Greater Manchester's Outline Business Case to tackle Nitrogen Dioxide Exceedances at the Roadside

E1 Economic Appraisal Methodology Report

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1 Introduction

1.1 Purpose of this Report

1.1.1 This Economic Appraisal Methodology Report (EAMR) details the methodology of the economic appraisal presented in the Economic Case of the Outline Business Case (OBC) for the Greater Manchester Clean Air Plan (GM CAP).

1.1.2 This EAMR is presented in conjunction with the Economic Case. The Economic Case presents the results of the economic appraisal, whereas the focus of this report is on the economic modelling[1] and subsequent analysis underpinning the results of the monetised impacts presented in the economic case. The methodology of the Distributional Impact Appraisal can be found in Appendix of the GM CAP OBC (Distributional Impact Appraisal Report). This report only refers to the monetised impacts and does not detail the non-monetised benefits and costs outlined in the GM CAP OBC document.

1.2 Economic Appraisal Framework

1.2.1 Assessments included in the Economic Appraisal

1.2.2 The economic appraisal incorporates the results from three main assessments:

- Health and Environmental Impacts – an assessment of the benefits gained in the form of health and environmental impacts, as a result of the expected reduction in harmful concentrations of NO_2 and other pollutant emissions.
- Costs to Transport Users – an assessment of the potential costs, benefits and disbenefits to transport users directly affected by the GM CAP
- Costs to the Government – an assessment of the implementation cost of the GM CAP, as well as the operating & maintenance costs. The revenue generated by the GM CAP are included as a transfer payment from transport users to the Government (i.e. they net to zero).

[1] For details about the transport modelling undertaken see Technical Reports T1 to T4

1.2.3 The GM CAP should be treated as one package and has been modelled as a package. Some of the component measures have not been assessed individually due to the critical inter-dependencies of the various measures.

1.2.4 The monetised cost and benefits of the options have been calculated to assess the net-present value (NPV) and cost-effectiveness of each option. In all instances costs and benefits are assessed against the baseline (Do Minimum) scenario.

1.2.5 Guidance

1.2.6 The methodology of the traffic modelling, air quality modelling and economic assessment is based on various guidance reports, mainly:

- JAQU Guidance for CAZ Options Appraisal (Defra 2017);
- JAQU Supplementary Guidance
- JAQU UK Plan for tackling roadside nitrogen dioxide concentrations – July 2017 (Defra 2017)
- JAQU National data inputs for local economic models (Defra 2017)
- Green Book: Central Government Guidance on Appraisal and Evaluation (HM Treasury, 2018)
- DfT WebTAG (DfT, last updated May 2018)

1.2.7 The economic assessment is primarily based on the JAQU guidance for CAZ Options Appraisal. As recommended by JAQU the approach and assumptions underpinning the assessment have been adjusted as necessary to incorporate specific issues related to the GM CAP.

1.2.8 Options

1.2.9 For the purpose of the economic appraisal, three options were shortlisted from a long-list of options. For a description of the optioneering of the GM CAP, please refer to GM OBC Appendix Optioneering Appraisal Report. The three best performing options are as follows:

- Option 5(i): A city centre penalty for high polluting vehicles including cars and GM-wide for commercial vehicles; and
- Option 5(ii): A city centre penalty for high polluting vehicles including all diesel cars and GM-wide for commercial vehicles.
- Option 8: A GM wide penalty for high polluting vehicles including all diesel commercial vehicles.

1.2.10 All of the above best performing options also include a package of non-CAZ measures as shown in Table 1-1 below.

Table 1– Best performing options: measures included in each option

	Measure	Option 5(i)	Option 5(ii)	Option 8
Communicating the message	Communications	✓	✓	✓
	Sustainable Journeys programme	✓	✓	✓
Promoting cleaner vehicles	Provision of 300 dual-headed Electric Vehicle (EV) charging points GM-wide	✓	✓	✓
	Promotion of EV	✓	✓	✓
Helping business and buses upgrade	Clean Air Funds Upgrade Car	✓	✓	
	Clean Air Funds Upgrade Freight / Commercial vehicles	✓	✓	✓
	Clean Air Funds Upgrade taxis and private hire vehicles (PHV)	✓	✓	✓
	Clean Air Funds Upgrade Buses	✓	✓	✓
	Loan Finance	✓	✓	✓
Clean Air Zones	City Centre CAZ D	✓		
	City Centre CAZ D+		✓	
	CAZ B/C across GM	✓	✓	✓
	Discounts and exemptions for CAZ	✓	✓	✓

1.2.11 General Assumptions

1.2.12 The economic assessment is constructed around the following general assumptions:

- Opening year of all options is 2021 (with some measures to help prepare for the CAZ schemes launching earlier than this);
- Each option is assessed against the ‘Do Minimum’ scenario[2];
- The monetised impacts of the GM CAP are presented in 2018 prices;
- Inflation has been applied using DfT’s WebTAG Databook GDP Deflator (May 2018 edition), except where an alternative inflation index is

[2] For a description of the Do Minimum scenario refer to Section 1.3 of the Strategic Case of the OBC

considered more appropriate for a particular cost element, details of which have been provided in the financial case section of the OBC;

- The monetised impacts of the GM CAP are discounted to the year 2018, applying the discount factor of 3.5% in accordance to the Green Book guidance; and
- The appraisal period of the GM CAP is assessed from the opening year 2021 to 2030.

