Unemployment in Policy Option 4s relative to the Baseline for 2030 – EU average

	GDP (% change to the Baseline)	Unemployment rate (p.p. difference to the Baseline)
EU15	-0,1%	0,0
EU13	-0,1%	0,0
EU28	-0,1%	0,0

Source: ASTRA model

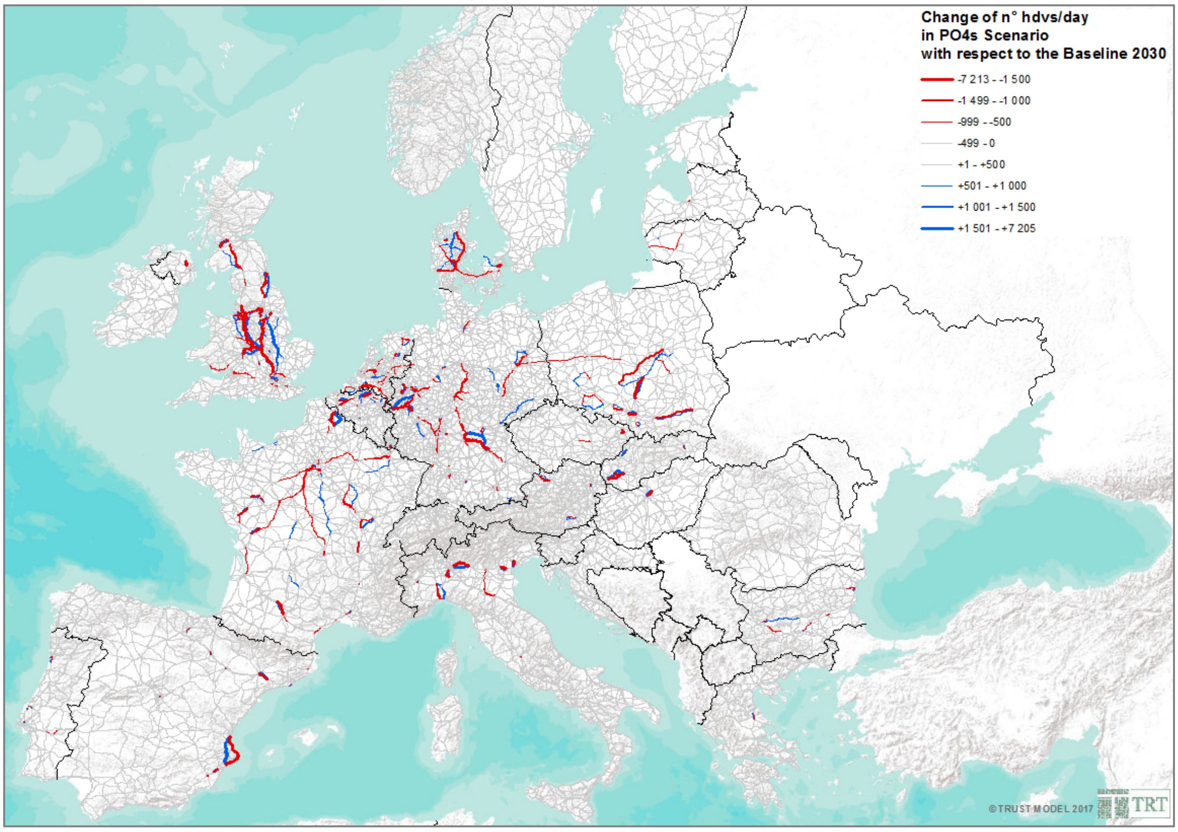
7.10.3. Modelling results – TRUST

Results of road traffic assignment of PO4s for HGVs and passenger cars are reported in Figure 7-24 and in Figure 7-25 respectively.

Results for HGVs confirms the tendency already observed in PO4 and suggesting a decrease in road freight traffic on some international routes due to the combined application of congestion charging and external costs in several Member States.

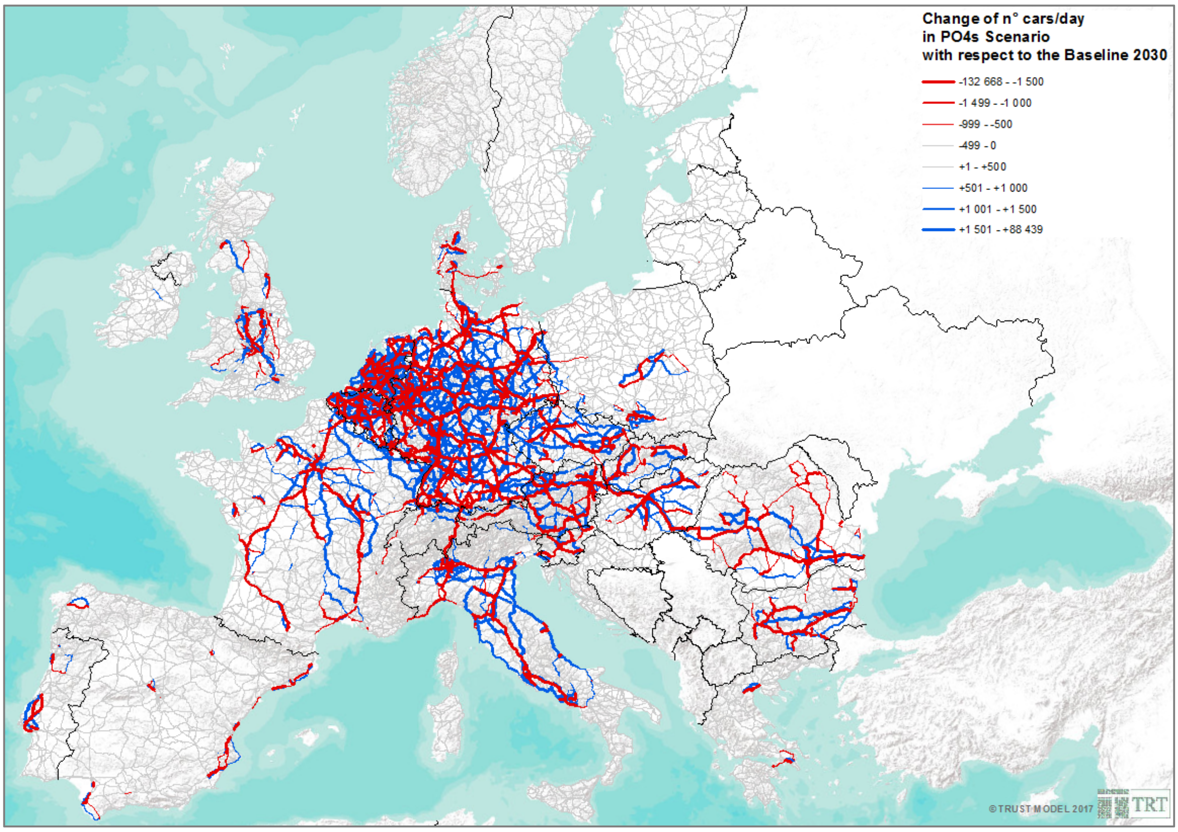
Also results for passenger cars confirm the traffic diversion to untolled routes, which in this case is more visible than in PO4 due to the extended application of distance-base charges and congestion charges to four other Member States.

Figure 7-24: PO4s Scenario – Difference on link flows, comparison with Baseline, HGV traffic



Source: TRUST model

Figure 7-25: PO4s Scenario – Difference on link flows, comparison with Baseline, Car traffic



Source: TRUST model

The variations of external transport cost for interurban congestion and noise relative to the Baseline in 2030 are reported respectively in Table 7-107 and Table 7-108.

Results for interurban congestion costs show that decreases at country level are dependent on the modelled local transport network conditions. The higher reduction of congestion costs in DE and BE seems to suggest that secondary roads have unused capacity to accommodate diverted traffic without reaching critical values for load/capacity ratios.

Results for noise confirm once more an expected increase due to traffic diversion towards secondary roads.

Table 7-107: External transport costs of interurban road congestion in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	-14,5%	-37,2%	-12,3%
BE	-33,3%	-31,6%	-33,5%
BG	-5,3%	-5,7%	-5,3%
CY	n.a.	n.a.	n.a.
CZ	-9,4%	-9,9%	-9,4%
DE	-22,1%	-30,6%	-20,9%
DK	-2,1%	-4,5%	-1,8%
EE	0,0%	-0,6%	0,1%
EL	-7,4%	-5,4%	-7,4%
ES	0,2%	-0,6%	0,3%
FI	-0,2%	-0,3%	-0,2%
FR	-0,8%	-2,2%	-0,7%
HR	0,0%	-0,3%	0,0%
HU	0,5%	-5,0%	1,3%
IE	0,7%	0,4%	0,7%
IT	-11,5%	-7,2%	-11,6%
LT	1,6%	3,8%	1,5%
LU	5,8%	14,8%	5,2%
LV	-0,7%	-1,8%	-0,5%
MT	n.a.	n.a.	n.a.
NL	-10,5%	-26,3%	-9,2%
PL	0,0%	-2,1%	0,3%
PT	-11,7%	2,5%	-12,3%
RO	-12,8%	-11,2%	-12,8%
SE	-0,6%	-1,6%	-0,4%
SI	-3,8%	-0,4%	-3,8%
SK	17,1%	-8,6%	18,6%
UK	-0,2%	-4,6%	0,2%
EU15	-7,1%	-9,6%	-6,9%
EU13	-0,8%	-3,5%	-0,5%
EU28	-6,1%	-8,6%	-5,9%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

Table 7-108: External transport costs of noise from interurban road transport in Policy Option 4s relative to the Baseline for 2030, by Member State (% change)

Country	TOTAL (cars + trucks)	Trucks	Car
AT	16,4%	-0,7%	22,1%
BE	11,0%	5,4%	12,9%
BG	0,3%	1,1%	0,0%
CY	n.a.	n.a.	n.a.
CZ	2,7%	1,5%	3,5%
DE	10,1%	0,7%	14,6%
DK	1,9%	5,7%	-0,3%

Country	TOTAL (cars + trucks)	Trucks	Car
EE	-0,4%	-1,6%	0,2%
EL	1,8%	1,3%	1,8%
ES	0,7%	1,4%	0,3%
FI	-0,1%	-0,1%	0,0%
FR	1,4%	2,2%	1,0%
HR	0,7%	1,9%	0,2%
HU	3,7%	5,6%	2,7%
IE	-0,1%	-0,5%	0,1%
IT	2,7%	4,3%	2,4%
LT	1,7%	5,8%	-0,1%
LU	6,2%	3,1%	7,3%
LV	3,5%	8,9%	0,0%
MT	n.a.	n.a.	n.a.
NL	17,1%	2,1%	21,7%
PL	1,0%	1,6%	0,4%
PT	1,4%	5,2%	0,4%
RO	-0,3%	-0,3%	-0,2%
SE	0,5%	1,2%	0,0%
SI	2,8%	-0,1%	3,3%
SK	0,7%	8,6%	-3,3%
UK	1,1%	5,4%	-0,3%
EU15	4,8%	2,6%	5,6%
EU13	1,3%	2,1%	0,8%
EU28	4,1%	2,5%	4,8%

Source: TRUST model
Data from Cyprus and Malta are not available since the TRUST model does not perform the assignment for these countries

8. ANNEX B: STAKEHOLDER CONSULTATION

8.1. Introduction

The aim of the stakeholder consultation was to collect the views of relevant stakeholders in order to inform the development of the Impact Assessment for the review of the Eurovignette Directive. It consisted of an online public consultation, which also invited additional contributions, and a targeted consultation that aimed to gather more detailed views and factual information on the options that were being considered.

8.2. The online public consultation

The online public consultation was open from 8 July to 5 October 2016, although later submissions were also accepted. It contained two sets of questions: the first targeting the general public by asking for their more general views on issues relating to the Directive; the second targeting experts with more detailed questions on the Directive and its application. Additional contributions were also received and have been analysed (see below).

The aim of the consultation was to verify the findings of the 2013 evaluation of EU road user charging policy, and to seek the opinion of stakeholders on potential policy options and their impacts. There were 135 responses to the consultation, as shown in Table 8-1. Responses were received from those residing, or based, in 20 Member States, with most respondents being from the EU-15, with more responses coming Belgium, Germany and Spain than from other countries.

Table 8-1: Classification of stakeholders responding to the questionnaire

Stakeholder category	Number of	% of responses
Construction industry / their representatives	10	7%
Consumers/citizens / their representatives	19	14%
Public authorities	17	13%
Public transport associations	6	4%
Tolling service / solution provers	6	4%
Transport undertakings / their representatives	57	42%
Other	20	15%
Total	**135**	**100%**

Notes: Other is based on the respondents' choice and includes: research centres, employers' associations, petroleum industry representatives, car and truck rental enterprises, and automotive associations.

With respect to the **fairness of pricing**, there was broad agreement that there were current distortions in competition. Seventy two percent of stakeholders – and 82% of transport undertakings – believed that different taxation and charging systems in different Member States were the source of market distortion, which called for greater EU harmonisation. A majority – 70% – also believed that the exemption for commercial vehicles of between 3.5 and 12 tonnes in some countries had the potential to distort competition. A slight majority – 54% – also believed that the lack of inclusion of LCVs in the Directive was a potential source of market distortion, although 31% disagreed. Eighty five percent of consumers/citizens – and 60% of stakeholders overall – believed that potential amendments to the Directive could improve fairness for non-resident car drivers. There was no consensus on whether existing charges were at an appropriate level: while 65% of transport undertakings thought that charges were too high, 52% of consumers/citizens thought that charges were too low. Respondents from EU-13 Member States were more likely to believe that prices were too low.

