FOI Ref Response sent

9290 **14 Jul 2021**

(CCC) Ultra Low Emission Taxi Infrastructure Scheme

Cambridge City Council was one of the recipients of a government grant under the Ultra-Low Emission Taxi Infrastructure Scheme. Please could you send me the feasibility study you commissioned, and provide an update on any follow-on actions which resulted from the funded work?

Response:

Copy of requested feasibility study attached.

Following the feasibility study for electric taxis carried out by Cambridge City Council we have implemented a number of measures. As part of our taxi licencing policy, we now require all Cambridge City licenced taxis to be zero or ultra-low emission by 2028. From the 1st April 2020 all new licenced vehicles needed to meet this requirement.

To support the introduction of this policy we also bid for and were successful in securing funding from OLEV (Office of Low Emission Vehicles, now Office of Ultra Low Emission Vehicles) to install 18 rapid and 3 fast charge points within Cambridge City and the South Cambridgeshire Districts. Currently 11 rapid and 1 fast charge point are operational across 6 sites, with a further 7 rapid and 2 fast charge points planned across another 7 sites. We expect these outstanding charge points to be operational by Autumn 2021.

All installed sites provide dedicated charging capacity for taxi use only, and we have worked with various partners, including the taxi trade to identify sites that best suit their requirements.

In addition to the taxi charge point infrastructure, we are also working with the County Council to provide on-street charging infrastructure for general use, and our car parks team are incorporating facilities in our public car parks. More information can be found on our Electric Vehicles Strategy:
https://www.cambridge.gov.uk/media/7988/electric-vehicle-and-infrastructure-strategy.pdf

Further queries on this matter should be directed to foi@cambridge.gov.uk

ULEV Taxi Scheme

Feasibility Study
Cambridge City Council

Ian Featherstone, Jacob Roberts & Bob Saynor

1st March 2016

Contents

01 Introduction

Background and project context

Cambridge has a population approaching 125,000, including nearly 25,000 students, and a strong and diverse economy. It is at the heart of 'Silicon Fen' with technology, software and bioscience companies, many set up as spin-offs from Cambridge University, which is ranked in the top five in the world. Cambridge Science Park is the largest commercial R&D centre in Europe and Microsoft's UK research offices are also based in Cambridge. The city is administered by Cambridge City Council.

Despite having some of the highest cycle use in the UK, Cambridge has a congested road network. In an effort to alleviate congestion Cambridge has five park-and-ride schemes, all of which operate 7 days a week, and several bus services including the Cambridgeshire Guided Busway. The mainline rail station has frequent direct trains to London King's Cross and Liverpool Street.

Cambridge City Council is surrounded by South Cambridgeshire Council, a mostly rural area with a population of 153,000. These two councils are responsible for licencing taxi services within their respective jurisdictions. Cambridge City Council licences approximately 320 taxi drivers (Hackney carriages).

Scope of project

This is a joint bid encompassing Cambridge City Council, South Cambridgeshire District Council (SCDC) and Cambridgeshire County Council. Cambridge City Council are co-ordinating all aspects of the bid and managing the project. The City and SCDC are covering engagement with the licenced trade, provision of information and promotion of initiatives arising from the project. The County Council's role concerns city centre access arrangements and wider transport related issues.

Wider stakeholders include: Abellio (train station operator), Cambridge Hackney Carriage Association, Cambridge University Hospitals NHS Foundation Trust, EValue8, Panther Cars, and University of Cambridge.

The city council provided all the necessary vehicle registration data, rank details and vehicle policy documents. Reports including air quality action plan, wider AQ research documents, local transport plan and unmet demand survey were also provided.

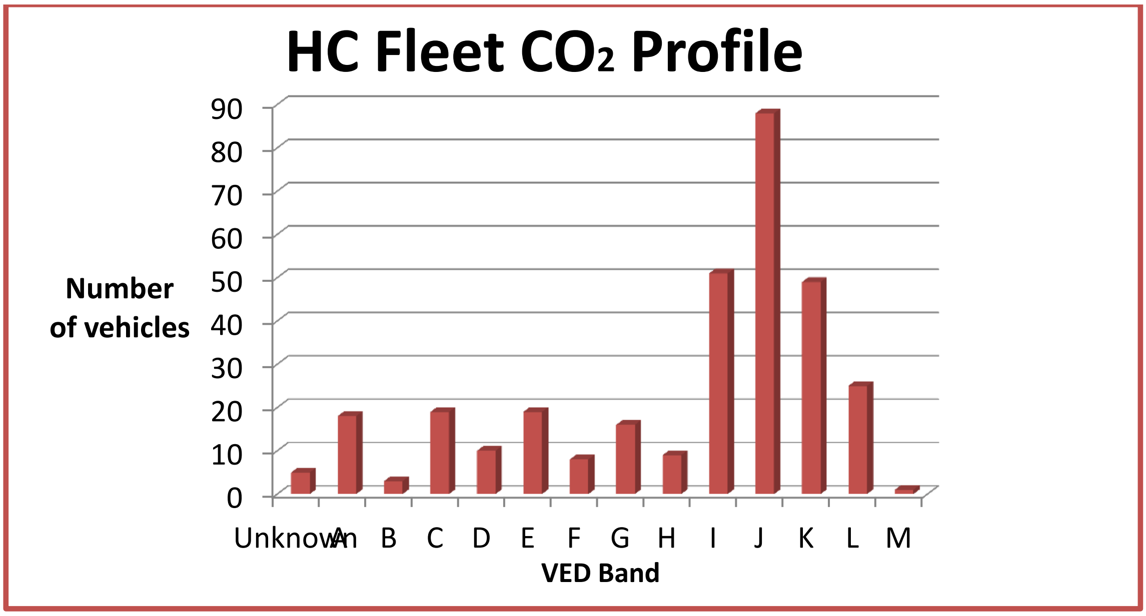
Hackney carriage and private hire vehicle fleet

Hackney carriage

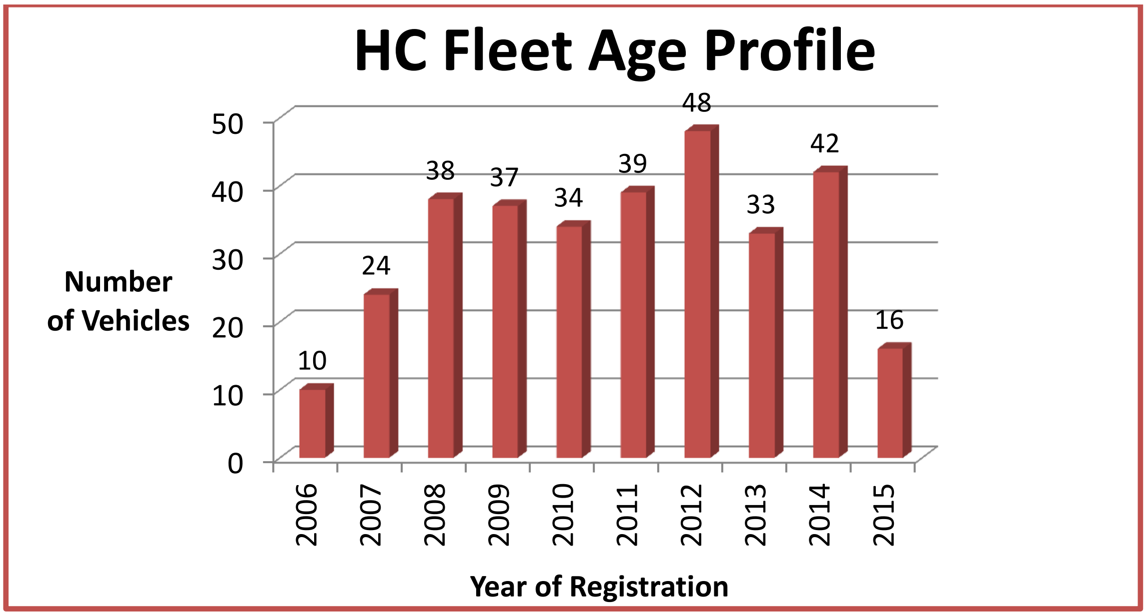
There are 317 licenced Hackney carriages in the city and c.200 private hire, with 36 operators in total. 121 of the hackney carriages are saloon cars with grandfather rights, the remainder are wheelchair accessible (side access), of which 17 are TX4 models. There is a cap on numbers and a new vehicle licence won't be granted unless it is less than four years old and either registered after 1st September 2009 or is compliant with Euro 5 standard or higher. A nine year age limit is in place (minimum Euro 4). Most of the 928 licensed drivers hold dual licences and 10% of survey respondents share a vehicle. Access to the station rank is negotiated on behalf of the drivers by Cambridge City Licenced Taxis (CCLT), around 160 drivers pay for access.

South Cambridgeshire District Council has only 11 licenced Hackney carriages. There are no age limits in place for hackney or private hire vehicles and therefore there is a relatively large private hire fleet.

The current fleet has average official CO_2 emissions of 177 g/km, with individual vehicles ranging from 85 to 251 g/km.1

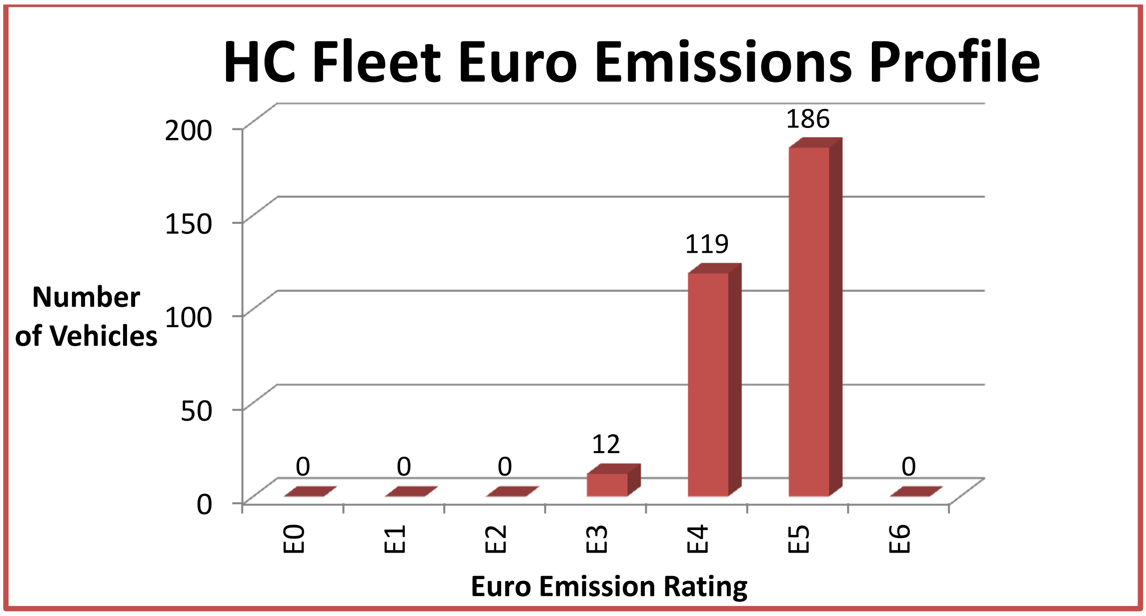


The average taxi is 4.6 years old, with no taxis more than 10 years old. This means the taxi fleet in Cambridge is relatively young compared to fleets in some other UK cities.

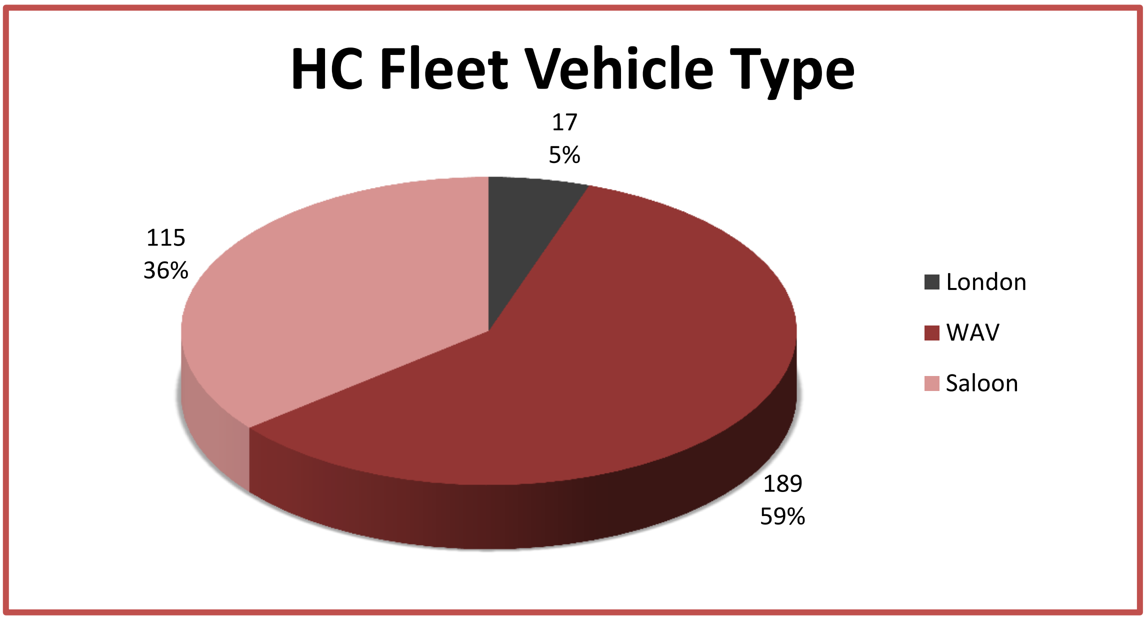


[1] Based on 317 vehicles for which data was available. The true average would be slightly higher as there were 5 van-derived vehicles for which CO_2 data were not available but which would be higher than the average stated above.

