

Greater Manchester's Clean Air Plan to tackle Nitrogen Dioxide Exceedances at the Roadside

Note 33: Option for Consultation – Sensitivity Analysis of Zero Emission Capable Taxi Upgrade Responses



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COVID-19 Pandemic Statement

This work has not considered the impact of the COVID-19 pandemic. Whilst we are continuing, where possible, to develop the Greater Manchester Clean Air Plan, the pandemic has already had an impact on our ability to keep to the timescales previously indicated and there may be further impacts on timescales as the impact of the pandemic becomes clearer.

We are also mindful of the significant changes that could result from these exceptional times. We know that the transport sector has already been impacted by the pandemic, and government policies to stem its spread. The sector's ability to recover from revenue loss, whilst also being expected to respond to pre-pandemic clean air policy priorities by upgrading to a cleaner fleet, will clearly require further thought and consideration.

The groups most affected by our Clean Air Plan may require different levels of financial assistance than we had anticipated at the time of writing our previous submission to Government.

More broadly, we anticipate that there may be wider traffic and economic impacts that could significantly change the assumptions that sit behind our plans. We have begun to consider the impacts, and have committed to updating the government as the picture becomes clearer over time.

We remain committed to cleaning up Greater Manchester's air. However, given the extraordinary circumstances that will remain for some time, this piece of work remains unfinished until the impact of the COVID-19 pandemic has been fully considered by the Greater Manchester Authorities.

1 Introduction

1.1 Overview

GM submitted the Clean Air Plan (GM CAP) Outline Business Case (OBC) to JAQU in March 2019. The methodology applied to modelling of conditions with and without action was set out in the supplementary Air Quality reports (AQ1/2/3) and Transport reports (T1/2/3/4), and the Economic Appraisal Methodology Report, set alongside a discussion of the limitations, uncertainties and risks of the evidence base in the Analytical Assurance Statement (AAS). A series of sensitivity tests were undertaken, supplied as appendices to the aforementioned reports.

Following OBC submission, various updates to the modelling process were implemented and these were reported in a series of Notes supplied to JAQU in July, August and November 2019, with revised results summarised in “Note 29: Option for Consultation Modelling Summary Note” supplied to JAQU in October 2019.

The preferred option from the OBC has been further developed into the Option for Consultation. This is set out in section 2.

The Clean Taxi Fund incentivizes a switch to a zero emissions capable (ZEC) electric taxi rather than a compliant diesel or petrol powered vehicle through limiting the funding options available for ICE vehicles and offering higher grants for ZEC vehicles. This brings additional air quality benefits because these lead to zero emissions from the tail pipe, as opposed just a relatively small reduction in NOx emissions from a compliant diesel engine and where real-world performance is still uncertain.

Given the declared climate emergency, and clear need to de-carbonise cities and transport, GM needs to ensure that taxi owners are not locked into internal combustion engine (ICE) vehicles due to the need to upgrade for the CAP immediately, which prevents them taking a more holistic and progressive, yet more expensive, approach to investing in their vehicles.

It should be noted, that whilst differential funding for ZEC taxis is critical to increased uptake of these cleaner compliant vehicles, this is not the only factor limiting driver behaviour. The evidence from GMs deliberative research with taxi drivers, and from other cities, is that electric charging infrastructure also needs improvement to provide reassurance to the sector that range will not be an issue.

The impacts of measures to promote the uptake of electric taxis were included in the consultation modelling by assuming that the taxi funding would encourage approximately 15% of licensed Hackney Carriages and private hire cars to switch to electric vehicles. The rationale behind this assumption is described in Section 3.2.

The purpose of this note is to describe the sensitivity tests that have been carried out to assess the impacts of changes to the electric taxi assumptions on expected emissions and compliance with Air Quality Standards for NO₂. The tests have been carried out for a forecast year of 2023 by re-calculating NO₂ concentrations based on low and high uptakes of electric taxis of 0% and 25% respectively.

The note summarises the analysis and presents the results of the tests.

