Specialist Professional and Technical Services (SPaTS-) Framework
Lot 1

Task 1-798
TSTR0009 Updating Marginal External Costs of Road Freight

Executive Summary Report
Final

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Document history

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1 Introduction

Marginal External Costs (MECs) reflect external costs of an additional vehicle (or vehicle kilometre) added to the transport system. In the case of MEC of road freight in the UK, they reflect the impact of an additional kilometre of Heavy Goods Vehicle (HGV) traffic entering the UK road network.

MECs are primarily used to inform and optimise pricing schemes and modal change support schemes. They are key inputs to mode shift grants provided by the Department for Transport (DfT) to encourage a shift from transporting freight by road to rail or water. Based on MECs, the Mode Shift Benefit Values are calculated to determine the allocation of mode shift grants. The objective of this research project (hereinafter: the project) was to update selected MECs of HGVs, for both articulated and rigid goods vehicles, hereby referred to as 'artics' and 'rigids', respectively. The scope of this project covers the Infrastructure, Accidents, Noise and 'Other' external costs of HGVs. The MEC Other category includes:

- Up and down stream processes,
- Soil and water pollution
- Nature and landscape
- Driver frustration/stress
- Fear of accidents
- Community severance
- Visual intrusions

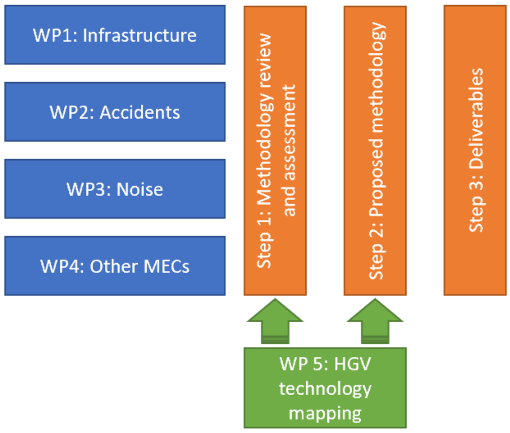

Figure 1: MECs calculation approach

As shown in Figure 1, the project was structured around five key work packages reflecting the MEC categories considered, respectively Work Package 1 (WP1), WP2, WP3 and WP4. An additional work package, WP5, provided input related to HGV technology uptake forecast. The first step in the process was to conduct a review of MEC calculation methodologies, highlighting the evolution of MEC methodologies and recommending the most suitable methods for MECs calculations, including the options and value added in developing new methodologies.

The next step was the development of the recommended methodology for DfT requirements. Technical guidelines for the updated MEC methodology provide a comprehensive description of data sources, calculation procedures, indexation methods and sensitivity scenarios. In the final step, the MECs calculation model was developed as a practical implementation of the methodologies.

This document presents the executive summary of the project. Further details on the methodologies analysed, calculations and results can be found in the accompanying technical report.

The scope and structure of the report is as follows:

- Sections 3 to 5 describe the methodological approaches developed for MEC Accidents, Infrastructure and Noise.
- Sections 6-8 present the methodology established for MEC Others, split into three distinct categories:
  - MEC Behaviour combines the sub-categories driver frustration/stress, fear of accidents, community severance (section 6)
  - MEC Environment covers the sub-categories soil and water pollution, nature and landscape and visual intrusions (section 7)
  - MEC Up and downstream processes accounts for the impacts of emissions from energy and fuel production and distribution (section 8).
- Section 9 describes the sensitivity scenarios of MEC to take into account the uptake of future technology and low carbon fuels in future years.
- Section 10 summarises the results and recommendations for all MEC categories.

2 Approach to updating the MECs

2.1 Methodology review

Over the last 20 years, numerous research projects addressed MEC calculation methodologies, including several EU funded initiatives which provided a comprehensive estimate of average and marginal external costs for all transport modes. This study was based on the review of these best practices complemented by additional subject-specific documents.

Table 1 summaries the methodology approaches, number studies and timeframe of the publications reviewed for each MEC category.

Table 1: Summary of MECs' methodology review

MEC category	Methodology approaches reviewed	Number of studies reviewed	Publications timeframe covered
MEC Infrastructure	Cost allocation approach Cost function approach Econometric approach	5	2001 to 2016
MEC Accidents	Cost allocation approach Marginal costs approach	10	1998 to 2016
MEC Noise	Top down approach Bottom up approach	7	2001 to 2016
MEC Behaviour	Stated preference studies Qualitative assessments Travel time value uplift Contingency valuation Stated preference and household surveys	13	1993 to 2018
MEC Environment	Ecosystem services assessment Landscape scale assessment Dose response / restoration cost	9	1999 to 2019
MEC Up and downstream processes	External costs of emissions of energy production and distribution Detailed cost of lifecycle emissions for all emission types Combined vehicle and energy impacts [1]	9	2008 to 2018

2.2 Methodology selection

The following criteria were used to select the most appropriate approaches for each MEC-specific methodologies:

- **Suitability of the methodology approach.** To estimate the marginal external costs of transport two general approaches are widely used: a bottom-up and top-down approach, summarised in Table 2. The existing literature recommends a bottom-up approach for efficiently pricing. In this project, feasibility of development of the bottom-up methodology was evaluated for all MECs against other criteria discussed below, namely, data availability, granularity and accuracy of the output values and deliverability). A mixture of top-down and bottom-up approaches was adopted to estimate the MECs.

[1] Other methodologies built on the above but limited to one fuel type or vehicle type

Table 2: Types of methodology approach for calculation of marginal external costs

Type of approach	Definition
Bottom-up approach	The bottom-up approach calculates the impacts of an individual vehicle, which are subsequently translated to overall impacts (per vehicle category) by multiplying them by the total number of vehicles (or vehicle kilometres). The overall impacts are multiplied with relevant shadow prices[2] to estimate the total external costs. The bottom-up method allows to consider specific traffic, vehicle and infrastructure conditions and commonly follows the impact pathway methodology[3]. This approach is widely recommended for pricing purposes as more precise and accurate, with a potential for better differentiation and disaggregation. On the other hand, the bottom-up approach is costly, time consuming and highly dependent on data availability and quality
Top-down approach	The top-down approach is used to a) benchmark the results of the bottom-up calculations, b) overcome data scarcities and lack of available impact pathways (or damage costs). In this approach, the starting point is to calculate the total impact of road traffic and translate it into total external costs by using relevant shadow prices. Subsequently, the total costs are allocated to different vehicle types based on appropriate weighting factors.

- **Data availability.** An assessment of data availability was conducted to determine which methodologies are feasible to implement within the scope and timescales of this project. Both the overarching data on HGV traffic, fleet structure and performance, and MECs-specific data sets were identified and used as the cut-off criteria to sift the methodology options.
- **Granularity and accuracy of the output values.** MEC methodologies were reviewed in the context of the granularity and accuracy of the outcomes. The fit-for-purpose approach was adopted to identify methods which provide disaggregation levels and accuracy which meets the project objectives. We made sure that the methodologies we recommend will provide outputs that are compliant with Transport Analysis Guidance (TAG) disaggregation levels and can be used in conjunction with TAG datasets.
- **Deliverability**. The methodologies which provide the best value for money and are feasible to be developed in the timeframe of the project were chosen for each MEC.

The summary of adopted methodologies is presented in Table 3.

Table 3: MEC methodologies adopted

MEC components	Options to Update MEC values
MEC Infrastructure	Extended cost allocation approach. A top-down methodology considering variations at the local authority level.
MEC Accidents	Cost allocation approach. A bottom-up methodology used in previous MEC calculations.

[2] In this study shadow prices refer to the price of carbon and other pollutants. These prices are estimated based on the cost of mitigating emissions, consistent with the UK's short and long-term greenhouse gas emissions targets.
[3] Impact pathways is a bottom-up approach that estimates the costs by following the pathway from source emissions via quality changes of air, soil and water to physical impacts.
The term impact pathway relates to the sequence of events linking an issue, in this case, emissions, to an impact, for instance, degradation of infrastructure and subsequent monetisation.

MEC components	Options to Update MEC values
MEC Noise	Bottom-up approach. A new methodology based on Nord2005 noise propagation model, compliant with TAG noise impact valuation data, and reflecting state-of-the-art research results on HGV impacts on noise.
MEC Environment	Bottom-up approach. A new methodology based on dose response and restoration cost method, linking HGV emissions to habitat damages, and reflecting state-of-the-art research on dose response and habitat restoration costs.
MEC Behaviour	Bottom-up approach. A new methodology based on the travel time uplift approach, reflecting state-of-the-art research on behavioural impacts of traffic conditions.
MEC Up and down stream processes	Bottom-up approach. A new methodology based on HGV fleet composition scenarios.

