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

Technical Note 35:

Forecasting the required number of rapid chargers for Hackney Carriages and Private Hire Vehicles

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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 GM CAP Context

1.1 Since 2010 the UK has been in breach of national Limit Values for annual mean concentrations of nitrogen dioxide (NO_2), as set by the Air Quality Standards Regulations 2010, which implemented the Ambient Air Quality Directive (2008/50/EC) into English law. This is as a result of elevated NO_2 concentrations in major urban areas, including GM.

1.2 The UK Government's Air Quality Plan1 requires local authorities with persistent exceedances to undertake local action to consider the best option to meet statutory NO2 Limit Values in the shortest possible time.

1.3 In March 2019, the ten GM Local Authorities collaboratively submitted an Outline Business Case (OBC) for the GM CAP to the Joint Air Quality Unit (JAQU) outlining a package of measures to deliver regional compliance with national Limit Value for NOx emissions.2

1.4 To support the transition to zero emission Hackney Carriages and Private Hire Vehicles, forecasting of the required number of rapid chargers has been performed.

2 Introduction

2.1 The purpose of this document is to quantify the number of electric vehicle (EV) chargers that will be required for Hackney Carriages and Private Hire Vehicles (PHVs) (referred to collectively as taxis) across Greater Manchester.

2.2 EV chargers and the uptake of EVs are closely linked. Without adequate charging infrastructure, drivers of taxis and PHVs will not be able to transition to EVs, even if they would like to.

2.3 The provision of EV charging infrastructure acts as an upper bound for the uptake of EVs, particularly for those vehicles that are dependent on accessing charging away from their usual residing place and during operation. Hackneys and PHVs are within this category of vehicles.

2.4 There will be rapid charging infrastructure targeted at the general public that Hackneys and PHVs will be able to use. This does not, however, provide a network of chargers that Hackney and PHV drivers can rely on during operation.

[1] Department for Environment, Food & Rural Affairs. 2017. UK Plan for tackling roadside nitrogen dioxide concentrations

[2] GM's Outline Business Case to tackle Nitrogen Dioxide Exceedances at the Roadside

2.5 The alignment of the increasingly important role of Hackneys and PHVs in urban mobility provision with the objectives of the Clean Air Plan motivates specific attention to be given to the charger infrastructure requirements of those vehicles.

3 Summary of conclusions

3.1 The EV charging infrastructure demand forecasting is based on the CAP cost model estimate that 15% of all Hackney and PHV trips will be made by electric vehicles in 2025[3] for GM to meet air quality compliance.

3.2 The modelling undertaken indicates the planned 30 x 50kW rapid charging devices delivered through secured OLEV funding would not meet any of the projected scenarios.

3.3 Given the uncertainty around EV uptake (other than those provided through the Try Before You Buy scheme) by the Hackney and PHV sector it is considered that the central scenario presents the most reasonable option to plan for. This indicates a need for an additional 60 rapid charging devices by 2025.

3.4 Of those 60 devices, it is considered that a further 40, publicly funded rapid charging devices are needed to provide confidence and certainty for the Hackney and PHV trade that there is sufficient volume of dedicated charging infrastructure available to transition to EV.

3.5 Combined with the 30 provided via OLEV funding, this would result in a total of 70 publicly funded charging devices, representing a 78% share of the total projected demand of the central scenario with the aim of stimulating accelerated EV up-take and, in turn, stimulating private investment.

3.6 Table 9 provides an overview of the potential contribution interventions to deliver 30 and 40 rapid charging devices individually and collectively.

Table 1 Projected percentage share of projected EV Charging Device Demand Scenario

Public Funding Charging Infrastructure Intervention	Total 50kW Rapid Chargers low scenario estimate	Total 50kW Rapid Chargers central scenario estimate	Total 50kW Rapid Chargers high scenario estimate
	34	**90**	**190**
OLEV 30 Rapid Charging Devices	88%	33%	16%
Additional 40 Rapid Charging Devices	118%	44%	21%
Total 70 Rapid Charging Devices	206%	78%	37%

[3] GM CAP Technical Note 33: Sensitivity Analysis of Electric Taxi Upgrade Responses

3.7 There are a number of factors that need to be considered when projecting EV charging demand and this may result in the need for additional forecasting to be undertaken. The main areas of sensitivity are considered here.