1.2 Structure of this Note

Following this introduction, the rest of the note is set out as follows:

- Section 2 recaps the proposed Measures;
- Section 3 describes how electric taxis were modelled for the consultation option;
- Section 4 describes the taxi sensitivity test and presents the results of the analysis; and
- Section 5 provides a summary of the key conclusions.

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2 Recap of the proposed Consultation Option Measures

2.1 Overview

The components of the implementation package are set out below:

- M1 – Sustainable Journeys;
- M2 – Clean Bus Fund and GM wide CAZ A for buses and coaches;
- M3 – GM wide CAZ A for taxis and private hire vehicles (PHVs);
- M4 – GM wide CAZ B for HGVs; and
- M5 – GM wide CAZ C for LGVs and minibuses.

The additional Clean Air Fund (CAF) measures are set out below, and these have been modelled individually with the full suite of Implementation measures as listed above, to isolate the specific impacts of each measure:

- M6 – Taxi Fund, including investment in electric charging infrastructure for taxis;
- M7 – Commercial Vehicles (HGV & LGV) Fund; and
- *M8 – Loan Finance (note that this measure was not modelled in the Consultation Option as described in Note 29 and has not been modelled here, but may be included in future modelling so is listed for completeness). Note that subsequent progress on the approach to funding M6 and M7 mean that it is anticipated that a vehicle finance measure would form part of the delivery mechanism for the M6 and M7 funding pot, rather than being considered a standard measure.*

The Consultation Option includes all the measures set out above. The Consultation Option also includes proposals for investment in electric charging infrastructure across Greater Manchester, which has not been incorporated in the modelling.

2.2 Modelling System

The impacts of the measures were assessed using the CAP modelling suite as illustrated below:



The modelling system consists of five components:

- The Demand Sifting Tool (DST), effectively a variable demand model, which models behavioral responses to the CAP measures and creates do-something assignment matrices for input to the Saturn model;
- The Saturn model, which provides details of traffic speeds and flows for input to the emissions model and forecasts of travel times, distances and flows for input to the economic appraisal;
- The emissions model, which uses TfGM's EMIGMA (Emissions Inventory for Greater Manchester) software to combine information about traffic speeds and flows from the Saturn model with road traffic emission factors and fleet composition data from the Emission Factor Toolkit (EFT) to provide estimates of annual mass emissions for a range of pollutants including oxides of nitrogen (NO_x), primary-NO₂, particulate matter (PM₁₀ and PM_{2.5}) and CO₂;
- The dispersion model, which uses ADMS-Urban software to combine information about mass emissions of pollution (from EMIGMA) with dispersion parameters such as meteorological data and topography; and
- Finally, the outputs of the dispersion model are processed to convert them to the verified air quality concentrations, using Defra tools and national background maps.

2.3 Components of each Measure and Modelling Approach

The assumptions around each component and the way in which they were modelled are summarised in **Table 2-1**.

Table 2-1 Summary of Measure Test

ID	Description	Assumptions	Measure Modelling Process
M1	Sustainable Journeys	Reduction in vehicle km	Applied within the highway model as a reduction in vehicle trips as drivers transfer to other modes. Mass emissions and concentrations calculated using EMIGMA and the dispersion model.
M2	Clean Bus Fund and GM wide CAZ A for buses	100% upgrade bus fleet to compliant vehicles Implemented from 2021 onwards	Applied post highway model in EMIGMA
M3	GM wide CAZ A for taxis (Hackney carriages) and private hire vehicles (PHVs)	Charge level of £10 per day, with a discounted weekly charge of £50 for owner-driver PHVs, assumed for modelling purposes to apply to all PHVs Implemented from 2021 onwards WAV exemption to 2023, assumed for modelling purposes to apply to all Hackneys and no PHVs	Behavioural response determined from bespoke Taxi Cost Model Implemented within Demand Sifting Tool (DST), assignment model (SATURN) and EMIGMA
M4	GM wide CAZ B for HGVs	Charge level of £60 per day Implemented from 2021 onwards	Behavioural response determined from bespoke cost model Implemented within DST, assignment model (SATURN) and EMIGMA
M5	GM wide CAZ C for LGVs (Full Implementation Package)	Charge level of £10 per day Implemented from 2021 onwards, with full exemption assumed to 2023 (so for modelling purposes implemented from 2023)	Behavioural response determined from bespoke cost model Implemented within DST, assignment model (SATURN), EMIGMA and the dispersion model
M6	Clean Taxi Fund	PHV Fund: (working assumption all PHVs are non-WAV). Funding values per vehicle assumed to be:	Behavioural response determined from bespoke Commercial Vehicles Cost Model