2.3 Methodology framework

Initially, four MEC categories were considered:

- Infrastructure,
- Accidents,
- Noise
- 'Other' external costs, including
  - Up and down stream processes,
  - Soil and water pollution
  - Nature and landscape
  - Driver frustration/stress
  - Fear of accidents
  - Community severance
  - Visual intrusions

In the course of the project, 'Other' category of external costs was divided into three separate MEC types:

- Environment, which addresses environmental costs such as soil and water pollution, nature and landscape, and visual intrusion
- Behaviour, which considers driver frustration and stress, fear of accidents, and community severance
- Up and downstream processes which accounts for the production of energy, from exploration at the primary energy source to the supply at the point of distribution.

These three categories were considered together with Infrastructure, Accidents and Noise. Six distinct methodologies were developed for evaluating the MECs of these categories.

In order to ensure consistency between MEC values, two overarching assumptions were made to guide methodology development for each MEC category:

1. **Consistent disaggregation levels** were defined for all MECs, which include 2 vehicle types, 3 road types and 4 area types. Also, a differentiation between congestion free flow and congested traffic conditions was considered and included in the methodology to calculate intermediate MEC values[4]. The MEC disaggregation levels (including the congestion levels used to estimate the intermediate MEC values) and their representation in TAG classification are presented in Table 4.

[4] The final MEC values report the results of the weighted average of the congestion levels.

Table 4: Disaggregation levels for MEC values

MEC Disaggregation Level	TAG Code
Vehicle type	
Rigid vehicles (rigids)	NA
Articulated vehicles (artics)	NA
Road type	
Motorways	Road type 1
A Roads	Road types 2-5
Other Roads	Road types 6-7
Area types	
London	Area types 1-3
Inner and Outer Conurbations	Area types 4-5
Other Urban	Area types 6-9
Rural	Area type 10

2. **Consistent price years** and forecast years for all MEC values were defined. The base values were calculated in 2020 prices for seven forecast years (2020, 2025, 2030, 2035, 2040, 2045, 2050). MEC values were also computed for additional combinations of price years and forecast years to provide required inputs for the DfT Mode Shift grant scheme (see Table 5).

Table 5: Price and impact year assumptions for MEC calculations

Price year	2020	2020	2025	2030	2035	2040	2045
Impact year	2020	2025	2030	2035	2040	2045	2050

The following sections summarise the recommendations for updating methodologies for each category analysed as part of this project. For each section the key results or updates to the respective MEC value is presented.

3 Accidents

Marginal external cost of accidents (MEC-A) is the extra cost imposed by an accident involving a freight vehicle on all other road users and the general public. The external costs of accidents in TAG and also the values applied for the mode shift grants, were calculated based on marginal cost approach presented in the study by Sansom et al (2001).

The bottom up marginal cost approach used by Sansom et al. remains the most appropriate method for calculating MEC-A for road freight as this method provides accident costs that are dependent on traffic volumes. MEC-A for this study was calculated by taking the risk elasticity[5] multiplied by accident costs and the accident risk rate, where the risk elasticity is the increase in the accident rate per vehicle kilometre for all transport users. In this study, a conservative risk elasticity estimation of 0.25 is used irrespective of the vehicle or road type and is assumed to be constant throughout all years modelled. However, we recommend to re-estimate the risk elasticities used by Sansom et al. based on the latest UK traffic and accident data.

The freight MEC-A values for different road and area types for 2025 calculated using the updated marginal cost approach is presented on Figure 2 and in Table 9 (Appendix 1 MEC Accidents). In general, 'Motorways' have the lowest marginal external cost, followed by 'A Roads' and 'Other Roads'. The lowest and highest MEC-A value was identified for 'Motorways' in Rural areas and 'Other Roads' in

[5] The impact of additional traffic on accident risk rates is known as the risk elasticity.

London, respectively. There is no available data to differentiate between impacts of artics and rigids, so they were analysed as one category.

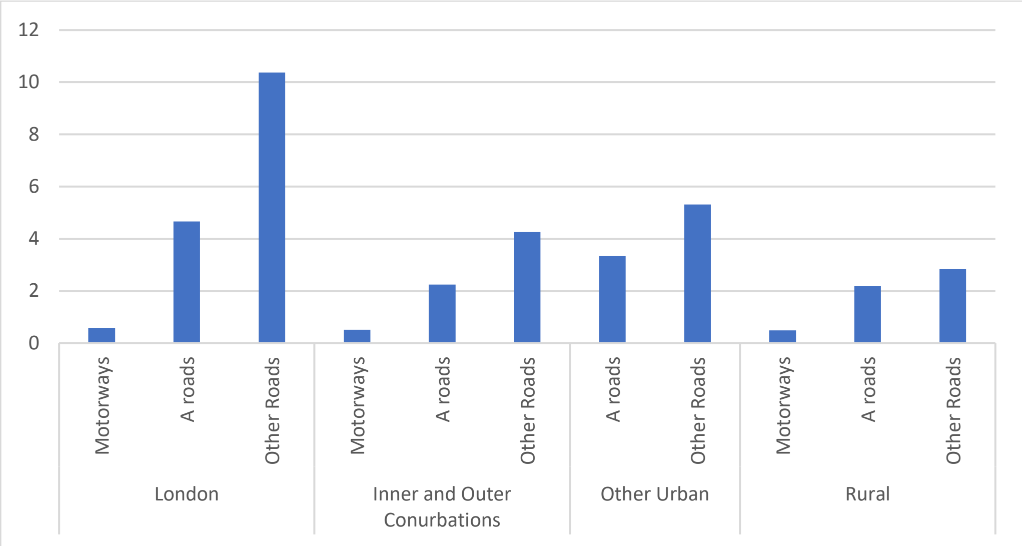

Figure 2: MEC-A values, pence per vkm, 2025 impact, 2020 prices, rigid and articulated HGVs

MEC-A values calculated using the updated methodology tend to be lower than values computed based on the previous method, both for rigid and articulated HGVs (see Figure 3). This is because HGV traffic volumes, in general, have not increased significantly in last 20 years, except for 'Motorways', and the casualty rate, for which HGVs are involved in personal injuries, reduced by 52.6% between 2000 and 2017. The only significant increase of MEC-A values was observed for Other roads in London area, where the new values are more than 100% higher than the previous ones.

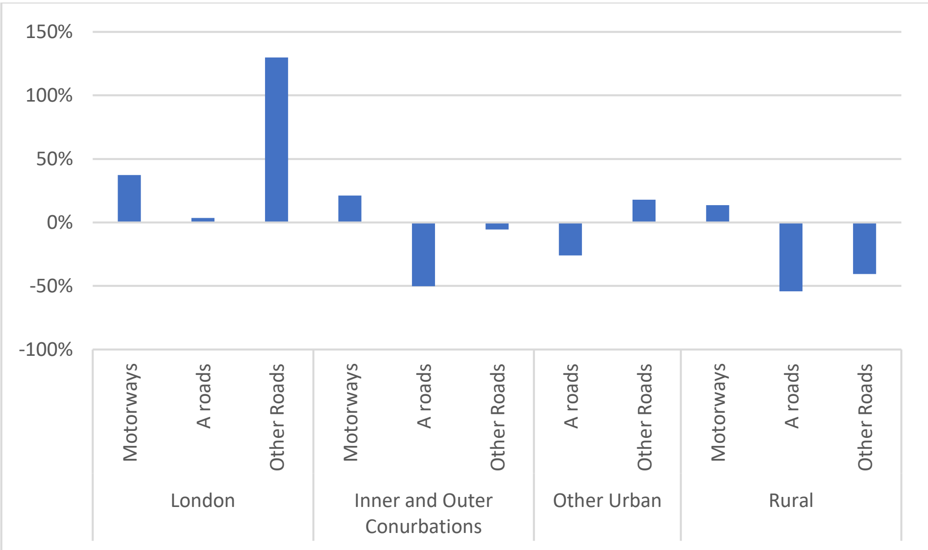

Figure 3: Difference between the MEC-A values computed using the new and the previous methodology, rigid and articulated HGVs, 2025 impact, 2020 prices, previous values = 100%

4 Infrastructure

Marginal external infrastructure costs (MEC-I) relate to direct expenditure for renewal of the road network, routine maintenance of road infrastructure and road operation, as well as the financing cost of capital investments. The infrastructure costs can be categorised into fixed costs, which are constant irrespective of traffic volumes, and variable costs, which vary with traffic volumes and should be taken into account in a marginal cost analysis. Variable road maintenance costs are typically used as a proxy to calculate the MEC-I. This proxy is based on the assumption that specific categories of road maintenance costs in a given year provide a reasonable indication of the damage to roads caused by vehicles, such as HGVs, using the roads in that year.

The extended cost allocation method has been the selected for calculating the MEC-I. This method involves allocating road maintenance expenditure across 12 road and area types at the local authority level, instead of just at the level of 11 area types. This approach is similar to the methodology currently used to calculate MEC-I in the TAG Data Book but the allocation of the road maintenance cost is determined using the volume and composition of traffic flows weighted by vehicle load (axle load). This approach is more methodologically rigorous than the original TAG cost allocation method as it uses data at the local authority level, namely expenditure on maintenance, and can potentially provide more accurate results and extra insights on regional distribution of MEC-I.