<u>Minimum Licensing Standards</u>

3.8 The timing and scope of Minimum Licensing Standards will influence EV take-up and consequently influences the number of EV charging devices needed for EV taxis and PHVs.

<u>Access to home charging</u>

3.9 It is not known whether there is a systematic difference between Hackney and PHV drivers and the general public in the ability to charge a vehicle at home.

3.10 Currently, home charging is where the majority of charging takes place for EV owners who can charge at home and this is likely to also be true for Hackney and PHV drivers due to convenience, low cost per kWh and the long term preservation of battery performance.

3.11 The planned Taxi Census will help understand the proportions of Hackney and PHV drivers that will have access to home charging.

<u>Battery Efficiency</u>

3.12 Weather conditions can have a large impact on efficiency. As shown in Table 5, cold and mild weather can influence the efficiency by approximately 50%.

3.13 Driving style can have a large impact on the efficiency of EVs. Driving style generally becomes more efficient over time[4].

<u>Utilisation of charge points</u>

3.14 How Hackney and PHV drivers use chargers is currently unknown as EV uptake is only at approximately 1%.

<u>Battery technology</u>

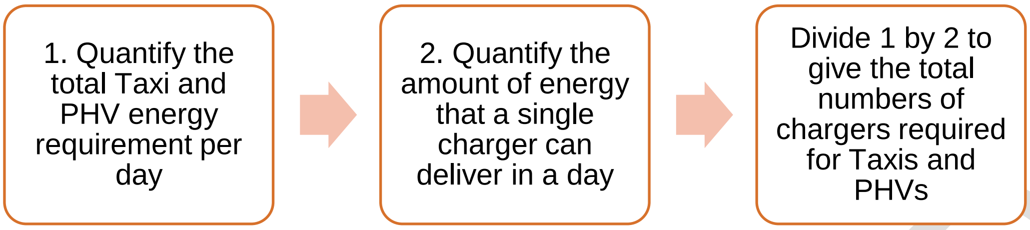
3.15 Battery technologies will change significantly in the coming years which will impact on the type and frequency of charging.

[4] Electric Buses: Lessons to be Learnt from the Milton Keynes Demonstration Project, Procedia Engineering

4 Methodology

<u>Overview</u>

Figure 1 Main steps to quantifying Rapid charger requirements for Hackneys and PHVs



4.1 The expression used to calculate the required number of chargers is shown later in Equation 1. The variables in this equation are as follows:

- $\mathbf{N_{taxis}}$ **:** the number of Hackneys or PHVs;
- **Distance per day:** The average distance travelled by a Hackney or PHV per day. This is converted into an energy requirement using typical EV efficiencies;
- **Electric trip fraction:** The fraction of trips performed by Hackneys or PHVs which are electric. An assumption is made that electric Hackneys and PHVs do not perform more or less mileage than Internal Combustion Engine (ICE) vehicles;
- **Ability to charge at home:** The fraction of Hackneys and PHVs that can charge their vehicle at home (f_{hc}). The fraction that cannot charge at home is therefore ($1-f_{hc}$);
- **Vehicle sharing factor:** The extent to which Hackney and PHV drivers share their vehicles;
- **Operational window:** The length of time that the Hackney or PHV is in operation for;
- **Time spent charging:** how long the Hackney or PHV is *charging* which is to be distinguished from the Hackney/PHV being plugged in and not charging;
- **Time between charge events:** The idle time when the charger is not actively being used to charge a Hackney/PHV; and
- **Charger power:** The power of the charger in kW.

Equation 1 calculating the required number of chargers

Total energy requirement from taxis for a day

How much energy is demanded during operation for an average taxi

$$\frac{N_{taxis} \times (Distance\ per\ day) \times (Electric\ trip\ fraction) \times \frac{1-f_{hc}}{Vehicle\ sharing\ factor}}{\frac{Operational Window}{time\ spent\ charging + time\ between\ charge\ events} \times (time\ spent\ charging \times charger\ power)} = \text{Number of chargers}$$

How many charge events are performed at a charger each day

How much energy is delivered during a charge event

5 Data and assumptions

5.1 The number of Hackneys and PHVs for each Local Authority is shown in Table 2.[5] This informs the Ntaxi parameter

Table 2 Number of Hackneys and PHVs in each Local Authority across Greater Manchester

Local Authority	Hackney	PHVs
Bolton	99	1531
Bury	58	898
Manchester	1083	3423
Oldham	74	922
Rochdale	109	1329
Salford	101	984
Stockport	134	913
Tameside	150	590
Trafford	139	922
Wigan	133	889

[5] GM CAP Taxi and PHV Fleet Research - Taxi Note.pdf

Hackney cab models

Table 3 Hackney cab models.