With respect to the **scope of the rules and the approach**, there was broad support for the polluter-pays (75%) and user-pays (80%) principles, while 54% of respondents supported the legislation covering all road vehicles, i.e. freight and passenger transport. Opinion was split as to whether the price of transport should cover all related externalities, with 51% in favour and 42% against, although 63% of consumers/citizens were in favour. Similar proportions of respondents were in favour of applying the legislation to all main and national roads or just to roads of European importance (33% compared to 36%). The majority believed that dealing with congestion should be left to Member States and local authorities, with the exception of toll service providers who were strongly supportive of congestion on the main road network being addressed by EU legislation. There was strong support (82%) for reinvesting any revenues generated from taxes and charges back into the road network, while ensuring transparency, although some also supported revenues being used to fund other transport, including public transport. Around three-quarters of respondents agree that the EU should ensure that vignette prices are set proportionately. With respect to CO_2 emissions, there was support for regulations on fuel consumption and CO_2 emissions for HDVs, and for taking account of CO_2 emissions in vehicle and fuel taxation. There were also concerns about charges effectively acting as a double taxation, which could be addressed by EU-wide harmonised rules to ensure fair competition.

With respect to the **proposed amendments to the Directive**, some proposals were well received, whereas respondents were less convinced by others. All three proposals relating to road maintenance received support from around two-thirds of stakeholders. The monitoring and reporting of revenues and expenditures was supported by 69% of respondents, while the introduction of liability rules on toll road operators and the requirements for Member States to develop national plans for the maintenance and upgrading of their road networks both received support from 65% of respondents. There was also good support for the phasing out of vignettes in favour of distance-based charging for HGVs; there was also support for covering light goods vehicles and buses and coaches by such charges.

Around two-thirds of respondents supported reduced charges to promote fuel efficient vehicles (68%) or fuel efficient technologies (66%) in order to address CO_2 emissions, although fewer (only 44%) supported phasing out the possibility of differentiating charges by Euro emissions standards. Most respondents agreed with the need for an adequate measuring methodology. Thirty two percent of respondents supported the extension of mark-ups beyond mountainous regions, whereas 29% were against, with there being more support from respondents in the EU-15 than in the EU-13. Some were concerned that further mark-ups risked leading to double charging, while others supported transparency if mark-ups were extended.

Finally, there was less support for the proposals for congestion charging with only 40% agreeing with allowing congestion charging for all vehicles, which was the most popular option. If congestion charging was to be applied, there was support for this being applied to all vehicles, not just HGVs, while others noted the possibility that such charges would have little impact as users often did not have alternatives.

Fifty three **additional contributions** were received, of which 32 were of direct relevance. One third of the latter were from public authorities and nearly one quarter from transport undertakings.

In the additional contributions, there was a lot of **discussion of distance-based charging versus vignettes**. Most contributions supported distance-based charging and the phasing out of vignettes, as the former were best able to internalise external costs in line with the user-pays and polluter-pays principles, as well as potentially delivering modal shift in line with EU targets. Other contributions underlined the greater costs associated with distance-based charging, and argued that while distance-based charging might be appropriate for HGVs, time-based vignettes were more appropriate and cheaper for other types of vehicles.

There were mixed views on the **internalisation of external costs**, with some additional contributions calling for the inclusion of external costs relating to congestion, accidents and CO_2 emissions in addition to air pollution and noise, while others believed that external cost charging was not appropriate or was difficult. For congestion, views ranged from support for such charges to be additional, rather than revenue-neutral, to arguing that additional provisions for congestion charging were not necessary, as the costs of congestion were already internalised by users. Some public authorities called for the maximum charging levels to reviewed or even directly removed to enable charging that actually reflects the costs of pollution; a similar view was held by a motorway operator in relation to congestion. There was some support for replacing the possibility to differentiate charges by Euro emissions class with CO_2-differentiated charging, but it was noted that the latter was difficult in the short-term as a result of a lack of relevant information for HDVs. An alpine region called for mountainous areas to be allowed to implement additional tolls to cover the additional infrastructure and external costs imposed on these sensitive areas. Some respondents also underlined the importance of ensuring that external costs were internalised for all modes, whereas others argued that rail is already subject distance-based pricing much more than the road sector.

Views on the **use of revenue** varied between making it mandatory for revenues to be used to support the development and maintenance of transport infrastructure to a more general belief in revenues being used to decrease external costs and promote cleaner transport modes. Member States, on the other hand, tended to argue that the use of revenue should be left to public authorities.

There was some support for **the scope of the legislation** to be extended to buses and coaches, and even to all vehicles. Some supported the legislation being amended to require mandatory distance-based charging, although road users in particular did not support such mandatory charging. Some Member States supported the removal of the possibility of exempting HGVs over 3.5 tonnes and less than 12 tonnes, but did not support the extension of the Directive to any type of vehicle lighter than 3.5 tonnes.

The need for an interoperable and harmonised framework for road user charging was highlighted by a number of contributions. A toll operator called for a mechanism to facilitate the cross-border enforcement of toll collection, while it was also noted that special conditions needed to be included for historic vehicles.

8.3. Stakeholder interviews

Selected stakeholders were contacted for interview. This resulted in a number of interviews and some additional written contributions being received from 21 different stakeholders. Nine of these were from Member States – four from the EU-15 and five from the EU-13 – five from transport companies, including two SMEs, four from EU level representative bodies, two from tolling companies and one national industry association. Stakeholders were asked questions on the potential policy options for amending the Directive.

Most of the nine Member States supported action to **incentivise the use of fuel efficient vehicles** in general, but not all of these were convinced of the ease and value of implementing this through CO_2-differentiated charges. Of those which supported other approaches, continuing to allow differentiation by Euro emissions classes or differentiating for alternatively-fuelled vehicles were also mentioned. The Member States that were most supportive of CO_2-based charges underlined that it needed to be applied simply and that a system of differentiation according to CO_2 emissions needed to be phased-in carefully as the Euro emissions class system was phased out. One of those Member States that was generally supportive noted that there would be objections from other countries on the basis that CO_2 emissions were already covered by fuel taxes, a point which was indeed noted by another Member State. The latter noted the likely industry resistance to additional charges without mechanisms being put in place to reduce fuel taxes. Where they expressed a view, Member States wanted CO_2-based charging to be voluntary.

Of those Member States that expressed an option, one stated that a CO_2-based charge should be revenue-neutral, while another argued that it should not, as ensuring revenue-neutral differentiation requires regular changes to the charges, which posed administrative challenges and was difficult to communicate to industry. Opinion was also divided on the challenges and costs of changing to a CO_2-based system, as one Member State noted that their existing toll system could be relatively easily adapted for CO_2-based charges, while others noted that the administrative burden was potentially the main issue, as verifying the appropriate CO_2 emissions could be high, at least in the transition period. It was suggested that this could be overcome by putting the burden of proof on service providers, with toll chargers able to allocate vehicles to the highest cost class in the absence of information. A number of Member States noted that a particular barrier would be confirming the CO_2 emissions of vehicles registered in other countries, including non-EU Member States, as this was more difficult to identify than for Euro emissions class (which was already difficult), and so increased the risk of fraud.

As noted above, a number of Member States were not in favour of CO_2-based charging. One felt that there were still benefits to be gained from being able to differentiate charges according to Euro emissions class, which could be lost if CO_2-based charging, for which there was still a lack of data, was introduced. Another also supported retaining differentiation by Euro emissions class, as this was easier to identify for a vehicle. This Member State did, however, support the extension of the Eurovignette Directive to all N-category vehicles. A third argued that differentiation according to Euro emissions class had been difficult, so was concerned that CO_2-based charging would be more difficult. This Member State believed that differentiating charges according to whether a vehicle used an alternative fuel would be easier, and that this was a better proxy for CO_2 emissions than Euro emissions class. It was proposed that a labelling system or EU level vehicle data platform should be created to assist Member States in this respect. Instead of CO_2-based charging, one Member State proposed that vehicle (or engines) that did not meet a certain CO_2 standard should be taxed or not allowed to be put on the market.

Amongst the other stakeholders, there was generally broad support for the principal of CO_2-based charging, but in practice some issues were identified. Two of the four EU level stakeholder organisations explicitly supported charging based on the results that emerge from VECTO, which will be used to monitor and report CO_2 emissions from HDVs and for setting emission reduction targets for these vehicles. In spite of the fact that information from VECTO will not be available to be used for the purpose of charging until 2020, these stakeholders underlined that the current Eurovignette amendment should enable the use of the VECTO's information as it becomes available, and then possibly phase out the use of Euro emissions classes. Other EU level stakeholders noted that the results of VECTO would not be accurate in practice, as the CO_2 emissions of an HDV in use depended on lot of factors. In spite of this, one noted that a vehicle that performs well "in the laboratory" would also perform well on the road, so that VECTO's results would be a good proxy for real-world emissions. The other EU level stakeholder was more cautious, arguing that it was too early to know whether the results from VECTO would be appropriate to use as the basis for CO_2-differentiated charges, and thus supported the retention of the possibility to continue to differentiate by Euro emissions class. The two EU level stakeholders that expressed an opinion stated that such differentiated charging should be applied to all vehicles, and one noted that the revenues should be earmarked to road transport projects that would reduce external costs.

The representatives of transport companies were supportive of taking account of transport's CO_2 emissions. One argued that it would be better to do this through fuel taxes, but as this was politically difficult, an approach based on the results of VECTO would be appropriate. They also noted that a vehicle's CO_2 emissions was based on a number of different factors, but that they generally supported any measures that further encouraged increased payloads. Another supported CO_2-differentiated charges, as long as this was mandatory for all vehicles, including light duty vehicles. A third thought that reaching an agreement on CO_2-based charges would be politically-difficult and lacked a clear rationale compared to internalising the external costs of CO_2, so was instead was in favour of the latter being mandatory. The transport companies underlined that the way in which differentiated-charging was implemented was of fundamental importance. A national industry association underlined that any system should be simple and sufficiently reward hauliers that use fuel-efficient vehicles.

The two representatives of transport SMEs that were interviewed were both generally supportive of the CO_2 differentiation of charges, but both underlined that it would be better if the same system was implemented and enforced in all Member States, otherwise there would be impacts on competitiveness. One underlined that this was a broader problem with respect to all EU legislation and that any new charging system should not end up penalising freight forwarders in ways that were not foreseen. The other argued that revenues raised should be invested in roads or in technologies that enable further CO_2 reduction.

The representatives of tolling companies were less supportive of CO_2-diferentiated charging, even though generally they supported measures to improve the environmental performance of transport. One was concerned that any changes to the structure of tolls always opened up wider discussions of contracts, which potentially led to problems. They argued that it would contractually simpler for CO_2-differentiated charges to be revenue-neutral, i.e. reduce charges for new vehicles while increasing charges for older vehicles, although it would be relatively easy to do this using an electronic charging system. They also noted that more charging was the obvious way of replacing fuel tax revenues, which were likely to decline. The other tolling company was concerned that CO_2-based charging would have an adverse effect on its business model and that it risked complicating tolling, as it would be more complex than differentiating charges according to Euro emissions classes.

Member States were generally not supportive of the policy options that might be implemented to **enhance the quality of road infrastructure**. With respect to existing tolled roads, it was underlined that in countries that have a lot of tolled roads already, such as Austria, Italy and Slovenia, the concessionaries already have performance indicators written into their contracts or agreements, which include *inter alia* maintaining the quality of their road network. In Member States that do not have extensive charging networks, indicators are sometimes used to monitor road quality and to prioritise investment. Concerns were raised that it would be difficult to agree a common set of indicators, as those relevant to Alpine countries would be different to those needed in relatively flat countries. Additionally, a standard set of EU-wide indicators could be difficult for some countries to achieve, as a result of a lower levels of resources. One Member State suggested that the Directive could include a general requirements to establish indicators, but leave it to Member States to decide what these should be, while another saw the value of common indicators, but did not want these to be imposed. Another Member State supported the establishment of EU performance indicators for infrastructure maintenance, but thought that these should not be implemented through the Eurovignette Directive.

Subsidiarity concerns were raised in many cases, with Member States suggesting that it should be up to them to decide how to manage and fund their respective road networks in light of other priorities, and to decide on what they should report. A concern was also raised that the policy options proposed were more administrative in nature and so would introduce administrative costs without necessarily delivering better roads. Three Member States noted that in their countries revenues from charges were earmarked for road development and maintenance, and one of these suggested that such earmarking could be a requirement more generally.

Other stakeholders were more supportive of action to ensure the quality of the road network, although many underlined that it was important to make a distinction between tolled and non-tolled roads. Again, it was noted that those who operated tolled roads in many countries had – or probably had – indicators built into their contracts, e.g. in Portugal, Slovenia, Austria, Italy and France. In general, it was considered that tolled roads were reasonably well maintained, although there was still support for a more common approach, particularly on the TEN-T network (although some felt that such a focus would be too narrow). A transport company identified the tolled roads in France as the benchmark on the basis of which a common approach could be defined. Several stakeholders supported the development of a common set of indicators, although many also recognised the associated challenges of achieving this. To overcome this, an EU level trade association proposed having a common road quality monitoring system that could be used across the EU with a central authority. Indicators that might be part of common set of indicators to monitor road quality indicators were proposed by a number of stakeholders. Some supported the use of a common set of indicators together with the development by Member States of national maintenance and upgrading plans. Other options proposed included the development of guidelines on the minimum level of maintenance, although the details should be left to individual countries, and a requirement to take action to remedy any issues identified by any indicators.