National MEC-I values are presented in 2020 prices on Figure 4 and in Table 10 (Appendix 2 MEC Infrastructure). In general, 'Motorways' have the lowest marginal external cost, followed by 'A Roads' and 'Other Roads'. The lowest and highest MEC-I value was identified for 'Motorways' and 'Other Roads' in London, respectively. Artics generally have much higher external infrastructure cost than rigids, especially for the 'Other Roads' category. This is because artics usually carry higher load, which leads to a higher weighting borne by artics in calculating MEC-I. MEC-I values were also evaluated at regional level and can be found in Table 11 and Table 12 in 2020 prices for rigid and articulated HGV, respectively.

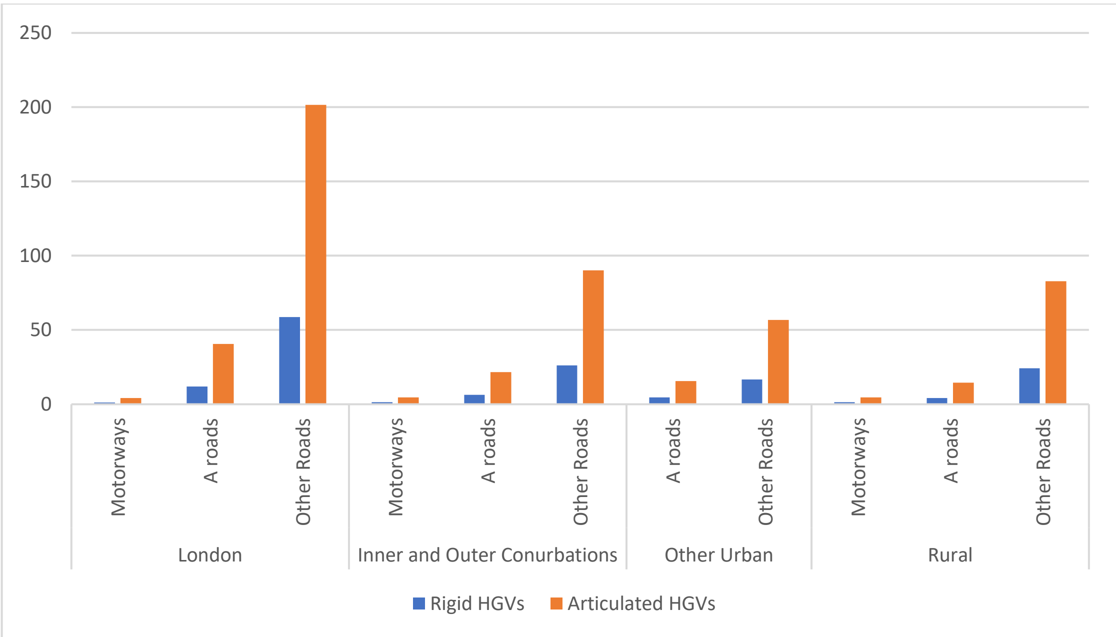

Figure 4: MEC-I values, pence per vkm, 2025 impact, 2020 prices, by HGV type

MEC-I values calculated using the updated methodology tend to be similar or lower than values computed based on the previous method, both for rigid and articulated HGVs (see Figure 5). The major exceptions are A-roads and Other roads in London area, where the new values are more than 50% higher than the previous ones. This is a result of a more detailed approach to calculation of regional MEC values on the local authority level, which enabled to capture the differences for the London area. The expenditures of London local authorities on road maintenance and related services to keep the required road infrastructure standards are much higher than in other areas.

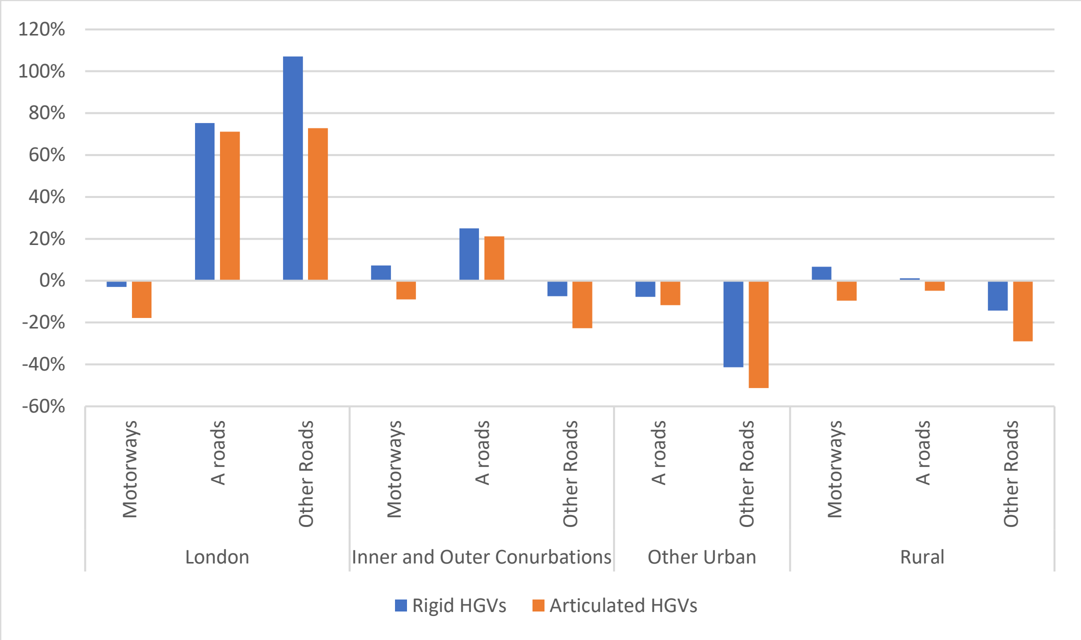

Figure 5: Difference between the MEC-I values computed using the new and the previous methodology, by HGV type, 2025 impact, 2020 prices, previous values = 100%

5 Noise

Marginal external cost of noise (MEC-N) is the extra cost imposed by the noise impact of an additional HGV vehicle entering the road network. Two major impacts are usually considered when assessing noise impacts: annoyance and health impact. Marginal noise costs are highly dependent on local factors. Three key drivers for marginal noise costs are identified as population density close to the emission source, existing noise levels and time of the day. Other relevant cost drivers include vehicle age, the slope of the road, the type of the road surface and the presence of noise barriers.

The MEC-N methodology proposed in this study is a bottom-up approach, where the noise generated by traffic was calculated and an economic cost in line with TAG guidelines was applied to it based on the noise levels at sensitive receptors or households located in proximity to it. The simplified process is shown in Figure 6.

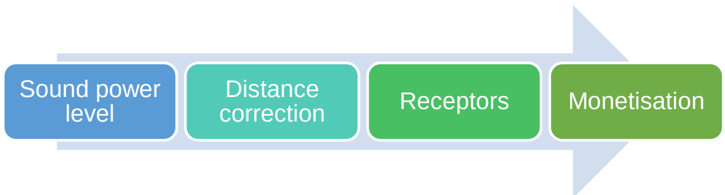

Figure 6: MEC Noise – key calculation steps

Road traffic noise levels were calculated based on the traffic flow on the road, the fleet composition and the average traffic speed. Based on the review of noise calculation methods, Nord2005 noise calculation method was used in this study to predict noise emissions. The method correlates reasonably well with CRTN (UK noise calculation method), providing flexibility in studying different mixes of heavy vehicles on the road network and allowing for potential changes in noise arising from changes in policy or technology (e.g. changes in propulsion noise due to use of electric heavy vehicles). The overall received noise levels considered in this project consisted of noise contributions from light vehicles (passenger cars) and heavy goods vehicles. The overall sound power level (noise from both light vehicles and heavy good vehicles) was then corrected for distance to reflect the effect of sound propagation. The information on corrected noise levels and population sizes at each of the distances where the sound pressure levels were predicted was transposed into a TAG workbook, which calculated the Net Present Value (NPV) and other monetised noise impacts. The results calculated in 2010 prices were transferred to 2020 prices.

The calculated MEC-N values (pence/vehicle kilometre) for the 2025 scenario are provided on Figure 7 and in Table 13 (Appendix 3 MEC Noise). The MEC-N values for ‘Other Roads’ are substantially higher than the corresponding values for ‘A roads’ and ‘Motorways’ in any given area type, HGV category and year of traffic projection. The total MEC-N costs for ‘Other Roads’ are smaller than for other road types, but a disproportionately smaller number of additional HGVs are required to result in a significant noise change. This results in a much higher MEC-N per vehicle km.