Company	Model	Pure EV range (miles)	Range extension	Maximum charger power DC (kW)	Battery size (kWh)	On board charger (kW)
London Electric Vehicle Company[6]	TX	80.6	297 miles (fuel extender)	50	23	11 or 22 depending on spec
Dynamo Motor Company[7]	Nissan e-NV200 Evalia MPV	170	N/A - pure electric vehicle	50	40	6.6
Metrocab[8]	Metrocab	-	1 litre petrol extender	-	12.2	3

[6] https://www.levc.com/ (accessed May 2020)
[7] https://www.dynamotaxi.com/ (accessed may 2020)
[8] https://metrocab.com/ (accessed May 2020)

Inputs and Assumptions

Table 4 Inputs and Assumptions to inform the parameters in Equation 1.

EV efficiencies

Input	Lower Scenario Estimate	Central Scenario Estimate	Higher Estimate	Source/Assumption
Fraction of taxi trips under taken by electric vehicles	14%	15%	16.5%	GM CAP Technical Note 33: Sensitivity Analysis of Electric Taxi Upgrade Responses
Taxi distance per day (miles)	75.15	83.5	91.85	Electric blue summary report Oldham Council.pdf
Efficiency (miles/kWh)	2.590	3.035463742	4.212	See efficiencies in Table 5 . Combined cold weather has been used.
Fraction of taxis able to charge at home (f_{hc})	51.3%	57%	62.7%	Housing type based on census data
Vehicle inactive time to allow for charge (minutes)	20	30	40	Electric blue summary report Oldham Council.pdf
Hackney cab charger power (kW)	50	50	50	Levc.com and https://www.dynamotaxi.com/
PHV charger power (kW)	50	50	50	Assumed rapid rate
Time between charge events at a charge post (minutes) i.e. deadtime of charge post	45	60	75	Assumed
Annual rate of growth for Hackneys and PHVs	1%	2%	3%	Derived from DfT Hackney and PHV statistics
Vehicle sharing factor	1.116	1.24	1.364	Derived from DfT Hackney and PHV statistics
Operational window of vehicle (hours)	14.4	16	17.6	Assumed

Table 5 Example efficiencies in different scenarios for different models of EV. The combined cold weather efficiency has been used.

	Volkswagen ID.3 Pro S	Tesla Model 3 Long Range Dual Motor	MG ZS EV	Average (miles/kWh)
City - Cold Weather *	3.7	3.8	3.3	3.6
Highway - Cold Weather *	2.7	2.9	2.2	2.6
Combined - Cold Weather *	3.1	3.3	2.7	3.0
City - Mild Weather *	5.6	5.9	4.9	5.4
Highway - Mild Weather *	3.4	3.8	2.8	3.3
Combined - Mild Weather *	4.3	4.7	3.6	4.2

<u>Additional assumptions</u>

5.2 Within the approach taken there are some implicit non quantitative assumptions. These are detailed below:

- It is assumed that if Hackney/PHV drivers do have access to charging at home then they have a home charger installed and use it to charge their vehicle when it is not in use. This assumption is based on the fact that home charging is advantageous for several reasons including low cost per kWH, convenience, slow charging is beneficial for battery performance, there is a government grant to cover a large fraction of the cost of the charger installation and it adds long term value to their home.

- The ability of Hackney/PHV drivers to charge at home is on average the same as the general public. In other words, Hackney/PHV drivers are no more or less likely to have a driveway or park on-street compared to the general public.

- Taxi distance per day includes the ‘dead’ mileage performed when travelling from home to the area of operation.

- Electric Hackneys and PHVs do the same average mileage as ICE Hackneys and PHVs such that the assumed fraction of taxi trips that are performed using electric Hackney and PHVs can be used to determine the total number of electric Hackney and PHV miles.

- As shown in **Table 3**, the LEVC and dynamo Hackney cab EVs can accept a 50kW DC rapid charger. It has been assumed that electric PHVs can also accept a 50kW DC rapid charger.

6 Results

6.1 The modelling outputs showed a broad range in demand for public charging infrastructure with the following key findings.