1.2.13 Further assumptions and parameters are outlined in this report under the relevant sections.

1.2.14 Data Sources:

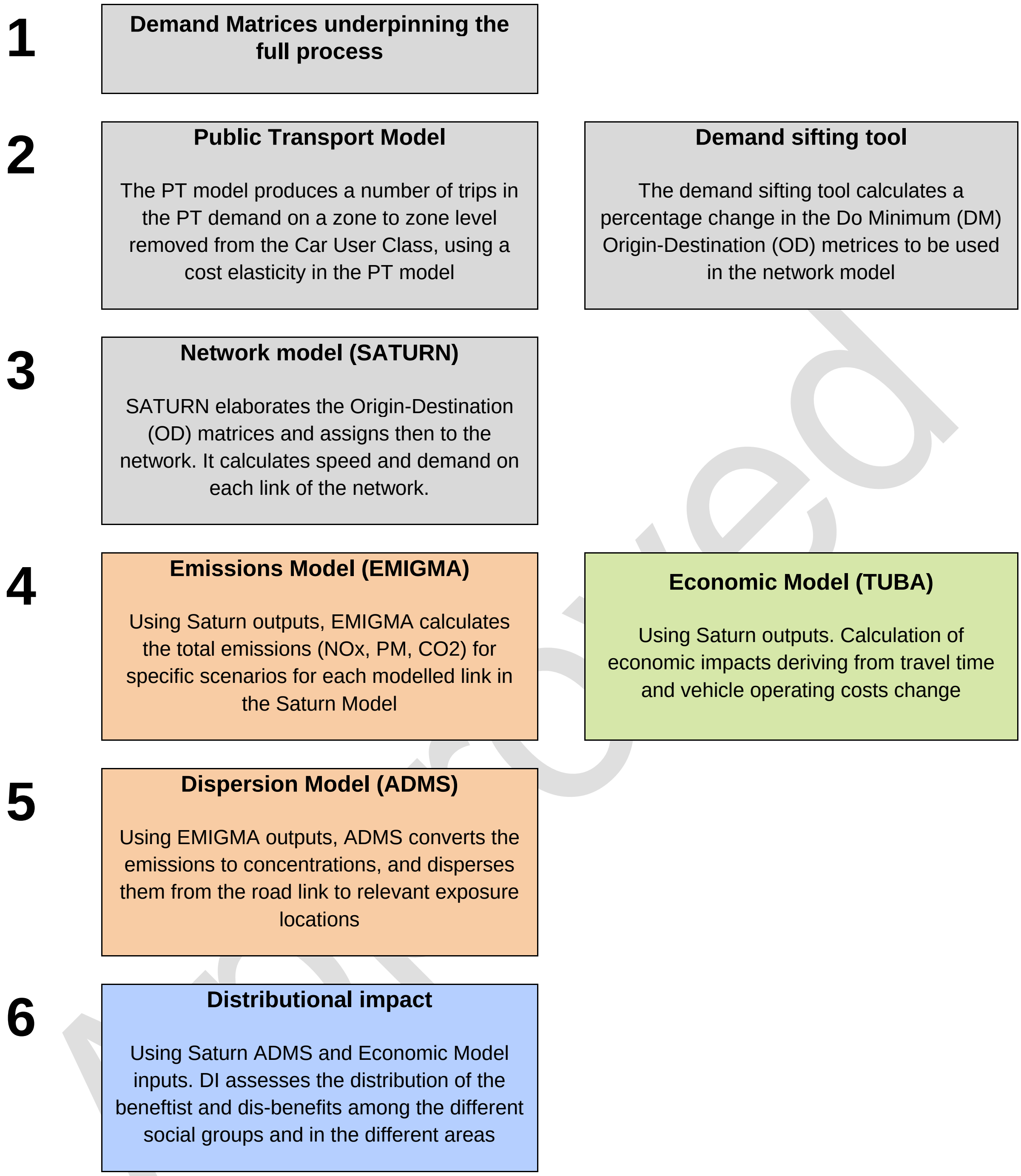
1.2.15 The main sources of data used to inform the economic assessment are:

- Transport and Air Quality model outputs;
- JAQU National data inputs for local economic models;
- WebTAG Databook (May 2018)
- GM Automatic Number Plate Recognition (ANPR) raw data
- Office for National Statistics
- TfGM Published Datasets (https://data.gov.uk/publisher/transport-for-greater-manchester)

1.2.16 Transport and Air Quality Modelling

1.2.17 The economic modelling undertaken is reliant on the traffic modelling and air quality modelling, as outlined in Figure 1-1 below. For more detail on the methodology applied to the traffic and air quality modelling, please see the associated methodology reports (AQ1-3 and T1-4).

Figure 1-1: Modelling Process



1.2.18 Going forward, the transport, air quality, and subsequently the economic, modelling will be modified and updated to incorporate the following:

- Further development of the measures;
- Feedback from the public and stakeholder engagement;
- New data from ANPR and other sources; and
- General refinement and improvement of the models.

1.3 Report Structure

1.3.1 The remainder of this report describes the stages involved in the development of the economic assessment. The structure of the remainder of this report is as follows:

- **Chapter 2** – Note on Clean Air Zone Charges
- **Chapter 3** – Scope of the Economic Appraisal
- **Chapter 4** – Health and Environmental Impacts
- **Chapter 5** – Changes in Travel Behaviour
- **Chapter 6** – Impact of Vehicle Upgrades
- **Chapter 7** – Congestion Effect
- **Chapter 8** – Cost to the Public Sector
- **Chapter 9** – Issues and Caveats

2 Note on Clean Air Zone Charges

2.1.1 Table 3-1 presents the assumed charges used for the economic analysis. The charges do not differ across the different cordons and assume a non-compliant vehicle will be charged once per day for travel into/out of, within or through the CAZ, regardless of how many times the CAZ boundary is crossed. For more detail about the methodology and behavioural responses assumed, please see the associated technical methodology reports (T4).

Table 2-2: Assumed daily Charges for non-compliant vehicle user trips entering the CAZ boundary for modelling purposes

Vehicle Type	Daily Charge, £
Cars	£7.50
Taxis/PHVs	£7.50
LGVs	£7.50
HGVs	£100.00
Buses/Coaches	£100.00

2.1.2 For HGVs, buses and coaches, a daily charge of £100.00 was assumed as it was consistent with the charges proposed in other cities at the time the assumptions were made, noting that some cities have come forward with revised charges following public consultation.

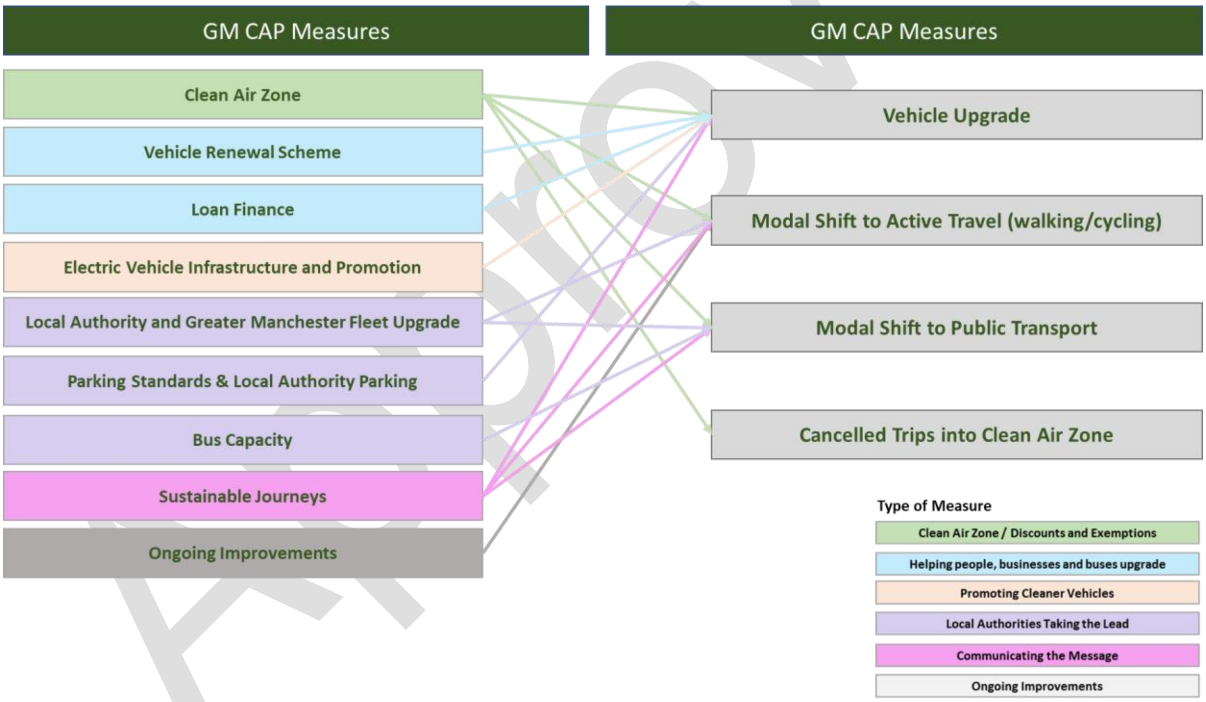
2.1.3 **Please note**: the CAZ charges proposed in Table 2-1 are assumptions applied for modelling purposes only. The CAZ charges are subject to change and may be revised based on public and stakeholder conversations, as well as further analysis.