For non-tolled roads, many interviewees acknowledged that, while there was a greater need for action to maintain these roads, a different approach was needed as a result of a lack of resources in many countries. Suggestions included that each Member State should have to put in place a structure for non-tolled roads that ensures that these roads offered an appropriate level of service to users, a requirement on Member States to demonstrate that sufficient funds had been invested to ensure that roads were safe and free-flowing and a need for more transparency in order to ensure that investment was spent on the roads in most need of it. An EU trade association felt that the Directive would go too far if it tried to ensure the quality of non-tolled roads. A number of interviewees noted that distance-based charging was a potential solution to the problem of funding non-tolled roads, while several explicitly supported the earmarking of revenues from such charges for road maintenance and development.

With respect to vignettes, Member States were split on the need for further measures to **avoid discrimination**, but there was little support for phasing out vignettes. There was some support for expanding the existing proportionality rules that applied to HGVs to other vehicles such as cars and buses, although others opposed this arguing that the focus of the Eurovignette Directive should remain HGVs as these were the main type of vehicles that travelled a lot internationally. One Member State argued that if it was considered that vignettes did not sufficiently cover costs, the response should not be to abolish vignettes, but to lift the restrictions on them as it was not currently possible to use these to cover the costs imposed by HGVs. Some Member States believed that there was no need for additional rules, as it was more a case of properly enforcing existing rules on proportionality, rather than creating additional legislation. Those Member States that already had a distance-based charging scheme in place for HGVs often did not object to phasing out vignettes for HGVs. Several Member States argued that, particularly for LDVs, the costs of implementing a distance-based charging scheme were prohibitive, whereas a time-based system could deliver similar results for much less in the way of costs, even though it was not the best way of implementing the user-pays principle. One Member State argued that some countries, if faced with a choice between a distance-based system and no charging would adopt the latter approach, and so phasing out vignettes could lead to less charging overall.

With respect to distance-based charging, Member States were again divided on the need for additional measures to **ensure a level playing field**, with one questioning the logic behind the need for action in the first place. Some Member States that already had – or were planning – a distance-based charging scheme in place for HGVs supported this being made mandatory on the TEN-T network and extended to LCVs, but noted that this might be a challenge in other countries. One Member State supported the extension of the road charging rules to all vehicles, including cars, as this would increase acceptability amongst road hauliers, while another supported an extension to buses and coaches. Other Member States were explicitly against mandatory distance-based charging for any vehicles or even a common approach to such charging, arguing that vignettes were more appropriate in some cases (see above). It was also pointed out that in those countries with lower levels of traffic, revenues from distance-based charging would be less, which would further undermine the benefits of the scheme.

The majority of other stakeholders were in favour of distance-based charging applying to all vehicles and the phasing out of vignettes, although some supported vignettes for reasons similar to the Member States. The arguments in favour of distance-based charging included that this was fairer and better applied the user- and polluter-pays principles. Many of the stakeholders supported mandatory distance-based charging, at least as the ultimate long-term goal, and noted that this needed to be phased in gradually. One stakeholder proposed that after HGVs, it would be most appropriate to apply distance-based charging to buses and coaches, followed by LCVs, as these were being used in some Member States instead of heavier commercial vehicles as their use is less regulated. Views were divided as to whether mandatory charging should cover the entire network, the main road network or be just on the TEN-T network. An EU level trade association set out a set of principles that charges should follow, and also questioned the Commission’s current approach for identifying the appropriate level of external costs to be included in charges. A number of stakeholders noted that distance-based charging was the obvious way for Member States to maintain revenue levels from road transport, with the likely decline of revenues from fuel duties in light of the increasing electrification and improved efficiency of the new vehicle fleet.

Costs were also identified as an issue. In this respect, references were made to issues of more relevance to the EETS Directive, including the need for more harmonisation, potentially even an interoperable distance-based charging system throughout the EU, and, from the perspective of tolling companies, the need to facilitate and enable cross-border enforcement. Many stakeholders also stressed that any increase in costs as a result of increased charges should be compensated for by reductions in other transport-related taxes. Those that were in favour of retaining the possibility of maintaining a vignette system noted that the increased costs for short-term users were justifiable as a result of the flexibility that the system provides to these users, and that the costs of introducing distance-based charging for cars in particular would be prohibitive. It was also noted that the fixed costs of a short- and long-term vignette were the same, so it was not appropriate for their price to be directly proportional to the length of time for which they were valid. Another stakeholder noted that vignettes were more appropriate than distance-based charging in urban areas. An EU trade association that supported distance-based charging argued that in the short-term the proportionality requirements on vignettes should be retained; a transport company supported such rules being applied to all vehicles.

Member States generally favoured more flexibility in the Directive to enable them to **ensure an efficient transport system**, rather than more prescriptive requirements. Several Member States argued that the current approach to external cost charging needed to be simplified and that restrictions on the ability to increase charges by the time of day should be lifted in order to give Member States more flexibility. One Member State argued that the maximum level of any charge should be fixed to ensure consistency between Member States. It was proposed that rather than the Directive setting more rules to govern charges, it would be simpler if Member States simply had to justify their actions. In relation to congestion charging, some Member States argued that such charging was not appropriate in their countries, as a result of a lack of congestion, or that time-based charging was difficult to implement in practice. Others argued that it was a very local issue so the Directive should provide sufficient scope to allow for appropriate local action. In relation to external cost charging more generally, it was noted that in countries with older vehicle fleets, introducing such charging could be expensive for users. It was also argued that the methodology to determine external costs should be agreed between Member States before external costs are applied. A general comment was that the more restrictions that were imposed on charging by the Directive, the less likely it was that a Member State would voluntarily implement a charging scheme, in spite of its potential benefits.

Views on whether the Directive should apply to all vehicles were divided, with some not supporting any extension to vehicles of less than 3.5 tonnes, while others supported non-mandatory principles being applied more generally. One Member State argued that congestion charging should first be applied to HGVs, whereas another believed that such charges would only be fair if applied to all vehicles; another argued for congestion charges to be allowed only on the TEN-T network. Some Member States were in favour of the revenues being used for specified purposes, but these varied from making transport more sustainable in general to specifically being used to improve the road network; other Member States opposed any requirement on the use of revenues.

Of the other stakeholders interviewed, many transport companies supported congestion charging, as long as it was mandatory and applied to all vehicles, while others were not convinced of the need for congestion charging. Those in favour argued that as the vast majority of vehicles on the roads were cars, it would make no sense to only charge HGVs for congestion, as this would have little impact in practice and simply increase costs, as many hauliers deliver at times demanded by customers. A mandatory scheme was preferred, as it was considered that if the choice was left to Member States, they might take the easier option politically and only apply congestion charges to HGVs rather than to all vehicles. One stakeholder noted that it was important for the Directive to be seen to facilitate congestion charging, so this should be explicit and congestion should be included as one of the external costs that could be covered by user charges, although Member States should be left with flexibility as to how to apply the charge. It was also suggested by this stakeholder that the current maximum charges for congestion allowed by the Directive were too low. The need for a common methodology for applying the charges allowed by the Eurovignette Directive was mentioned by a couple of stakeholders.

Others opposed allowing Member States to charge for congestion, arguing that the costs of congestion were already internalised by hauliers in terms of increased fuel, labour and vehicle costs. Others believed that for inter-urban roads, the provisions of the Eurovignette Directive were already sufficient to enable Member States to address congestion, or that there would be no need for congestion charging if distance-based charging was introduced, as they had advocated. Some stakeholders underlined that congestion charging was more relevant for urban areas than for inter-urban routes, and had been demonstrated to work in urban areas using time-based systems. It was argued that in such cases, restrictions on access at other times for HGVs should be relaxed. A stakeholder suggested extending the Eurovignette Directive to cities in order to provide, at least in the first instance, a common framework in which cities were able to introduce congestion charges. Those that expressed a view on the use of revenues, argued that these should be used for new transport infrastructure and abatement measures. A couple of stakeholders believed that the decision as to whether to implement external costs charging generally, and congestion charging specifically, should be left to Member States and cities.

Few stakeholders had any views on **potential adverse or beneficial impacts on SMEs**. The main observation was that anything that increased costs or complexity had the potential to have an adverse impact.

8.4. Concluding discussion

There were some differences of note with respect to the responses from the different elements of the consultation.

There was general support for measures to **incentivise the use of fuel efficient vehicles**, although less specific support for doing this through charges and phasing out the possibility of differentiating charges by a vehicle's Euro emissions class. Only 44% of respondents to the online public consultation supported phasing out differentiation according to a vehicle's Euro emissions class, although this was a higher proportion than opposed this. Some additional contributions and many non-Member State interviewees supported the introduction of CO_2-based differentiation and the phasing out of differentiation by Euro emissions class, whereas Member State interviewees were generally less supportive of this approach.

In relation to possible measures to **ensure the quality of road infrastructure**, there was a distinct difference between, on the one hand, the views expressed in the online public consultation and the views of most stakeholders interviewed, and on the other, the views of the Member States interviewed. Around two-thirds of respondents to the public consultation supported each of the proposed measures to ensure the quality of road infrastructure, while other stakeholders interviewed were often supportive of some of the options for tolled roads. On the other hand, Member States were generally not supportive of the measures, citing subsidiarity concerns, that the proposals were unnecessary as tolled roads were already of sufficient quality and the challenges with identifying a common set of indicators.

With respect to possible measures to **avoid discrimination and avoid a level playing field**, there is again a distinct difference between the views of Member States and others. Respondents to the online public consultation strongly supported the application of the user-pays and polluter-pays principles, and for the EU to ensure that vignette prices are set proportionately. Many additional contributions and non-Member State interviewees supported the phasing out of vignettes and the introduction of mandatory user charging. On the other hand, Member State interviewees were divided on the need for further action in this respect, they generally did not support the phasing out of vignettes (particularly for cars) and tended to support distance-based charging only if they already had such a system in place. Many argued – as did some other interviewees – that vignettes were more appropriate and cheaper for cars.

With respect to **ensuring an efficient transport system**, the majority of respondents to the online public consultation believed that dealing with congestion should be left to Member States, with the most popular option for congestion charging being that it should apply to all vehicles. The need for any congestion charging to cover all vehicles, not just HGVs, was underlined by those non-Member State interviewees who supported congestion charging. Member State interviewees were in general in favour of more flexibility about implementing the measures to ensure an efficient transport system.

9. ANENX C: ANALYSIS OF ADDITIONAL POLICIES AIMED AT IMPROVING ROAD QUALITY

9.1. Identification of options

9.1.1. Retained options

Two options were retained that aimed at ensuring fair road quality in return for user charges:

A. **Require Member States to publish regular (annual) infrastructure reports, providing information on toll revenues as well as expenditures on maintenance/operation of toll roads.** This could help Member States identify financing gaps before the problem exacerbates and ensure that the necessary resources are in effect allocated to maintenance.

B. **Quality indicators would be introduced to ensure that the manager of a toll road will maintain the given road section in sufficiently good/safe condition.** Such indicators are already used by most Member States. However, the information is not strictly comparable since different methodologies are used. A harmonised definition based on current national practices in monitoring road characteristics could be adopted by the Commission through an implementing act.

C. **Both options combined –** since the Policy Options A and B address different issues (reporting vs monitoring), it is feasible to combine them into a single option that would incorporate the benefits and costs of both.

These options were examined as a separate exercise, since there are limited interactions between the other measures foreseen and hence they could be combined with any of the main packages. The relevant impacts for these policies are assessed in the following sections.

9.1.2. Discarded option – rules on liability

An initial policy option was discussed with stakeholders, namely: **introduction of rules on the liability of the keeper of a toll road** to maintain the given road section in sufficiently good/safe condition. This would effectively introduce a legal obligation to ensure that the objective of achieving fair road quality is met.

A review of current practices showed that there are various systems in place in Member States, with responsibility for maintenance lying with different bodies and effected by different contractual arrangements (Wirahadikusumah et al, 2015). Regardless of the system, there is normally a contractual duty to maintain the road infrastructure in good condition based on criteria specified in the agreement. Clearly the purpose of such requirements includes the safety of the road users as well as the need to constantly repair the inevitable deterioration caused by the elements, and by heavy use, if more serious and costly damage to the infrastructure is to be avoided. Well drafted contracts will set out clear objective indicators to establish what is required as well as specifying the consequences of breaching such duties.

Where failures in maintenance give rise to injury or damage to the road user, other civil liabilities may arise. Damage caused by fault, as conceived in civil law systems, or tort as in common law, in principle offer recourse by the road user against the party responsible for maintaining the road, when shown to be at fault in allowing the toll road to fall into such a state as to cause injury or damage to the road user. Whether legal liability can be established will depend upon evidence as to causation and will, for example, commonly involve the party responsible for maintenance producing records to establish the adequacy or otherwise of inspection procedures. Potential liability to road users is also frequently reinforced in national law by means of statutory duties that are imposed upon those responsible for the safety and maintenance of roads[85].

The proposed measure on liability envisages buttressing the rights of road users by establishing a form of statutory duty on the keeper of the toll road with respect to road maintenance, so as to assist the road user in establishing fault where damage or injury results from breach of that duty. However, this gives rise to a number of problems.