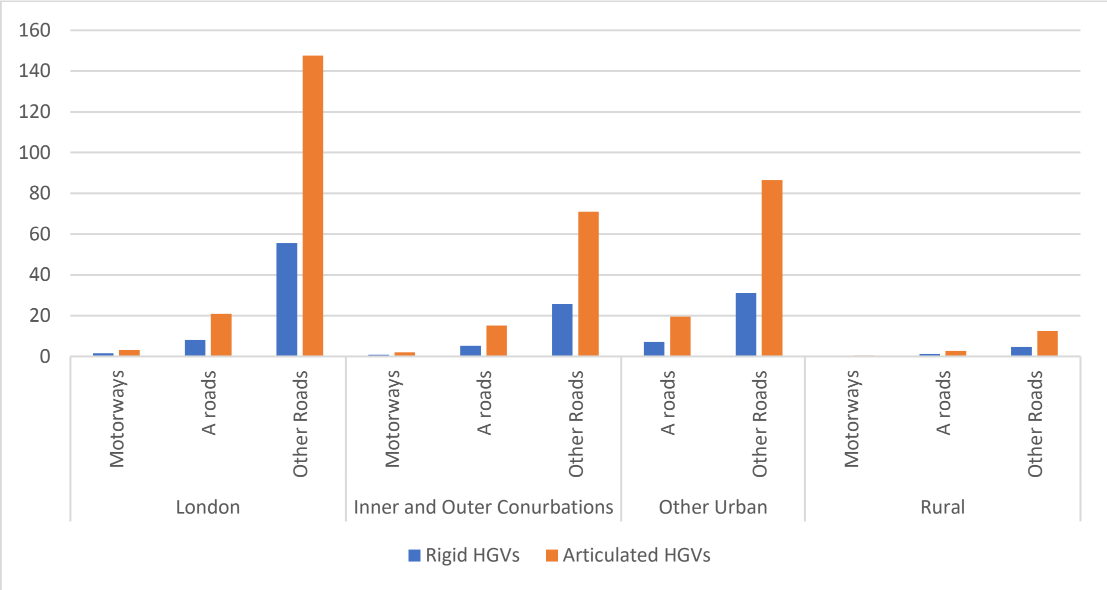

Figure 7: MEC-N values, pence per vkm, 2025 impact, 2020 prices, by HGV type

MEC-N values calculated using the updated methodology tend to be much higher than values computed based on the previous method for Other roads, both for rigid and articulated HGVs (see Figure 8). This is a result of the fact, that the current bottom-up methodology enables to capture the noise impacts for different traffic conditions. Although the total MEC-N costs for ‘Other Roads’ are smaller than for other road types, due to traffic composition a disproportionately smaller number of additional HGVs are required to result in a significant noise change.

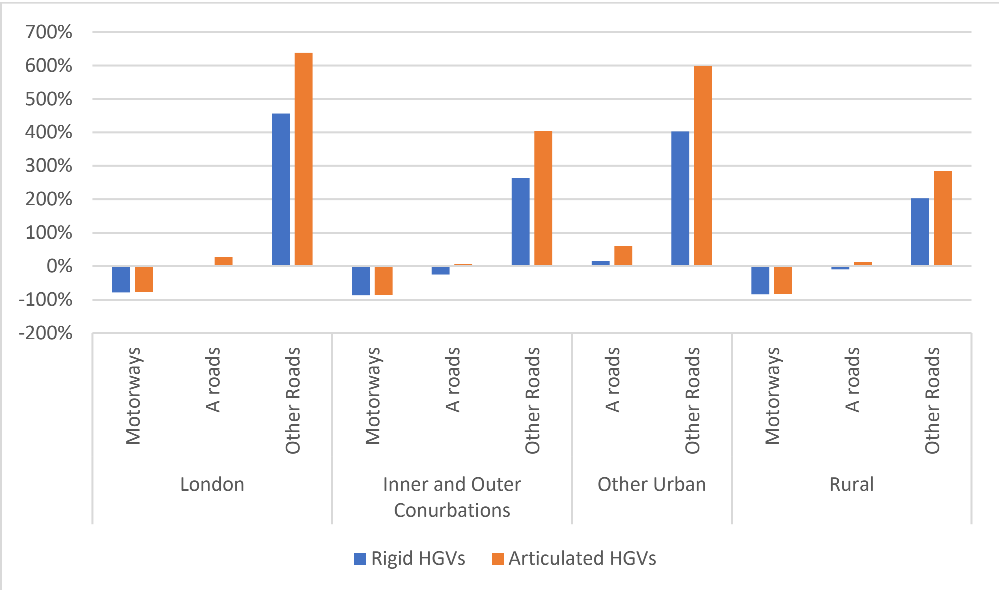

Figure 8: Difference between the MEC-N values computed using the new and the previous methodology, by HGV type, 2025 impact, 2020 prices, previous values = 100%

6 Behaviour

The marginal external behavioural costs (MEC-B), including driver frustration/stress, fear of accidents and community severance, are not currently differentiated by the DfT. Encountering an HGV was identified as one of three key causes for driver's frustration and stress (including fear of accidents). The researches demonstrated that there is a direct relationship between driver frustration and the number of HGVs encountered on the road. Drivers are willing to travel longer to minimise the number of HGVs encountered on the route.

The travel time uplift methodology has been adopted to estimate MEC-B values in this study. It covers the behavioural impacts of driver frustration/stress and fear of accidents resulting from an additional HGV entering the system. It is a bottom-up approach built upon the recent research results on the level of frustration and stress experienced by drivers encountering HGVs. In this methodology, the marginal behavioural cost of an HGV is represented by additional time which drivers are willing to add to their journey to avoid encountering an HGV.

The results for the different road and area types in 2020 price year are presented on Figure 9 in Table 14 (Appendix 4 MEC Behaviour). It shows that 'A Roads' exhibit the largest MEC Behaviour values, while 'Motorways' have the largest value for Rural areas. The highest MEC-B values are identified for 'A Road' in London and the lowest for 'Other Roads' in the Rural. In general, artics introduce slightly higher marginal external cost then rigids for all area and road types.

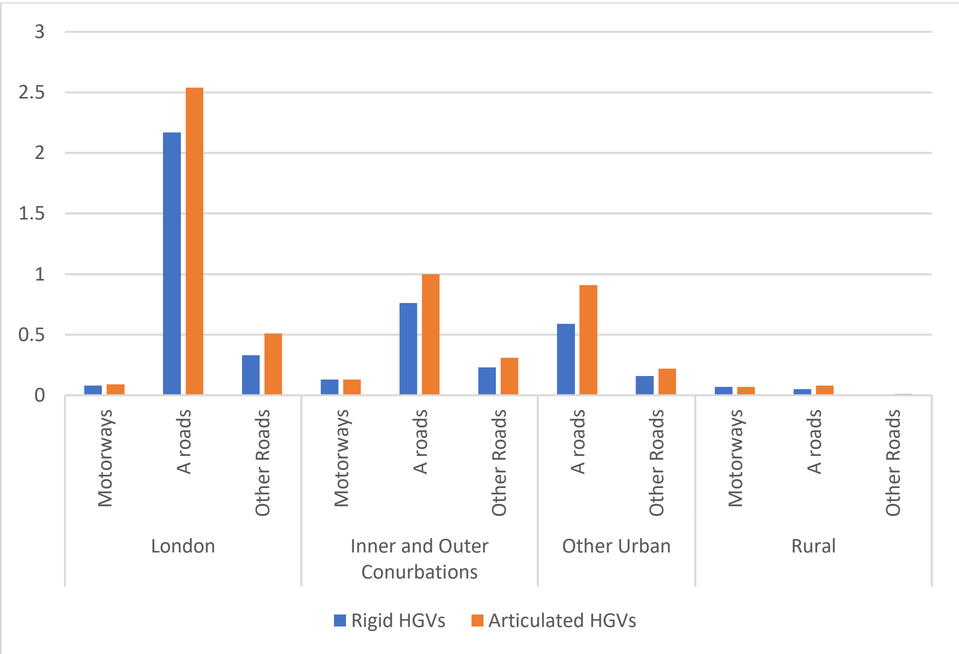

Figure 9: MEC-B values, pence per vkm, 2025 impact, 2020 prices, by HGV type

The methodology previously used for MECs calculation did not include computing separate MEC-B values, so the comparison between previous and current MEC-B values is not possible.

7 Environment

External environmental costs associated with the HGV transport are borne from both habitat effects and vehicle emissions. In this study the external costs falling into marginal external environmental cost (MEC-E) are 'Soil and Water Pollution' and 'Nature and Landscape'.