3 Scope of the Economic Appraisal

3.1.1 The implementation of the GM CAP will result in a wide-range of impacts across the economic, environmental and social spectrum to transport users. The economic analysis aimed to quantify and monetise as many impacts of the GM CAP within the given time, resource and data available. Any impacts not quantified and/or monetised may be considered for further assessment in the Full Business Case. Table 4-1 outlines the impacts considered within the economic analysis and whether they were assessed quantitively or qualitatively.

3.1.2 Please note, for the economic appraisal the cost and benefits are not assessed by individual sub-measures of the GM CAP. There are critical inter-dependencies between the CAZ and the non-CAZ measures, therefore it would be inappropriate to present the benefits derived from each measure separately. The dependencies between the measures and the behavioural response to the GM CAP is illustrated in Figure 3-1, which shows the interaction between the measures and the behavioural responses.

Figure 3-1: Measures and Dependencies



3.1.3 The scope of the economic appraisal excludes the user charges (to transport users) and the revenue (received by the public sector) due to the high level of uncertainty over the user charges and revenue forecasts. The exclusion of the user charges and revenue has no material impact on the economic appraisal as the two elements are treated as a transfer from the transport user to the public sector.

Table 3-1: Scope of the impacts of the GM CAP

Impact	Benefits/Cost	Description	Methodology
Health and Environmental Impacts	Air Quality (NO2 and PM)	The impact of the reduction in NO2 and PM emissions in terms of avoided health and environmental damage.	The change in emissions (tonnes) of NO2 and PM is modelled using outputs from the transport model to provide an indication of the level of change across Greater Manchester. The NO2 and PM savings are then monetised using damage costs (per tonne saved) recommended by JAQU.
	Greenhouse Gases Emissions	The impact on GHG emissions as a result of the change in vehicle fleet and network effects.	The change in CO2 emissions is estimated based on the link level emissions in DM and DS estimated within EMIGMA software.
Changes in Travel Behaviour	Health Benefits	The health benefits gained from those switching from cars to walking and cycling.	The health benefits associated with increased walking/cycling are calculated using World Health Organisation (WHO)'s Health Economic Assessment Tool (HEAT). For more details of the methodology, please refer to https://www.heatwalkingcycling.org/#homepage
	Welfare Loss (Cancelled Trips)	The welfare loss of those opting to cancel their trip altogether.	This impact assumes that there is a disbenefit to users in choosing an alternative to their original course of action. The loss of welfare from changing travel behaviour is estimated using the rule of a half (RoH) for trips foregone (cancelled), and trips re-moded (i.e. change to public transport). This implies that the value of the disbenefit falls somewhere between £0 and the price of the charge (or else users would have simply paid the charge and taken made their original journey as planned). The midpoint is taken to be the average dis-benefit and multiplied by the number of trips foregone, or re-moded, to determine the overall welfare loss.
	Welfare Loss (Re-moded Trips)	The welfare loss of those opting to switch from car travel to public transport and/or active travel.	
Vehicle Upgrade	Welfare Loss	The welfare loss of having to purchase a new/used compliant vehicle earlier than planned.	The welfare loss associated with vehicle upgrade induced by the GM CAP is estimated based on the difference between the purchase price of a compliant vehicle and the deprecation value of the non-compliant vehicle that is traded in. The rule of a half is applied to account for the consumer welfare loss to account for the fact that the user will experience some benefit in having a newer vehicle beyond the fact that it is merely compliant.

Impact	Benefits/Cost	Description	Methodology
	Loss of Asset Value	The loss in asset value for those choosing to scrap (as opposed to trade in) their older, non-compliant vehicles.	Based on the number of vehicles upgrading estimated, the average loss of asset value (after the GM CAP implementation) of each vehicle type and euro standards was estimated using JAQU's depreciation rate assumption.
	Transaction Cost	For vehicle owners choosing to upgrade their non-compliant vehicle earlier than planned, they are likely to incur a cost in having to locate a vehicle to their taste.	The transaction cost was estimated using JAQU's average transaction cost per vehicle type and euro standards.
	Fuel Switch Cost	Vehicle owners upgrading to a compliant vehicle may choose to upgrade to a different fuel type, for example a diesel car owner could upgrade to a compliant petrol car. The switch in fuel type leads to a change in running costs.	The total vehicle kilometres by non-compliant vehicle owners upgrading to a different fuel type is estimated based on the average vehicle kilometre travelled per vehicle. The average fuel consumption (of petrol vs diesel) is calculated, based on values provided by DfT WebTAG, and then the total fuel cost is estimated based on the average fuel price per litre consumed. The fuel switch cost is estimated by subtracting the Do Something fuel cost (i.e. the fuel type they switch to) from the Do Minimum fuel cost (i.e. the original fuel type).
	Financial Subsidy	Non-compliant vehicle owners choosing to upgrade early may receive a financial subsidy via the Clean Car Fund, Clean Freight Fund, Clean Taxi Fund and the Clean Bus Fund. This would offset some of the welfare loss gained from upgrading.	The financial relief which offsets the welfare loss associated with upgrading was estimated by the financial model, taking into the account the number of vehicles upgrading and the maximum financial subsidy offered per applicant via the measures Clean Car Fund, Clean Taxi Fund, Clean Bus Fund and Clean Freight Fund.

Impact	Benefits/Cost	Description	Methodology
Congestion Effect	Travel Time Impact	Due to the nature of the GM CAP, there may be an impact on traffic flow. For example, if more non-compliant vehicle owners opt to avoid the CAZ boundary, this may result in fewer vehicles crossing and moving within the CAZ boundary, leading to travel time savings.	The congestion effects are modelled using DfT's Transport User Benefit Appraisal (TUBA) software. The input for TUBA is generated by the transport model.
	Changes in vehicle operating cost	Vehicles may see a difference in vehicle operating costs as a result of travel time savings or costs and an increase or decrease in fuel consumption	
Cost to the Public Sector	Implementation Cost	The up-front cost of implementing the GM CAP.	Assumptions on the implementation costs and how they were derived can be found in the Financial Case (section 3)
	Operating & Maintenance Cost	The on-going cost of operating and maintaining the GM CAP.	Assumptions on the O&M costs and how they were derived can be found in the Financial Case (section 3)

4 Health and Environmental Impact

4.1 Air Quality (NO_2 and PM)

4.1.1 The objective of the GM CAP is to improve air quality in Greater Manchester by targeting a reduction in exposure to harmful concentrations of NO_2 and other polluting particulates. The reduction in air pollution will subsequently have health benefits for residents and workers within Greater Manchester, as well as a knock-on effect on those outside of Greater Manchester. As well as health, the GM CAP will lead to environmental benefits such as a reduction in building soiling and ecosystem damages.

4.1.2 The change in NO_x and PM across Greater Manchester was estimated using the outputs of the EMIGMA model (Emissions inventory Greater Manchester). The EMIGMA model provides the concentration of NO_2 and PM for each modelled road link within Greater Manchester. This data was manipulated in GIS to calculate the change in emissions at a lower super output area (LSOA) level, and summed to a district level, between the Do Minimum (2021 & 2025) and the clean air option scenario (2021 & 2025).