58% of taxis meet the Euro 5 emissions standard introduced in 2009/10. 37% meet the Euro 4 standard and the remaining 4% meet the Euro 3 standard[2].



The hackney carriage fleet in Cambridge is comprised of both wheelchair accessible vehicles and saloon vehicles. Cambridge City Council presently holds ‘grandfather licenses’ for 121 saloon type hackney carriages, but only 115 of these were included in the analysis dataset. Saloon vehicles represent 36% of the hackney carriage fleet. The remaining 64% are wheelchair accessible vehicles (WAVs), which further breaks down to 5% conforming to the London specification for hackney carriages and 59% not[3].



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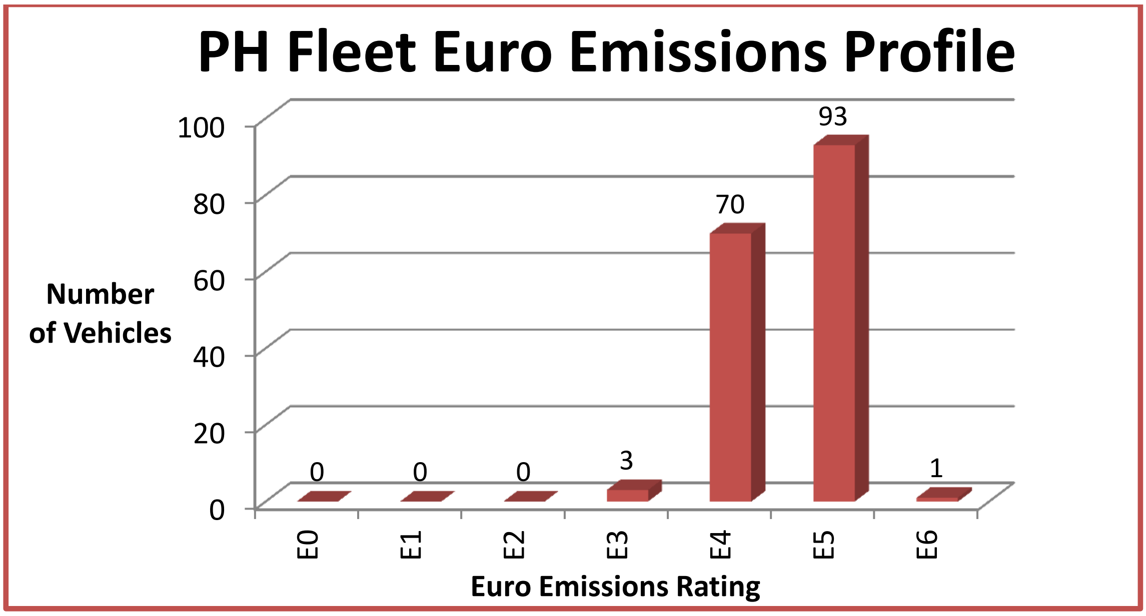
[2] Euro data not available for 4 vehicles (approx 1% of the fleet) but the age of these 4 vehicles implies they would all be Euro 4
[3] It was assumed for the purposes of this analysis that only purpose-built ‘black cab’ type taxi vehicles completely conform to the London specification (e.g. LTC TX series, Metrocab, etc.). There is insufficient evidence to categorically identify London specification conversions. For example, a Mercedes Vito Taxi conversion may or may not be rear steering, where rear steering would be required to meet London standards. DVLA information against the vehicle does not clarify this and therefore we assume the vehicle does not meet the London specification.

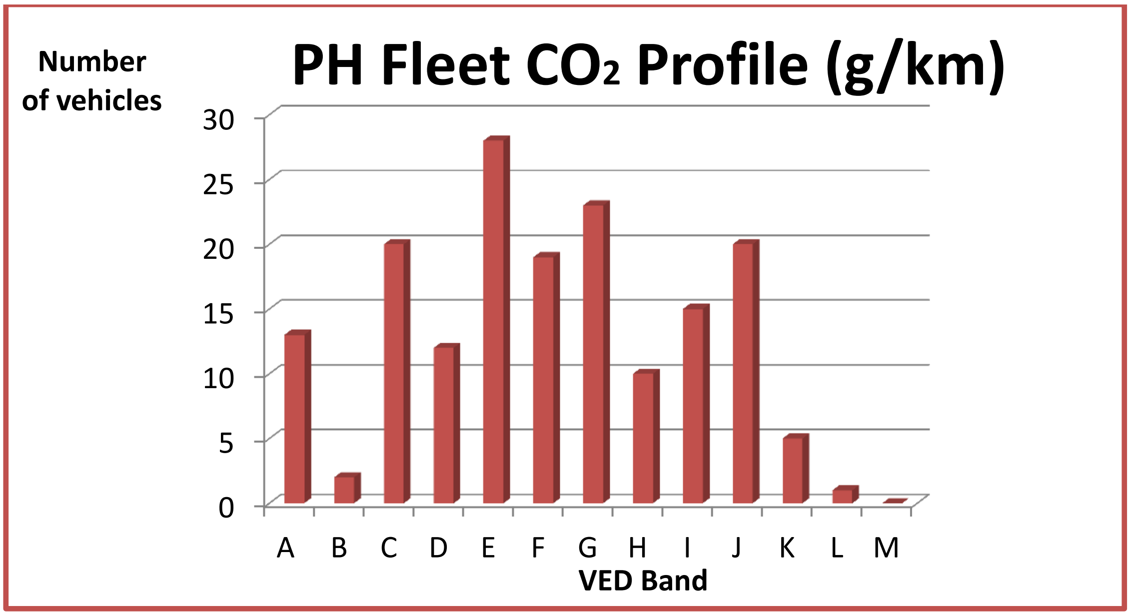
Private hire

Cambridge City Council licenses 854 private hire vehicles and 1,020 drivers, with a further 50 on the private hire waiting list. Due to the conditions of fitness in Cambridge and the vehicle age restriction in place the private hire fleet, in common with the hackney carriage fleet, is relatively modern.

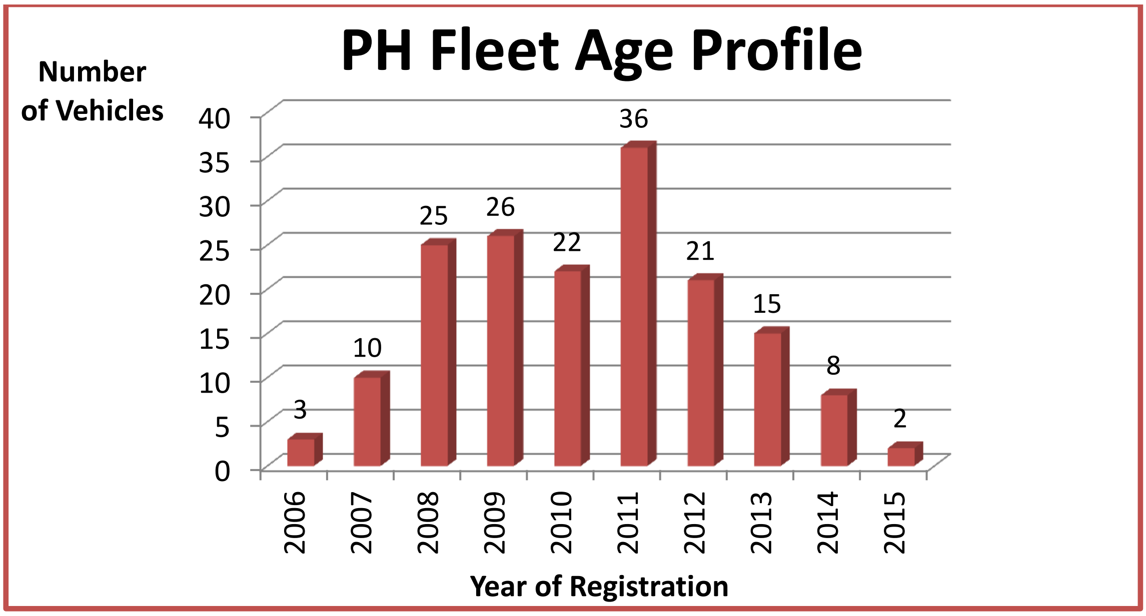
With 55% of the fleet being Euro 5 and 42% Euro 4, the adoption of pure electric and plug in hybrid vehicles should be relatively straightforward as the range of models available from manufacturers grows further.



The CO_2 profile of the vehicles is relatively modest too, with 45% of the vehicles having tailpipe emissions of 140g/km or fewer.



Less encouraging is that only ten cars have registration dates in 2014 or 2015, indicating that many are bought as used vehicles by drivers.

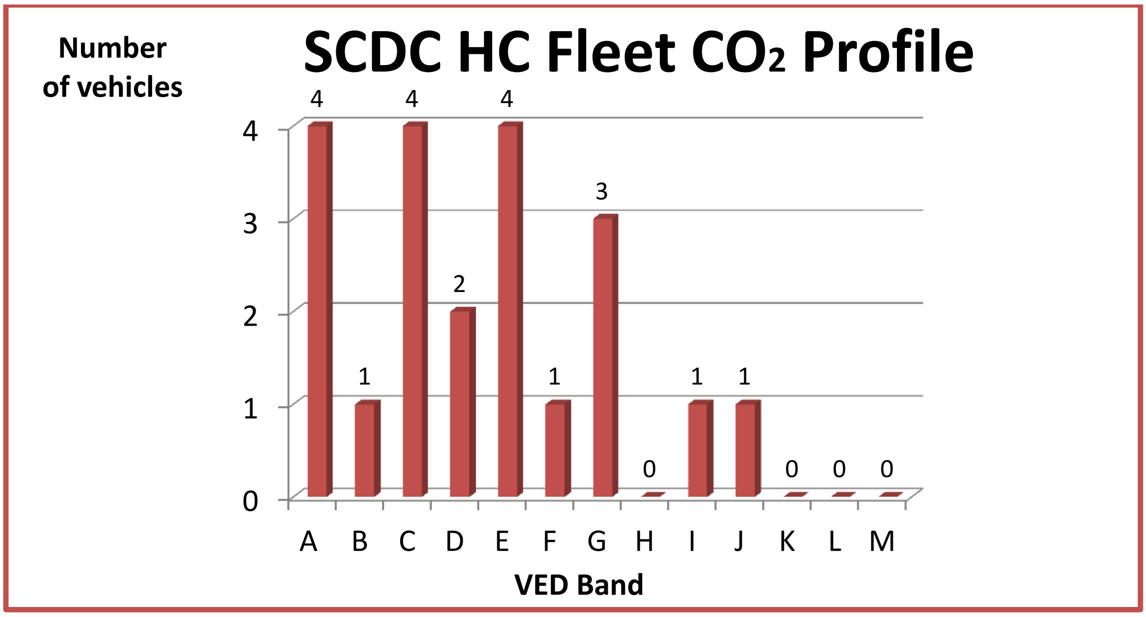


South Cambridgeshire District Council fleet analysis

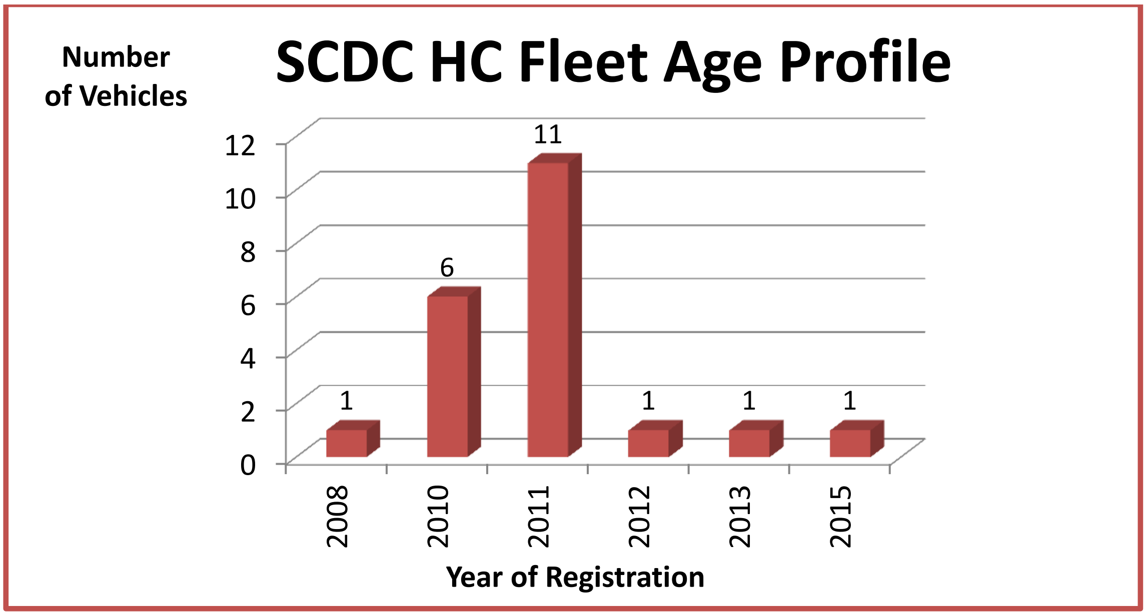
Hackney carriage

SCDC licenses only 21 hackney carriages. Saloon cars are allowed as hackney carriages and this accounts for the lower average CO_2 rating of the fleet (there are no larger wheelchair accessible vehicles). Vehicles must be no more than five years old when first presented for licencing.