		<ul style="list-style-type: none"> – All PHV = £3,000 <p>Hackney Fund: (working assumption that all Hackneys are WAV)</p> <p>Note: as majority of Hackneys are already WAV funds are not introduced until 2023. Funding values per vehicle assumed as:</p> <ul style="list-style-type: none"> – Zero Emission WAV Hackney = £10,000 – Retrofit = £5,000 	Implemented within DST, assignment model (SATURN), EMIGMA and the dispersion Model
M7	Commercial Vehicles Fund	<p>HGV Fund: varies by weight category (scrappage required) assumed to be:</p> <ul style="list-style-type: none"> – 7.5t = £2,500 – 18t = £3,500 – 26t = £4,500 – 32t = £5,500 – 44t = £4,500 <p>LGV Fund assumed to be: (scrappage required)</p> <ul style="list-style-type: none"> – £3,500 Fund level for all eligible LGVs 	<p>Behavioural response determined from bespoke cost model</p> <p>Implemented within DST, assignment model (SATURN), EMIGMA and the dispersion model</p>
M8	Loan Finance	Not modelled in current iteration. <i>Note that subsequent progress on the approach to funding M6 and M7 mean that it is anticipated that a vehicle finance measure would form part of the delivery mechanism for the M6 and M7 funding pots, rather than being considered a separate measure.</i>	
-	GM CAP Consultation Option	Includes all assumptions as set out above for Implementation and CAF proposals	As per methodology for each measure set out above

3 Modelling ZEC Taxes for the Consultation Option

3.1 Introduction

This section provides an overview of the methodology for modelling the uptake of ZEC taxes for the consultation option. It describes:

- the method for forecasting the uptake of ZEC vehicles; and
- the approach taken to represent ZEC vehicles in the emissions modelling.

3.2 Forecasting the Proportions of ZEC Taxes

The proportions of Hackney Carriages and PHVs switching to ZEC vehicles have been derived from the output responses from the taxi vehicle cost model, which identified a proportion of taxi that would be upgraded in response to the CAP. These upgrade responses were derived for the year where charging is introduced for that vehicle type, 2021 for PHVs and 2023 for Hackneys. Wheelchair accessible licensed vehicles (WAVs) will be eligible for an exemption to end 2022. Most Hackney Carriages are WAVs, whilst very few PHVs are. Therefore, for modelling purposes, it has been assumed that all Hackney Carriages and no PHVs are eligible for the exemption to end 2022.

The Taxi cost model identified the following upgrade response for taxis for vehicles upgrading as a result of the CAP. It is noting that the cost model was reviewed and is in line with behavioural responses from the Sheffield SP surveys which provided a significant upgrade response to ZEC taxes for both Hackneys and PHVs.

Table 3-1 ZEC Taxi Upgrade Response

Peak Hour	PHV proportion (2021)	Hackney Proportion (2023)
Purchase ZEC	37.6%	30.1%
Change to Lease (ZEC)	9.6%	0.2%
Total Upgrade to ZEC	46.3%	30.3%

These upgrade responses were then applied to the trips volumes within the DST to understand the overall composition of journeys that would be made by ZEC Vehicles due to the CAP. This is shown below for PHVs and Hackney Carriages.

Table 3-2 Numbers of ZEC PHV Trips – 2021 (Trips)

Peak Hour	DM Compliant	DS Compliant	DS - DM	ZEC Taxes Proportion	ZEC Taxes	Proportion ZEC
AM	14,027	21,097	7,070	46%	3,274	16%
IP	11,604	17,453	5,849		2,708	
PM	14,339	21,566	7,228		3,346	

Table 3-3 Numbers of ZEC Hackney Carriage Trips – 2023 (Trips)

Peak Hour	DM Compliant	DS Compliant	DS - DM	ZEC Taxis Proportion	ZEC Taxis	Proportion ZEC
AM	1,433	2,380	948	30%	287	12%
IP	1,188	1,972	784		237	
PM	1,465	2,433	967		293	

The proportion of ZEC trips calculated above was then applied within each of the forecast years and is summarised below for 2023 and 2025, identifying 15% of taxi trips to be undertaken using ZEC vehicles.