4.1.3 Each LSOA was assigned a classification based on ONS residential-based area classifications. Out of 1,673 LSOAs, the majority (97%) were assigned the 'Road Transport Urban Big' classification. 'Road Transport Urban Medium' and 'Road Transport Rural' account for 2.3% and 0.8% respectively.

4.1.4 The quantified reduction in NO_2 and PM (tonnes) was then monetised using JAQU's damage cost for a range of health and environmental impacts (e.g. mortality, respiratory disease, building soiling etc.). These were converted from 2015 prices to 2018 prices using the GDP Deflator Series from DfT's WebTAG Databook.

4.1.5 The monetised benefits of the GM CAP were extrapolated across the appraisal period, where we see the health and environmental benefits reduce year by year until 2030 to reflect the increasing rate of compliance.

4.2 Greenhouse Gas Emission (GHG)

4.2.1 Similar to the expected change in NO_2 and PM, the change in the traffic network as a result of the GM CAP may lead to either an increase or decrease in GHG emissions in GM. The difference in the level of GHG emissions between the Do Minimum and Do Something scenario were calculated based on total CO_2 emissions at a link level for the DM and DS scenarios in year 2021 and 2025

4.2.2 The emissions, estimated for the year 2021 and 2025 were then interpolated between the two modelled years and extrapolated for the whole appraisal period using the average reduction rate between year 2021 and 2025.

4.2.3 The CO_2 emissions have been then multiplied by the non-traded value per tonne of CO_2 emitted (central case) reported in the WebTAG (ver. May 2018).

5 Changes in Travel Behaviour

5.1 Active travel impacts

5.1.1 When non-compliant vehicle users change their mode of travelling to the walking or cycling mode, health benefits are gained from increased exercise, subsequently reducing the rate of mortality.

5.1.2 The health benefits associated with increased walking/cycling is calculated using World Health Organisation (WHO)'s Health Economic Assessment Tool (HEAT). Please note, the active travel health benefits are identical for Option 5(i) and Option 5(ii) as the number of trips forecast to switch to active travel is assumed to be same. These are referred to as "Option 5" during this section.

5.1.3 The number of trips forecast to switch to active travel was estimated by the demand sifting tool for the opening year 2021 and converted into the number of unique vehicles switching into active travel using the trips to vehicle conversion factor (Table 5-1). The number of unique vehicles switching to active travel were then split between the proportion switching to cycling, and those switching to walking[3]. For the purpose of the economic modelling, we have assumed 90% of vehicles would switching to cycling and 10% would switching to walking. There is a high level of uncertainty over the proportion adopted and would require further fieldwork to understand the behavioural response to the GM CAP. Additionally, we did not consider trips which involve both cycling and walking, as the HEAT tool can only assess purely cycling and walking trips separately.

[3] Active mode trips are capped at 5 miles in length. Re-moding longer trips all switch to public transport

Table 5-1: Number of unique vehicles (per day) forecast to switch to active travel (2021)

Vehicle Type	No. of Unique Vehicles Switching into Active Travel (1)	Number of Unique Vehicles Switching to Cycling (90% *(1))	Number of Unique Vehicles Switching to Walking (10% *(1))
Option 5			
Cars	1022	920	102
LGVs	35	31	4
Total	1057	951	106
Option 8			
Cars	0	0	0
LGVs	516	464	52
Total	516	464	52

5.1.4 For more details on the methodology, please refer to https://www.heatwalkingcycling.org.

5.2 Impact of cancelling or re-moding trips

5.2.1 When non-compliant vehicle users change their travel behaviour in response to the GM CAP, a welfare cost is incurred as the vehicle users are no longer choosing their preferred action. For example, a non-compliant vehicle owner may choose to cancel their trip rather than cross the CAZ cordon and pay the charge. The cancellation of the trip means the vehicle owner is no longer able to fulfil the purpose of the original trip at the destination (for e.g. trip to cinema within the IRR). Note that this analysis does not allow for the possibility that the activity is replaced with another of equal merit to the trip-maker and so may somewhat overestimate the welfare loss of cancelled trips. Similar to the approach set out in section 7.1, this impact aims to capture the reduction in consumer surplus, using the ROH approach:

5.2.2 **Step 1:** Estimate the number of trips (using the DM cordon crossings from the traffic model) that are either cancelled or shift travel mode using the behavioural response assumption by vehicle type.

5.2.3 **Step 2:** Convert the number of trips from AADTs to number of unique vehicles affected per day, based on the average number of trips per vehicle. The number of unique vehicles is then annualised by 253 days.

5.2.4 **Step 3:** Multiply the number of vehicles (for the modelled years 2021 and 2025) affected by the CAZ charge and ROH.

5.2.5 **Step 4:** Extrapolate the 2021 and 2025 value across the appraisal period, based on the percentage of non-compliant vehicles in each year, relative to the opening year. This assumes the total welfare loss will diminish as we approach 2030.

5.2.6 The number of trips re-moded or cancelled was provided by the demand sifting tool for the AM, IP and PM peak period for the year 2021 and 2025. The AADTs were then calculated using the expansion factors, as shown in Table 5-2. For the purpose of the economic appraisal, HGV trips were converted using the average expansion factor of articulated and rigid HGVs.

Table 5-2: Expansion factors form peak hour to peak period

Vehicle Type	AM Peak Hour to AM Peak Period	Inter-Peak Hour to Off-Peak Period	PM Peak Hour to PM Peak Period
Cars/Motorcycles	2.693	9.649	2.807
LGVS	3.125	9.649	3.071
Rigid HGVS	3.04	9.649	3.472
Articulated HGVS	3.018	9.649	3.049
Buses	2.941	9.649	3.098

5.2.7 The AADTs were then adjusted to take into consideration that a vehicle owner is very likely to be making more than one trip per day. The number of vehicles affected were then calculated using the average trips per vehicle factors presented in Table 5-3. As expected, taxis on average make the most trips per day, whilst cars, LGVs and HGVs on average make 2-3 trips per day, most likely reflecting the return trips.

Table 5-3 Conversion factor from trips to unique vehicles

Vehicle Type	Cars	Taxi	LGVs	HGV
Trips per day	2.63	9.65	2.79	2.95

5.2.8 For the purpose of the economic appraisal, the following assumptions have been done in relation to the estimation of the trips cancelled or re-moded process:

- The consumer welfare impact is assumed the same for option 5 (i) and option 5 (ii) as the transport model assumes the traffic network changes between the baseline and Do Something scenario are identical for the two versions of option 5. In reality, the Ultra-Low Emission Zone within the Inner Ring Road in Option 5(ii) would mean that all diesel cars are non-compliant which would result in a higher number of trips cancelled or re-moded.
- The appraisal assumes that the option of switching mode of travel is only applicable to cars, PHVs, and LGVs.

- HGVs are assumed to be unable to switch to active travel or public transport but are able to cancel their trip.
- Neither taxis nor buses experience welfare loss due to trips re-moded, as we have assumed both vehicle types would be 100% compliant by 2021.
- Note that the possibility of changing mode to another vehicle type, for example from HGV to LGV, or LGV to car, has not been considered here.