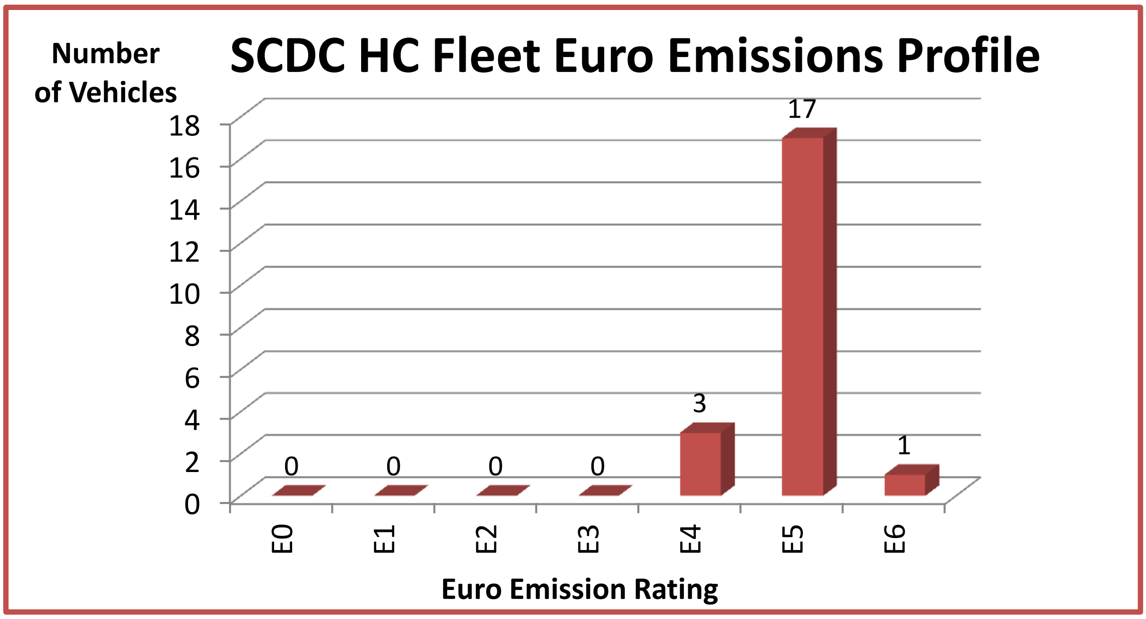
The current fleet has average official CO_2 emissions of 129 g/km, with individual vehicles ranging from 92 to 186 g/km.



The average taxi is 4.7 years old, with the oldest being 8.1 years. This means the taxi fleet in South Cambridgeshire is relatively young compared to fleets in some other UK cities.



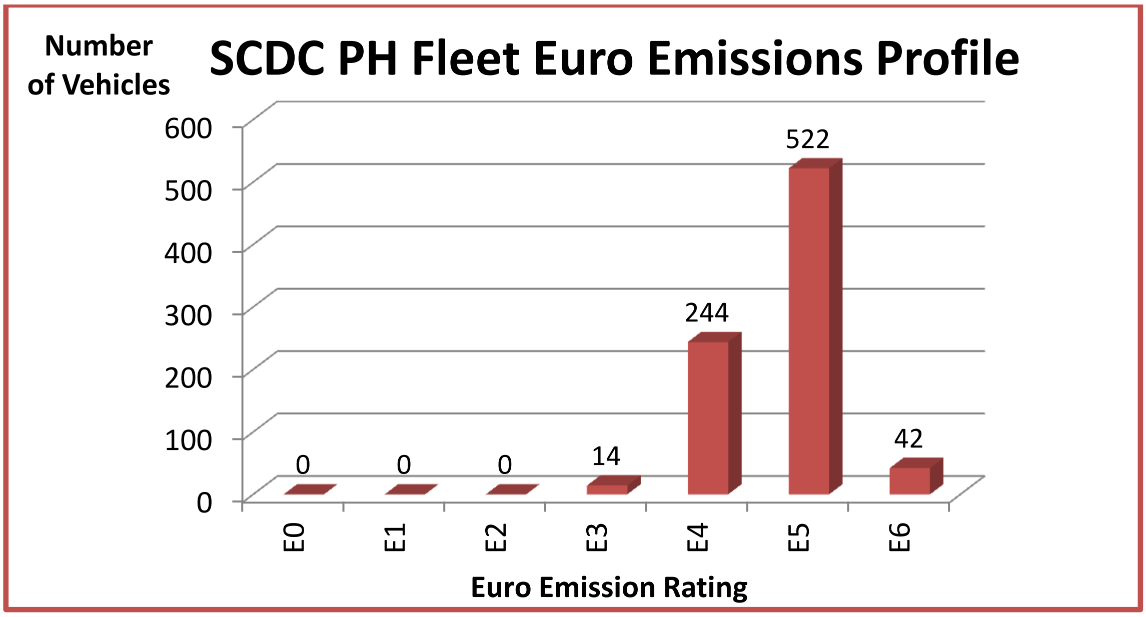
The majority (81%) of taxis meet the Euro 5 emissions standard, 14% meet the Euro 4 standard and the remaining vehicle is Euro 6.



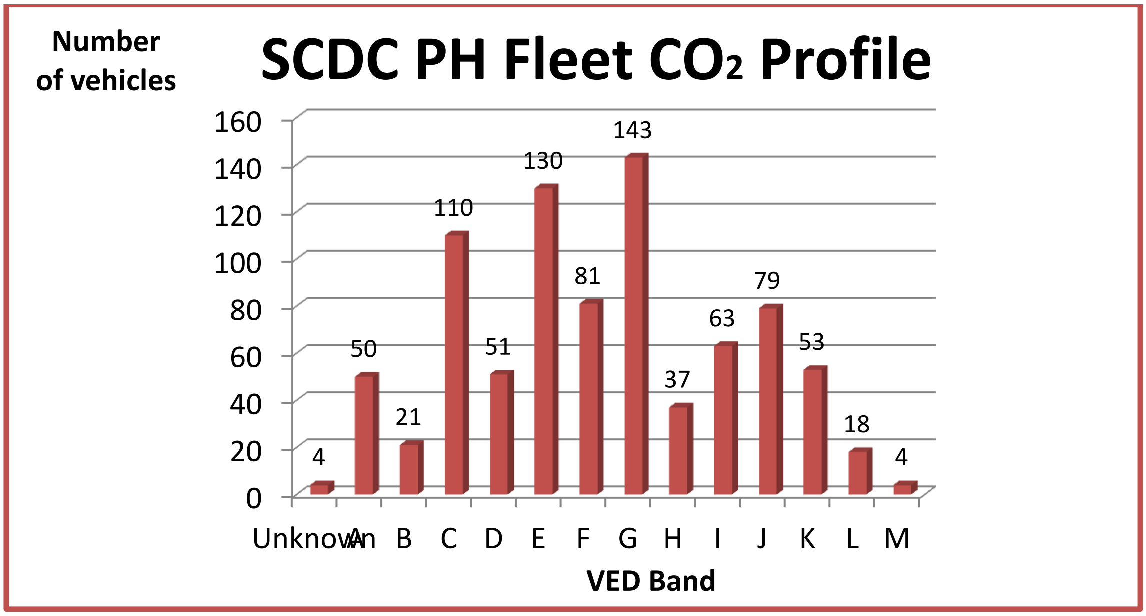
Private hire

South Cambridgeshire District Council licenses 867 private hire vehicles and 1,020 drivers, with a further 50 on the private hire waiting list. The private hire fleet is relatively modern, with an average age of 5.1 year, however, there is no age limit on private hire vehicles and therefore there are cars dating back to 2003 on the fleet.

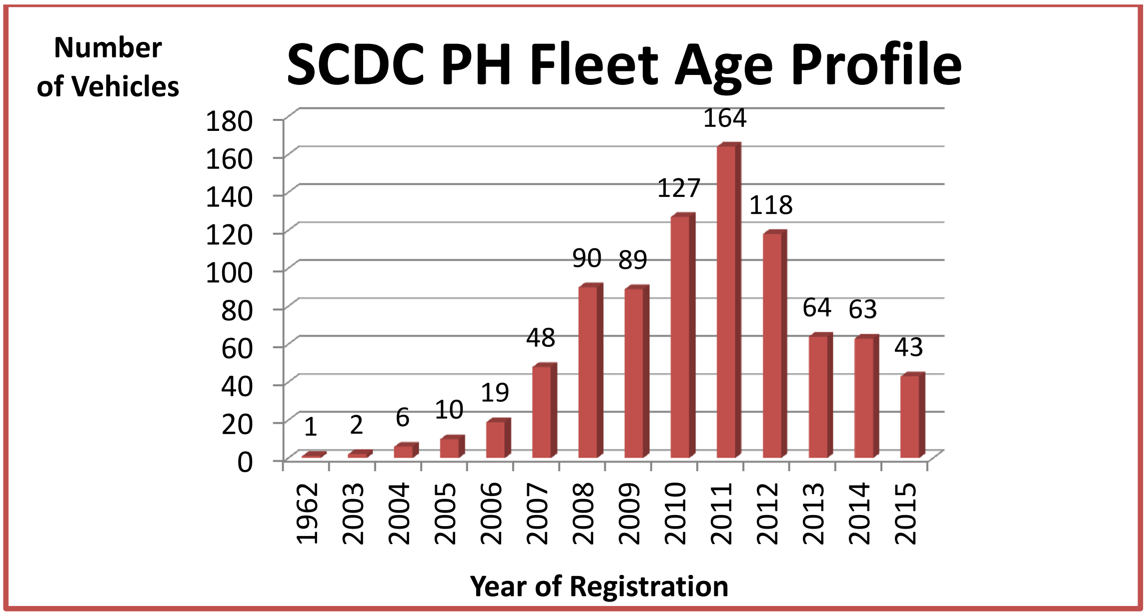
The vehicles perform relatively well in terms of Euro emissions factors with 6% being Euro 5 and 5% Euro 6.



The CO2 profile is similar to the Cambridge City fleet with 44% of the vehicles having tailpipe emissions of 140g/km or fewer.



106 cars have registration dates in 2014 or 2015, indicating that a small but significant number of vehicles may be registered from new.



Air quality in Cambridge

The central area of Cambridge was declared an Air Quality Management Area in 2004. The first Air Quality Action Plans focussed on lowering emissions based on improving Euro standards of the Cambridge bus and taxi fleets. Because these emissions did not improve as predicted, Cambridge City Council was granted funding from Defra in the form of an Air Quality Grant in 2012 to measure real exhaust emissions in the city. The study found that taxis comprised 27.4% of the traffic in King St (in the controlled city access area) and that they contributed up to 11% of NOx locally-derived traffic exhaust emissions and 21% of measured PM locally-derived traffic exhaust emissions in this location. NOx locally-derived traffic exhaust emissions from Euro 2-4 diesel taxis were found to be around 2.5 times as high as those from diesel cars.

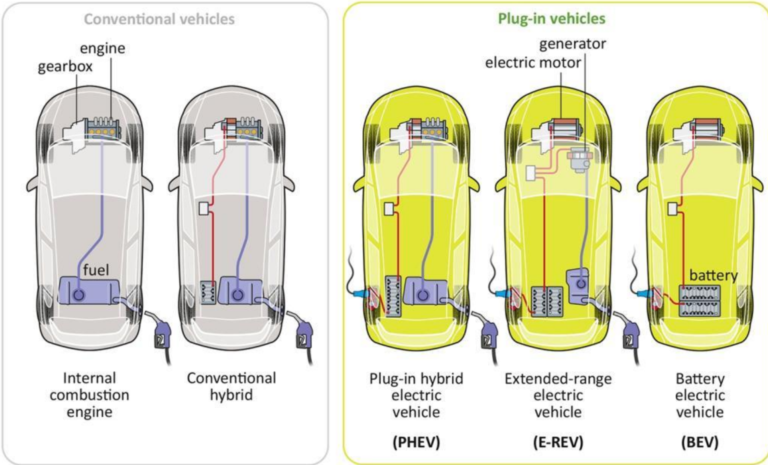
There is a clear public health benefit for those who work in the city from the adoption of ULEV taxi and private hire vehicles and they would complement the work the County Council has embarked on with Stagecoach to improve the bus fleet (which the study found contributed 80% NOx and 65% of PM locally-derived traffic exhaust emissions in King Street).