- It would entail changes to Member States' domestic law on civil liabilities in order to achieve the limited objective of improving road infrastructure. Any such European regulation may either duplicate or conflict with national law and this may be said to be disproportionate to the policy objective and offensive to the principle of subsidiarity.
- Depending on the legal route envisaged issues may well arise regarding the source of competence under the TFEU.
- The toll chargers' duties with respect to road maintenance are generally addressed in toll concession agreements and, if anything, supporting the contractual rights of the bodies granting the concessions would seem to be a more effective policy.
- Feedback from stakeholders that were interviewed for this study was uniformly unfavourable to attempting to improve road maintenance by way of rules relating to the potential liabilities. More specifically, objectives raised by stakeholders included:
    - Subsidiarity: a common theme was that responsibility for maintaining and improving road infrastructure, and especially attempting to stimulate better practice by way of rules regarding liability, were matters best dealt with at the Member State level.
    - The difficulty in formulating common criteria for road standards that could be applied throughout the EU given differences in topography and climate: benchmarking of this sort would, however, be needed for any

[85] E.g. in the UK, the duty to maintain the public highway in the Highways Act 1980 s.41(1). We were referred by one interviewee to a national court decision to the effect that the road user who pays a toll is entitled to expect a certain standard of road quality. In Italy the 'Carta dei Servizi' sets out the rights of road users in the relevant area.

common approach to liability. That said, there was some support for setting out some general indicators to demonstrate an adequate level of infrastructure maintenance.

- Infrastructure of toll roads was seen as a less pressing problem than that of secondary roads.
- Concern was expressed at the likely cost of implementing such a measure.
- Substantial differences between Member States as to the tolled proportion of their road networks was felt to reduce the likely effectiveness of any such policy option.
- A more limited approach which focused on minimum standards relating to road safety on the Ten-T network could be more appropriate.

The general lack of support for this policy option amongst stakeholders, as well as the other considerations we have outlined above, suggest that the option should be discarded. Also on the basis of the considerations and comments outlined above, it was decided to modify the proposed option to a more limited version that could be take forward for the more detailed analysis, i.e.: to focus on quality indicators to ensure that the manager of a toll road will maintain the road section in sufficiently good/safe condition (option above).

9.2. Impacts on road quality

The main intended impact of the two additional Policy Options A and B is to improve road quality. Most other impacts derive directly from the impact on road quality.

Policy Option A – reporting on revenues and expenditures

The mechanisms through which option A could improve road quality are outlined in the following causal chains:

- Increased transparency around road tolling revenues and spending:
  - ➔ Increased public awareness and acceptance of road tolls, allowing for greater uptake of such schemes and potential for revenue.
  - ➔ Greater transparency would enable users, and the groups that represent them, to review the rationale for road user charging. This would allow them to apply political pressure where appropriate, thus enabling action to ensure high road quality.
- Improved understanding of infrastructure maintenance spending:
  - ➔ Helping Member States identify financing gaps before the problem exacerbates and ensure that the necessary resources are in effect allocated to maintenance.
  - ➔ Reduction in poor road quality that has been occurring due to lack of adequate reporting.

The links between the different stages of the causal chain are not direct or measurable, hence it is not possible to quantify the extent to which this policy could be successful in ensuring better road quality. With regard to the first causal chain, <u>previous experience following the introduction of road pricing in various countries has shown that transparency about the use of revenues increases the public acceptability of charging systems</u>. This is particularly the case where the revenues are hypothecated towards transport system improvements (Gaunt et al, 2007), but increased transparency in general can work to build support even in cases where the primary objective of the scheme is not necessarily road improvements (for example, the congestion charges in Singapore aimed mainly to reduce demand rather than raise revenue for infrastructure) (Walker, 2011). More generally, crediting of revenues to the general budget received the least support, while directing it towards road investments was seen favourably (CEDR, 2009). Hence, more transparency will enable public pressure to direct funding toward more widely supported uses, such as road investments.

Regarding the second causal chain, more complete reporting of revenues and expenditure may help to identify issues with maintenance gaps sooner, and therefore allow them to be addressed earlier. Policy Option A could therefore help to improve road quality in cases where a lack of information is the underlying problem. A recent study found that there is limited data availability across many Member States – in particular for maintenance expenditure (European Parliament, 2014)[86] – and hence this policy option would help to improve information availability in at least these Member States. It is it is not possible to determine whether, underinvestment occurs due to insufficient funds being spent, or whether funds are being spent ineffectively (for example, due to poor planning), so the potential for this policy to improve road quality is unclear. Overall though, better information should have a positive effect.

In summary, <u>it is likely that Policy Option A will have a positive effect on road quality by creating enabling conditions that improve public acceptance and contribute to better understanding of potential expenditure issues. At the same time, it is also likely that the policy on its own will not be adequate to ensure good road quality in all Member States and so it should be implemented as part of a wider package of measures.</u>

Policy Option B – quality indicators

Road condition data is important for strategic long-term planning, support in daily construction and maintenance, research studies and in performance control of contractors (Sjögren, 2015). There is some harmonisation of road monitoring of EU roads, through Directive 2008/96/EC, although this is limited to roads on the TEN-T network. At national level, there are several well-established approaches that focus on common parameters (such as skid resistance, surface roughness, rutting, cracks, defects etc).

Yet, even where national authorities may apply similar monitoring techniques, the way in which data are compiled and reported varies. Outputs typically fall into three main types, as shown in Table 9-1. Some Member States (e.g. Austria and Germany) also employ modern Pavement Management Systems (PMS) that identify an optimum maintenance strategy taking into consideration budget and other constraints (European Parliament, 2014).

Table 9-1 Performance Measurement Approaches

Member State	Qualitative	Index-based	Value-based	Comments
France		✓	✓	Use sophisticated tools which provide information that feed into the calculation of two main indicators on the national network. The monitoring tools are very expensive and thus not used to monitor local roads
Germany	✓			Characteristics are converted into a score ranging from 1 (very good) to 5 (very bad). Federal roads are inspected every 4 years; state/district roads every 5 years and there

[86] A lack of information for maintenance expenditure was identified for BE, CY, DK, DE, GR, HU, MT, PT and RO. In addition, the definitions of road maintenance and investment activities are not always clear or consistent, making it unclear what activities should be recorded in the two categories (European Parliament, 2014)

Member State	Qualitative	Index-based	Value-based	Comments
				is no schedule for urban roads
Poland	✓	✓		Road surface parameters are grouped into four categories, A (good), B, C or D (bad). Measurement of the technical conditions of the road is carried out twice a year using radar techniques
Portugal	✓			Prioritise worst roads for maintenance. To evaluate the condition of the roads, an index that ranges from 0 and 5 is used, where a highest result corresponds to the best quality.
United Kingdom	✓	✓	✓	A set of indicators are collected annually using road scanning technologies. The parameters recorded are weighted to obtain the RCI for each 10 metre section of road surveyed. Any value above 100 indicates that road conditions are unsatisfactory, and are likely to require maintenance within the next year.
Ireland			✓	Annual surveys of the whole national network. Local roads are not surveyed as it is not cost effective. The recorded parameters were reported for every 100 metre sample unit
Austria		✓	✓	Use two RoadSTAR vehicles equipped with high-performance sensor, positioning and camera technology. Measures skid resistance, evenness, macrotexture and surface distress

*Notes: **Qualitative:** a qualitative score is assigned to different sections of roads based on the observed conditions; **Index-based:** road conditions for different stretches of roads are tracked over time and compared to a given year, assessing whether conditions have worsened or improved; **Value-based:** road conditions are pulled together to compile a single value for a stretch of road that is compared to others, either in relative or absolute terms.*
Source: (European Parliament, 2014)

The introduction of more uniform quality indicators contribute to raising minimum standards to a common level across the EU. Road infrastructure assets represent the largest capital asset of most countries, and they need to be managed with a long-term perspective. Although asset management practices vary between countries, the same basic principles apply and the core information needs are the same (TRIMM, 2014). In addition, since adequate maintenance of road infrastructure is closely connected to road safety, if harmonised criteria and methodologies for gathering such data could be adopted, and especially where they are clearly related to matters relevant to drivers' safety, this would appear to be proportionate and justifiable.

Policy Option B would allow Member States that do not have well established monitoring procedures to introduce tools able to improve the cost effectiveness of their actions. In addition, exchange and sharing of best practice and experience that would be possible via use of common indicators could certainly be of use. Overall, <u>Policy Option B is likely to make a positive contribution to road quality by improving the quality and consistency of information available on road condition.</u>

9.3. Main economic impacts

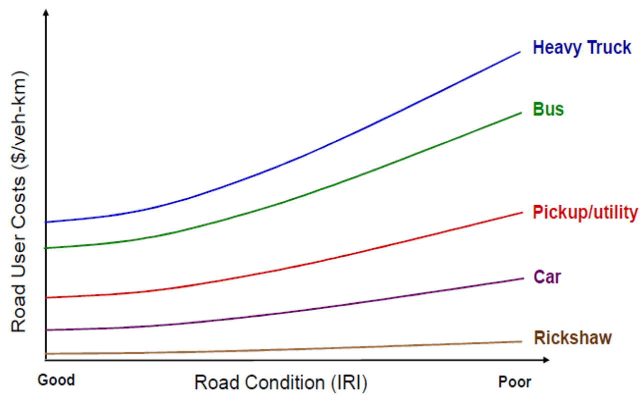
9.3.1. Transport costs

To the extent that Policy Options A and B can improve road quality (as described above), it can be expected that there would be a reduction in transport costs that would be directly proportional to the improvement in road quality.

In general, poor road quality results in increased vehicle operating costs due to fuel, oil, tyres, parts and increased travel time (World Bank, 2010b). Specifically, poor road quality have been identified to increase fuel consumption of LDVs by 34%, and 12% for HDVs, and to increase maintenance costs by 185% for LDVs and 129% for HDVs (European Parliament, 2014). In Poland, the additional operating cost per km has been estimated for vehicles travelling at 60 km/h as €0.004/km for passenger cars and €0.02km for HGVs without trailers (European Parliament, 2014).

The relationship between road condition and vehicle operating costs for different types of vehicles is illustrated in Figure 9-1. A World Bank study suggests that vehicle operating costs increase by US$2 to US$3 for each US$1 saved by avoiding maintenance costs (World Bank, 2010a). As can be seen, improved road quality significantly decreases vehicle operating costs.

Figure 9-1: Impact of road condition on vehicle operating costs



Notes: Road condition measured in terms of International Roughness Index

Source: (World Bank, 2010b)

These figures indicate that operational cost savings are possible from improved road quality. Although it is not possible to estimate the direct effect of Policy Options A or B on road quality (and study results are highly sensitive to the input assumptions) it is likely that greater improvements in road quality will result in greater benefits. Hence, it can be expected that the impact of both policy options together would be stronger due their potentially greater combined impact.

9.3.2. Congestion costs

A small impact on non-recurrent congestion could be expected in line with the extent to which the policies improve road quality. This is because poor road surface conditions may increase the risk of accidents due to skidding and also due to road users taking evasive action to avoid hazards (e.g. potholes), although lower vehicle speeds due to poor conditions may at least partially offset this (Transport Scotland, 2012). In turn, accidents may cause congestion and queues in traffic, although the relationship is difficult to concretise due to the vast range of different local factors that could be in play (RAC Foundation, 2013).

Road users may also experience reductions in route security and journey time reliability as a result of lower road maintenance budgets (RAC Foundation, 2013). Overall the impacts on congestion due to improved road quality have been shown in previous studies to be difficult to quantify (see for example (Transport Scotland, 2012), as such calculations depend on complex risk analysis and assumptions), but in general it can be assumed that increased road quality would have a small positive impact on congestion.

9.3.3. Impacts on SMEs

SMEs may be affected by changes in road quality, especially in some areas of the service sector (e.g. deliveries, construction, servicing/repairs etc) where there is a high share of SMEs who typically use vehicles for work purposes. A survey of SMEs in the UK found negative impacts in terms of time wasted, higher vehicle operating costs and fuel consumption, estimated at £13,600 per year (€16,300) (European Parliament, 2014). In general, SMEs will be affected by similar mechanisms as for transport costs in general (i.e. higher operational costs), and it can be expected that improved road quality will benefit them by avoiding the additional costs (circa (€16,000 per year, estimated in the UK).

9.3.4. Administrative / operational costs

Costs could arise from **Policy Option A** due to increased reporting requirements. In general, where information is collected already, this measure should not be expected to result in additional costs. In the case of administrations in charge of local roads, authorities may not have the resources to accurately record the budgets allocated and/or spent (European Parliament, 2014). However, since Policy Option A applies to toll roads, rather than local roads, and thus such limitations would not apply.

In the case of concession contracts, toll revenues and expenditure on toll road infrastructure are typically governed by the terms of a concession or operating agreement between a government and the toll charger. The ability to report information on revenue and expenditure arising under such contracts will therefore depend on their terms. Road toll concession agreements differ significantly between Member States in their allocation of toll revenue to maintenance and other infrastructural costs, which will have a bearing on the ease or difficulty of monitoring and publicising figures to show what proportion of the toll revenue is being spent on road infrastructure. That said, the terms of concession contracts do frequently allocate future toll revenue to planned maintenance as well as to meeting costs as they arise from regular inspection and compliance procedures. Some form of linkage will normally be specified between infrastructural expenditure and the concessionaire's right to increase the level of tolls and this will in turn feed into public debate about the quality of toll roads. Overall, there should not be significant additional administrative burdens arising from Policy Option A, and previous experience with communicating toll rates should help to minimise costs (Ricardo-AEA et al, 2014b).