6 Impact of Vehicle upgrade

6.1.1 The implementation of the GM CAP will result in a number of non-compliant vehicle owners opting to upgrade to a compliant vehicle. The upgrade to compliant vehicles imposes a cost to the vehicles owners in the following form:

- Welfare Loss
- Loss of asset value
- Fuel switch cost
- Transaction cost

6.2 Welfare loss

6.2.1 Our approach combines the concept of consumer surplus and the financial cost associated with upgrading. The consumer surplus approach is set out by JAQU on the basis of the following assumptions:

- Owners of vehicles value them differently. It is assumed the levels at which the vehicles are valued is equally distributed between the minimum value (i.e. market price) and the maximum (i.e. minimum price of a vehicle one Euro standard above);
- The market price is the minimum price at which owners would value their vehicle. This is assumed on the basis that they would otherwise sell their vehicle in the baseline; and,
- The maximum value placed on a vehicle is the value of a vehicle one Euro standard above. This is based on the assumption that people always prefer newer vehicles, and if they are willing to pay more for a vehicle, they would purchase the higher Euro standard in the baseline.

6.2.2 The welfare loss of upgrading is based on the difference in depreciation that the vehicle owner would experience in the baseline compared to the with-CAZ scenario. To determine this, we use the financial cost approach as set out by JAQU which values two elements for both the year that the user would upgrade in the baseline, and the year the user is forced to upgrade in the with-CAZ scenario. They are the following:

- The extra cost of purchasing a vehicle exempt from the charge; and,
- The benefit gained by selling the baseline vehicle (residual value).

6.2.3 In order to calculate this, certain assumptions are invoked regarding the vehicle the user would decide to upgrade to, and when. The assumptions are as follows:

- The decision to upgrade is made independent of vehicle age (i.e. the proportion of upgrading vehicles of each Euro class reflects the wider fleet proportions of each Euro class);
- The vehicle owner would upgrade to the same compliant vehicle in the CAZ scenario as they would do in the baseline;
- The timing of the upgrade in the baseline can be predicted by the rolling fleet assumptions used in the Traffic Modelling Forecasting Report;
- All users would upgrade in the baseline within the appraisal period; and,
- Each owner would upgrade to the cheapest possible vehicle that is at least one Euro standard higher than their current vehicle.

6.2.4 With this we have the necessary information to calculate the maximum loss of consumer surplus to each user that upgrades. The rule of a half (RoH) is applied to the maximum consumer surplus welfare loss as a result of upgrading through the following formula, summed for all x, u :

$$W(E^x, E^u) = \frac{1}{2} \times \big((RV2020(E^x) - RV2020(E^u)\big) - (RV202Y(E^x) - RV202Y(E^u)) \times VY(E^x, E^u)$$

6.2.5 Where:

- E^x represents a given Euro class of a type of vehicle in the baseline;
- E^u represents the Euro class of the same vehicle type that the user would upgrade to in the scenario
- RV represents the residual value function based on average fleet age and depreciation rates
- 202Y represents the year that the user would have upgraded their vehicle in the baseline scenario
- VY is the function that determines the number of users that upgrade from E^x to E^u in the scenario in year 202Y.
- The VY and RV calculations are explained in the following sections.

6.2.6 The total welfare loss of upgrading is offset, to an extent, by the vehicle renewal funds, whereby non-compliant vehicle owners (if eligible, subject to meeting minimum requirement of the funds) have the option to apply for financial aid to subsidise the up-front cost of upgrading to a compliant vehicle.

6.3 Number of Vehicles Upgrading

6.3.1 The number of vehicles forecast to upgrade due to the GM CAP was estimated based on the proportion of trips to upgrade (see Table 3-2) and the frequency data calculated from the ANPR data available. The following steps were taken:

6.3.2 **Step 1**: Estimate the Do Minimum AADTs by vehicle type, using output from the traffic model.

6.3.3 **Step 2**: Disaggregate the Do Minimum ADDTs by frequency of trips per non-compliant vehicle in one week (using Table 7-1).

6.3.4 **Step 3:** Convert the Do Minimum AADTs into weekly trips.

6.3.5 **Step 4**: Convert the percentage of trips forecast to upgrade (see Table 3-2) to the percentage of unique vehicles forecast to upgrade by vehicle type.

6.3.6 **Step 5:** Calculate the number of vehicles upgrading by applying the percentage of vehicles upgrading (step 4) by the total number of vehicles in Greater Manchester.

6.3.7 The frequency distribution of each vehicle type is presented in Table 6-1, sourced from the local ANPR data provided, presenting the percentage of vehicle counts captured within one given week, from various different locations in GM, by vehicle type and Euro standards. The table shows that 53% of cars travelled one of the seven days of the given week the ANPR data was collected and only 10% travel at least 5 times a week. As expected Taxi, PHV and Bus are travelling more often, with respectively 56%, 51% and 44% of the vehicles travelling at least 5 times week in the IRR.

Table 6-1: Frequency Distribution of non-compliant vehicles by vehicle type capture in one week. (Option 5(i) and 5(ii)) (source: ANPR data)

Vehicle	1 per week	2 per week	3 per week	4 per week	5 per week	6 per week	7 per week
Car	53%	19%	10%	7%	6%	3%	1%
Taxi	20%	9%	8%	8%	8%	15%	33%
PHV	14%	12%	11%	12%	14%	16%	21%
LGV	50%	20%	12%	8%	7%	3%	1%
HGV	59%	18%	9%	6%	5%	2%	1%
Bus	28%	12%	7%	9%	12%	15%	16%

6.3.8 The frequency distribution presented in Table 7-1 and the AADTs were then used to convert the percentage of trips upgrading to the percentage of unique vehicle upgrading. The conversion between trips and vehicles is based on the assumption that:

- The ANPR data from one week for non-compliant vehicles is representative of the set.
- The most frequent entrants to the CAZ are first to upgrade.

6.3.9 The results showed that the most frequent travellers were responsible for a disproportionate volume of trips/vehicle kilometres (VKM). Table 6-2 presents the adjusted response from proportion of non-compliant trips upgraded to the proportion of non-compliant vehicles due to upgrade.

Table 6-2: Proportion of trips and vehicles due to upgrade (Option 5(i)

	Trips	**Vehicles**
Cars	65%	37%
Taxi	100%	100%
PHV	38%	24%
LGV	75%	49%
HGV	86%	75%
Bus/Coach	100%	100%

6.3.10 As the ANPR data was only recorded in one week, not all vehicles that travel within GM were captured within the ANPR data. Therefore, we must treat the ANPR data as a sample of vehicles travelling in and around GM and treated as the absolute minimum number of vehicles impacted.

6.3.11 The total number of non-compliant vehicles were then estimated based on the percentage of unique vehicles upgrading, as shown in Table 6-3, and the total number of vehicles in Greater Manchester. The total number of vehicles, by vehicle type, was sourced mainly from the DVLA. The figures were adjusted to 2021 projection using the growth factor of car ownership from the base year (column "base year" of Table 7-3) to the opening year sourced from the software Trip End Model Presentation (TEMPro).