There is scope for further infrastructure improvement in the city centre which is already a restricted access area with transponder controlled bollards. The County Council is considering improving the management of this zone through the replacement of the bollards, replacing them with an ANPR camera system, which could be used to restrict access to vehicles with lower emissions.

02 Technical overview

Vehicle technology

There are several different vehicle types which involve some degree of electric power.



Source: Office for Low Emission Vehicles

Conventional hybrids: Hybrids burn fuel in an internal combustion engine (ICE) which drives the wheels via a gearbox. A battery charged by regenerative braking stores energy which is used to drive an electric motor and therefore the vehicle for a short distance (usually < 1 mile).

Plug-in hybrid electric vehicle (PHEV): Combine a battery, electric motor and ICE like a conventional hybrid, a larger battery provides a longer electric only driving range. The battery can be recharged from a charge point reducing the amount of fuel consumed over a given distance. The vehicle reverts to petrol or diesel power when the battery charge is depleted.

Extended-range electric vehicle (E-REV): Also combines a battery, electric motor and an ICE, however unlike a PHEV the electric motor always drives the wheels. The ICE acts as a generator when the battery is depleted. The vehicle can also be recharged from a chargepoint. The battery in an E-REV battery is usually larger than in a PHEV, providing longer electrically driven range.

Battery electric vehicle (BEV or Pure-EV): Powered only by electricity, a pure-EV has a larger battery than an E-REV or a PHEV and does not have an ICE.

Charging plug-in vehicles

Vehicle range is primarily determined by the storage capacity or size of a battery (measured in kWh). Larger batteries take longer to charge at a given charging rate and vehicles may be offered with more than one charging technology. Charging rates can be expressed more usefully as the mileage added for a particular time on charge. The following diagram shows how useful fast and rapid charging is when the time available for charging is constrained[4].

7 kW	10 miles in 30 minutes

20/22 kW	25 miles in 30 minutes

50 kW	35 miles in 15 minutes

Standard and fast charging:

Vehicle charging uses either alternating current (AC) or direct current (DC). AC supply is used for slower rates of charging (typically 3.5 kW or 7kW) and three phase 22kW charging5. An appropriate charging cable must be carried in the vehicle when using AC public chargepoints which deliver up to 22kW. Chargepoints providing a fast charging rate of 20kW DC are available which use the same connectors and tethered cables as DC rapid chargers.

For home charging a dedicated chargepoint is recommended, typically rated at 16 amps (c. 3.5kW) or optionally for faster charging, at 32 amps (c.7kW). Drivers would be eligible for the Electric Vehicle Homecharge Scheme, a grant which at the time of writing provides 75% towards the cost of an installed chargepoint up to £700 (inc. VAT) per household or vehicle[6].

Rapid charging:

Rapid chargepoints are usually 43kW AC or 50kW DC. In the UK, three rapid charge protocols are in use by mainstream manufacturers:

1. CHAdeMO, primarily used by Japanese manufacturers as well as Citroen and Peugeot.

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[4] It should be noted that the mileage added per 15 or 30 minutes is indicative only and does not relate to any specific vehicle.

[5] The connector illustrated is suitable for fast charging at 22kW AC, a similar range will be provided by a 20kW DC chargepoint using one of the two DC connectors.

[6] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/418525/electric-vehicle-homecharge-scheme-guidance-for-customers-2015.pdf

2. Mennekes (Type 2) is the adopted UK standard for public 3.5 and 7kW chargepoints. It can also be used for fast AC charging at 22kW or rapid AC at 43kW.
3. Combined Charging System (CCS or Combo 2) is currently used by BMW and Volkswagen. Ford and General Motors have indicated that they will use CCS.

Rapid chargepoints all have a tethered cable. Chargepoints which incorporate connectors for all three protocols are available, providing fast or rapid rates of charge. The fast chargepoints are approximately half the cost of rapid units and generally require fewer electricity supply upgrades.

Plug-in taxis

Plug-in vehicles emit zero tailpipe emissions while driving using electric power, making them the ideal solution to reduce taxis' impact on air quality. Equally, taxis' duty cycles make them ideal for utilising plug-in technology:

- They are driven predominantly in an urban, stop-start environment, where plug-in vehicles operate most effectively.
- Plug-in hybrids or extended range EVs could meet the needs of drivers who carry out a mixture of predominantly urban driving with occasional longer journeys.
- Duty cycles usually include periods of downtime, for example waiting for a passenger or during breaks, so charging events can be incorporated into working patterns.

A number of manufacturers are developing plug-in electric Hackney cabs. Vehicles are expected to be on the market by 2017 with specification details including charging protocol and rates of charge to be announced closer to their on sale date. In Cambridge standard saloon cars and people carriers are licensed as Hackney carriages for which a range of plug-in hybrid and pure electric vehicles are available from mainstream manufacturers. For example some models from Nissan are available in a specification suitable for licensed use including non-tinted rear passenger windows. The Office for Low Emission Vehicles (OLEV) provides grants for plug-in cars and vans; details of the eligible models can be found online at: https://www.gov.uk/plug-in-car-van-grants.

03 Private hire survey and implications for future vehicle charging network

Introduction

Cambridge City Council provided registration data for the 168 licenced vehicles in the city. The age restrictions for private hire licences echo those for hackneys; a new vehicle licence won't be granted unless it is less than four years old and either registered after 1st September 2009 or it meets Euro 5 standard or higher. A nine year age limit is in place (minimum Euro4); there is no requirement for wheelchair accessible vehicles.

South Cambridgeshire has 867 licenced vehicles and although they cannot be more than five years old when first presented for licencing, there are no upper age limits in place and the vehicles simply require a Certificate of Compliance. The larger operators have a licence in both the city and SCDC. There is some concern in Cambridge that older vehicles licensed outside the city are operating in and contributing to the areas of poor air quality in the city centre.

The three main operators in the area are Panther who have a mixed fleet of hackney and private hire vehicles, A1 who also have a mixed fleet and Camcab, private hire only. A smaller operator Green Air Cars, are planning to introduce pure EV private hire vehicles.

Meetings with trade representatives

Representatives from Panther taxis, the largest company and Green Air Cars were interviewed. As well as providing details about the operation of the trade in the area, their views on the practicality of introducing ULEV private hire vehicles was sought and where charging infrastructure should be located, taking into account the anticipated performance of vehicles currently on the market. Their willingness to complete a survey and engage with the project on the future was confirmed.

Private hire survey

A concise survey distributed by e-mail to private hire operators is the basis of the detailed engagement with the private hire trade. Unlike Hackney drivers who, in the main, determine their ranking locations and working patterns, the activity of private hire drivers is managed, to a significant extent, by the company they take their bookings from. Certain jobs may be allocated to certain drivers due to vehicle, for example wheelchair accessible, or driver, for example skilful in the care of vulnerable passengers, attributes. This ability to allocate appropriate types of work can enable drivers operating pure electric vehicles to be integrated into the operator's business model. In addition to the ability to allocate appropriate jobs to drivers, many drivers prefer certain types of work. This may take the form of airport and long distance runs; however others prefer to spend their day working within the city boundary.

The survey captured details including:

- Vehicle numbers, ownership and vehicle type
- Daily mileage driven and end of shift location
- Future plans for the introduction of ULEVs
- Best locations for charging infrastructure
- Measures that would encourage/increase the number of ULEVs

Responses to the survey sent out by the city council to the main trade representatives resulted in replies from Panther and Green Air Cars. Their responses contributed significantly to the final locations of charging points / hubs.

04 Hackney carriage drivers' survey and implications for future vehicle charging network

Introduction

To prepare for the introduction of plug-in taxis and ensure that suitable charging infrastructure is available, it is crucial to understand how drivers use their current vehicle, including:

- How many miles do they cover during a typical shift?
- How far do they travel from their home location?
- Which ranks do they frequent?
- Where and for how long do they stop for breaks?
- What are their attitudes towards plug-in vehicle technology?

Licensed hackney carriage taxi drivers were invited to complete a short online survey about their working patterns. 72 out of 322 licenced taxi drivers completed the survey, a sufficiently high proportion (22.5%) for the data to be analytically useful. However we would urge caution when using this sample to draw conclusions about the total population as it is impossible to tell to what extent those that responded were representative of the whole population.

Drivers' working patterns and implications for a chargepoint network

Mileage covered

The mileage covered by taxis and therefore the effective vehicle range required is arguably the most important factor in planning chargepoint infrastructure. It is vital that plug-in vehicles do not restrict the distance that drivers wish to cover. The table below shows the average mileage of survey respondents and the proportion within various mileage thresholds.

	Daily Working mileage	Total Daily Mileage (Commuting & working)
Average (median / mean)	**91 / 90**	**112 / 111**
<= 60 miles per day	17%	2%
<= 80 miles per day	30%	8%
<= 100 miles per day	72%	20%
<= 120 miles per day	76%	53%
<= 140 miles per day	100%	65%
<= 160 miles per day	100%	88%

Break durations

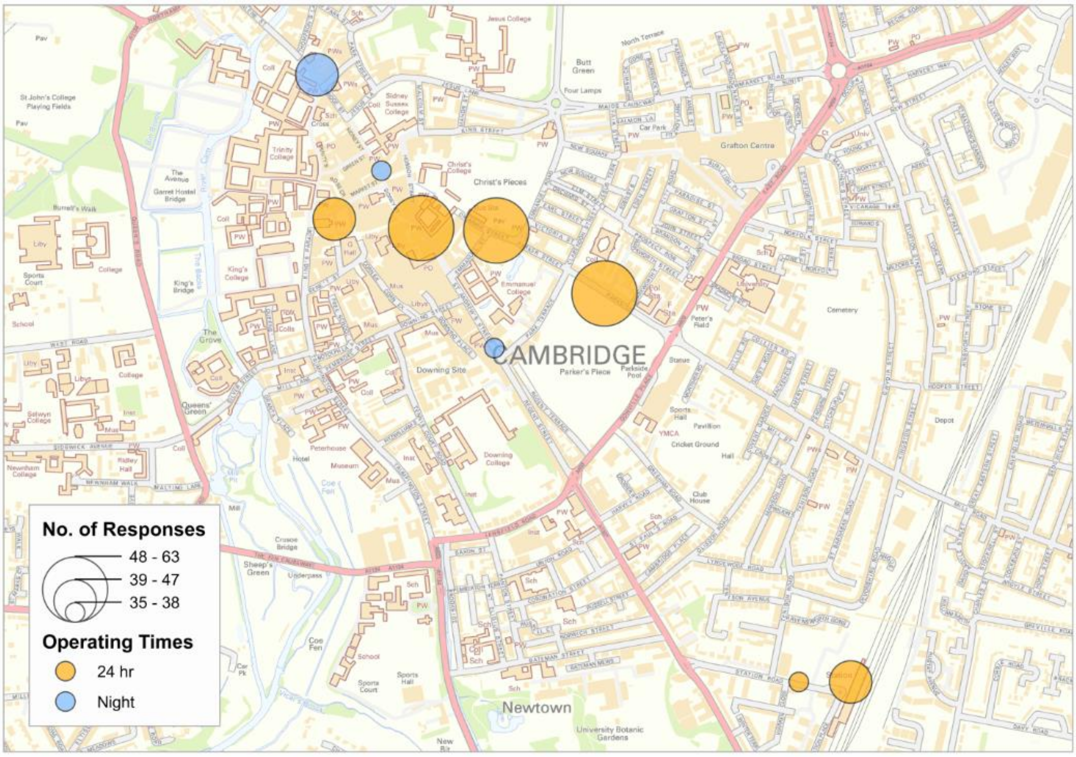
The survey included questions about the number and duration of breaks that drivers take during the day as these could provide vehicle recharge opportunities.

61 drivers provided information for at least one break they take during a typical day. 11 drivers did not respond to the questions about breaks. It is possible that all or most of these 11 drivers omitted the questions because they do not take breaks. Therefore in the table below we have presented the analysis in two ways: as percentages of the 61 drivers that supplied information about breaks, and also as a percentage of all 72 drivers that responded to the survey.