Costs from **Policy Option B** would be directly related to any changes in monitoring practices enacted as a result of the measure. This in turn depends on the systems already in place in Member States, and what (if any) additional equipment would be required to measure the harmonised indicators. As a general point, specially-built measurement equipment is expensive due to heavy and complex hardware, low volume of production and the need of sophisticated systems and accessories (Forslöf & Jones, 2015). There are also significant costs associated with the time needed to take the measurements and process the results (Forslöf & Jones, 2015). In recent years, modern approaches (such as using built-in vibration sensors in smart phones) have been developed as alternatives, which significant reduce the costs and produce measurements that are highly correlated with more expensive laser measurement systems (Forslöf & Jones, 2015). Overall, for Policy Option B, it should be expected that many Member States that already practice advanced techniques will incur little or no additional costs, whereas there may be costs associated with equipment and staff time for countries that need to adopt new approaches. The cost can be mitigated through use of innovative measurement approaches, and also flexibly designing the policy in order to take different national circumstances into account will determine the ultimate costs.

The introduction of best practice indicators under Policy Option B may also help to improve contracting of maintenance works, which in turn could be expected to improve road quality in the longer term. For example, "traditional" lump-sum maintenance contracts are where payments are based on the *amount of inputs* (labour, materials etc) – in this case, performance standards are a part of this contract, but they refer to short term expectations of performance (e.g. response times to defects and end specifications for activities). *Performance-based* contracts (including concession-type agreements) require the contractor to maintain the road to a given standard as measured by agreed performance indicators. Typical indicators include road riding quality, vehicle velocity, safety and deflection life criteria (Wirahadikusumah et al, 2015); (Parkman, 1998). The key difference compared to lump-sum or method-based contracts is that the contractor is not paid for the number of potholes he has patched, but for the output of his work: i.e. no pothole remaining open (or 100% patched) (Wirahadikusumah et al, 2015). Studies by the World Bank suggest that road agencies adopting performance-based contract approach have claimed the following achievements: i) cost savings from 10% up to 40%; ii) expenditure certainty, iii) reduction of the in-house workforce, iv) improved conditions of contracted road assets and reduction of roads in poor condition, v) greater road user satisfaction, and vi) multi-year financing of a maintenance program (Wirahadikusumah et al, 2015). It may be expected that improved monitoring data would allow Member States to better control contracting works for maintenance, leading to cost savings in the longer run.

In addition, various studies also indicate that preventative maintenance helps to reduce costs in the long run – as noted in the problem definition, deferring preventative maintenance can therefore lead to substantial increases in repair/rehabilitation costs by up to three to four times more than if timely maintenance had been adequately funded (PIARC, 2005); (European Parliament, 2014). Both Policy Options could contribute to helping Member States more effectively identify and address maintenance gaps, and hence it can be expected that they will reduce maintenance costs in the longer term, thereby offsetting any additional administrative costs.

9.3.5. Macroeconomic environment

Several studies indicate that improvements in road quality can be beneficial for GDP. For instance, calculations for Lithuania indicate net benefits of €2.20 to €2.80 for every Euro invested in road rehabilitation, maintenance and reconstruction (European Parliament, 2014). ADAC (2011) claims that the worsening condition of roads in Germany causes macroeconomic impacts of 4% of German GDP, in the form of increased accidents, vehicle wear and tear and delays due to hampered traffic flow.

Impacts on GDP can occur through "first round effects", which involve direct employment in construction and materials supplying industries. A second round effects occurs in the production sector in response to the demand for additional inputs required by construction materials supplying industries. The value of these first and second round of effects for investments in transport infrastructure have a total multiplier effect of 2.34, meaning that each €1 investment returns €2.34 output in goods and services (European Commission, 2011b).

Studies indicate that investments in better road quality result in a multiplier effect, bringing general benefits to GDP of around €2.4 (range from €2.2 to 2.8) for each €1 invested

9.3.6. Competitiveness of EU economy

Investments in improving the quality of roads are likely to have an overall positive impact on economic performance due to increased connectivity, accessibility and connections for international trade (European Commission, 2011b), as well as the reductions in transport costs outlined above. Various studies on logistics performance also show a correlation between economic growth and freight transport logistics effectiveness and efficiency (World Bank, 2010c).

Better road quality is associated with competitiveness improvements due to the lower operational costs for road users and better connections, which will improve the efficiency of transport and contribute to a more competitive economy.

9.4. Main environmental impacts

9.4.1. Climate change / GHG emissions

As noted previously, part of the savings in vehicle operating costs are due to lower fuel consumption. This is because vehicles consume more fuel on rougher roads. Estimates tend to vary widely because of the range of vehicles and potential operating/environmental conditions. The literature gives a range of estimates that indicate that road quality is expected to result in lower fuel consumption from vehicles, by 12-34% for LDVs and 4.5-12% for HGVs (European Parliament, 2014); (EAPA, 2004).

9.4.2. Air quality

As roads deteriorate, driving styles and vehicle speeds are likely to change, leading to changes in fuel consumption and levels of emissions. Local air quality may also be affected by changes in disruption to the road network; however, the literature is inconclusive as to whether there is a relationship between air quality and road quality (RAC Foundation, 2013).

9.4.3. Noise

After an initial settling-in period, road surfaces generally generate more road traffic noise as they age. Asphalt pavement noise increases about 3 dBA (this is a doubling of noise levels) after six to seven years of usage and in later years of usage it can increase up to 4 dBA (European Parliament, 2014). On the other hand, a study in Scotland considered that changes in noise due to higher investment expenditure were likely to be neutral, although there may be a lost opportunity to invest in more expensive surfacing that reduce noise (Transport Scotland, 2012). There is an association between delayed maintenance and increased noise emissions, although the extent is uncertain.

9.5. Main social impacts

9.5.1. Safety (risk of accidents)

In its resolution issued on the 27th September 2011 on the European road safety 2011-2020 the European Parliament stressed the importance of a well-preserved road infrastructure to contribute to reducing fatalities and injuries of road users.

As noted under the analysis of congestion, poor road condition can increase accident rates. An investigation of over 600 truck accidents in seven European countries (France, Germany, Hungary, Italy, the Netherlands, Slovenia and Spain) found that accidents linked to infrastructure conditions represented 5.1% of total accidents. Over 10% of these accidents happened on highways (ETAC, 2007).

Moreover, delaying maintenance until reconstruction is essential can result in extensive and disruptive work that increases the potential for accidents among motorists and road workers (FHWA, 2008). In the ETAC study, approximately 8% of the accidents occurred where there was some ongoing engineering work on the infrastructure, and the engineering works were found to be the main cause of the accident for a third of those cases (ETAC, 2007). *To the extent that the policy measures encourage better planning of road maintenance and higher road quality, they could be expected to decrease the risk of accidents.*

9.5.2. Equal treatment of EU citizens

Policy Option A would have a positive effect on equal treatment because it aims to ensure that there is transparency both with the setting of toll levels and the use of revenues. The former could improve the acceptance of some charges and would help to protect user rights by enabling them to scrutinise the rationale. Clearly stating the components of such charges could facilitate a wider debate about what such charges should or should not cover and enable user groups, or others, to apply political pressure where this was appropriate to change the way in which charges are estimated.

Policy Option B would also benefit equal treatment of EU citizens, by ensuring that approaches to monitoring road quality are similarly implemented across Europe, and helping to harmonise the divergent practices seen today.

9.6. Comparison of options to improve road quality

The following sections compare the effectiveness, efficiency and economic/environmental/social impacts of the options, including the trade-offs and synergies. The final section explains which is the preferred option on the basis of the analysis.

9.6.1. Effectiveness

The main indicator of the effectiveness (in terms of meeting objectives) is the potential for the Policy Option to improve road quality. Compared to the baseline scenario, it can be expected that both options can contribute to improvements, but on their own cannot guarantee improvements – therefore, the effects in practice are rather uncertain.

It is likely that Policy Option A will have a positive effect on road quality by creating improving information availability to authorities and the public, particularly in Member States where there is limited information at the moment[87]. It may also increase public acceptability of any road charging schemes, thereby indirectly contributing to road quality by enabling revenue-raising. More complete reporting of revenues and expenditure may help to identify issues with maintenance gaps sooner, and therefore allow them to be addressed earlier.

Policy Option B would introduce more uniform road quality indicators, and therefore contribute to raising minimum standards to a common level across the EU. The provision of adequate road quality indicators is important for strategic long-term planning, as well as shorter-term maintenance and management of contractors. Currently, no common approaches exist across Europe, and practices vary widely. By improving the implementation and consistency of road quality monitoring – especially in Member States that have not adopted best practices - it can be expected that Option B will contribute to better quality roads.

The two options work on different issues and can be seen as complementary. Moreover, the combination of better monitoring with more transparent reporting will provide additional information on the costs associated with deferred maintenance spending and bring this to the attention of decision makers – this synergistic effect will increase the effectiveness of both options together more than a simple addition.

9.6.2. Efficiency (cost-effectiveness)

In the case of Policy Option A, the requirements call for reporting of information that is (to a large extent) already likely to be collected. Hence the additional costs are low. At the same time, the obligations to act on the available information are also limited

[87] For instance, a lack of information for maintenance expenditure was identified for BE, CY, DK, DE, GR, HU, MT, PT and RO (European Parliament, 2014)

(relying on public/political pressure for improvements). This option can therefore be seen as creating enabling conditions that can smooth the way for better road quality through providing more information/transparency, without any guarantee of this outcome.

Conversely, Policy Option B would require greater changes for at least some Member States in the form of changes to monitoring practices and/or equipment. This is more administratively intensive and will likely involve some amount of additional cost for implementation, especially if expensive equipment is needed. The cost can be mitigated through use of innovative measurement approaches (such as use of smart phone data) and also flexibly designing the policy in order to take different national circumstances into account will determine the ultimate costs. At the same time, many Member States that already practice advanced techniques will incur little or no additional costs.

The introduction of best practice indicators under Policy Option B may also help to improve contracting of maintenance works, where evidence suggests that adopting performance-based contract approaches can result in cost savings from 10% up to 40%; (Wirahadikusumah et al, 2015).

Furthermore, preventative maintenance can be more cost-effective in the long. Specifically, if road condition deteriorates to the point that reconstruction is needed, the costs can be three to four times more than if timely maintenance had been adequately funded (PIARC, 2005). Policy Option B can help to identify problems of road quality as part of an overall asset management system, whereas Policy Option A can help to improve information flows that could identify maintenance expenditure gaps. Both Policy Options could therefore contribute to cost savings due to preventative maintenance.

9.6.3. Main economic, environmental and social impacts

The **economic impacts** largely relate to the extent to which each Policy Option is capable of improving road quality – larger improvements indicate more positive benefits in terms of reductions in transport and congestion costs, GDP, competitiveness etc. Therefore, overall it is clear that the Policy Option that has the greatest potential to improve road quality, also has the most positive economic impacts. In this case, the combination of Policy Option A and B has the most potential.

Similarly, the **environmental impacts** are also directly related to the extent to which options are capable of improving road quality – again, the option with the greatest potential to improve road quality has the greater environmental benefits.

Social impacts relate to the risk of accidents, which again are correlated with the extent of improvements in road quality. In addition, the policies may affect equal treatment of EU citizens, where both Policy Option A and B have the potential for positive impacts. Policy Option A achieves this through more inclusive debate and better information, whereas Policy Option B achieves this through mandating a more harmonised approach to liability.

Overall, there is plenty of evidence to connect improved road quality with the main economic and environmental benefits described above, with studies from various EU-15 and EU-13 European countries that report positive interactions[88]. Although it is not possible to quantify any of these benefits due to the uncertain effect of the Policy Options on the most important indicator – road quality itself – it is clear that both options are likely to be beneficial.

[88] Reports were found indicating positive benefits in ES, LT, UK, DE, PL.

9.6.4. Coherence

Ensuring coherence implies that the Policy Options should seek to integrate and support overarching EU policy objectives and principles. In the context of the options on road quality, it can be seen that the main economic, environmental and social impacts are positive, and contribute to various high level EU level goals outlined in the 2011 White Paper around CO_2 reductions, safety and congestion reduction.

For Policy Option A, the reporting of infrastructure investment and maintenance is currently inconsistent between Member States. A common set of definitions has been provided by the United Nations System of National Accounts, but uptake among Member States is not uniform (European Parliament, 2014). If Policy Option A was introduced, it would be useful to further support the ongoing actions being taken at the international level by the OECD/ITF to increase standardisation of definitions, thereby ensuring coherence with existing initiatives.

At the same time, it is also likely that Policy Options A and B on their own will not be adequate to ensure good road quality in all Member States. Namely, positive changes with respect to monitoring and management must be combined with establishing an adequate and stable source of funds – otherwise road quality cannot be improved (World Bank, 1995). The policy options on road quality should therefore be combined with the main policy packages above, since these include measures to increase the uptake of road tolls, which can generate additional revenues.

9.6.5. Overall conclusion / preferred option

Table 9-2 summarises the comparison of options. On the basis of the analysis, it is clear that combining Policy Options A and B is preferred, and it is recommended to introduce them in concert with the preferred main policy package.