Table 6-3: Total Number of Vehicles in Greater Manchester

Vehicle Type	Base Year	Base Number of Vehicles	Projected Number of Vehicles in 2021	Source:
Cars	2016	1,139,980	1,200,741	DVLA
LGV	2016	111,872	117,835	DVLA
HGV	2016	30,525	32,152	DVLA
Bus/ Coach	2016	2,739	2,885	DVLA
Taxi	2018	2,135	2,202	DfT statistics, Table TAXI0104 “Taxis, Private Hire Vehicles (PHVs) and their drivers: England and Wales by licensing area”
PHV	2018	11,681	12,047	DfT statistics, Table TAXI0104 “Taxis, Private Hire Vehicles (PHVs) and their drivers: England and Wales by licensing area”

6.3.12 Table 6-4 shows the number of vehicles upgrading due to GM CAP.

6.3.13 Option 5(ii) presents the highest number of vehicles forecast to upgrade in response to the GM CAP, mainly due to the ULEZ imposed along the IRR cordon, meaning all diesel cars are considered non-compliant. Option 8 presents the lower number of vehicles upgrading, as it does not affect cars. The difference in the number of LGVs upgrading in option 8 is due to the fact that the CAZ C will become operational in 2023, when a smaller number of non-compliant LGVs will be circulating.

Table 6-4:Number of vehicles upgrading due to GM CAP

	Option 5(i)	Option 5(ii)	Option 8
Cars	81,801	198,694	0
PHVs	966	2,464	1,965
Taxis	2,127	2,127	2,127
LGVs	41,271	41,271	32,277
HGVs	6,995	6,955	6,955
Buses/Coaches	1,154	1,154	1,154
Total	134,314	252,665	44,478

6.4 Vehicle Asset Value

6.4.1 The aim of the GM CAP is to induce uptake of cleaner vehicles, whilst simultaneously discouraging the use of older vehicles. Scrappage schemes are designed to encourage this behaviour, but they will result in a loss of asset value as cars that still function have their value reduced to zero through being scrapped and not being allowed to enter the second-hand market. The loss of asset value therefore considers the loss in total vehicle fleet value due to scrappage.

6.4.2 It is assumed that vehicles are only scrapped when a scrappage scheme is available. When a scrappage scheme is available it is assumed that vehicles which are Euro class 6 or above will not be eligible for the scheme. It is then assumed that 50% of those cars which are upgrading, and are in Euro class 5 or below, will scrap their vehicle and the loss will be the residual value of that vehicle.

6.4.3 Table 6-5 shows the depreciation rates (using the reducing balance depreciation method) that were used for the cost of upgrade, which are assumptions defined by JAQU.

Table 6-5: Depreciation rates by vehicle type provided by JAQU

	Year 1	**Year 2**	**Year 3+**
Cars	37%	18%	16%
LGVs	37%	18%	16%
RHGVs	35%	18%	18%
AHGVs	35%	18%	18%
Buses	35%	18%	18%

6.4.4 Table 6-6 presents the assumed price of a new vehicle by vehicle type, and the source of that assumption. The price of new vehicles was assumed to remain constant in real terms (i.e. a new car will cost £13k in 2018 in 2018 prices and will also cost £13k in 2029 in 2018 prices). The prices of new cars have been estimated as an average cost of the 10 most popular cars on Autotrader website sold in the year of registration. Same source has been used for LGVs, not limiting it to any make/model but splitting it by large/medium/small vehicle size.

Table 6-6: New vehicle price

Vehicle Type	Up-Front Cost (2018 prices)	Source
Car/PHV	£ 12,997	AutoTrader UK
Taxi	£ 46,000	http://www.levc.com/new-taxis/new_tx4_taxi/
LGV	£ 13,328	AutoTrader UK
HGV	£ 65,700	5-year financed price averaged across a number of HGV types, "Road Haulage Association Cost Tables 2014", DFF International Ltd, 2014. Average between rigid and artic HGV
Bus	£ 160,000	JAQU, “National Data Inputs for Local Economic Models”
Coach	£ 250,000	JAQU, “National Data Inputs for Local Economic Models”

6.4.5 The average age of each Euro standard was calculated using the midpoint year between the year of implementation of that euro standard and the year of implementation of the next euro standard.

6.4.6 Table 6-7 shows the residual value of each vehicle type and Euro class in 2021 based on the vehicle price assumption and depreciation rates.

Table 6-7: Average residual value of vehicle by type and euro standards in 2021

	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	Euro 6c	Euro 6d
Car Petrol	102	205	413	986	1,981	4,738	8,188	12,997
Car Diesel	102	205	413	986	1,981	4,738	8,188	12,997
PHV Petrol	102	205	413	986	1,981	4,738	8,188	12,997
PHV Diesel	102	205	413	986	1,981	4,738	8,188	12,997
Taxi Petrol	362	727	1,460	3,491	7,012	16,768	28,980	46,000
Taxi Diesel	362	727	1,460	3,491	7,012	16,768	28,980	46,000
LGV petrol	149	251	423	1,012	2,032	4,858	8,397	13,328
LGV diesel	149	251	423	1,012	2,032	4,858	8,397	13,328
HGV	299	662	1,463	3,236	7,158	19,308	42,705	65,700
Bus	728	1,611	3,563	7,882	17,432	47,021	104,000	160,000
Coach	1,138	2,517	5,568	12,315	27,238	73,470	162,500	250,000

6.5 Fuel Switch Cost

6.5.1 For vehicles upgrading to a different fuel type, this will incur a change in the running cost of the vehicle. As Table 6-8 demonstrates, the cost per litre of fuel consumed is higher for diesels than it is for petrol. The fuel cost comprises of resource cost, fuel duty, and 20% VAT.

Table 6-8: Average Fuel Cost (£ per litre) in the opening year 2021

Fuel Type	£ per litre
Petrol	£1.21
Diesel	£1.25

6.5.2 To estimate the difference in fuel consumption, the annual vehicle kilometres has been multiplied by the fuel consumption (litres per km) and by the fuel cost (£ per litre).

6.5.3 The number of vehicles switching fuel type when upgrading are presented in Table 6-9. For the purpose of the economic appraisal, we only considered vehicles switching from diesel to petrol only. This doesn't account for those potentially switching to electric, nor petrol cars switching to diesel. More field research is required to understand the behavioural response of non-compliant vehicle owners, and the likelihood they will upgrade to a different fuel type.

6.5.4 Note that this is under-estimating the fuel saving benefits derived from the proposed investment in electric vehicle infrastructure and associated increase in uptake of electric cars and vans. This benefit would be common across all Options. The benefits of increased uptake of EVs will be considered in more depth at FBC.

Table 6-9: Number of vehicles switching fuel from diesel to petrol

	Option 5(i)		Option 5(ii)		Option 8	
	Car	PHV	Car	PHV	Car	PHV
Total	42,038	539	107,791	1,381	0	1096

6.5.5 The total vehicle kilometres of the Do Minimum and Do Something scenario have been estimated based on the average vehicle kilometres travelled per vehicle per year, presented in Table 6-10.