Table 3-4 Numbers of ZEC Taxi Trips 2023 and 2025

Year	Peak Hour	2023		2021	
		DS Compliant	ZEC Taxis	DS Compliant	ZEC Taxis
PHV	AM	21,715	3,369	22,441	3,482
	IP	18,004	2,794	18,629	2,891
	PM	22,210	3,446	22,920	3,556
Hackney Carriages	AM	2,380	287	2,560	308
	IP	1,972	237	2,124	256
	PM	2,433	293	2,614	315
Taxi Combined	AM	24,095	3,656	25,001	3,790
	IP	19,976	3,031	20,753	3,146
	PM	24,643	3,739	25,534	3,871
Proportion ZEC	AM		15%		15%
	IP		15%		15%
	PM		15%		15%

3.3 Modelling the Air Quality Impacts of ZEC Taxis

The air quality impacts of measures to promote the increased take up of ZEC taxis have been modelled post assignment by adjusting the compliant vehicle flows that are output from the Saturn model and that are input to EMIGMA assuming that ZEC vehicles generate zero emissions at the exhaust.

In the case of the Consultation Option this involved reducing the compliant Taxi flows that are input to the EMIGMA calculations by 15% thereby reducing the NOx emissions from taxi by the same proportion, based on the analysis shown above.

4 Taxi Sensitivity Test

4.1 Introduction

This section describes the ZEC taxi sensitivity test, as requested by JAQU, and presents the results of the analysis.

4.2 Methodology

The sensitivity test has been carried out for a forecast year of 2023 using the CAP modelling suite, as discussed in Section 2.2.

Two tests were performed by re-calculating NO₂ concentrations for the consultation package based on Low and high uptakes of ZEC taxis of 0% and 25%, respectively. These tests represent reasonable minimum and maximum ranges for ZEC upgrade rates for Hackney Carriages, where there is a differential increase in the Funds provided to encourage uptake of ZEC vehicles over ICE compliant vehicles.

For the 25% test, this was based on the core assumption for PHVs, though assumed that all Hackney Carriages become Zero Emissions Capable (ZEC), which results in an overall 25% of taxi trips as ZEC instead of 15% under the core scenario.

The Low test was implemented by feeding the traffic flows from the consultation package Saturn model into EMIGMA without making any changes to the compliant Taxi flows, effectively meaning all compliant taxi emissions are ICE. The High test was implemented by reducing the compliant Taxi flows that are output from the Saturn model and that are input to EMIGMA by 25%, effectively reducing NO_x emissions by 25%. The outputs from EMIGMA for both tests were then assessed using the dispersion model to investigate the air quality impacts of the scenarios.

4.3 EMIGMA Results

The results of the EMIGMA modelling are presented below in Table 4.1, which shows modelled changes in annual mass NO_x emission totals for 2023 for each of the sensitivity tests relative to the Consultation Option.

Changes in NO_x emissions are reported for roads inside the Regional Centre and for Greater Manchester as a whole, for taxis and for all vehicles combined. The location of the Regional Centre cordon is shown in Figure 1, and has been defined as within the Inner Relief Road.