Table 9-2: Overview of policy options

	PO A – reporting of revenues / expenditures	PO B – quality indicators	PO A + B
Effectiveness	✓ Improved information availability may highlight maintenance shortfalls and increase public acceptability of tolls	✓ Raising minimum standards for monitoring road quality, ensuring more consistency within and between MS leading to better planning	✓✓ POs are complementary – synergies would increase effectiveness, especially wrt. identifying maintenance gaps
Efficiency	✓ Few additional costs. Possibility for better identification of maintenance gaps to lead to longer term cost savings	✓/× Increased costs for some MS (mitigated by flexibility and technology choices). Possibility to offset some costs through better contractual management	✓ Costs would be combined, but potential to offset them through better identification of maintenance gaps is increased
Economic impacts	✓ To the extent that road quality is improved – lower transport & congestion costs, improved GDP and competitiveness		✓✓ Combined effects of improved road quality, leading to greater economic benefits
Environmental impacts	✓ To the extent that road quality is		✓✓ Combined effects of improved road

	PO A – reporting of revenues / expenditures	PO B – quality indicators	PO A + B
	improved – lower fuel consumption and CO_2, lower noise. Impact on air quality is uncertain		quality, leading to greater environmental benefits
Social impacts	✓ To the extent that road quality is improved – lower risk of accidents. More and better information allows for more equal treatment of EU citizens		✓✓ Combined effects of improved road quality leading to greater social benefits
Coherence	✓ Make positive contributions to EU level goals. Could also contribute to existing efforts to harmonise monitoring/reporting of investment and maintenance expenditure	✓ Make positive contributions to EU level goals. Would be more effective in combination with main policy packages	✓ Make positive contributions to EU level goals. Would be more effective in combination with main policy packages

10. ANNEX D: IMPACT OF CONGESTION CHARGING ON LOCAL COMPETITIVENESS

10.1. Approach

Congestion charging can have broad economic impacts on the profile and competitiveness of the region in which it takes place. Transport infrastructure plays a key role in the location of economic activity and individuals, in the efficient operation of the economy and in shaping the fabric of cities and towns. Altering the cost of using one part of the system can have knock-on effects on the geographical distribution of economic activities and their competitiveness by changing the area's comparative advantage as a place to live, do business and visit. There are opposite effects at play: on the one hand the charge can make an area more costly and less attractive to some businesses; on the other, the improved traffic conditions boost its competitiveness. These drivers are likely to affect different businesses differently and could result in shifts in the mix of economic activities in some areas.

An extensive search of the literature has not provided information on the economic effects of local charges. At the same, time dealing with this issue using the same modelling tools used for the analysis of the packages of options would be extremely complex, full of arbitrary assumptions and would therefore not yield any meaningful results. Thus, a simplified approach has been developed to analyse the regional impacts of congestion charges.

The approach presented here is based on the relationship between accessibility and local/regional impacts. This relationship is explored in the literature, although in theoretical terms rather than providing empirical quantifications (also because disentangling the effect of accessibility to other local drivers is complex). However, at least one model exists which use accessibility changes to derive regional economic impact (Spiekermann and Wegener, 2006).

A congestion charge increases travel cost on some roads -> given the higher cost, some traffic is diverted to other roads or modes -> given the lower traffic speed is improved on charged roads -> the generalised cost to travel is therefore modified because of higher cost but lower travel time -> a different generalised cost means a different accessibility -> a different accessibility has an impact on the regional economy.

In order to capture the range of possible impacts of congestion charging on regional economies, several types of regions need to be considered:

a) Regions that are considered to be "attractive" (i.e. in this case productive) areas.

b) Regions that experience various levels of congestion.

c) The effect of a congestion charge on demand depends on many local factors. For instance, the impact of the charge on traffic is heavily dependent on the overall level of congestion on the network, the available alternatives to charged corridors and so on. It is however impossible to consider local conditions at the required level of detail for the analysis. Instead, some parameters can be used to reflect the elasticity of demand and test what happens if different levels of elasticity are assumed.

Therefore, the approach uses an estimation based on parametric assumptions for some sample regions. Given the importance of local conditions in determining the results, the quantitative outcome of the approach is provided as range of values for the potential effect. It is also accompanied by notes to highlight the elements that should be considered on a case by case basis to assess whether the impact would be likely to fall closer to the lower or the higher threshold.

10.2. Methodology

The methodology to model regional economic impacts involved the following steps:

a) For each region a potential accessibility indicator is calculated with reference to the NUTS3 regions within a distance of 300 km. It is assumed that beyond this threshold the effect on local economy is negligible. A potential accessibility indicator is calculated as:

   $PAi = \Sigma_j (GDP_j * \exp(-0.075 * \text{Generalised Cost}_{ij}))$

   Generalised cost is defined as the monetary cost plus the monetary equivalent of travel time[89].

b) A congestion charge is assumed to be applied on paths connecting Origin-Destination pairs where, according to the modelled speed, some congestion occurs[90]. The application of the charge has two effects. First, it increases the travel cost on the O/D pair. Second, it improve speed on the O/D pair by reducing some of the traffic flow. Both these two effects depend on local conditions (see section 3 below). This defines range that encompasses the potential for a low and a high impact.

c) By considering combinations of the low and high impact on travel cost and the low and high impact on travel speed, four scenarios are defined (low effect on cost and low effect on speed, high effect on cost and low effect on speed, etc.). For each scenario the accessibility indicator is recalculated.

d) From the data reported in Spiekermann and Wegener (2006), the elasticity of regional GDP to a change of accessibility is estimated to be 0.25 (i.e. a percentage point improvement of the accessibility[91] gives rise to a 0.25% increment of regional GDP).

e) The elasticity is applied to the accessibility change in each scenario with respect to the reference case. Four different values are obtained from which minimum and maximum effect can be identified.

As discussed above, the approach is a parametric one, adopting a low and high threshold for the assumed impact of congestion charging on travel cost and travel speed. In order to understand if in a specific region one should expect lower or higher elasticities, there are several elements to be considered as discussed in Table 10-1.

[89] A value of travel time of 15 Euros/hour has been used to compute the generalized travel cost. Value of travel time depends on local conditions. Representative values for road transport in European countries (Victoria Transport Policy Institute, 2010) range from 4 Euros/hour for non-working trips to 6 Euros/hour for commuting trips, 21 Euros/hour for business trips to 45 Euros/hour for trucks. The chosen value of 15 Euros/hour is representative of all types of traffic (passenger and freight) taking into account that congestion charge should be applied in peak time where commuting trips are a large share of car trips.

[90] Speeds are drawn from the TRUST model. It should be noted that the approach is based on the identification of origin-destination pairs where speed is below ideal free-flow speed. It is unimportant to detect exactly on which links congestion occurs.

[91] In the study used to estimate the elasticity, the accessibility indicator is a potential one, so the methodology is consistent. Furthermore, data related to the impact of a road charging scenario has been considered.

Table 10-1: Main factors affecting elasticity of travel demand

Impact of congestion charge on travel cost	Impact of congestion charge on travel time
The size of the charge. The larger the charge applied, the greater the increase in travel cost.	***Availability of alternative routes***. When some links are charged, spill over effect on other links can occur. This is more likely when different options are available. If alternative routes are lacking either because the infrastructures are poor or because the whole network is congested (as it often is the case around metropolitan areas), the elasticity of demand will be lower. It should be also considered that if one road is congested and other roads on the same corridor are not, most likely the level of service (i.e. speed) on the alternative routes is anyway lower than on the most used link (otherwise as soon as congestion arises some vehicles would switch on alternative road). Therefore even when alternatives exist and some traffic is diverted onto them, the overall effect on average speed of trips is hardly large.
The length of the charged network. The relevant travel cost is for origin-destination pairs. If a congestion charge is applied to some links, the travel cost will be affected more when these links represent a larger portion of the overall trip distance. Even large charges will not affect the total cost very much if they are only applied on a small number of short road stretches.	***The localisation of the charged links***. The availability of alternatives can depend on the position of congested links. Often congested links are close to large attractors (e.g. a metropolitan area, an industrial zone) where many trip are destined to. In this situation it is hard to find alternative routes. In some cases interurban corridors become congested because traffic related to several different O/D pairs sharing part of their route converge to the same infrastructure. This second case is generally more favourable to find alternatives.
The initial travel cost. The same charge level can have a different impact depending on the initial cost. Especially making reference to perceived costs, a given charge will raise car travel cost more than truck travel cost.	***Availability of alternative modes.*** Another reaction to road charging can be mode shift. This is more likely when good alternative services (e.g. rail connections) exist along the corridor.
	The length of the charged network. As already mentioned for travel cost, if travel time is referred to the whole trip, the effect of a congestion charge depends on the share of route charged. If the policy is applied to only a minor part of the route, even in case demand reacts significantly, the overall effect on the average travel speed for the trip will be small.
	Flexibility of departure time. If a congestion charge is applied only in peak hours, travellers who can move their departure time before or after the charged period can avoid paying the charge (and at the same time traffic in peak time is reduced). The larger the share of demand with a flexible travel time and the larger the effect on travel speed.

Impact of congestion charge on travel cost	Impact of congestion charge on travel time
	Average income. Demand of higher income groups is usually less elastic than lower income groups'. If the congestion charge is based on an estimation of marginal cost of congestion and, in turn, such an estimation is based on some demand curve, the average level of income will be reflected in the level of the charge (as the demand curve will be more or less steep). However if an average value e.g. by country is applied in region with significantly different levels of income the response of demand can be diverse.

10.3. Model results

The results summarised in Table 10-2 were obtained, assuming elasticities within a reasonable range as defined above.

Table 10-2: Impact of congestion charge on regional economies –results

Zone Type	Region	Effect on regional GDP
1	A region located at medium distance from a large economic pole and with a few congestion spots along its connections (e.g. Essex CC (UK))	Min -0.6% Max 0.5%
2	A region located in the middle of a large productive area where congestion is significant especially on short/medium distance (e.g. Milan (IT))	Min -0.7% Max 0.4%
3	A region which is the main economic pole in a large area where congestion is significant (e.g. Warsaw (PL))	Min -0.5% Max 1.0%
4	A region located in an area where GDP is evenly distributed congestion is limited to some spots (e.g. Oporto (PT))	Min -0.3% Max 0.3%
5	A region located at medium/long distance from main economic poles and in an area with widespread congestion (e.g. Harz (DE))	Min -1.1% Max 0.7%
6	A region located at medium/long distance from an economic pole and with some congestion along its connections (e.g. Maine et Loire (FR))	Min -0.3% Max 0.2%

The main findings from the calculations are:

- The effect of congestion charges on regional economies are expected to be limited. This seems reasonable, since congestion charge should be limited in space and time. Furthermore, even if the charge can improve travel speed it will also increase travel cost, so the impact on accessibility is not necessarily positive in all circumstances.
- The effects are larger where the effect on speed is assumed to be bigger and the effect on cost is assumed to be smaller.
- The effect is larger where there is more congestion (even if in more congested areas, demand has probably fewer alternatives and so the more optimistic scenario based on higher elasticity of speed is unlikely).
- The impact is different across regions not only because of different levels of congestion, but also because congestion is "located" at diverse distances from the economic poles. Where charged (i.e. more congested) links are those connections to the main economic poles, the impact on the economy is larger. Again this is not surprising. One message behind this result is that if congestion exists on a corridor because of poor infrastructure (i.e. even if surrounding

regions do not generate much traffic, demand is forced to use the only road available) a congestion charge is not effective.

In summary, the main purpose of congestion charging can be the internalisation of congestion cost or to disincentive drivers to use congested roads and improve the level of service. Congestion charges can have indirect effects including those on local economies; however these indirect effects are probably not large and do not represent a major factor that will determine the overall success of the charge.

11. ANNEX E: SME TEST

11.1. Consultation with SME representatives

Consultation with SMEs took place throughout the following processes:

- The open public consultation (12 weeks from 8th July 2016) gave SMEs the opportunity to respond directly to the questionnaire:
    - Seven SMEs in the road haulage sector (from Spain, Austria, Hungary, Poland and Portugal) responded to the consultation.
    - Representatives of SMEs (UETR and UEAPME) responded to the public consultation via answers to the survey or through submission of a position paper.
- Interviews were carried out with two SMEs, who requested to be remain anonymous. The questions covered potential impacts on SMEs of different policy measures.
- Interviews with all stakeholders included questions that invited interviewees to think specifically about the potential impacts on SMEs and whether they might be disproportionate.

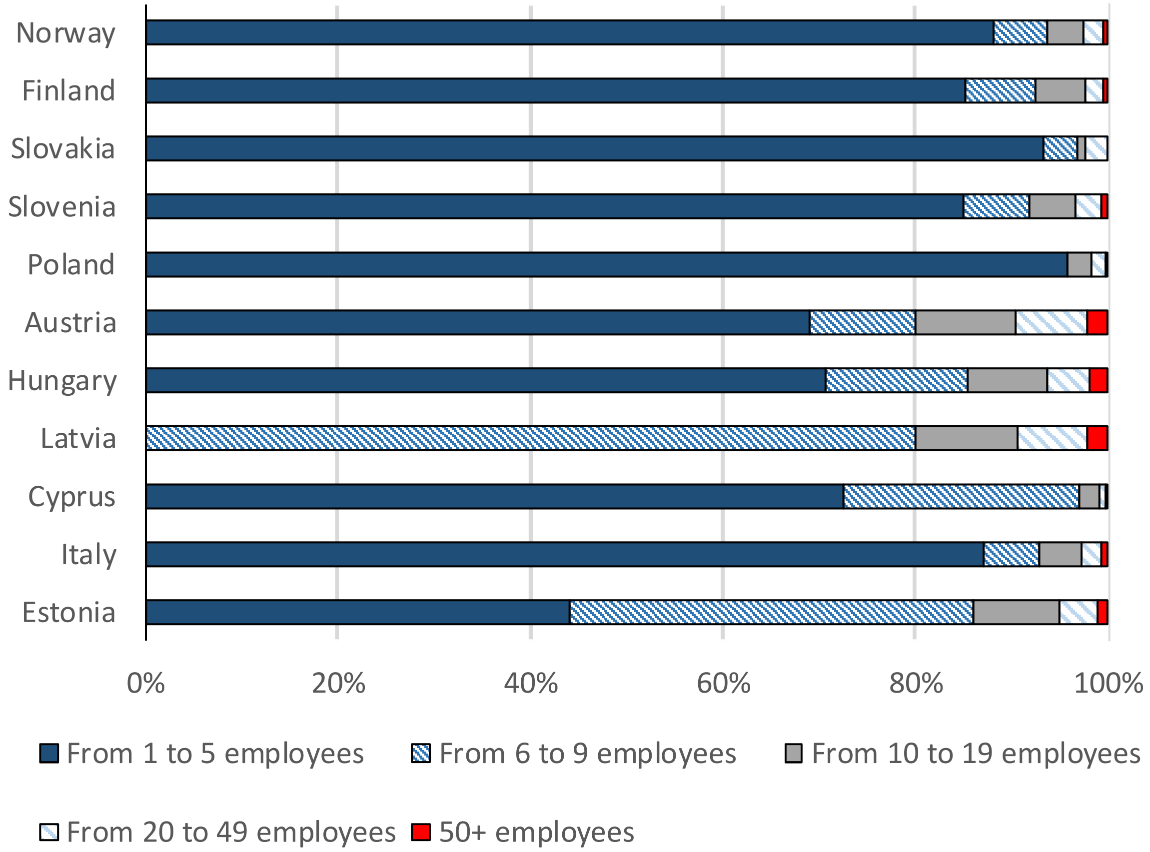
As can be seen above, direct feedback from SMEs via the survey and interviews was limited and so their responses cannot be considered representative. Where we were able to speak directly with two individual SMEs in the interviews, their responses were broadly supportive of the changes in terms of reducing the environmental impact of goods vehicles and congestion, as well as re-investing revenues into road infrastructure. The position of UEAPME was to support the proportional pricing of vignettes and phasing out of vignettes for HGVs (with optional distance-based charging). They did not support the inclusion of freight vehicles in congestion charges given that cars are the primary cause of congestion. Nor did they support the inclusion of CO_2 emissions in the Eurovignette Directive since CO_2 emissions are generally internalised through fuel taxation and thus this type of charging could lead to double taxation.