Table 6-10: Vehicle Kilometres per vehicle per year

Vehicle type	Vehicle Kilometres	Source
Petrol Car	10,460	DfT, 2017 - https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy
Diesel Car	16,254	DfT, 2017 - https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy
Petrol PHV	40,233	taxi survey 2016 https://www.insuretaxi.com/2016/08/taxi-driver-survey-2016/
Diesel PHV	40,233	taxi survey 2016 https://www.insuretaxi.com/2016/08/taxi-driver-survey-2016/
Petrol Taxi	40,233	taxi survey 2016 https://www.insuretaxi.com/2016/08/taxi-driver-survey-2016/
Diesel Taxi	40,233	taxi survey 2016 https://www.insuretaxi.com/2016/08/taxi-driver-survey-2016/
Petrol LGV	20,617	DfT, 2017 - https://www.telegraph.co.uk/connect/small-business/operations-and-logistics/renault/how-many-miles-do-vans-clock-up/
Diesel LGV	20,617	DfT, 2017 - https://www.telegraph.co.uk/connect/small-business/operations-and-logistics/renault/how-many-miles-do-vans-clock-up/
OGV1 (rigid)	28,000	DfT, 2017 road freight statistics table 0112
OGV2 (artic)	77,000	DfT, 2017 road freight statistics table 0113

6.5.6 The average new car fuel consumption assumed in the estimation is reported in Table 6-11.

Table 6-11: Average new car fuel consumption, Great Britain: 2000 to 2016 (litres per 100Km)

Vehicle	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Petrol Car	8.0	7.9	7.8	7.7	7.6	7.5	7.4	7.2	7.0	6.5	6.3	6.1	5.8	5.6	5.5	5.4	5.4
Diesel Car	6.3	6.2	6.1	6.2	6.2	6.2	6.3	6.2	5.9	5.7	5.5	5.2	5.0	4.9	4.7	4.6	4.5

6.6 Transaction cost

6.6.1 The transaction cost is the cost involved in searching for a new vehicle. It has been estimated by multiplying the number of vehicles (cars, LGV and HGVs) upgrading by the weighted transaction cost.

6.6.2 The weighted transaction cost has been taken from the JAQU's "National Data Inputs for Local Economic Models" workbook, whereby the transaction cost associated searching for a new vehicle are tailored according to the age and ownership length of the fleet composition. Users pay an amount based on the cost imposed by bringing the date of upgrade forwards. The assumed transaction cost is £76 for cars, £154 for LGVs and £181 for HGVs (based on WebTAG values for time and an average of 15hrs to search for a new vehicle) – users are impacted only by the change in perceived (discounted) cost of upgrading sooner than they would have done without the introduction of the CAZ.

Table 6-12: Weighted Transaction Costs

	Weighted Transaction Costs		
Euro Standard	**Car**	**LGV**	**HGV**
Euro 5	£5.77	£10.13	£6.71
Euro 4	£3.40	£7.89	£7.70
Euro 3	£3.38	£9.65	£6.67
Euro 2	£6.07	£12.17	£5.58
Euro 1	£6.07	£12.17	£5.58

6.6.3 For the purpose of the economic appraisal of Option 5(ii), we assumed the weighed transaction cost of the euro classes 6, 6c and 6d to be the same as the Euro 5.

7 Congestion effect

7.1.1 The introduction of the GM CAP will lead to non-compliant vehicle owners cancelling their trips or shifting to alternative mode of travel. Effectively, vehicle users, whether they are compliant or not, will experience a change in travel time and vehicle operating cost (VOC).

7.1.2 The calculation of the travel time and VOC impact to road users incorporates use of the DfT's Transport Users Benefit Appraisal (TUBA) v1.9.11 program. TUBA compares the economic costs for the Do Something (DS) situation with the costs for the Do Minimum (DM) situation to establish the value of forecast savings in travel time and vehicle operating costs.

7.1.3 Data input to TUBA comprised trip, flow weighted average travel time and travel distance skim matrices. These matrices were prepared for each option scenario separately for combinations of three time periods (AM, IP, PM), eight user classes (see Table 7-2) and two forecast years (2021 and 2025) for both Do Minimum (Without GM CAP) and Do Something (With GM CAP)

7.1.4 TUBA works on the basis of five standard-definition time periods as follows:

- AM peak (weekday 07:00 to 10:00);
- PM peak (weekday 16:00 to 19:00);
- Inter-peak (weekday 10:00 to 16:00);
- Off-peak (weekday 19:00 to 07:00); and
- Weekend.

7.1.5 The traffic model comprises three weekday time periods; an AM peak hour (08:00-09:00), an average inter-peak hour (10:00-15:30) and a PM peak hour (17:00-18:00). The off-peak and weekend time periods are not included within the appraisal. Note that this means that the congestion benefits are likely to have been somewhat underestimated.

7.1.6 The modelled period benefits calculated by TUBA were converted into an estimate of annual benefits using the following peak hour to peak period factors:

- Weekday AM peak period (7am to 10am, 3 hours) – 2.82 * AM peak hour
- Weekday IP period (10am to 4pm, 6 hours) – 6.45 * IP average hour; and
- Weekday PM period (4pm to 7pm, 3 hours) – 2.77 * PM peak hour

7.1.7 The annualisation factor for each TUBA time period also has to incorporate the number of times the period occurs per year, with the year divided up as follows:

- 253 normal weekdays

7.1.8 The two sets of factors above were combined to create annualisation factors applicable to the standard TUBA time periods. Table 7-1 summarises the TUBA periods and relevant annualisation factors.

Table 7-1 : Time slices and annualisation factors

No	Time Slice	Time Period	Duration (mins)	Formula	Annualisation Factor
1	07:00-10:00	AM Period	60	2.82 * 253	679
2	10:00-16:00	IP Period	60	6.45 * 253	1512
3	16:00-19:00	PM Period	60	2.77 * 253	707

7.1.9 The traffic model user classes split into eight user classes within TUBA, and the purpose split was derived using the default WebTAG split:

Table 7-2: User Classes

User Class	Description
1	Compliant Cars
2	Non-Compliant Cars
3	Compliant LGVs
4	Non-Compliant LGVs
5	Compliant OGVs
6	Non-Compliant OGVs
7	Compliant Taxis
8	Non-Compliant Taxis

7.1.10 The TUBA outputs were converted from present value 2010 prices to present value 2018 prices using the GDP deflator series sourced from DfT's WebTAG Databook (May 2018 edition).

7.1.11 In order to bypass a limitation of the software (which doesn't allow to have two different user classes with same vehicle type, purpose and person type), the 8 user classes have been divided into 4 separate runs. The user classes have been split in the groups reported in Table 7-3.

7.1.12 The results from the different runs have been summed up later to obtain the total results.

Table 7-3: User classes included in the TUBA runs

Run Nr.	User Classes
1	Compliant Cars, Compliant LGVs, Compliant OGVs
2	Non-Compliant Cars, Non-Compliant LGVs, Non-Compliant OGVs
3	Compliant Taxis
4	Non-Compliant Taxis

8 Cost to the public sector

8.1.1 As part of this economic appraisal, costs for scheme implementation, operating and maintenance costs and revenue for the public sector have been analysed as well. For more details on the methodology and the results refer to the main OBC document, section Financial Case.

8.2 Implementation cost

8.2.1 The implementation costs include all costs associated with setting up scheme measures, this includes purchasing and administering the implementation of depreciable and non-depreciable assets. Table 8-1 summarises the implementation cost types by scheme and outlines the key drivers underlying cost forecasts.