The methodological framework developed for calculating MEC-E is based on a dose response function and a penalty factor. Work by Natural England (2016) has demonstrated that increases in emissions tend to promote the level of habit degradation. The dose response factor explores how a change in vehicle emissions, specifically nitrous oxides (NO_X) will result in a change to the degree of habit degradation over time. The environmental impact measured through the dose function estimates the cost of restoring degraded habitat (as a function of NO_X emissions) to a non-degraded state to infer the average marginal external cost associated with HGV transport. In addition to employing a dose response function, a penalty uplift factor accounts for marginal change in HGV traffic through sensitive or unique landscapes. This is important because these sites are highly prized for their natural characteristics and the MEC values need to consider the higher marginal costs associated with HGV traffic in these areas.

Results for the base scenario for the different road and area types in 2020 prices are presented in Figure 10 and in Table 15 (Appendix 5 MEC Environment) for artics and rigids. The base scenario represents the reference case in line with Transport Analysis Guidance and that of the NTM, which assumes all HGVs are diesel until 2050, with just vehicle efficiency improvements (12% for rigids and 21% for artics between 2015 and 2050).

The value estimates from this scenario are highest for 'Other Roads' in rural areas since the natural proportion of land cover is much higher despite the fact that emissions on rural roads are generally lower than for other area types. Conversely, the least costly road type is motorways in inner and outer conurbations.

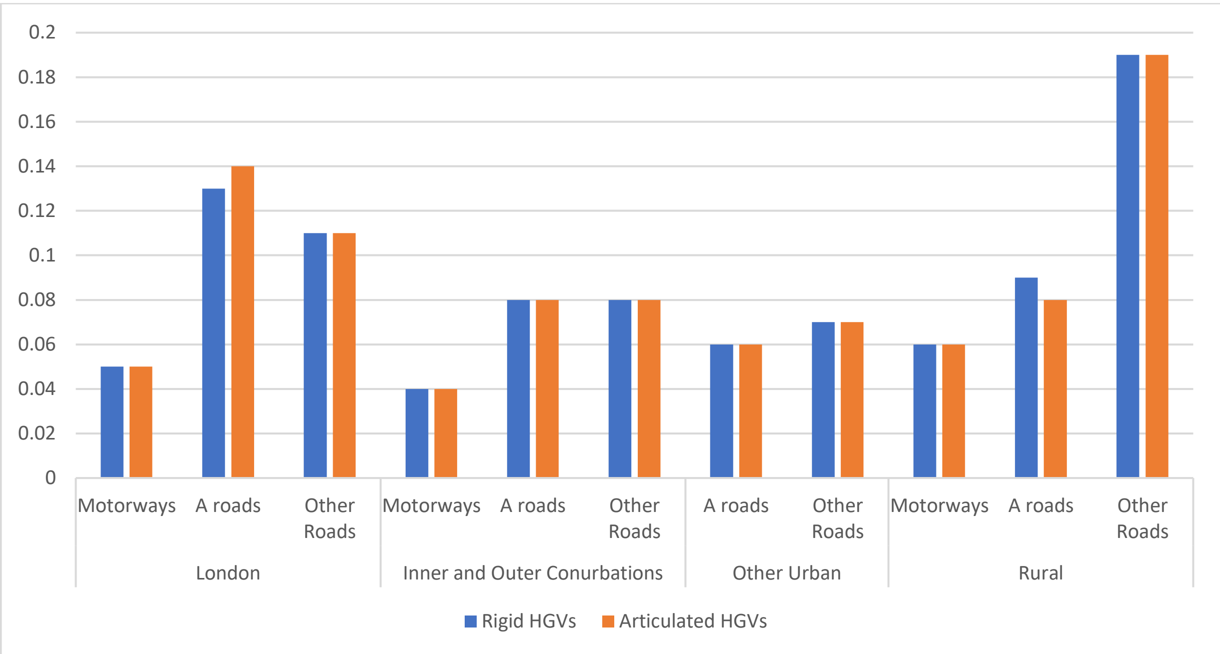

Figure 10: MEC-E values, pence per vkm, 2025 impact, 2020 prices, by HGV type

The methodology previously used for MECs calculation did not include computing separate MEC-E values, so the comparison between previous and current MEC-E values is not possible.

8 Up and Downstream Processes

The marginal costs of up and downstream processes represent the indirect effects arising from the vehicle lifecycle emissions. Impacts of up and downstream processes include emissions generated throughout the process of production and distribution of fuel and energy, emissions related to vehicle production and end-of-life and those that result of infrastructure provision.

In this study, a segmentation of up and downstream processes proposed by Patterson (2018)[6] was used as the basis of the methodology approach developed. Patterson classifies lifecycle emissions in three distinct categories:

- Well-to-Tank (WTT) emissions, which are emissions generated throughout the process from fuel production at the primary fuel source to distribution.
- Tank-to-Wheel (TTW) correspond to the emissions that result of running a vehicle, including tailpipe emissions, maintenance and servicing of vehicles.
- Embedded emissions, which are the emissions associated with the vehicle production and the corresponding vehicle end-of-life.

Figure 11 presents the disaggregation of the vehicle lifecycle emissions according to these categories.

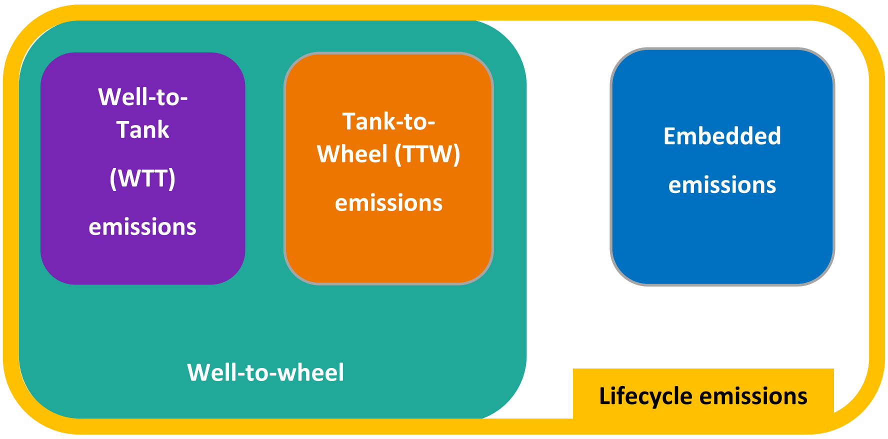

Figure 11: Vehicle lifecycle emissions

The adopted methodology to calculate MEC-UD in this study exclusively estimates the cost of WTT emissions, corresponding to energy production and distribution. The effects of TTW and WTT environmental pollutants (such as NO_X, PM_{10} and $PM_{2.5}$) were excluded as they have been registered in MEC-Air Quality[7] calculations. Also, TTW emissions (greenhouse gases emitted as a result of vehicle use) were excluded as they have been accounted in the MEC-Greenhouse Gases calculations. The downstream embedded emissions were excluded from the analysis as there is not enough industry data to back up this aspect of cost calculations.

Marginal costs of WTT emissions were calculated based on conversion of tailpipe emissions (TTW) using DEFRA's conversion factors. Finally, the average cost of the up and downstream emissions of one additional HGV in the road network was used as a proxy to estimate the MEC-UD.

MEC-UD for the base scenario in 2020 prices are presented in Table 16 (Appendix 6 MEC Up and downstream processes) for artics and rigids, by road and area types. The base scenario represents the reference case in line with Transport Analysis Guidance and that of the NTM, which assumes all HGVs will remain diesel fuelled until 2050, with just vehicle efficiency improvements (12% for rigids and 21% for artics between 2015 and 2050).

The value estimates from this scenario are highest for 'Other Roads' in London. Conversely, the least costly road type is rural 'Other Roads'. MEC-UD values are on average marginally higher for artics than rigids which is a function of the variation in CO_2 emissions (artics tend to emit more CO_2 than rigids as they generally carry higher volumes of cargo). Motorways are not present for the 'other urban' area type and so no values were computed.