Figure 1 Regional Centre Cordon

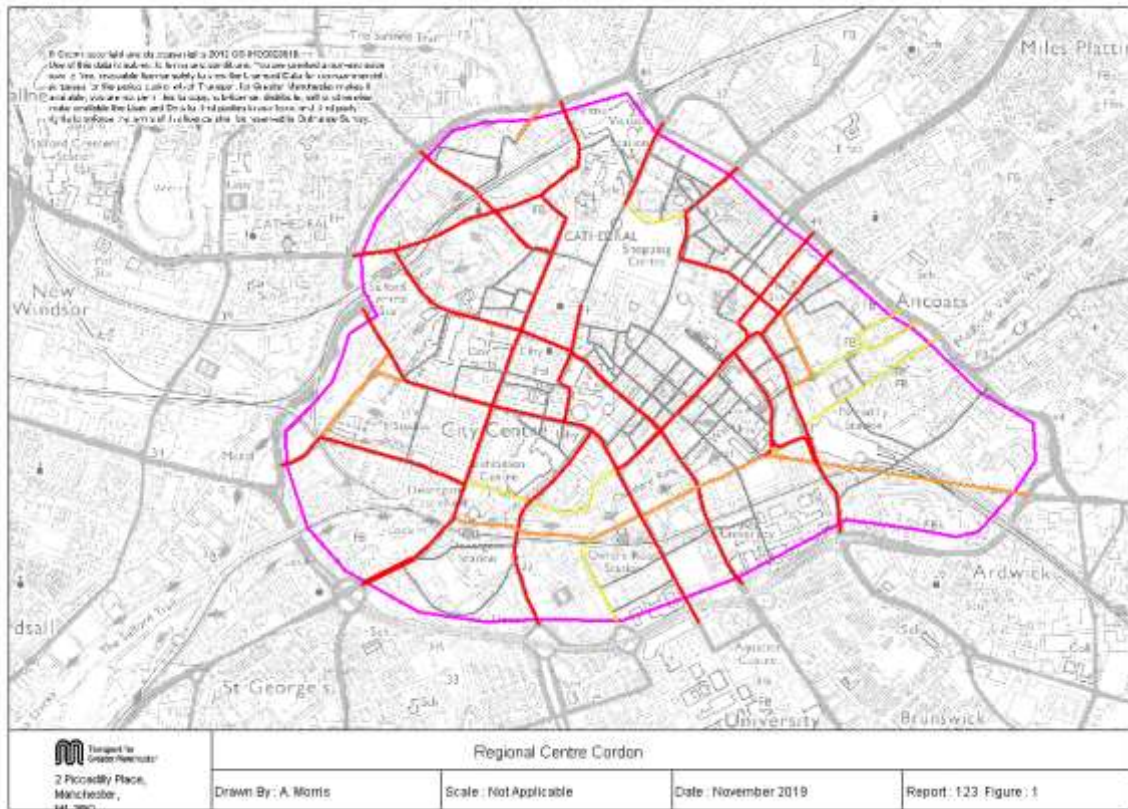


Table 4-1 EMIGMA Mass NOx Emission Totals (2023, Tonnes per Year)

Vehicle Source	Regional Centre				
	Consultation Option	Low Sensitivity Test		High Sensitivity Test	
		0% EV Upgrade	% Change	25% EV Upgrade	% Change
Taxi	1.5	1.7	+16%	1.3	-11%
All Vehicle	35.4	35.7	+0.7%	35.3	-0.5%
Vehicle Source	Greater Manchester				
	Consultation Option	Low Sensitivity Test		High Sensitivity Test	
		0% EV Upgrade	% Change	25% EV Upgrade	% Change
Taxi	248	289	+16%	221	-11%
All Vehicle	4,818	4,858	+0.8%	4,791	-0.6%

The results for the Low (0%) upgrade test show that mass NOx emissions from taxis within the Regional Centre and Greater Manchester are very similar are forecast to be approximately 16% greater than those for the Consultation Option, with an increase in road traffic NOx emissions overall (from all vehicle types) of approximately 0.7%.

The results for the High (25%) upgrade sensitivity test show that mass NOx emissions from taxis within the Regional Centre and Greater Manchester are forecast to be reduced by approximately -11% relative to the Consultation Option, with a reduction in road traffic NOx emissions overall (from all vehicle types combined) of approximately -0.5%.

The similarity in response between the Regional Centre and the whole of Greater Manchester under this specific test reflects the approach to modelling taxi demand, which is set as a fixed proportion of car trips, based on ANPR data analysis, because there is no specific data on taxi demand available. In reality, it would be expected that there are a greater proportion of taxi movements in the Regional Centre and other urban centres, and the impacts associated with taxi responses would be greater in these locations than the wider road network. However, it is not possible to test this under the current approved modelling process.