	% of Drivers that Responded about Break Duration	% of All Drivers Responding to Survey
No breaks	3%	3%
At least one break of any duration	97%	82%
At least one break of more than 15 minutes	69%	58%
At least one break of more than 30 minutes	39%	33%

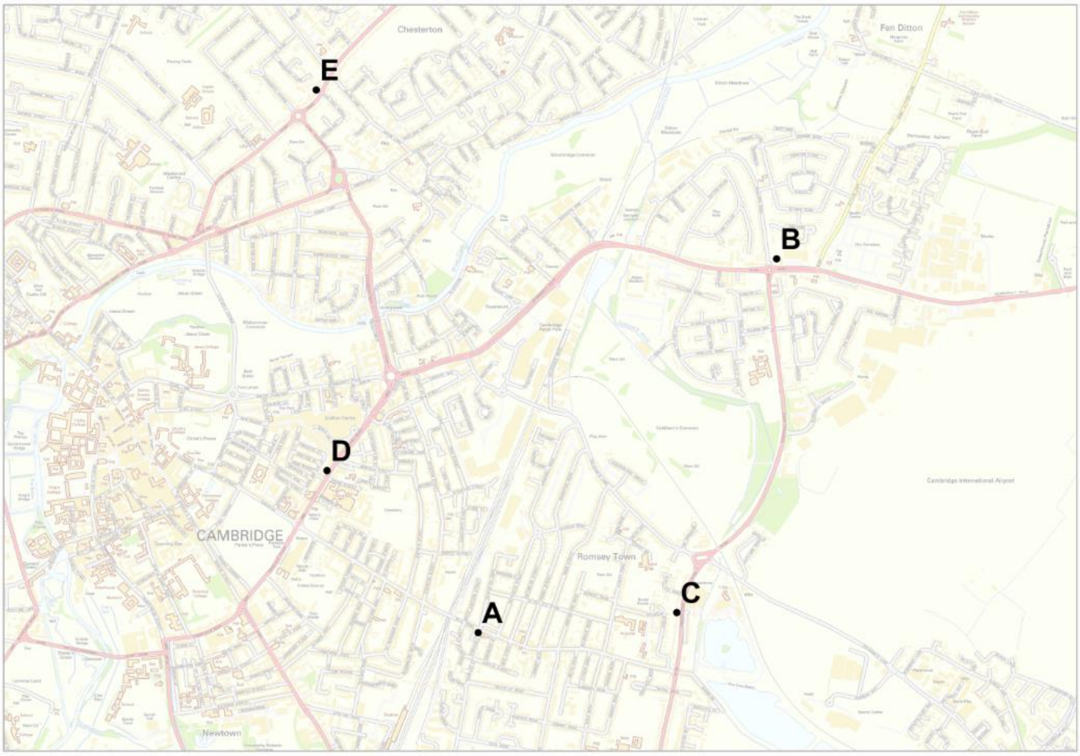
Frequented ranks and break locations

Survey respondents were asked to identify ranks they use most frequently. The results are shown on the map below.



Rank Name	Number of responses
St Andrew's Street	63
Parkside	55
Drummer Street	55
Cambridge Rail Station	47
Market Hill / Market Square	45
Bridge Street	42
Sidney Sussex	38
Station Road	38
St Andrew's Street, Park Terrace	35

The locations where drivers most frequently take breaks are shown on the map below.



Rank Name	Point
Mill Road	A
Newmarket Road	B
Sainsbury's Coldham Road	C
Adam & Eve Street	D
Milton Road	E

Drivers' attitudes to plug-in vehicles

Drivers were asked how likely they are to consider acquiring a vehicle with different drivetrains when they next replace their vehicle. The results are shown in the table below:

	Diesel	Petrol	Pure electric	Plug-in hybrid
Very unlikely	12%	33%	21%	18%
Unlikely	10%	35%	16%	7%
Likely	38%	16%	21%	31%
Very likely	26%	7%	28%	31%
Don't know	14%	9%	16%	13%

- Nearly half (49%) of respondents are likely or very likely to consider a pure electric taxi when they next replace their vehicle.
- 62% of respondents are likely or very likely to consider a plug-in hybrid taxi when they next replace their vehicle.
- If we exclude those who answered "Don't know", the proportion of respondents likely or very likely to consider a pure electric taxi rises to 57% and the proportion likely or very likely to consider a plug-in hybrid taxi rises to 72%.

Drivers were also asked about their perceived barriers to operating ULEV taxis:

Perceived barrier	Proportion of sample
High lease / purchase cost	57%
Nowhere to charge during shifts	48%
Nowhere to charge between shifts	48%
Insufficient range (in miles) between charges	65%
Charging during the day would impact on my productive working time	48%
The technology is new and unreliable	22%
None	6%
Other	4%

The provision of a network of chargepoints to support plug-in taxis is not without its challenges and these will be addressed in more detail in the following sections of this report.

05 Regulatory change and ULEV taxi uptake scenarios

Introduction to taxi licensing

The hackney carriage and private hire trade (TPH) operate under local licence and are therefore subject to regulation that is established and enforced by local government authorities. This means that taxi fleets vary considerably between different local authority areas. This variation can come in the form of several factors over which local authorities may choose to regulate their respective local taxi industries. These factors include:

- Total number of hackney carriages licensed to operate in a local authority area
- Vehicle restrictions; including age limits, accessibility criteria and technical conditions of fitness
- Rate-setting on taxi fares
- Annual licence fees
- Location and size of taxi ranks

Additionally, many local authorities also tender for and subsequently contract TPH companies to provide transport services for local schools and social services contracts. These contracts can provide a significant source of income to local operators and drivers, meaning that local authorities also have some degree of influence over the local industry in the criteria they set when tendering these contracts.

Taxi vehicle caps and unmet demand surveys

In setting a cap on the number of taxis licensed in their area, local authorities typically commission unmet demand surveys, which assess whether the existing number of taxis in the area is appropriate for the level of local demand for taxi hire. Cambridge City Council's most recent unmet demand survey concluded that there was no significant unmet demand, and therefore recommended that it maintain its existing cap of 317 vehicles.

Regulatory measures available to increase electric taxi uptake

There are a number of regulatory measures to encourage or enforce the uptake of zero-emission capable vehicles. We have divided these measures into soft measures - largely focussing on encouragement and small, step-changes – and firm measures – involving specific and firm regulation and enforcement.

Soft measures

Many local authorities have separate age restrictions for new taxi licenses and license renewals and, in phasing in more ambitious age restrictions; we would recommend that local authorities first **revise the age restrictions for newly licensed vehicles**. This will ensure all newly licensed vehicles meet a higher environmental standard and will make zero-emission capable taxis a more competitive option in terms of capital expense. In only applying this to new taxis, local authorities may mitigate the risk of trade resistance to the measures.

This measure could be combined with **phasing in a more ambitious age restriction on existing vehicles**, allowing local authorities to more rapidly phase out the older, more pollutive taxis. In doing this, local authorities would need to consider not only the age restriction itself, but also the consequences for vehicles older than that age. Many local authorities enforce a policy where vehicles over the age limit are allowed to operate, but must pass more frequent vehicle examinations to ensure they are in exceptional condition. In changing this to a more comprehensive restriction on older vehicles, the impact of an age restriction on existing taxi fleets could be far more effective.

Local authorities could also consider **including criteria in their TPH contract tenders to make them more favourable to operators with a low or ultra-low emission fleet of vehicles.** This is an effective soft measure as it utilises local market competition to encourage taxi operators to utilise zero-emission capable taxis in order to obtain lucrative local authority contracts.

Finally, local authorities could **work with operators of local transport hubs to ensure zero-emission capable taxis are permitted to ply for trade in desirable locations at less or no expense.** Railway stations and airports typically charge a recurring fee to hackney carriage drivers, in order for them to accept fares from customers on their property. Local authorities could negotiate the cessation of these fees for zero-emission capable taxis, on the basis that there is some benefit to the property owner in encouraging environmentally sound taxis to work on their property. This would provide a considerable financial incentive to encourage taxi drivers and operators to purchase zero-emission capable taxis, as transport hubs are generally regarded as prime locations to ply for trade.

Firm measures

In terms of firmer, more specific measures, local authorities could **revise conditions of fitness for newly licensed vehicles to state that they must be zero-emission capable**. This would be an incredibly effective measure in enforcing a transition towards electric taxis, but care should be taken to ensure that the local industry will support such conditions. We would recommend that such a measure should be phased in over a significant length of time, with considerable notice.

Another firm option available to local authorities is to **restrict access to either current or future air quality management areas (AQMAs)/low emission zones (LEZs) to all but low and ultra-low emission taxis and private hire vehicles.** As these areas typically form central locations with lucrative potential for the trade, incorporating taxis into the restrictions enforced as part of current or future AQMAs/LEZs would provide a compelling business case for TPH drivers and operators to purchase zero-emission capable vehicles. Care should be taken to ensure this does not lead to unmet demand in central locations.

Introducing ULEV only taxi ranks (or spaces at the head of ranks) in prime locations would provide a great financial incentive for taxi drivers and operators to utilise zero-emission capable taxis. However, a measure such as this would require a great deal of proactive enforcement and engagement with the trade, especially in its initial stages. Local authorities must therefore consider the cost and benefit of imposing such regulation in several locations and assess the local benefit of such regulation.

Hackney carriage age limit policy analysis

Cambridge City Council's taxi licensing policy currently enforces an eight-year age limit on all new and renewed licensed hackney carriages. After this age, hackney carriages will no longer be granted a license (with the exception of limousines and other specialised vehicles). This is fairly uncommon in the sense that most local authorities enforce an age limit by requiring more frequent vehicle inspections, rather than refuse a license entirely.

The clear advantage of this eight year age limit is Cambridge City Council's existing hackney carriage fleet is comprised of very young vehicles, compared to many other fleets. The other advantage of this limit is that a very predictable pipeline of hackney carriage vehicles leaving the fleet every year has already been established.

We would recommend that this cap is maintained at eight years, as it already represents a very effective measure (and an ambitious one in the context of most other local authorities). Maintaining this cap, rather than reducing it to less than eight years, will reduce the likelihood of relationships with the trade being compromised and will continue to produce a consistent pipeline of ineligible vehicles leaving the fleet. The following table illustrates how many vehicles this limit would effect and how different limits impact upon the consistent and predictable pipeline.

Age limit imposed	Number of existing licenses expiring per year			
	2017	2018	2019	2020
6	110	48	33	42
7	71	39	48	33
8	37	34	39	48
9	0	75	34	39
10	0	0	109	34

As is displayed above, imposing an age limit of six years would result in a considerable spike of ineligible vehicles leaving the fleet occurring in 2017, as this would include all vehicles first registered in a larger period of time (between 2009 and 2011). On the other hand, imposing a limit of ten years would result in very few vehicles becoming ineligible as there are no vehicles in Cambridge City Council's hackney carriage fleet which currently exceed this age, or will do for another two years.

Scenarios for ULEV uptake and chargepoint network requirement

Hackney Carriage

Without regulation to enforce uptake of plug-in taxis, acquisition of these vehicles is likely to occur slowly. We have created three potential scenarios of plug-in vehicle uptake rates, based on a combination of increasingly firm regulatory change and on preferences shown in the drivers' survey. The method used to calculate these scenarios is as follows:

1. **Low.** Eight year cap is maintained for vehicles; voluntary uptake (supported by top-up grants) of a proportion of taxis older than eight years, with that proportion being based on "*very likely"* responses to survey question on whether next vehicle will be pure-electric or PHEV
2. **Medium.** As above, with accelerated uptake associated with the availability of new models; a greater proportion of taxis older than eight years, with that proportion being based on "*very likely" and "likely"* responses to survey question on whether next vehicle will be pure-electric or PHEV, as well as undecided responses shown in the survey of taxi drivers
3. **High.** As above, with regulatory change to mandate that, as of 2017, all newly licensed taxis must be ULEVs

These scenarios are based on a predictable pipeline of vehicles becoming ineligible due to their age, as a result of maintaining the existing eight year age limit. Without imposing any upper-limit on vehicle age, demand will be unpredictable, more difficult to respond to and almost certainly lower.

ULEV uptake is taken as a proportion of hackney carriage owner/operators opting to replace their old, outgoing vehicle with a brand new zero-emission capable taxi. This proportion reflects vehicle preference results obtained through the drivers' survey.

Based on the assumptions made in the explanations of each scenario, the forecast **annual** numbers of plug-in taxis entering the fleet are as follows:

Scenario	2017	2018	2019	2020	Total
Low	6	6	7	8	27
Medium	16	14	17	20	67
High	37	34	39	48	158

The forecast **cumulative** numbers of plug-in taxis in the hackney carriage fleet, with proportion of fleet being ULEVs expressed as a percentage (assuming fleet remains at present size) are as follows:

Scenario	2017		2018		2019		2020	
	No.	%	No.	%	No.	%	No.	%
Low	6	1.9	12	3.8	19	6.0	27	8.5
Medium	16	5.1	30	9.5	47	14.9	67	21.2
High	37	11.7	71	22.5	110	34.8	158	50

Based on these numbers and a range of assumptions[7] about the market, the forecast **annual** chargepoint numbers that we suggest should be installed by the end of each year to 2020, split by charging speed, are in the table below. R: Rapid, F: Fast, T: Total

Scenario	2017			2018			2019			2020			Total		
	R	F	T	R	F	T	R	F	T	R	F	T	R	F	T
Low	1	0	**1**	1	0	**1**	1	0	**1**	1	0	**1**	4	0	**4**
Medium	3	0	**3**	2	0	**2**	3	0	**3**	3	1	**4**	11	1	**12**
High	4	3	**7**	3	3	**6**	4	3	**7**	4	4	**8**	15	13	**28**

The forecast **cumulative** chargepoint numbers that we suggest should be installed by the end of each year to 2020 are in the table below.

Scenario	2017	2018	2019	2020
Low	1	2	3	4
Medium	3	5	8	12
High	7	13	20	28

[7] Average daily working and total mileages are 91 and 112 miles respectively. It is assumed that PHEV / E-REV drivers use electric power for working and ICE for commuting. Vehicles are assumed to have an approximate energy consumption of 210 Wh/km.