More generally, all interviewed stakeholders were invited to provide their perspective on possible impacts on SMEs; however most did not have an opinion or did not respond to this question. Of the few responses received, one hauliers association (PL) believed that SMEs would find the policy measures more challenging, as these firms had fewer resources to invest in cleaner vehicles, new equipment or pay higher road charges. An interviewee from an EU-15 national authority highlighted the costs of investing in new equipment - such as on-board systems- would have a disproportionate impact on SMEs, particularly for occasional road users. Conversely, another EU-15 National ministry (who requested to remain anonymous) responded that they did not foresee any particular costs burdens for SMEs.

11.2. Assessment of businesses likely to be affected

SMEs play a significant role in the road haulage industry. The market structure is characterised by having a small number of large, pan-European logistic companies providing complex services at the top, which dominate the largest contracts but subcontract a significant proportion of their work to SMEs (AECOM, 2014). This is illustrated in the data from Eurostat on company size (Figure 11-1). For the countries where data is available, SMEs with less than 50 employees represent 97-100% of all road haulier enterprises in 2012 (the latest year for which data are available). The vast majority (80-97%) are micro-SMEs, i.e. companies with fewer than 10 employees. At the EU level, 90% of enterprises in the sector have fewer than 10 employees and account for close to 30% of turnover (including self-employed) (Eurostat, 2017).

Figure 11-1; Size of enterprises in the Haulage Industry in 2012



Source: (Eurostat, 2017) - *Adapted from road_ec_entemp*

The haulage industry is highly competitive and operators are forced to operate on low profit margins (AECOM, 2014). Cost pressures for logistics providers mean that many heavily rely on subcontracting less profitable operations to smaller enterprises and owner-operators (AECOM, 2014). This presents a risk that additional road charges could push some players out of the market, especially among smaller firms that tend to compete mainly on price (WTO, 2010). The risk of such impacts is examined further below.

11.3. Measurements of the impacts on SMEs

The proposed policy measures will likely lead to **increases in the costs of transport**. SMEs may be disproportionately affected by these increases, since a large firm may be better able to absorb increased costs of road pricing compared to a smaller firm (Mahendra, 2010). As shown in the modelling results (Section 4.1.1), small increases in the cost of transport are foreseen for all options due to the introduction of new road tolls in certain Member States and the greater use of external cost charges (and to a lesser extent, mark-ups in mountainous regions).

The capacity to offset additional costs from road user charging may differ depending on the size and competitive position of firms. It could be argued that SMEs may have lower capacity to optimise their operations, and hence would be most affected by road charges. Evidence from Germany and Switzerland suggests that road hauliers were able to offset higher road charges through reducing empty runs or increasing loading factors (BMT Transport Solutions, 2006); (CEDR, 2009). SMEs with smaller vehicles and fleets, or a lower density customer network, could lack the scale needed to enhance efficiency according to these mechanisms. A qualitative study of the effect of the UK HGV levy on Irish hauliers also suggested that the costs would be borne by industry, due to their *"low bargaining power to push the road charge on to freight forwarders and exporters"* (Vega & Eversa, 2016). In addition, extending the Directive to HGVs <12 tonnes could potentially have a greater impact on SMEs since, according to one interviewed stakeholder (UK authority), SMEs typically operate smaller vehicles.

That said, it is generally assumed that 100% of cost increases due to road tolls are passed through, consistent with experience in several European countries. For instance, in Germany, Austria and Switzerland, the cost increases after introduction of tolls were passed to customers (BMT Transport Solutions, 2006); (Ruehl et al, 2015). Although these studies did not specify whether the results applied specifically to SMEs, since the haulage industry is made up almost entirely of SMEs it seems reasonable to assume that the outcome of passing through most (if not all) of the additional costs is representative. As such, it is expected that increased transport costs in PO1-4 will not have significant disproportionate impacts on SMEs.

Introducing **congestion charging** will also likely impact SMEs, since they have lower flexibility in their operations (as described above). SMEs with operations based primarily in affected areas (e.g. that often travel through congested road networks), or that have fewer resources available to be flexible in the timing of operations (e.g. from a shift to off-peak operations) would be disproportionally affected by increased charges. In particular, small firms may have no choice but to drive in peak hours because they have to maximise utilisation of their vehicles (Mahendra, 2010).

Interview feedback from a pan-European logistics company was that congestion charging is particularly challenging for trucks, as deliveries are often dependent on the demand of customers. This is demonstrated by the introduction of the congestion charge in London, where the number of goods vehicles remained almost unchanged, indicating that hauliers did not change behaviour in order to avoid the charges (CEDR, 2009). In their position paper, UEAPME noted that transport companies are already motivated to avoid congestion and driving in peak times would be because they have no alternative choices, and suggested that freight vehicles should be exempted from congestion charges.

At the same time, the same firms would likely benefit from lower congestion, which would result in time savings and an effective increase in the catchment area for the business. If the congestion charge is effective, it will improve the reliability and speed of deliveries along the supply chain. Given the limited real-world experience with inter-urban congestion charging, it is difficult to say what the net impacts would be – however, evaluations of the London congestion charge found no discernible impact on businesses (TfL, 2008), suggesting that more limited, targeted interurban congestion charging foreseen in the policy options would not have significant impacts (positive or negative).

Finally, the proposed measures to **promote zero-emission vehicles (included in PO1-4) through allowing lower road user charges** could have different impacts on SMEs compared to larger firms. In general, the impact on firms from this measure is expected to be positive, since the lower per-km road charges will contribute to lower running costs overall (in addition to other fiscal incentives, such as tax breaks and lower prices for alternative fuels). Over time, these lower running costs should more than outweigh the additional purchase costs of zero-emission light vehicles compared to a diesel equivalent (EEA, 2016b); (Energy Saving Trust, 2017). Taking subsidies into account, the total cost of ownership of a commercially-owned electric van is lower than a conventionally-fuelled van in most Member States – with larger savings if annual mileage is higher (Schimeczek et al, 2015). For HDVs, the picture depends strongly on the mission profile of the vehicle – for long-haul and distribution trucks, electric vehicles could be nearly cost-competitive with diesel by 2030 (CE Delft, 2013), but the calculations are highly sensitive to assumptions about the future development of technology and fuel costs.

SMEs in particular may face more difficulties in making the upfront investment for the more expensive vehicle. For example, Nissan e-NV200 electric van is 47% more expensive to purchase and lease compared to its diesel equivalent, the NV200 (Low Carbon Vehicle Partnership, 2016). For HDVs the differences in purchase costs compared to conventional vehicles is even larger, with retail costs of electric trucks being between 170% and 280% higher than a conventional equivalent (CE Delft, 2013).

If SMEs are less able to purchase or lease zero-emission vehicles, they will *initially* benefit less from the measure compared to a larger firm – both in terms of have less potential to access the lower rates for road user charges, as well as the co-benefits of owning zero emission vehicles in the form of lower fuel costs etc. There are, however, two reasons that the impact may not be a concern in the longer term:

- Firstly, the difference in investment costs between zero-emission vehicles and conventional vehicles is largely due to the powertrain costs (i.e. the battery). It is widely predicted that the cost of batteries will decrease significantly between 2015 and 2030 – by around 60% (Wolfram & Lutsey, 2016) - meaning that upfront investment will be less of an issue than today.
- Secondly, SMEs typically buy their vehicles on the second-hand market (BCA, 2012). If the measure stimulates additional first-hand purchases of zero-emission vehicles, these will eventually reach the second-hand market and SMEs will benefit from having access to zero-emission vehicles that they would otherwise not have been able to purchase.

11.4. Assess alternative options and mitigating measures

The analysis shows that the initiative might result in a slight disproportionate increase in costs for SMEs, but this is generally found to be small and likely to be passed on to customers. Experience from existing HGV road user charges (a sector primarily made up of SMEs) in countries such as Germany, Switzerland and Austria found that increases in costs were generally small and passed on to customers (Ruehl et al, 2015). Impacts from interurban congestion charging are expected to be limited. Consequently, there is no indication of a need for SME-specific measures in order to ensure compliance with the proportionality principle.

12. ANNEX F: WHO IS AFFECTED BY THE INITIATIVE AND HOW

This annex sets out the practical implications of the preferred option for different stakeholders.

Who is affected	How are they affected?
Member States public administrations	Vignettes would be phased out in Member States that currently have them in place. Those Member States would have the option to do nothing, in which case they would lose the direct revenues from the vignette (although they may seek to replace these with revenues from other sources such as fuel taxes) – or alternatively to introduce distance-based charges, in which case they would face additional implementation and ongoing costs. All other Member States would also be affected by additional costs where they introduce new road tolls (voluntarily). 1. Increasing fuel tax could be a meaningful alternative to road charging as it is paid in proportion of fuel burnt and in principle by all road users. It is very easy to implement at virtually no cost. For example, in the case of Luxembourg, the revenues forgone thanks to abolishing the Eurovignette system could be compensated by less than 2% increase in fuel tax. However, increasing fuel taxes can be politically difficult in some countries, and many Member States are seeking alternative sources of revenue as vehicles become more fuel efficient (eroding the tax base). 2. Road charging provides a more direct price signal to the user, whereas the fuel price, once paid, is already a sunk cost. Distance-based road charging can also be adjusted according to the environmental performance of vehicles, noise levels and time of day, thereby contributing to reducing external costs. Steady revenues collected from the users can ensure a quick payback period (generally within the same year), and long-term benefits in any case. Furthermore, the cost of operating different electronic toll schemes varies between 4.5 and 12% of toll revenues. The cost of on-board units is on a downward path. [92] For Member States choosing to introduce new road tolls, this result in an initial investment cost of around €150m (€82m to €232m, depending on the size of the county) and ongoing maintenance/enforcement costs of around €20m per year (€9m to €41m). These costs would be counterbalanced by increased revenues from road user charges in all cases. There may be small additional costs for implementing the measures regarding monitoring and reporting of investments, expenditures and road quality (although several Member States already do this), but these would be very minor, especially in comparison to the system costs explained above.
Transport operators and logistics companies –	Transport operators will experience slightly higher transport costs due to the introduction of new road tolls, external cost charges and congestion charges. Firms can react in several ways: they can absorb these costs; they can pass on these

[92] Ex-post evaluation of Directive 2004/52/EC on the interoperability of electronic road toll systems in the Community and Commission Decision 2009/750/EC on the definition of the European Electronic Toll Service and its technical elements

Who is affected	How are they affected?
many of which SMEs	costs to their customers; or they can reduce the impact on operating costs by adapting their operation to the new circumstances through route shift, travel time shift, frequency reduction, modal shift, or increased uptake of low/zero emission vehicles. The overall impact is generally expected to be small/insignificant, although it will likely vary depending on location of the firm, with those located in peripheral regions seeing the most negative impacts. SMEs may also be more affected, since they have less capability to adapt to changes using the mitigation actions explained above. There are also corresponding benefits in the form of increased reliability and speed of deliveries from lower congestion and better road quality. Firms investing in low/zero emission vehicles will benefit from lower fuel/running costs that are expected to more than compensate for increased purchase prices over the lifetime of the vehicles. In addition, hauliers will probably be compensated through reduced taxes, where Member States choose to reduce these as (partial) compensation for new road user charges.
Private road users	Regular users of toll roads would experience hardly any difference in road charge on average but, like hauliers, would benefit from better road conditions and reduced congestion. Occasional road users would benefit from fairer treatment (lower charges) in Member States with time-based charging. Those travelling regularly by car in rush-hour on roads with distance-based charging may – only in case the Member State decides to introduce time-differentiated charging – either be required to change habits and/or transport mode, or would face higher road charges and be the main beneficiaries of reduced congestion in exchange. The exact level of road charge will depend on the specific local context; however, as an example, a trip with 10 km in near capacity condition (7 km on rural and 3 km on metropolitan motorway) may be charged up to 1-2 euro – a price very much comparable to an equivalent trip by train or bus. Indeed it would be possible to mitigate even this small cost by carpooling. The cost of long distance travel by bus may slightly increase (around 1 euro per passenger on trip involving 400 km of motorways).
Road operators	Assuming that a significant portion of collected tolls would be allocated to the operator of the toll road, they would dispose of a stable revenue stream to maintain their road network in good/safe condition. This would make it possible for road operators to time their maintenance activities in an optimal way thereby reducing long-term maintenance costs. Those operators that have no regular road quality monitoring in place, would be required to implement such a scheme; they may need to consult other operators for the purpose of exchanging good practices and capacity building, and would be required to report on the results on a yearly basis. The costs associated with these obligations would be covered by toll revenues (the inclusion of such costs in the calculation of tolls is already provided for in the Directive).