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4.4 Dispersion Modelling Results

In order to understand the impact of the Measures on NO₂ concentrations, and their effect on compliance with the Limit Values, dispersion modelling has been undertaken for the low and high ZEC taxi uptake test, for 2023.

The results on the number of exceedances, set out by concentration band are provided in Table 4-2.

Table 4-2 Number of sites by scale of exceedance, for each Test (2023)

Measure Test	Compliant sites		Non-compliant sites				Change from Do Min.
	Very compliant (below 35 µg/m ³)	Compliant but marginal (35 to 40 µg/m ³)	Non-compliant (>40 to 45 µg/m ³)	Very non-compliant (>45 to 50 µg/m ³)	Extremely non-compliant (>50 µg/m ³)	Total non-compliant (>40 µg/m ³)	
2023							
Do Minimum	2,287	209	55	13	1	69	n/a
Consultation Option	2,485	51	3	0	0	3	-66
Low test – 0% EV uptake	2,484	50	5	0	0	5	-64
High test – 25% EV uptake	2,487	49	3	0	0	3	-66

4.5 Commentary on impact on air quality

Without action, there are predicted to be 69 locations remaining in exceedance across Greater Manchester in 2023. The full CAP Consultation Option, which includes the increased funding provision for ZEC taxis, reduces the number of exceedances in 2023 to three, with full compliance across GM predicted in 2024.

Under the Low test without any predicted upgrade to ZEC taxi, the number of exceedances in 2023 increases from three to five. Whereas, under the High test, the number of exceedances in GM in 2023 is unchanged from the Consultation Option.

In order to better understand the effect of ZEC taxi upgrade on compliance at specific sites, the predicted NO₂ concentrations have been presented for the most persistent locations of poor air quality, where exceedances are still predicted in 2023 for the Low test, set out in Table 4-2.

At these locations, the impact of the Low and High tests is typically equal in terms of increase or decrease in predicted NO₂ concentrations at each site, with changes up to ± 0.2 ug/m³.

Site 1268_1269 (A34 John Dalton St) is predicted to have the maximum NO₂ concentration in 2024, at 40.4 ug/m³. This determines that the GM CAP is predicted to deliver compliance in 2024 by the narrowest possible margin. Under the Low Test scenario, the concentration at this site in 2024 is predicted to increase by 0.1 ug/m³, to 40.5 ug/m³. This would be deemed an exceedance, and the predicted first year of compliance within GM would be delayed until 2025.

Table 4-3 Modelled NO₂ Concentrations at sites predicted to exceed in 2023 for the Low Test

Site Details			Modelled NO ₂ Concentrations (ug/m ³)					
Site ID	LA	Road Name	Do Minimum	Consultation Option	Low Test: 0% ZEC Taxi	Consult. Option – Low Test	High Test: 25% ZEC Taxi	Consult. Option – High Test
MAXIMUM CONCENTRATION IN EACH SCENARIO			50.8	41.5	41.6	na	41.4	na
2237_3790_DW	Bury	A58 Bury Bridge	46.9	40.9	41.1	+0.2	40.7	-0.2
1268_1269	Manchester	A34 John Dalton St	50.8	41.5	41.6	+0.1	41.4	-0.1
1349_2993_DW	Salford	A57 Regent Rd	45.7	40.3	40.5	+0.2	40.1	-0.2
1268_46301	Manchester	A34 Bridge St	49.0	41.1	41.2	+0.1	41.1	0.0
NonPCM_207	Manchester	A34 Bridge St / A56 Deansgate	49.4	40.4	40.5	+0.1	40.4	0.0

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5 Conclusions

- 5.1 The sensitivity testing of the modelling of ZEC taxi upgrade rate has shown the impacts on the predicted NO₂ concentrations compared to the Option for Consultation and shows a benefit of the ZEC taxi upgrade in terms of ensuring compliance with the Air Quality Standard for NO₂ in 2024, compared to upgrade to ICE compliant vehicles, which risks delaying compliance to 2025.

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