[6] Patterson, J. (2018) Understanding the life cycle GHG emissions for different vehicle types and powertrain technologies. LowCVP

[7] MEC-Air Quality and MEC-Climate Change were not in the scope of this study

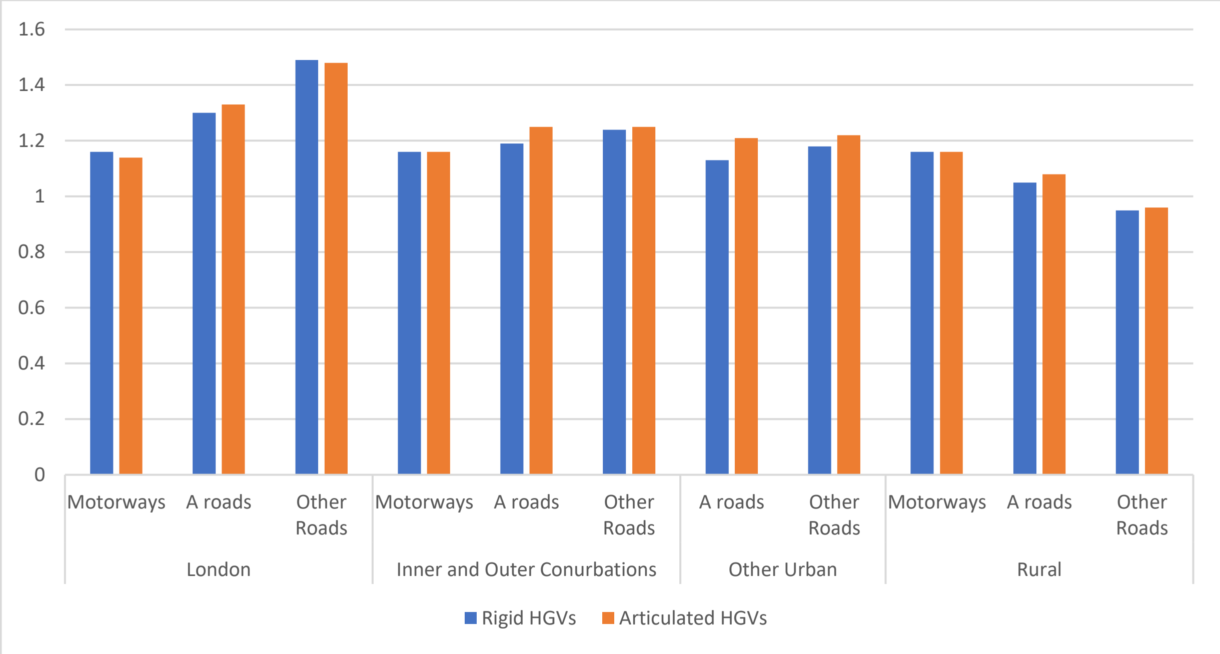

Figure 12: MEC-UD values, pence per vkm, 2025 impact, 2020 prices, by HGV type

The methodology previously used for MECs calculation did not include computing separate MEC-U/D values, so the comparison between previous and current MEC-U/D values is not possible.

9 Sensitivity scenarios

In order to reflect the key uncertainties around the uptake of new technologies two sensitivity scenarios were created, built on the base current scenario. The medium and high scenario aim to cover two areas of uncertainty: future technology uptake and the low carbon fuel deployment in freight. A review of the influence of the first element of uncertainty – future technology uptake – to the majority of the MEC categories in this study showed that currently there is limited evidence base to support a robust calculation method to account for the potential impacts of technology developments in the MEC methodologies. The effect of technology uptake has been tested on MEC-Accidents only and has been further limited to the uptake of technology progress in safety systems. With regards to the uncertainty of low carbon fuel deployment, only MEC-Environment and MEC-Up and downstream have been identified as categories where the effect of a change of fuel could pose a potential change on the MEC appraisal.

The MEC values computed for each sensitivity scenario are presented in the technical report submitted to the Department for Transport as the final deliverable of this study in October 2019.

The following sections provide further details of the sensitivity scenarios considered in the two dimensions – technology uptake and low carbon fuels uptake.

9.1 Technology uptake

A base, a medium and a high scenario of the MEC-Accidents were created to account for the future technology uptake. The scenarios have been defined as follows:

- Base scenario – uses the current accident rates (proportion of the accidents involving HGVs) based on DfT's data on vehicles in reported road accidents by vehicle type. It is assumed that no additional reduction in HGV accident rates will occur between 2015 and 2020.
- Medium scenario – The medium scenario assumes an estimated 25% reduction in the proportion of accidents involving HGVs between model base year 2015 and 2020 based on the historical trends (5% annual drop in HGV accident rates from 1999 to 2015) and expected effects of road safety technology and legislative developments that occur between 2015 and 2020. The following developments are expected to reduce road accidents between 2015 and

2020:
  - Lane Departure Warning System (LDW) - In 2015 the EU mandated the installation of LDW on all commercial heavy vehicles. Given the typical HGV life it is expected that by 2024 most HGVs will have LDW. Based on Germany published research a 70% market penetration rate of LDW systems would reduce crashes by 2.9%.
  - Automatic Emergency Breaking (AEB) – Also in 2015 the EU legislation has mandated AEB systems on newly registered HGVs. Independent safety bodies have estimated that AEB have led to a 38% reduction in rear-end crashes

- High scenario – assumes an ambitious further reduction of 5% every five years in HGV accident rates for next 25 years, resulting in an overall 25% drop in HGV accident rates between 2025 and 2050. For 2025 to 2050 the following developments are expected to reduce HGV related road accidents:
  - Advanced Driver Drowsiness Detection Systems - Advanced DDD systems such as the Denson facial detection system are currently in trial phase and likely to be commercially available in the mid-2020s.
  - TfL Direct Vision Standard and Safety Permit for HGVs - Forms part of the Mayor and TfL's Vision Zero approach to eliminating all deaths and serious injuries from London's roads by 2041.
  - The development of increasingly connected and autonomous vehicles (CAVs).

9.2 Low carbon fuels uptake

A base, a medium and a high scenario of the MEC-Environment and MEC-Up and downstream were created to account for the forecast of potential uptake of low carbon fuels. The scenarios have been defined as follows:

- Base scenario – corresponds to the current DfT forecast, where the HGV fleet is maintained at 100% diesel with efficiency improvements only.
- Medium scenario - a balanced approach to CO_2 emission reduction based on Transport Energy Infrastructure Roadmap to 2050 (Element Energy for LowCVP) and Technology Roadmap 2015 - Energy and Fuels (APCUK), focusing on the natural technology revolution and use of already available low emission fuels. This scenario is aligned with the government target of achieving an 80% reduction to CO_2 emissions by 2050.
- High scenario - based on the Hydrogen Further Ambition scenario set out in the Net Zero report produced by the Committee on Climate Change (CCC). The scenario explores how a hydrogen-based fleet of HGVs would reduce emissions and results in almost zero CO_2 emissions by the year 2050.

10 Summary and recommendations

10.1 Methodology approach

The review of the methods for calculating MECs resulted in the identification of a recommended options which ensure that each MEC category is significantly improved and provides a state-of-the-art approach to MECs calculations within the existing limitations of project duration.

- In case of MECs categories with a mature research background (MEC Infrastructure, MEC Accidents), it is proposed that the existing approach is continued with extensions and improvements focused on input data quality.
- For MEC Noise, a new methodology is recommended, based on the internationally recognized road noise calculation methods and MECs calculation approaches.
- For MEC Other, specific MECs were aggregated into three MEC categories with separate methodology recommendations: MEC Environment (including Soil and Water Pollution, Nature and Landscape and Visual intrusions), MEC Behaviour (including Drivers' stress and frustration, Fear of Accidents and Community severance) and MEC Up and Downstream processes. For

each category a new integrated methodology was proposed, providing a unique and comprehensive approach to MEC calculations based on the most recent UK data and internationally recognized impact assessment methods.

The summary of the proposed methodology developed for each MEC category and the respective improvements achieved are summarised in Table 6.

Table 6: Summary of MEC proposed methodology and corresponding improvements

MEC category	Proposed methodology	Improvements to existing approach
MEC Infrastructure	Extended cost allocation approach	Disaggregated approach offers potential for better accuracy, taking into account a detailed approach to calculate regional values based on local authority level data.
MEC Accidents	Update values using existing approach	Improvement of existing methodology by updating casualties' figures, risk rates, by reviewing internalisation and insurance deductions and costs to society. Reflects current accidents' trend.
MEC Noise	New methodology based on Nord2005 noise propagation model	Significant improvement to the existing approach, compliant with TAG noise impact valuation data. Reflects state-of-the-art research on HGV impacts on noise; provides flexibility in studying different mix of heavy vehicles on the road network and allows for potential changes in noise arising from policy or technology to be investigated.
MEC Environment	New methodology based on dose response and restoration cost method, including Environmentally sensitive areas (ESAs) penalty	Significant improvement to the existing approach, links HGV emissions to habitat damages and additionally adds an uplift factor to reflect the magnified impact associated with HGV transport through ESA. Reflects state-of-the-art research on dose response and habitat restoration costs.
MEC Behaviour	New methodology based on the travel time uplift approach	Significant improvement to the existing approach (at present behavioural impacts are not monetised). Reflects state-of-the-art research on behavioural impacts of traffic conditions, uses well-established valuation techniques. The approach minimizes the risk of double counting by including both drivers frustration/stress and fear of accidents.
MEC Up and Downstream processes	Bespoke model to estimate energy up and downstream emissions of energy and fuel production and distribution	Significant improvement to the existing approach. Wholly based on UK data based on conversion of tailpipe emissions to Well-to-Tank emissions using DEFRA's conversion factor (tailpipe emissions as a by-product of the NTM model).Reflects state-of-the-art and represents current mix of the vehicle parc as well as forecast changes to the fleet composition through to 2050.