6.2 There is a projected demand for between 34 and 190 rapid charging devices to meet the requirements of 15% of all Hackney and PHV trips being made by electric vehicles by 2025.

Table 6 GM totals for low, central and high demand scenarios for Hackney and PHV EV charging demand by 2025

Total 50kW Rapid Chargers low scenario	50kW Rapid Chargers central scenario	50kW Rapid Chargers high scenario
34	**90**	**190**

6.3 Of the total demand (see Table 8 for more detail):

- PHVs make-up the majority of demand with between 31 and 163 rapid charging devices. This accounts for between 84% and 91% depending on the scenario; and

- Hackneys create a lower demand with a range of 3 and 27 charging devices. This accounts for between 16% and 9% depending on the scenario.

6.4 The spatial distribution of charging infrastructure needed varies across the GM districts (see

6.5 Table **9** for more detail):

- Manchester presents the highest projected demand for Hackney and PHV charging infrastructure, accounting for 31% of total demand; and

- Bolton is second with around 11%, followed by Rochdale third (9%), Salford, Stockport, Trafford, Oldham and Wigan equal 5th (7%). Bury accounts for 6% with Tameside the lowest at 5%.

Factoring in planned 50kW Rapid Charging Device Installations

6.6 The results of the demand forecasting have then factored in the planned installations to be delivered through the OLEV funded Taxi project. This aims to deliver 30 rapid charging devices for Hackney and PHV EVs.

6.7 This reduces the estimated demand across each scenario resulting in a range of 4 to 160.

Table 7 Reduced GM totals for low, central and high demand scenarios for Hackney and PHV EV charging demand by 2025, factoring in planned deployment of 30 rapid charging devices through OLEV funded Taxi project

Total 50kW Rapid Chargers low scenario	50kW Rapid Chargers central scenario	50kW Rapid Chargers high scenario
4	60	160

Table 8 Projected EV Charging Device demand for Hackneys and PHV by 2025

LA	Number of 50kW taxi chargers low estimate	Number of 50kW taxi chargers central estimate	Number of 50kW taxi chargers high estimate	Number of 50kW PHVs chargers low estimate	Number of 50kW PHVs chargers central estimate	Number of 50kW PHVs chargers high estimate	Total Chargers low scenario estimate	Total Chargers central scenario estimate	Total Chargers high scenario estimate
Manchester	3	7	14	9	21	45	12	28	59
Bolton	0	1	1	4	9	20	4	10	21
Rochdale	0	1	1	3	8	17	3	9	18
Salford	0	1	1	3	6	13	3	7	14
Stockport	0	1	2	2	6	12	2	7	14
Trafford	0	1	2	2	6	12	2	7	14
Wigan	0	1	2	2	5	12	2	6	14
Bury	0	0	1	2	5	12	2	5	13
Oldham	0	0	1	2	6	12	2	6	13
Tameside	0	1	2	2	4	8	2	5	10
Total	3	14	27	31	76	163	34	90	190

Table 9 Projected EV Charging Device demand a percentage of total for Hackneys and PHV demand by 2025

LA	Number of 50kW taxi chargers low estimate	Number of 50kW taxi chargers central estimate	Number of 50kW taxi chargers high estimate	Number of 50kW PHVs chargers low estimate	Number of 50kW PHVs chargers central estimate	Number of 50kW PHVs chargers high estimate	Total Chargers low scenario estimate	Total Chargers central scenario estimate	Total Chargers high scenario estimate
Manchester	100%	50%	52%	29%	28%	28%	35%	31%	31%
Bolton	0%	7%	4%	13%	12%	12%	12%	11%	11%
Rochdale	0%	7%	4%	10%	11%	10%	9%	10%	9%
Salford	0%	7%	4%	10%	8%	8%	9%	8%	7%
Stockport	0%	7%	7%	6%	8%	7%	6%	8%	7%
Trafford	0%	7%	7%	6%	8%	7%	6%	8%	7%
Wigan	0%	7%	7%	6%	7%	7%	6%	7%	7%
Bury	0%	0%	4%	6%	7%	7%	6%	6%	7%
Oldham	0%	0%	4%	6%	8%	7%	6%	7%	7%
Tameside	0%	7%	7%	6%	5%	5%	6%	6%	5%
Total	3	14	27	31	76	163	34	90	190