Table 8-1: Implementation costs and primary cost drivers

CAP Measure	Cost Drivers
Clean Air Zone	Signs, Automatic Number-Plate Recognition (ANPR) cameras and associated installation costs IT systems to manage the scheme and Penalty Charge Notice PCN process Detail design work and marketing campaigns prior to scheme launch Mobilisation and recruitment costs for staffing the scheme
Local Authority and Greater Manchester Fleet Upgrade	Upgrade of non-compliant vehicles owned by the Districts to lowest emission possible, including all Local Authority operated cars/vans, refuse collection vehicles, HGVs
Clean Taxi Fund	Population of non-compliant taxis and PHVs Amount allocated per vehicle
Clean Bus Fund	Population of non-compliant buses in Greater Manchester Cost to retrofit buses, where possible

CAP Measure	Cost Drivers
Clean Freight Fund	Population of non-compliant vehicles Amount allocated per vehicle
Electric Vehicle Infrastructure and Promotion	Cost to buy and install dual head rapid chargers
Sustainable Journeys	Resource to deliver interventions Costs are profiles from 2019 to 2018
Loan Finance	This measure is yet to be further defined, however, a general assumption for cost to administer a loan scheme is c1% of the loan book value

8.3 Operating & Maintenance Cost

8.3.1 Operational costs are assumed that will continue for a period of 8 years after implementation, which is the agreed NO2 compliance date plus one year, with decommissioning infrastructure taking place in year 9.

8.3.2 Table 8-2 summarises the operation and maintenance cost types by scheme and outlines the key drivers underlying cost forecasts.

Table 8-2: Operation and maintenance costs and primary cost drivers

CAP Measure	Cost Drivers
Clean Air Zone	Staff to recover PCN charges Premise space and systems ANPR camera and sign maintenance Mobile enforcement units
EV Infrastructure and Promotion	Ongoing maintenance of the charge points Electricity costs are assumed to be covered by revenue generated
Vehicle Renewal Scheme: Clean Air Funds	Population of non-compliant vehicles Amount allocated per vehicle
Vehicle Renewal: Clean Taxi Fund	Population of non-compliant taxi and PHVs Amount allocated per vehicle
Vehicle Renewal: Clean Bus Fund	Population of non-compliant buses in Greater Manchester Cost to retrofit buses
Sustainable Journeys	Resource to deliver interventions Costs are profiled from 2019 to 2027

9 Issues and Caveats

9.1 Sensitivity Testing

9.1.1 There is considerable uncertainty about the possible impacts of the proposed GM CAP on travel patterns and thus on the economy and quality of life. More work is required to better understand and test the proposals: this will be carried out at FBC.

9.1.2 Sensitivity testing is an important step in analysing the impact of uncertainty on results and subsequently on decision making and is required by JAQU. Sensitivity testing has been carried out and is reported in the supplementary technical report. The wider implications of the sensitivity testing are discussed in the Analytical Assurance statement.

9.1.3 Further sensitivity testing is likely to be required at FBC.

9.2 Assessing Air Quality Benefits

9.2.1 Changes in NO_2 and PM have been quantified using the damage cost approach which relies on the change in total (gross) emissions. This does not reflect the change in ambient concentration levels over the appraisal period which ultimately drive improved health outcomes. A more thorough methodology will be explored at FBC.

9.2.2 The air quality impact of option 5(ii) is underestimated for two reasons. Firstly, the model is only able to assess the benefit within the CAZ area, such that the same vehicle is considered to be a petrol vehicle within the zone and a diesel vehicle whilst travelling outside the zone. Secondly, the modelling does not assume any diesel euro 6 car trips to be cancelled or re-moded. Realistically, we would expect to see a substantial amount of diesel trips cancelled or re-moded, especially for those that do not enter the CAZ frequently and have reasonable accessibility to public transport. These assumptions were imposed by the limitations of the modelling tools available.

Appendix 1 - Key Assumptions

General Parameter	Assumption-Description	Source
Active Travel	10% of all trips switching into active travel are walking trips, and 90% are cycling trips	Jacobs
Average price of compliant vehicles (new vehicles)	The average cost for petrol and diesel cars developed from online research	JAQU National data inputs for Local Economic Models.xlsm (available on Huddle) Online research (AutoTrader)
Behavioural Response	The proportion of vehicles to upgrade, pay charge, re-mode etc.	Jacobs
Buses	The oldest vehicles will be replaced rather than retrofitted.	TfGM/Jacobs
Buses	The average cost of retrofitting a bus is £18,000	Jacobs
Buses	All buses will be 100% compliant by 2021.	Jacobs
Congestion Effect	The travel time savings and change in vehicle operating cost is identical between option 5(i) and option 5(ii)	TfGM/Jacobs
Daily charges	Cars/LGV/PHV & Cabs = £7.50 HGVs/buses/coaches = £100.00	Jacobs
Euro/GBP conversion	The Euro/pound conversion used is 1.12168. This is based on the conversion rate of 21/11/2018	Jacobs
Fuel switch	Assume diesel car owners may switch to petrol, but no petrol car owners will choose to switch to diesel	Jacobs
Fuel switch	Assume the vehicle km travelled for diesel vehicle owners do not change when switching to petrol	Jacobs
Fuel switch	Assume the vehicle km travelled per vehicle is constant throughout the appraisal period	Jacobs
Fuel switch	The average fuel consumption (litre/km) for euro 6 is assumed the same for euro 6c and 6d.	Jacobs
Fuel switch	Vehicles switching from Diesel to petrol are assumed to make the same km as a diesel vehicle	Jacobs
General	Opening year of the CAZ is 2021, and last year of appraisal period is 2030	TfGM/Jacobs
General	The value of all monetised impacts will be presented in 2018 values	JAQU's Option Appraisal Guidance

General Parameter	Assumption-Description	Source
General	All values will be discounted to 2018 base year using a 3.5% discount factor per annum	JAQU's Option Appraisal Guidance
General	The annualisation factor is 253 days	TfGM
Health and Environmental Impact (appraisal period)	To estimate the health and environmental benefits over the appraisal period, the 2021 estimate will be adjusted according to the % of non-compliance across 2021-2030 relative to the opening year	Jacobs
HGVs	Assume HGVs trips cannot be switched to either public transport, nor active travel.	Jacobs
Impacts in non-modelled years	Future year costs and benefits will decrease relative to scheme opening year at the same rate as non-compliant users would upgrade to compliant vehicles in the baseline	Jacobs
Scrappage	50% of non-compliant vehicles eligible for the Vehicle Renewal Fund will choose to scrap their vehicle	Jacobs
Taxis	Taxis (hackney cabs) are assumed to be 100% compliant by 2021, meaning all non-compliant taxis we assume to upgrade only.	TfGM/Jacobs
Transaction cost	Euro 6, 6c and 6d transaction cost is assumed to be the same as euro 5	Jacobs
Transaction costs	Transaction costs based on JAQU-recommended transaction cost values	JAQU
Upgrade to compliant vehicles	Car drivers who choose to replace a non-compliant vehicle with a compliant model would purchase compliant vehicles in the same proportions as compliant vehicles in the existing fleet mix.	TfGM/AQ Consultants
Vehicle Upgrade	If upgrade response is triggered then 25% of those upgrading will purchase a new vehicle and 75% will replace their non-compliant vehicle with a second-hand compliant vehicle.	JAQU
Vehicle Upgrade	All vehicle upgrades are assumed to take place in 2021, with the exception of LGV's in option 8 which are assumed to upgrade in 2023, no growth in LGV's is assumed between 2021 and 2023.	Jacobs
Vehicle Upgrade	The market price is the minimum price at which owners would value their vehicle.	Jacobs
Vehicle Upgrade	The maximum value placed on a vehicle is the value of a vehicle one Euro standard above.	Jacobs
Welfare Loss (trips cancelled and re-moded)	There is no difference in the number of trips cancelled and re-moded between option 5(i) and option 5(ii). Subsequently, this means the value of welfare loss attributed to trips cancelled/re-moded is the same.	TfGM/Jacobs