10.2 Updated MEC values

This study presents the methodology for updating the values for the following MEC categories:

- Infrastructure,
- Accidents,
- Noise
- Environment, including soil and water pollution, nature and landscape
- Behaviour, including driver frustration and stress and fear of accidents
- Up and downstream processes, including Well-to-Tank emissions

The methodology approach adopted for each MEC differs based on availability of the data and research studies on the impact measurement and valuation. Based on these methodologies, the MEC values were calculated. The summary of MEC values for rigid and articulated vehicles (2025 impact in 2020 prices) is presented in Table 7 and Table 8.

Table 7: MEC values for Artics by road type and MEC component (pence per vehicle kilometre, 2025 values in 2020 prices)

MEC categories	MEC-B	MEC-I	MEC-A	MEC-UD	MEC-N	MEC-E
Inner and Outer Conurbations						
Motorways	0.13	4.62	0.51	1.16	2.07	0.04
A Roads	1.00	21.67	2.24	1.25	15.10	0.08
Other Roads	0.31	90.14	4.26	1.25	70.98	0.08
London						
Motorways	0.09	4.17	0.58	1.14	3.05	0.05
A Roads	2.54	40.52	4.67	1.33	20.95	0.14
Other Roads	0.51	201.60	10.37	1.48	147.61	0.11
Other Urban						
A Roads	0.91	15.55	3.33	1.21	19.59	0.06
Other Roads	0.22	56.84	5.31	1.22	86.61	0.07
Rural						
Motorways	0.07	4.59	0.48	1.16	0.44	0.06
A Roads	0.08	14.62	2.20	1.08	2.86	0.08
Other Roads	0.01	82.86	2.85	0.96	12.44	0.19

Table 8: MEC values for Rigids by road type and MEC component (pence per vehicle kilometre, 2025 values in 2020 prices)

MEC categories	MEC-B	MEC-I	MEC-A	MEC-UD	MEC-N	MEC-E
Inner and Outer Conurbations						
Motorways	0.13	1.36	0.51	1.16	0.96	0.04
A Roads	0.76	6.34	2.24	1.19	5.32	0.08
Other Roads	0.23	26.23	4.26	1.24	25.65	0.08
London						
Motorways	0.08	1.23	0.58	1.16	1.47	0.05
A Roads	2.17	11.86	4.67	1.30	8.13	0.13
Other Roads	0.33	58.65	10.37	1.49	55.59	0.11
Other Urban						
A Roads	0.59	4.55	3.33	1.13	7.18	0.06
Other Roads	0.16	16.62	5.31	1.18	31.13	0.07
Rural						
Motorways	0.07	1.35	0.48	1.16	0.20	0.06
A Roads	0.05	4.28	2.20	1.05	1.15	0.09
Other Roads	0.00	24.27	2.85	0.95	4.69	0.19

10.3 Recommendations

The analysis represented in this report revealed that in some areas the current state of the art in research on marginal external costs of heavy vehicles is limited and further research could be conducted in the future to further improve calculation methodologies. Several areas were identified where further research could bring additional value.

- **MEC Accidents**. Future research opportunities for more robust results include re-estimating the risk elasticities, the level of internalisation and disaggregate accident data by articulated and rigid vehicles and congestion bands.

- **MEC Up and downstream processes**. Further research is recommended to assess the net value of the externalities related to embedded emissions such as emissions related to the production of HGV's raw materials (e.g. metal and plastic) and disposal or re-using of vehicle's components. Also, there is a need to evaluate the impact of maintenance and servicing of vehicles on the emissions produced by freight vehicles which has been excluded from this study.
- **MEC Noise**. It may be desirable to adapt future rounds of strategic noise mapping, to allow for more detailed MEC-N studies to be conducted at a national level. However, this would require the underlying calculation methods, as well as the physical road network and classification, to be aligned with the preferred MEC-N methodology.
- **MEC Behaviour.** Further research is recommended on community severance aspect of HGV traffic impacts, as well as differences in stress and frustration generated by different HGV types (rigid and articulated vehicles), and stress impacts related to different driving patterns in relation to HGVs (e.g. there's no available research on driving along an HGV).
- **MEC Environment.** Further research is recommended in the area of ecosystem services valuation and natural capital (e.g. the valuation of landscape impacts associated with transport interventions using an ecosystem services approach). Currently available research is not suitable for calculating the MEC values, but as the science evolves there may be scope to reconsider such approaches.

Appendices

Appendix 1 MEC Accidents

Table 9: MEC Accidents – values in pence/vkm, Artics, Rigids 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	0.49	0.51	0.55	0.60	0.66	0.72	0.79	0.49	0.51	0.55	0.60	0.66	0.72	0.79
A Roads	2.13	2.24	2.42	2.62	2.87	3.16	3.47	2.13	2.24	2.42	2.62	2.87	3.16	3.47
Other Roads	4.05	4.26	4.59	4.99	5.45	6.00	6.58	4.05	4.26	4.59	4.99	5.45	6.00	6.58
London														
Motorways	0.55	0.58	0.63	0.68	0.74	0.82	0.90	0.55	0.58	0.63	0.68	0.74	0.82	0.90
A Roads	4.44	4.67	5.03	5.46	5.97	6.57	7.21	4.44	4.67	5.03	5.46	5.97	6.57	7.21
Other Roads	9.86	10.37	11.18	12.13	13.26	14.59	16.02	9.86	10.37	11.18	12.13	13.26	14.59	16.02
Other Urban														
A Roads	3.17	3.33	3.59	3.90	4.26	4.69	5.15	3.17	3.33	3.59	3.90	4.26	4.69	5.15
Other Roads	5.05	5.31	5.73	6.21	6.79	7.47	8.21	5.05	5.31	5.73	6.21	6.79	7.47	8.21
Rural														
Motorways	0.46	0.48	0.52	0.56	0.61	0.68	0.74	0.46	0.48	0.52	0.56	0.61	0.68	0.74
A Roads	2.09	2.20	2.37	2.57	2.81	3.09	3.39	2.09	2.20	2.37	2.57	2.81	3.09	3.39
Other Roads	2.71	2.85	3.07	3.33	3.64	4.01	4.40	2.71	2.85	3.07	3.33	3.64	4.01	4.40

Appendix 2 MEC Infrastructure

Table 10: MEC Infrastructure – values in pence/vkm, Artics and Rigids, 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	4.16	4.62	5.17	5.80	6.49	7.28	8.15	1.23	1.36	1.53	1.71	1.91	2.14	2.40
A Roads	19.54	21.67	24.28	27.21	30.48	34.15	38.27	5.72	6.34	7.11	7.96	8.92	9.99	11.20
Other Roads	81.28	90.14	101.00	113.16	126.79	142.05	159.16	23.65	26.23	29.39	32.93	36.89	41.34	46.31
London														
Motorways	3.76	4.17	4.67	5.24	5.87	6.57	7.36	1.11	1.23	1.38	1.54	1.73	1.94	2.17
A Roads	36.54	40.52	45.40	50.87	57.00	63.86	71.55	10.69	11.86	13.28	14.88	16.68	18.69	20.94
Other Roads	181.77	201.60	225.88	253.08	283.55	317.70	355.95	52.88	58.65	65.72	73.63	82.50	92.43	103.56
Other Urban														
A Roads	14.02	15.55	17.42	19.52	21.87	24.50	27.45	4.10	4.55	5.10	5.71	6.40	7.17	8.03
Other Roads	51.25	56.84	63.69	71.36	79.95	89.57	100.36	14.99	16.62	18.62	20.87	23.38	26.19	29.35
Rural														
Motorways	4.14	4.59	5.14	5.76	6.45	7.23	8.10	1.22	1.35	1.52	1.70	1.90	2.13	2.39
A Roads	13.18	14.62	16.38	18.35	20.57	23.04	25.82	3.86	4.28	4.79	5.37	6.02	6.74	7.55
Other Roads	74.71	82.86	92.84	104.02	116.55	130.58	146.31	21.88	24.27	27.19	30.47	34.14	38.25	42.85

Table 11: MEC Infrastructure – regional values pence per vehicle km 2020 – Rigid HGV, 2020 prices

Area type	London			Inner and Outer Conurbations			Other Urban		Rural		
Road type	**Motorways**	**A Roads**	**Other Roads**	**Motorways**	**A Roads**	**Other Roads**	**A Roads**	**Other Roads**	**Motorways**	**A Roads**	**Other Roads**
South West							5.6	10.2	1.4	3.8	15.3
East of England	0.6	1.8					2.9	15.4	0.9	1.8	14.5
South East	1.4	12.0					6.0	15.0	1.3	3.6	20.1
North West				1.5	7.9	15.1	3.3	19.5	1.2	4.0	27.5
North East				4.3	4.3	8.4	3.5	10.6	1.2	2.5	26.1
East Midlands				0.6	11.4		2.1	7.1	0.7	1.2	13.5
West Midlands				0.8	4.8	27.4	1.8	9.1	0.9	2.3	14.3
Yorkshire and The Humber				0.9	3.4	22.8	4.0	9.5	0.9	1.5	14.0
London	1.1	10.7	52.9								
Wales							5.9	17.2	2.1	10.9	30.2
Scotland				1.6	4.3	22.0	4.2	29.3	1.5	6.0	26.6