Private Hire

In the case of private hire, we have applied a different methodology to each scenario in order to forecast number of ULEVs entering the private hire fleet by 2020. The methods used to calculate these scenarios are as follows:

1. **Low.** Voluntary uptake, with no proactive encouragement or incentive. Based on private hire operators trialling ULEVs in 5% of their fleets (1/20 vehicles) in order to establish business case prior to more substantial ULEV procurement.
2. **Medium.** Lucrative local private hire contracts are tendered to specify that private hire companies will be expected to own a fleet comprised of at least one third ULEVs. Free market competition results in 30% ULEV uptake by private hire companies.
3. **High.** As above, but regulation changed to enforce that, as of 2017, all private hire vehicles must meet Euro 5 standard and all newly licensed vehicles must be zero-emission capable.

Projecting the uptake of ULEVs by year in the private hire fleet is more difficult to achieve, as drivers typically have less say than the private hire operators whom employ them. These operators are more capable of making large changes to their fleet relatively quickly, therefore providing an annual projection would be unreliable without further study.

However, considering the measures and the assumptions made in the scenarios above, the number of private hire ULEVs predicted to enter the fleet in Cambridge by 2020, as well as the number of chargepoints required to support these vehicles, is as follows:

Scenario	ULEVs by 2020	% of Existing Fleet	Rapid Chargepoints	Fast Chargepoints	Chargepoints Required
Low	8	5%	1	0	1
Medium	50	30%	7	2	9
High	73	44%	7	6	13

Measures proposed to attain ULEV uptake in different scenarios

Low

The low scenario is assumed to be of a reactive nature. This implies that infrastructure will be provided as demand arises, which will not improve confidence within taxi fleets and will limit short-term uptake considerably. In this scenario, uptake is predicted to be limited to taxi drivers who are already considering purchasing an ULEV. This level of uptake would quite possibly occur without any intervention but we would suggest the following measures would be appropriate to achieve this scenario:

- Monitoring mechanism implemented to track the licensing of ULEVs, in order to assess and respond to demand and evaluate success of measures taken
- Internal processes and working groups established to streamline selection of chargepoint sites and subsequent installation
- Further engagement with hackney carriage and private hire trades to ensure actions taken are done so with a degree of support from local TPH industry
- ULEV awareness raising exercise undertaken with hackney carriage drivers and private hire operators

Medium

The medium scenario involves a degree of proactive encouragement, undertaken mostly through free-market principles. This implies infrastructure will be provided in surplus to immediate demand, in order to improve confidence and generate a local increase in short-term uptake. In this scenario, uptake will include drivers who are already considering purchasing an ULEV, as well as drivers who are encouraged to purchase ULEVs on the basis of good confidence in the commitment of their respective local authority to provide and maintain infrastructure and support. This level of uptake would require some intervention by local authorities, additional to the measures suggested to achieve the low scenario. These additional measures include:

- Commit to installing the number of chargepoints required to support the predicted uptake of ULEVs in the local TPH industry
- Work with local NHS Trust(s) and/or schools to modify criteria of patient/pupil transport contract tenders to require private hire operators to possess and use a certain amount of ULEVs in their fleet
- Work with local land owners and station operators, as well as internally cross-departments, to provide a package of benefits to ULEV taxi drivers/operators, which allow them to be more competitive (e.g. access to AQMAs/LEZs and/or ranks on privately owned sites)
- Conduct analysis and produce case studies illustrating the local, real-life business case for taxi drivers and operators
- Engage with hackney carriage and private hire trades to gain feedback on what actions could be taken to facilitate the greater uptake of ULEVs and consider their suggestions

High

The high scenario involves considerable regulatory change, undertaken on the basis of a market failure. In this scenario, uptake will include all drivers matching criteria set out in new regulation (such as drivers with vehicles over a certain age). This scenario would require further, additional intervention to the measures expressed above, including:

- Make an assertive effort to remove oldest taxis from the roads through regulation and enforcement
- Regulating that all or a selected proportion of TPH vehicles must be ULEVs by a certain date
- Review all appropriate local regulation which could potentially serve to make ULEVs more competitive in the local market

Air quality implications of hackney carriage ULEV uptake scenarios

The average NOx output of vehicles in Cambridge City Council's hackney carriage fleet is 0.288g/km. This is a very low value for what is a predominantly diesel fuelled fleet and suggests that, on average, each vehicle in the fleet qualifies for a Euro 4 classification.

The average daily mileage of the hackney carriage fleet (combined working and commuting mileage), as indicated by the drivers' survey is 110 miles. Assuming a six day working week, this means the approximate total NOx emissions of Cambridge City Council's hackney carriage fleet is 5.06 tons per year. The table below shows how this NOx output would be improved by the various ULEV uptake scenarios described in this section.

	Present	Low	Medium	High
NOx Ave. g/km	0.288	0.227	0.201	0.144
Total NOx (g)	5,068,718	3,996,620	3,548,157	2,534,359
Total NOx Change (g)		1,072,098	1,520,561	2,534,359
Percentage Change		21%	30%	50%

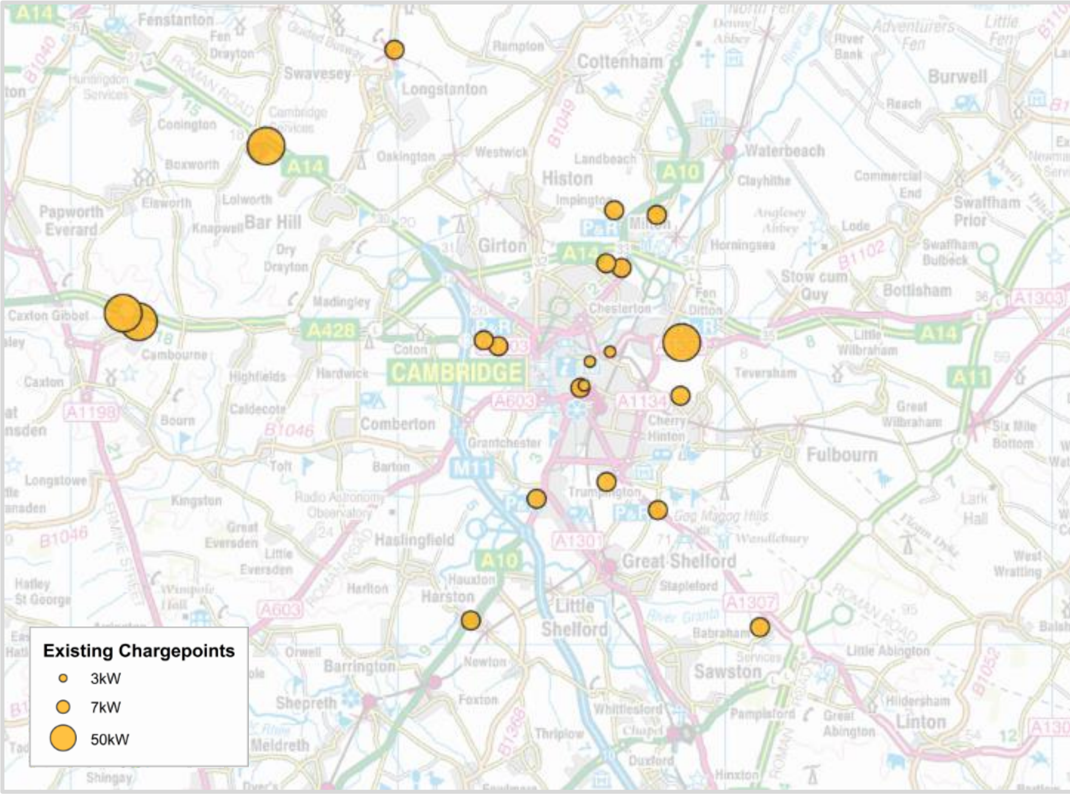
Depending on which scenario is achieved, Cambridge City Council could reduce its annual taxi-attributable NOx output by between approximately 1.07 tons per year and 2.5 tons per year. This would represent a reduction of 21% to 50%, assuming that the hackney carriage fleet remains the same size.

This total amount does not necessarily have any direct correlation with improvements in localised air quality, as this is determined only in part by the emission performance of fleet vehicles. The remainder of the factors governing localised air quality concern driver behaviour and areas of work, for which further investigation would be required to determine. That being said, a reduction of the total NOx emitted by the taxi fleet would almost certainly have a positive impact on local air quality.

06 Infrastructure: guidance for installers and operators

Existing chargepoint network

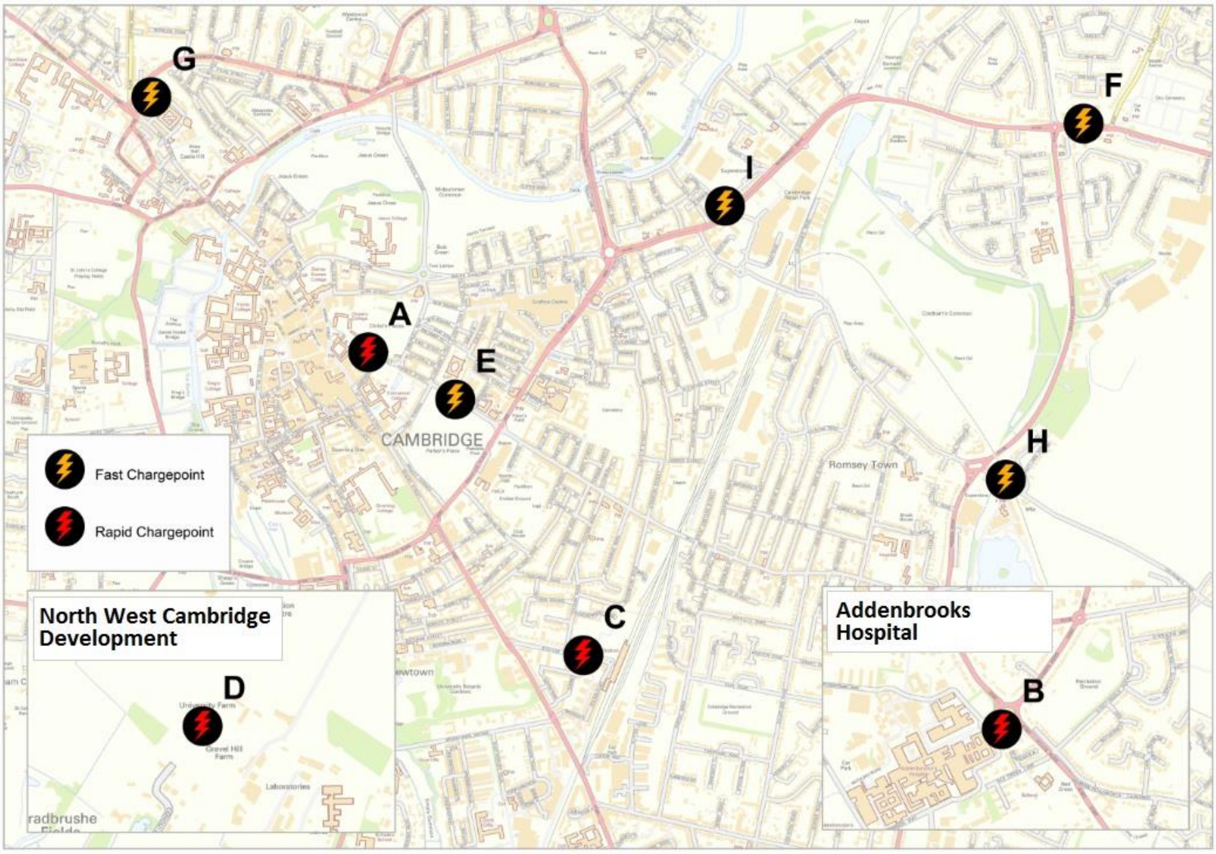
The map below displays the chargepoints in the Cambridge City area which provide 3kW/7kW (slow) or 43kW/50kW (rapid) rates of recharging. The full list of these chargepoints, as well as a brief description of their respective locations, is available in the annex. Currently there are insufficient chargepoints providing an appropriate rate of charge to support the introduction of plug-in taxis.



Proposed chargepoint locations

The locations displayed on the map on the following page are shown in the table below The proposed chargepoint locations A to I are listed in priority order, based on their importance to the continuity of the existing taxi trade (as indicated by survey responses from the industry).

Rank Name	Indicator	Charge Speed
Drummer Street Bus Station	A	Rapid
Addenbrooks Hospital	B	Rapid
Station Road	C	Rapid
North West Cambridge	D	Rapid
Parkside	E	Fast
Barnwell Road/Newmarket Road	F	Fast
Castle Hill Car Park	G	Fast
Coldhams Lane/Brooks Broad	H	Fast
Newmarket Road	I	Fast



The high-priority chargepoint locations (A-D) proposed form a linear network of rapid charging coverage running from the North West, through Cambridge City Centre and to the south east. This covers many of the typical journeys made by taxis in Cambridge, as indicated by the drivers' survey these points will allow most early-adopters of ULEVs to continue accepting the majority of their current typical fares.