Who is affected	How are they affected?
Manufacturers of vehicles	Manufacturers of vehicles are likely to experience a small increase in demand for zero/low emission vehicles in response to the financial incentives provided by the option. Overall, this should work in synergy with more direct supply side measures (i.e. CO_2 Regulations) to provide incentives for production of cleaner vehicles, which in turn may improve competitiveness of manufacturers. Overall, the increase in demand for low CO_2 vehicles is expected to be small.
Shippers and Consumers	Shippers might be required to adapt their shipping practices to slightly modified transport prices (depending on the itinerary), but would benefit from more efficient transport operations, reduced delays, more predictable delivery times. This is especially important to firms working for sectors such as manufacturing and retail (where there is high reliance on just-in-time delivery). Impacts on consumer prices are expected to be negligible, even under cases of 100% cost pass-through.

13. ANNEX G: ADMINISTRATIVE AND COMPLIANCE COSTS

The annex explains the key assumptions and the method used to estimate the costs implied by the different policy options for the Member States and the road users in terms of phasing out of vignette schemes and moving towards distance-based charging schemes.

Please note that these costs correspond to a worst-case scenario, as the calculations made in the frame of this study cannot take into account either potential synergies between Member States nor the economic or the most adapted technological choices the impacted Member States would make in the proposed scenarios (e.g. when phasing-out vignette scheme for passenger cars in PO4).

13.1. Costs for authorities

One of the key parameters for the evaluation of the costs of new/expanded tolling systems is the number of On-Board Units (OBUs) that would need to be procured by the Member States in order to provide for all of the relevant vehicles driving in their tolled network.

To estimate this parameter for HGVs, we have compared the traffic of the different countries with the figures of Belgium and extrapolated the approximate number of OBUs needed in these countries from the 700,000 OBUs in use in Belgium.

It is then assumed that the fleet of buses equals 1%[93] of the size of the fleet of HGVs.

For LDVs, we formulate the assumption that the fleet is twice the size of the HGVs fleet, on the basis of the following aspects:

- According to EC data, LDV traffic is nearly 6.5 times higher than HGV traffic[94];
- However, LDV users are less likely to equip with an OBU than HGV users:
    - For DSRC, we can observe that the equipment rate of LDV users in countries such as Spain (c. 10%), France (c. 20%) or Italy (c. 25%) is lower than for HGVs (c. 80%). Portugal is an exception as the equipment rate for LDV is around 80%. Therefore, if we assume that the equipment rate of LDVs equals on average nearly one third of the one of HGVs, the OBU fleet for LDVs would be approximately twice as big as the one of HGVs.
    - For GNSS, we can assume that the scale could be similar as for DSRC. Indeed, we can assume that smartphones could be used instead of OBUs, by a majority of LDV users.

Finally, in the case of Policy option 4, we need to isolate the LCVs (light commercial vehicles) from the total of LDVs (i.e. including cars) for some countries: this category accounts for nearly 12% of the total of LDVs[95].

13.1.1. Impacts of policy option 1

In this scenario, no impacts in terms of uptake of new schemes is to be foreseen. The situation of Belgium is impacted as the country would integrate buses in the scope of its charging scheme. This should have no perceptible impact as this category accounts for nearly 1% of the HGV fleet and that the system is today robust enough and features enough OBUs to support this growth.

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[93] c.11,000 buses are involved in the traffic in Europe vs. c.920,000 HGVs (source: Support study for the Impact Assessment for the Revision of EETS Legislation, Ricardo/TRT/4icom, 2017)

[94] Calculation based on the data on the traffic on tolled networks available from ASECAP

[95] https://ec.europa.eu/clima/policies/transport/vehicles/vans_en

13.1.2. Impacts of policy option 2

In this scenario, it is assumed that all countries currently with a vignette regime for HGVs above 3.5t (incl. buses) undertake a phase-out of the vignette by 2025 and implement a distance-based charging scheme. The table below provides the implementation costs and the yearly operational costs for the impacted countries. **The total cost of implementation for the 9 countries amounts to around €1.2 billion and the yearly operational costs are around €168 million.**

Table 13-1: CAPEX and OPEX impacts per country

Country	CAPEX (€)	OPEX (€/year)
Bulgaria	96,100,000	10,742,000
Denmark	123,320,000	21,670,000
Latvia	133,160,000	12,240,000
Lithuania	141,270,000	13,724,000
Luxemburg	79,830,000	11,707,000
Netherlands	158,500,000	19,342,000
Romania	87,350,000	8,988,000
Sweden	163,050,000	38,364,000
United Kingdom	219,300,000	31,487,000
Total PO2	**1,201,980,000**	**168,264,000**
Estonia*	76,270,000	8,978,000
Finland*	108,500,000	22,379,000
Total PO2s	**1,386,650,000**	**199,621,000**

** EE and FI in addition to the countries included in PO2*

13.1.3. Impacts of policy option 3

In this scenario, the situation in terms of impacts of uptake of new schemes is the same as in policy option 2.

13.1.4. Impacts of policy option 4

In this scenario, due to the phase-out of vignettes, from 2025, 7 countries would charge LGVs and 9 would charge passenger cars via a distance-based toll (see Table 13-2).

Table 13-2: Phase-in of distance-based scheme from 2025 for light vehicle categories

Country	LGVs	Passenger cars
Bulgaria	X	X
Latvia	X	
Lithuania	X	
Romania	X	X
Austria	X	X
Czech Republic	X	X
Hungary	X	X
Slovakia	X	X

Country	LGVs	Passenger cars
Slovenia	X	X
Luxemburg*	X	X
Netherlands*	X	X
Belgium*	X	X
Germany*	X	X

** Countries in the scope of PO4s (in addition to the countries included in PO4)*

For the countries that would introduce new tolling systems we calculated the economic impact using the same method described previously, but taking into account the inclusion of LDVs. For the 7 other countries, since toll systems are in operation in the baseline scenario, we only calculated the cost of adaptation to a larger fleet of vehicles implied by the inclusion of LDVs in the charging scheme. These calculations are based on the following assumptions:

- OBU procurement and management: needs are increased by 200%[96] if all types of LDVs are addressed and by 24%[97] if only LGVs are addressed (although rough estimations, there are no better sources of data, and these assumptions are used to gain an indication of the approximate level of costs associated with policy measures – but should be interpreted with caution given the uncertainties involved);
- Service Points: needs are increased by 50% if all types of LDVs are addressed and not increased if only LGVs are addressed (as we assume that the growth in volume can be handled by the existing Service Point network);
- Volume of transactions: increased by 200% if all types of LDVs are addressed and by 24% if only LGVs are addressed.

For the countries that already have a distance-based scheme for HGVs, we conducted an estimation of the cost of *adaptation* to a larger fleet of vehicles implied by the inclusion of LDVs for Belgium (GNSS) and Slovenia (DSRC).

- For Belgium, which is representative of GNSS-based systems, the variations amount to around 110% for the CAPEX and around 138% for the OPEX.
- For Slovenia, which is representative of DSRC-based systems, the variations amount to around 3% for the CAPEX and around 39% for the OPEX.

The significant difference between the two cases is mainly due to the much higher cost of GNSS OBUs compared to DSRC OBUs (c. 150€ vs. c. 10€) for the CAPEX and to the telecommunication costs (which vary with the number of OBUs and which are not existing in the case of DSRC) and the OBU maintenance costs (which are much higher for GNSS OBUs).

Table 13-3 provides the implementation costs and the yearly operational costs for countries affected by policy option 4.

Table 13-3: CAPEX and OPEX for the impacted countries in PO4[98]

Country	Type	CAPEX (€)	OPEX (€/year)

[96] As mentioned above, we assume that the OBU fleet for LDVs equals the double of the one of HGVs

[97] As mentioned above, we assume that OBU fleet for LGVs accounts for 12% of the total of LDV fleet, so 24% of the one of HGVs

[98] For Austria, Czech Republic, Slovakia, Germany and Hungary, the CAPEX and OPEX only take into account the additional costs implied by PO4 related to the bigger fleet of OBUs (i.e. purchase of new OBUs for CAPEX; telecommunication and OBU maintenance for OPEX)

Country	Type	CAPEX (€)	OPEX (€/year)
Bulgaria	New scheme	127,300,000	14,202,000
Denmark	New scheme	123,320,000	21,670,000
Latvia	New scheme	133,400,000	12,943,000
Lithuania	New scheme	141,610,000	14,689,000
Luxemburg	New scheme	79,830,000	11,707,000
Netherlands	New scheme	158,500,000	19,342,000
Romania	New scheme	118,550,000	12,406,000
Sweden	New scheme	163,050,000	38,364,000
United Kingdom	New scheme	219,300,000	31,487,000
Slovenia	Extension	3,088,000	3,880,000
Austria	Extension	18,000,000	612,000
Czech Rep.	Extension	14,000,000	476,000
Slovakia	Extension	6,000,000	204,000
Hungary	Extension	28,080,000	2,347,200
Total PO4	**-**	**1,334,028,000**	**184,329,000**
Estonia*	New scheme	76,270,000	8,978,000
Finland*	New scheme	108,500,000	22,379,000
Luxemburg**	New scheme	10,165,000	9,706,000
Netherlands**	New scheme	159,500,000	22,418,000
Belgium	Extension	223,650,000	41,495,296
Germany	Extension	280,800,000	23,472,000
TOTAL PO4s	**-**	**2,192,913,000**	**312,777,480**

**From PO2s*

***Additional cost for including LDVs in the sensitivity option PO4s on top of new scheme in PO4*

13.2. Costs for road users

The evaluation of the cost borne by road users with the introduction of distance-based charging schemes in the studied countries is based on three main parameters:

- The size of the OBU fleet of the different countries and for the different vehicle categories (as explained above). We assume that the OBU fleet in use by the road users accounts for 80% of the OBU fleet procured by the countries, as c. 20% is usually in the "off" stages of the OBU lifecycle and thus not in use by road users (e.g. in refurbishment, in Service Points etc);
- The average yearly cost of an OBU for a road user calculated in the frame of the Support study for the Impact Assessment for the Revision of EETS Legislation (Ricardo/TRT/4icom, 2017), which covers OBU procurement costs, time losses and related administrative costs;
- The penetration rates of the EETS providers in the different EU-countries, as evaluated in the of the Support study for the Impact Assessment for the Revision of EETS Legislation (Ricardo/TRT/4icom, 2017).

For each country, we estimation the number of OBUs in use in the different policy options, we adjust it with the penetration rate of EETS providers (which allow road user to use in a given country an OBU already used for other countries), and we price the total cost it means for road users with the average yearly cost.

13.2.1. Policy option 2

We evaluate the yearly compliance costs borne by HGV road users stemming from the introduction of distance-based schemes in the impacted countries at nearly **8 million euros from 2020 to 2025** (as only Bulgaria is concerned) and at **198 million euros from 2025 onward.**

In the context of PO2s, the cost borne by road users from 2025 onwards would be brought to 228 million euros.

13.2.2. Policy option 3

In this scenario, the situation in terms of impacts of uptake of new schemes is the same as in policy option 2.

13.2.3. Policy option 4

We evaluate the yearly compliance costs borne by road users stemming from the introduction of distance-based schemes in the 9 countries with no existing distance-based schemes according to the scenario of policy option 4 at nearly **8 million euros from 2020 to 2025** (as only Bulgaria is concerned) and at nearly **206 million euros from 2025 onward**.

We evaluate the yearly compliance costs borne by the road users entering in the scope of the extension of distance-based charging to LDVs in the remaining countries with exiting distance-based schemes at nearly **34 million euros from 2025 onward.**

In total, we estimate the impact of policy option 4 on road users at nearly 8 million euros from 2020 to 2025 and at nearly 240 million euros yearly from 2025 onward.

In the context of PO4s, the cost borne by road users from 2025 onwards would be brought to 310 million euros.

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15. ANNEX I: GLOSSARY

DRSC	Dedicated Short Range Communication
EC	European Commission
GNSS	Global Navigation Satellite System
GHG	Greenhouse gases. Pollutant emissions from transport and other sources, which contribute to the greenhouse gas effect and climate change.
HDV	Heavy Duty Vehicle – HGVs and buses and coaches
HGV	Heavy Goods Vehicle
LCV	Light Commercial Vehicle, or vans, vehicles up to 3.5t
LDV	Light Duty Vehicles, meaning LCVs and passenger cars
Polluter pays principle	Stipulates that the user should pay the full social cost (including environmental costs and other external costs) of their activity. The principle is enshrined in the Treaty on the Functioning of the European Union, as this stipulates that the principle should underpin the EU's environmental policy.
User pays principle	Aims at recovery of infrastructure costs. This is consistent with the elements of a fair and efficient pricing system for transport, where prices paid reflect the real costs of the journeys.

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