Table 12: MEC Infrastructure – regional values pence per vehicle km 2020 – Artic HGV, 2020 prices

Area type	London			Inner and Outer Conurbations			Other Urban		Rural		
Road type	**Motorways**	**A Roads**	**Other Roads**	**Motorways**	**A Roads**	**Other Roads**	**A Roads**	**Other Roads**	**Motorways**	**A Roads**	**Other Roads**
South West							19.1	35.2	4.8	13.1	52.6
East of England	2.0	6.1					9.8	52.8	3.0	6.2	49.9
South East	4.9	41.0					20.6	51.5	4.6	12.3	69.1
North West				5.2	27.0	51.9	11.3	67.1	4.1	13.8	94.4
North East				14.5	14.9	29.0	12.1	36.3	4.2	8.6	89.7
East Midlands				2.2	38.8		7.0	24.5	2.5	4.1	46.3
West Midlands				2.7	16.3	94.0	6.2	31.3	3.2	7.8	49.3
Yorkshire and The Humber				3.0	11.7	78.2	13.5	32.7	3.1	5.1	48.2
London	3.8	36.5	181.8								
Wales							20.0	58.7	7.0	37.3	103.8
Scotland				5.5	14.8	75.7	14.5	97.7	5.2	20.6	88.0

Appendix 3 MEC Noise

Table 13: MEC Noise – values in pence/vkm, Artics, Rigids 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	2.11	2.07	2.02	1.97	1.92	1.88	1.85	0.97	0.96	0.94	0.91	0.88	0.87	0.85
A Roads	15.42	15.10	14.78	14.46	14.14	13.81	13.49	5.43	5.32	5.21	5.07	4.94	4.79	4.65
Other Roads	74.22	70.98	67.76	65.74	63.73	62.62	61.50	26.83	25.65	24.48	23.73	22.98	22.61	22.23
London														
Motorways	3.16	3.05	2.95	2.86	2.75	2.57	2.39	1.52	1.47	1.43	1.39	1.34	1.25	1.16
A Roads	21.69	20.95	20.21	19.58	18.96	18.83	18.70	8.43	8.13	7.83	7.58	7.33	7.26	7.19
Other Roads	155.83	147.61	139.52	141.11	142.40	140.26	138.15	58.74	55.59	52.51	53.21	53.82	53.09	52.35
Other Urban														
A Roads	20.05	19.59	19.14	18.71	18.29	17.90	17.53	7.35	7.18	7.02	6.84	6.66	6.52	6.39
Other Roads	88.47	86.61	84.72	81.51	78.31	75.94	73.59	31.76	31.13	30.49	29.32	28.15	27.29	26.44
Rural														
Motorways	0.45	0.44	0.42	0.41	0.40	0.39	0.38	0.21	0.20	0.20	0.19	0.19	0.18	0.18
A Roads	2.94	2.86	2.78	2.69	2.60	2.56	2.53	1.18	1.15	1.12	1.08	1.04	1.03	1.01
Other Roads	12.07	12.44	12.81	12.27	11.74	11.40	11.07	4.54	4.69	4.84	4.66	4.49	4.37	4.25

Appendix 4 MEC Behaviour

Table 14: MEC Behaviour – values in pence/vkm, Artics and Rigids, 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	0.11	0.13	0.17	0.21	0.27	0.34	0.41	0.11	0.13	0.16	0.21	0.27	0.34	0.41
A Roads	0.89	1.00	1.16	1.37	1.63	1.90	2.21	0.66	0.76	0.90	1.09	1.31	1.56	1.85
Other Roads	0.27	0.31	0.37	0.44	0.51	0.60	0.70	0.19	0.23	0.27	0.33	0.39	0.46	0.54
London														
Motorways	0.08	0.09	0.11	0.16	0.22	0.28	0.34	0.07	0.08	0.10	0.14	0.20	0.25	0.30
A Roads	2.22	2.54	2.98	3.46	4.04	4.58	5.17	1.87	2.17	2.58	3.03	3.57	4.08	4.64
Other Roads	0.44	0.51	0.61	0.75	0.92	1.08	1.26	0.26	0.33	0.41	0.52	0.66	0.78	0.93
Other Urban														
A Roads	0.81	0.91	1.06	1.25	1.48	1.71	1.97	0.51	0.59	0.70	0.85	1.03	1.22	1.43
Other Roads	0.19	0.22	0.27	0.32	0.38	0.45	0.53	0.14	0.16	0.20	0.24	0.28	0.34	0.39
Rural														
Motorways	0.06	0.07	0.09	0.12	0.16	0.21	0.27	0.06	0.07	0.09	0.13	0.17	0.22	0.27
A Roads	0.07	0.08	0.09	0.11	0.13	0.17	0.20	0.05	0.05	0.07	0.08	0.10	0.13	0.16
Other Roads	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.00	0.00	0.01	0.01	0.01	0.01	0.01

Appendix 5 MEC Environment

Table 15: MEC Environment – values in pence/vkm, Artics and Rigids, 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	0.06	0.04	0.02	0.02	0.02	0.02	0.02	0.07	0.04	0.02	0.02	0.02	0.02	0.02
A Roads	0.12	0.08	0.04	0.04	0.04	0.04	0.04	0.13	0.08	0.04	0.04	0.04	0.04	0.04
Other Roads	0.12	0.08	0.03	0.03	0.03	0.03	0.03	0.12	0.08	0.03	0.03	0.03	0.03	0.03
London														
Motorways	0.07	0.05	0.02	0.02	0.02	0.02	0.02	0.07	0.05	0.02	0.02	0.02	0.02	0.02
A Roads	0.21	0.14	0.06	0.06	0.06	0.06	0.07	0.21	0.13	0.06	0.06	0.06	0.06	0.06
Other Roads	0.17	0.11	0.05	0.05	0.04	0.04	0.05	0.18	0.11	0.05	0.05	0.05	0.05	0.05
Other Urban														
A Roads	0.09	0.06	0.03	0.03	0.03	0.03	0.03	0.10	0.06	0.03	0.03	0.03	0.03	0.03
Other Roads	0.11	0.07	0.03	0.03	0.03	0.03	0.03	0.11	0.07	0.03	0.03	0.03	0.03	0.03
Rural														
Motorways	0.10	0.06	0.03	0.03	0.03	0.03	0.03	0.10	0.06	0.03	0.03	0.03	0.03	0.03
A Roads	0.13	0.08	0.03	0.03	0.03	0.03	0.03	0.14	0.09	0.03	0.03	0.03	0.03	0.03
Other Roads	0.31	0.19	0.07	0.07	0.06	0.06	0.06	0.31	0.19	0.07	0.07	0.06	0.06	0.06

Appendix 6 MEC Up and downstream processes

Table 16: MEC Up and downstream processes – values in pence/vkm, Artics, Rigids 2020 prices, base scenario

Vehicle type	Artics							Rigids						
Years	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Inner and Outer Conurbations														
Motorways	1.10	1.16	1.22	1.74	2.25	2.76	3.28	1.10	1.16	1.22	1.75	2.25	2.78	3.29
A Roads	1.20	1.25	1.30	1.86	2.40	2.98	3.56	1.15	1.19	1.23	1.75	2.25	2.79	3.32
Other Roads	1.26	1.25	1.23	1.71	2.13	2.62	3.09	1.24	1.24	1.21	1.68	2.09	2.56	3.03
London														
Motorways	1.09	1.14	1.19	1.71	2.20	2.72	3.22	1.10	1.16	1.21	1.74	2.24	2.76	3.27
A Roads	1.23	1.33	1.43	2.10	2.76	3.44	4.13	1.20	1.30	1.40	2.05	2.70	3.36	4.03
Other Roads	1.39	1.48	1.56	2.25	2.91	3.59	4.25	1.40	1.49	1.58	2.27	2.93	3.61	4.28
Other Urban														
A Roads	1.15	1.21	1.26	1.82	2.36	2.93	3.50	1.09	1.13	1.17	1.68	2.17	2.68	3.20
Other Roads	1.22	1.22	1.19	1.66	2.07	2.53	2.98	1.19	1.18	1.16	1.61	2.00	2.44	2.88
Rural														
Motorways	1.10	1.16	1.21	1.73	2.23	2.75	3.26	1.10	1.16	1.21	1.74	2.24	2.76	3.27
A Roads	1.03	1.08	1.13	1.61	2.07	2.55	3.01	1.01	1.05	1.10	1.56	2.01	2.47	2.93
Other Roads	0.93	0.96	0.97	1.38	1.76	2.16	2.55	0.93	0.95	0.97	1.37	1.74	2.14	2.53