The lower priority points (E-I) both strengthen this linear network and expand it to cover the east of the city. It is proposed that these lower priority points are fast charging, as opposed to rapid, in order to save costs. Most of these chargepoint locations are proposed to be near to local amenities, making them ideal for drivers taking breaks and not requiring a rapid charge. The locations were also proposed to reflect the preferences that were shown in the drivers survey, regarding where they typically take breaks

Best practice for operators and installers

Choosing the right equipment

It is recommended that a mix of fast (20kW DC/22kW AC) and rapid (50kW DC /43kW AC) chargepoints are installed at different locations. These recommendations are based on the nature of use that can be foreseen for a given chargepoint site. For example, sites which will be used frequently and/or typically on shift are better suited to rapid charging, where speed is essential to prevent loss of earnings. Sites which will be used less frequently and/or whilst drivers are on breaks are better suited to fast charging, where speed is of less importance than convenience of location. This mitigates excess expenditure on unnecessary rapid charging equipment and additional infrastructure upgrades required to support them.

Business planning

The estimated infrastructure costs in relation to the grant required in the period to 2020 (see roadmap) relates purely to the charging equipment. Cambridge City Council should use the chargepoint locations and number of chargepoints required to provide location and capacity details to UKPN who will provide budget estimates for the proposed installations. It is recommended that the city appoints a chargepoint network operator who will manage the network and provide a payment system. Determining the cost to charge by time or kWh should be carefully considered. It is important to encourage the use of the infrastructure by maintaining a positive financial benefit to drivers, particularly those in range extended vehicles, who will otherwise elect to drive the vehicle on its petrol engine once the energy in the battery is depleted. It will be possible to model the cost to charge more accurately once the energy consumption of the new vehicles is known, including their fuel consumption when driven by their ICE.

Grid capacity

One of the potential issues in many cities is constraints on the supply of electricity from the grid, particularly when installing rapid chargepoints or several fast chargepoints at a single site. UK Power Networks (UKPN) the Distribution Network Operator (DNO) covering Cambridge offer an “ask the expert” service providing a 90 minute one-to-one meeting to take callers through technical advice on electrical connections to their network. In addition EValu8 have been contracted to provide advice to Cambridge City Council in respect of EV charging infrastructure.

We recommend that a network operator is appointed to oversee the process, from site identification through to chargepoint operation. Electrical contractors will manage tasks such as installing and testing the infrastructure.

Site selection and planning

1. Identify sites for installing infrastructure based on land availability and the locations proposed in this report.
2. Apply to UKPN for a free initial budget estimate, providing details of the location and the required power. UKPN will provide an approximate idea of costs for connection and any necessary upgrades. Any capacity identified is not reserved at this stage.
3. Carry out a site audit, taking into account the following considerations:
    - The layout and location of charging bays, including whether double lines or underutilised existing parking bays are appropriate.
    - The location of the existing or proposed substation in relation to the parking bays which may need to be rearranged to reduce cable runs and ground works.
    - Land ownership in the vicinity may impact on routing of electricity connections.
    - Location of other utilities such as gas, sewers and telephone. Service covers may indicate underground congestion, increasing complexity of connection.
    - Proposed bays should be away from areas of high density footfall. Ensure that proposed infrastructure will not negatively impact surroundings.
    - CCTV and lighting to ensure security and safe operation of infrastructure
    - Availability of GPRS (2G) mobile phone signal or specified alternative
    - For an on-street site audit, consider how parking will fit in with existing restrictions and where signage for parking bays will be installed.
    - Ensure that vehicular access to and from the site is adequate.

4. Chargepoint appearance should be discussed with the relevant planning department. Refer to Department for Transport[8] guidance on the impact of street furniture on traffic management and streetscapes.
5. Request a free formal quotation from UKPN to determine exact costs, providing the power on date, substation location and meter positions. A contingency will be necessary to cover any unforeseen additional costs incurred by the DNO.
6. If the chargepoint will be on-street, a Traffic Regulation Order (TRO) will be required to allow enforcement of the bay.
7. Engage an electricity supplier.

Installation

UKPN must carry out all non-contestable work, including determining the connection point to the distribution system, reinforcing the distribution system, agreeing and obtaining legal consent, connecting to the distribution system and energisation. Contestable work (the rest of the installation process) can be carried out by an Independent Connection Provider (ICP) or UKPN.

Further considerations when completing the installation include:

- Controls and outlets should be between 0.75 and 1.2m above the ground so that they are accessible to everyone, including disabled users.
- Chargepoints should be installed so that maintenance access covers can be removed.
- Trip hazards should be avoided and provision made for the storage of tethered cables.
- Impact protection should be installed, e.g. bollards to protect the infrastructure.

Service Level Agreements (SLA)

It is crucial that hardware is reliable to facilitate adoption of the new technology by drivers and vehicle owners. The network operator(s) will be responsible for reliability and it is suggested that a relatively high rate of uptime[9] (c. 90 per cent) should be set as a KPI.

Payment methods

Electric vehicle charging is generally paid for by a Pay as you go (PAYG) model. Options include:

- SMS
- RFID card, currently used for much of the public infrastructure installed in the UK.
- Smartphone app.
- Contactless credit or debit card

Connectivity and back office software

Chargepoints should communicate with a back office system through the Open Charge Point Protocol (OCPP)[10]. OCPP allows chargepoints and control systems from different vendors to communicate with each other, rendering the network operator less vulnerable to individual suppliers. OCPP should facilitate

[8] Department for Transport streetscape guidance www.gov.uk

[9] The time that an individual chargepoint will be fully functional
[10] Details of the OCPP are available from the Open Charge Alliance www.openchargealliance.org

the integration of new technologies (e.g. inductive charging) as the software to provide additional functionality would be compatible across the network.

Back office software should provide functionality including:

- Detailed information on chargepoint activity including real-time status.
- Charging start and finish times.
- Electricity consumption by chargepoint.
- Energy provided to each vehicle during each charge event.
- Power demand management to avoid network overload.
- Remote software updates and maintenance.
- Support for customer service and chargepoint maintenance staff.
- Ability to book chargepoint access.

A comprehensive management system will enable identification of the most popular chargepoint locations and peak periods of use. This should be used to inform expansion of the network.

07 Potential challenges to ULEV taxi uptake

Existing charging infrastructure

There are two issues with the existing EV charging infrastructure in Cambridge, that each represent challenges to the swift uptake of ULEV taxis. Firstly, there are very few EV charging options in Cambridge City Centre, meaning much work needs to be done to facilitate the practical use of ULEVs in the local taxi industry. This lack of existing infrastructure can also impact the confidence of taxi drivers and private hire operators in ULEVs, playing a major role in any decision whether or not to purchase them.

Secondly, the limited charging options presently available in and around Cambridge generally provide a slow charge (3/7kW, 2-4hrs for 80% charge). Whilst charging at this speed can be a cost-effective solution to consumers, especially in off-street public car parks, taxi drivers and private hire operators would not remain profitable, or even sustainable, if their vehicles were required to spend a significant portion of their working time being charged. The use of ULEVs in the taxi industry is therefore heavily dependent on the provision of fast and rapid charging infrastructure and, in that provision, Cambridge is presently lacking.

Convenient charging sites in central locations

As a city of great heritage, development of sites in the city centre could prove challenging. However, charging infrastructure is most effective when installed in central locations, where they can be easily accessed by taxi and private hire drivers from across the city and beyond. Central charging locations are of even greater importance to hackney carriage drivers, as working time would be lost were they required to significantly depart from the main city centre taxi ranks in order to charge their vehicles. The challenge this presents to Cambridge is how to provide charging infrastructure in convenient central locations, without any significant redevelopment.

Vehicle running costs

Plug-in vehicles must cost less per mile in fuel when charged from a fast chargepoint than a new, efficient taxi would cost to run on conventional fuel. A taxi powered by petrol would cost around 14 pence per mile (ppm) for fuel if it returns 35 mpg[11]. The table below compares this to the cost per mile of using a 20kW rapid chargepoint for a plug-in vehicle with an energy consumption of 210 Wh/km:

Cost per 30 minute charging event	Cost per mile on electric power
£1.00	5p
£2.00	9p
£3.00	13p
£4.00	17p
£5.00	21p

[11] An E-REV taxi with a depleted battery being driven on petrol power may return a figure of this order.

A fee of more than £3 per 30 minute charging event is unlikely to offer drivers of plug-in hybrid and extended range vehicles an incentive to use electric rather than petrol power. In the absence of this price incentive:

- The air quality benefits associated with plug-in vehicles will not be maximised.
- Chargepoint utilisation rates will be low and therefore installing infrastructure may not be cost effective.
- Drivers will not achieve the full benefit of the potentially lower running costs of plug-in vehicles.

Where drivers are able to recharge vehicles at home or at rates equivalent to, or lower than home recharging costs, there is a positive financial benefit when driving a pure electric vehicle or a plug in hybrid in electric mode as the following table demonstrates.

Electric Vehicle				Diesel or Petrol Vehicle					
Hackney/Executive		Saloon		30mpg		40 mpg		50 mpg	
ppm	£/10K	ppm	£/10K	ppm	£/10K	ppm	£/10K	ppm	£/10K
4.7	**475**	**4.1**	**412**	**15.6**	**1,561**	**11.7**	**1,171**	**9.4**	**936**

The energy consumption of the hackney/executive cars in this example are assumed to be 210Wh/km and the conventionally fuelled saloon vehicle to be 182Wh/km (NEDC consumption of Nissan LEAF + 21% real world factor). The cost of petrol or diesel is assumed at £1.03 per litre and domestic electricity at 14.05 pence per kWh.

Fuel consumption petrol or diesel (MPG)	Cost saving potential per 10,000 miles (Hackney EV)	Cost saving potential per 10,000 miles (Saloon EV)
30	£1,086	£1,149
40	£696	£759
50	£462	£525

Drivers’ perceptions of plug-in vehicles

The survey responses indicate that more is required than simply making chargepoints available; concerns highlighted include the high lease / purchase cost of plug-in vehicles, (perceived) insufficient vehicle range and the impact of charging on productive working time. Provision of appropriate and reliable charging infrastructure must be supported by measures such as training for drivers in techniques to maximise the range of their plug-in vehicle and instructions on how to use chargepoints.

In light of the above, one option may be for Cambridge City Council to support the introduction of plug-in hybrid and extended range vehicles (both of which have petrol engines as well as battery drivetrains) without providing such an extensive network of chargepoints around the city. Plug-in hybrid vehicles typically have real-world electric-only ranges of around 30 miles, which would cover the average return commute – 20 miles – but leave little more for driving within the city. This could lead to the vehicles being run predominantly on petrol, rather than electricity and, whilst this would reduce pollutant emissions compared to the diesel taxis currently on the fleet, it would not maximise either the potential air quality benefits or the potential cost savings for drivers. A consideration which Cambridge City Council would need to make, were they to promote the use of plug-in hybrid vehicles for taxi purposes, would be how to encourage drivers to maximise their electric-only travel time by utilising charging infrastructure effectively.

Current regulatory framework

In many ways, Cambridge City Council's existing taxi licensing regulations provide an excellent position from which to generate uptake in ULEVs for taxi purposes. The maximum licensing age of eight years, for example, means that not only is the current fleet of taxis relatively modern but it also means that there is a predictable timescale over which ULEVs could be phased in, were Cambridge City Council to regulate further.

However, Cambridge City Council's current regulatory framework poses some challenges in terms of offering taxi drivers and operators the best incentives available, through an enhanced top-up grant (to be made available by OLEV). The criteria for this grant is, at present, that the applicant's vehicle must be a purpose-built, wheelchair accessible taxi. One third (121/321) of Cambridge's hackney carriage fleet currently possesses 'grandfather' licenses for saloon type vehicles, which have no ULEV equivalent that would satisfy this criteria. Therefore, this portion of existing hackney carriage drivers would not be able to access the enhanced top-up grant and would have less incentive to purchase an ULEV. It may be necessary for Cambridge City Council to consider changing this element of their licensing regulation to maximise uptake. This will be discussed in section 08.

08 Roadmap

Total funding requirement

The table below shows the total amount of grant funding required between 2017 and 2020, in order to achieve ULEV taxi uptake targets across the three uptake scenarios (described in section 05), split by funding requirements for vehicle top-up grants and infrastructure grants for both hackney carriage and private hire use.

Scenario	Top-up Grants	HC Infrastructure Grant	PH Infrastructure Grant	Total
Low	£30,000	£120,000	£30,000	**£180,000**
Medium	£78,000	£345,000	£225,000	**£647,000**
High	£180,000	£635,000	£300,000	**£1,115,000**

The following table shows the total amount of grant funding required between 2017 and 2020, in order to achieve ULEV taxi uptake targets across the three uptake scenarios (described in previous sub-section), split by year with amounts shown per year and cumulatively. These figures do not include private hire requirements, as these requirements cannot be broken down by year without further evidence and engagement with local private hire operators.

Scenario	2017		2018		2019		2020	
	Yearly	Cmtive.	Yearly	Cmtive.	Yearly	Cmtive.	Yearly	Cmtive.
Low	£36,000	£36,000	£36,000	£72,000	£39,000	£111,000	£39,000	£150,000
Medium	£108,000	£108,000	£78,000	£186,000	£108,000	£294,000	£129,000	£423,000
High	£207,000	£207,000	£164,000	£371,000	£210,000	£581,000	£234,000	£815,000

Hackney carriage top-up grants

Taxi top-up grants are available specifically for purpose-built, wheelchair accessible taxis. The predicted number and cost[12] of taxi top-up grants are as follows:

Scenario	2017		2018		2019		2020	
	Grants	Cost	Grants	Cost	Grants	Cost	Grants	Cost
Low	2	£6,000	2	£6,000	3	£9,000	3	£9,000
Medium	6	£18,000	6	£18,000	6	£18,000	8	£24,000
High	14	£42,000	13	£39,000	15	£45,000	18	£54,000

Cambridge presently licenses 121 saloon-type taxis, which have no ultra-low emission equivalent that is eligible for the top-up grant, under present criteria. Therefore, the predicted number of ULEVs entering the taxi fleet (as described in section 05) has been modified to reflect this.

[12] This assumes a top-up grant value of £3,000 per vehicle, with all vehicles being purpose built for taxi use. OLEV has not released any information about this grant; the figure used has been selected by EST and is indicative only.

Hackney carriage chargepoint funding

The forecast **annual** chargepoint numbers that we suggest should be installed by the end of each year up to 2020, split by charging speed, are in the table below. R: Rapid, F: Fast, T: Total[13]

Scenario	2017				2018				2019				2020			
	R	F	T	Cost	R	F	T	Cost	R	F	T	Cost	R	F	T	Cost
Low	1	0	**1**	£30,000	1	0	**1**	£30,000	1	0	**1**	£30,000	1	0	**1**	£30,000
Medium	3	0	**3**	£90,000	2	0	**2**	£60,000	3	0	**3**	£90,000	3	1	**4**	£105,000
High	4	3	**7**	£165,000	3	3	**6**	£125,000	4	3	**7**	£165,000	4	4	**8**	£180,000

This study recommends that the required number of chargepoints (as described in section 05) are all newly installed to support the uptake of zero-emission capable taxis. This is due to the current stock of city centre public chargepoints being of predominantly slow charge speed (3/7kW), making them of limited use to taxi drivers whilst on shift.

Recommendations to help overcome identified challenges

This feasibility sets out a road map by which Cambridge can introduce charging infrastructure across the city and encourage the adoption of ULEVs by the taxi and private hire trade.

Existing charging infrastructure

Determine the feasibility of the locations identified for charging points and future hubs and obtain budget estimates from UKPN. Further engagement with the University and NHS Trust is required to ensure that infrastructure is installed where the drivers need it. Considerable development (including additional housing) at these locations is underway or planned and there is a great opportunity to ensure that any infrastructure upgrades can take account of the charging requirements.

Convenient charging locations in central locations

The main city centre locations required for infrastructure to be installed are the bus and railway stations or in their locality. The railway station redevelopment is underway and the operator (Abellio) should be further engaged in the project with a view to providing charging for both trades. In discussions over the proposed redevelopment there appears to be a road parallel to the current station rank which should be explored for this purpose. It is not sensible to install chargepoints on the station rank which is particularly busy and this would also remove the possibility of the private hire trade being able to recharge in an area close to where they will be dropping off fares.

Vehicle running costs

With a relatively new fleet in the city the medium scenario for vehicle uptake is almost aligned with the city's ambitions to achieve 30% ULEV uptake by 2020. The cost of the new vehicles will be covered to

[13] Chargepoint installation costs are displayed at an indicative £30,000 per rapid charger and £15,000 per fast charger. These prices will vary dependent on location, both regionally and site-by-site. These costs are based on general estimates from leading chargepoint suppliers.

some extent by the top-up grants but further measures will be required to overcome the relatively low numbers of new vehicles registered in the private hire trade. Cambridge should consider further incentives to encourage drivers and operators to purchase plug-in taxis, such as:

- Lower access costs to the station rank
- Review of local authority tender scoring to encourage drivers to invest in the vehicles.
- Further work with the University and NHS trust to review travel arrangements.

Plug-in vehicles must cost less per mile to fuel when charged from a chargepoint than a new, efficient taxi would cost to run on petrol or diesel. The city should work with potential network operator(s) to ensure that suitable fees are charged to taxi drivers.

Drivers perceptions of plug-in vehicles

The city should engage with LTC in particular once the specifications and costs of the TX5 are known. By providing drivers and their representatives with whole life vehicle running cost predictions and access to cost effective driver training in the operation of the vehicles will help overcome many of the negative perceptions. It is recommended that the private hire trade should be encouraged to obtain vehicle demonstrators to determine real world range and costs; the City Council can play a central part in this process.

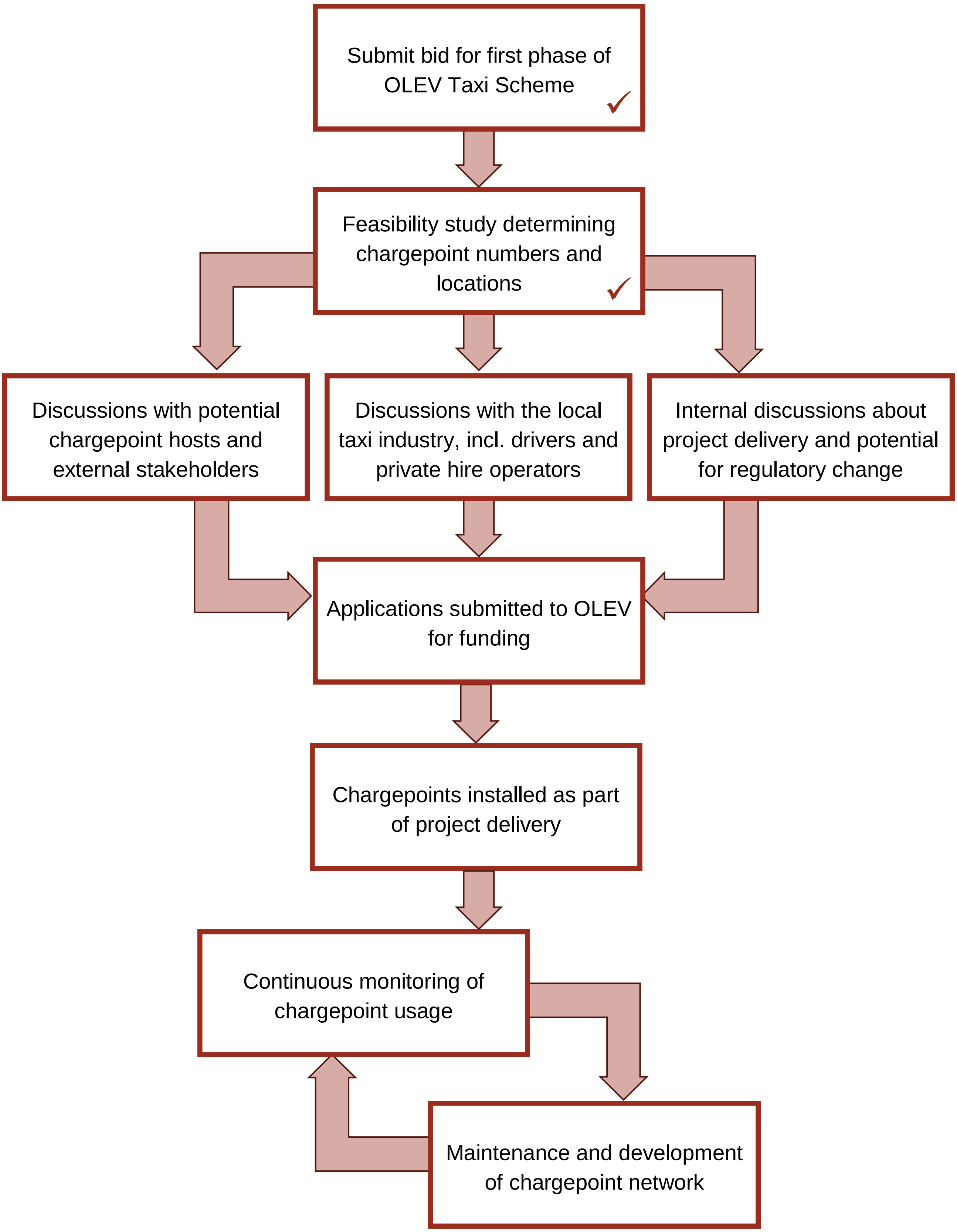
Current regulatory framework

With an established licensing policy which removes the license from taxi vehicles older than eight years, a step-change to this policy could ensure that all newly licensed taxis are ULEVs. This approach is reflected by the 'high' scenario of the uptake analysis at the beginning of this section of the study. Were this policy applied immediately, Cambridge City Council would have an entirely ULEV hackney carriage fleet by 2024.

Secondly, using Cambridge City Council's network of rising bollards and road traffic cameras to control road access to the city centre, there is an opportunity to provide taxi drivers with the incentive that only ULEVs will be permitted into the centre. This would likely be unpopular if introduced quickly, but may prove effective if phased in with the agreement of the industry. These opportunities for regulatory change should be explored further in order to maximise uptake.

Next steps

The flowchart below illustrates the next steps for Cambridge City Council in their bid to receive government funding from the Office for Low Emission Vehicles to develop infrastructure and provide grant support in order to hasten its transition towards an ultra-low emission taxi fleet.



Annex

Glossary of terms

Term	Definition
AC	Alternating current
Battery electric vehicle (BEV or pure-EV)	A vehicle powered only by electricity. The vehicle is charged by an external power source and incorporates regenerative braking which helps to extend the available range.
CHAdeMO	A charging protocol for delivering a DC supply to plug-in vehicles. CHAdeMO is primarily used by Japanese vehicle manufacturers, including Nissan and Mitsubishi, as well as Citroen and Peugeot.
Charging event	The time when a vehicle is connected to a chargepoint while power is transferred
Combined Charging System (CCS or Combo)	A charging protocol for delivering a DC supply to plug-in vehicles. It is currently used by BMW and VW. Most American and European manufacturers, including Ford, General Motors and Porsche have indicated that they will use CCS.
Conventional hybrid	Vehicles primarily powered by petrol or diesel which also have a storage battery charged by regenerative braking. This stored energy is then used to drive an electric motor which can assist the conventional engine to drive the wheels or drive them entirely for a short distance (usually less than a mile).
DC	Direct current
DNO	Distribution network operator
Euro (3, 4, or 5)	Increasingly stringent standards for the acceptable limits for exhaust emissions of new vehicles sold in EU member states.
Extended range electric vehicle (E-REV)	A vehicle which combines a battery, electric motor and an ICE. The electric motor always drives the wheels with the ICE acting as a generator when the battery is depleted.
Fast charging	Charging a plug-in vehicle at typical rates of 7kW AC, 20kW DC or 22kW AC
kW	Unit of power
kWh	Unit of energy
Mennekes (Type two)	The recommended standard for public 3.5kW and 7kW AC chargepoints. It can also be used for fast AC charging at 22kW or rapid AC at 43kW.
NOx	A generic term for nitric oxide, nitrous oxide and nitrogen dioxide.
On-board charger	Systems on-board plug-in vehicles which use a rectifier circuit to transform alternating current (AC) to direct current (DC).
Open Charge Point Protocol (OCPP)	A protocol which allows chargepoints and central control systems from different vendors to easily communicate with each other
Opportunity charging	Re-charging a plug-in vehicle during daily use (rather than overnight at home or depot). Typically requires a fast or rapid chargepoint.
Plug-in car grant / plug-in van grant	Grant funding to support private and business buyers looking to purchase a qualifying ultra-low emission car or van.
Plug-in hybrid electric vehicle (PHEV)	Similar to a conventional hybrid, with a larger battery and the ability to charge the battery from an external power source.
PM (10 and 2.5)	Suspended particulate matter categorised by the size of the particle (for

	example PM10 is particles with a diameter of less than 10 microns).
Private hire operators / vehicles	Operators including minicab, executive car and chauffeur-driven services. Private hire vehicles cannot be hailed in street and must be pre-booked with a licensed private hire operator.
Rapid charging	Charging a plug-in vehicle at typical rates of at least 43kW AC or 50kW DC
Regenerative braking	Converting the kinetic energy of the car into electricity which is stored in the battery.
Slow or standard charging	Charging a plug-in vehicle at typical rates of no more than 3.5kW AC
Taxi	Licensed cabs which can be hailed in the street or from a rank.
TCO (total cost of ownership or whole life cost)	The full cost of owning or operating a vehicle, including purchase / lease cost, fuel, tax, insurance and residual value.
TPH	Taxi and private hire

Existing chargepoint locations and type

Postcode	Location Type	Charge Speed
CB1 1ND	Public	3kW
CB1 1PS	Public	3kW
CB5 8HD	Dealership	3kW
CB1 1LY	Hotel	7kW
CB1 3LN	Dealership	7kW
CB10 1HH	Public	7kW
CB2 0QQ	Public	7kW
CB2 9FT	Public	7kW
CB22 3AB	Public	7kW
CB22 3AT	Public	7kW
CB22 7NH	Public	7kW
CB24 3DS	Public	7kW
CB24 6DB	Public	7kW
CB24 6DQ	Public	7kW
CB3 0DY	Public	7kW
CB3 0EX	Public	7kW
CB4 0FZ	Public	7kW
CB4 0WN	Public	7kW
CB8 0TF	Public	7kW
CB23 4WU	Public	50kW
CB23 6BW	Hotel	50kW
CB23 6EF	Dealership	50kW
CB5 8SQ	Dealership	50kW
CB8 0XG	Public	50kW