Appendix 4

ULEV Taxi Scheme

Feasibility Study
Oxford City Council

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Contents

01 Introduction

Background and project context

Oxford is a city in south-east England with a population of nearly 160,000, including approximately 30,000 students[1] The city has a diverse economy: the suburb of Cowley is the principle production site for Mini cars; Oxford's two science parks are home to many science and research based companies; the two universities are large employers; and the city is a major tourist destination. The city is administered by Oxford City Council.

Oxford has good transport links including a mainline train station and easy access to the M40 motorway. Several bus companies operate in the city including the Oxford Bus Company, Stagecoach and Arriva. The city has five park and ride schemes[2]. Oxford has the UK's second highest proportion of people cycling to work[3] and road traffic is strongly discouraged from using the city centre.

Scope of project

This is a bid by Oxford City Council working in partnership with Oxfordshire County Council. The city council provided all the necessary vehicle registration data, rank details and vehicle policy documents. Reports including an Air Quality Action Plan, Local Transport Plan and the latest Unmet Demand Survey were also provided.

Wider stakeholders participating in the study include: ABC Radio Taxis, A1 Taxis, City of Oxford Licenced Taxicab Association (COLTA), Oxford Brookes University, Oxford Health NHS Trust, Royal Cars, SSE Power & Distribution, and University of Oxford. A meeting was also held with Hackney carriage owning city councillors.

Hackney carriage and private hire vehicle fleet

Hackney carriage

There are 107 licenced hackney carriages and 538 private hire vehicles in Oxford, with 28 operators in total, four large operators and the rest quite small. 113 hackney carriages were included in the study; the additional vehicles are hire vehicles, given temporary licences to cover vehicles off the road. The vast majority (110) of the hackney carriages are LTI TX1, TX2, TX3 or TX4. One Mercedes Vito and two Peugeot Expert E7s complete the fleet.

There is a cap on hackney carriage numbers (107) and a new vehicle licence won't be granted unless it is less than five years old at the time of licencing. There is no upper age limit for vehicles. All vehicles must be purpose built wheelchair accessible vehicles.

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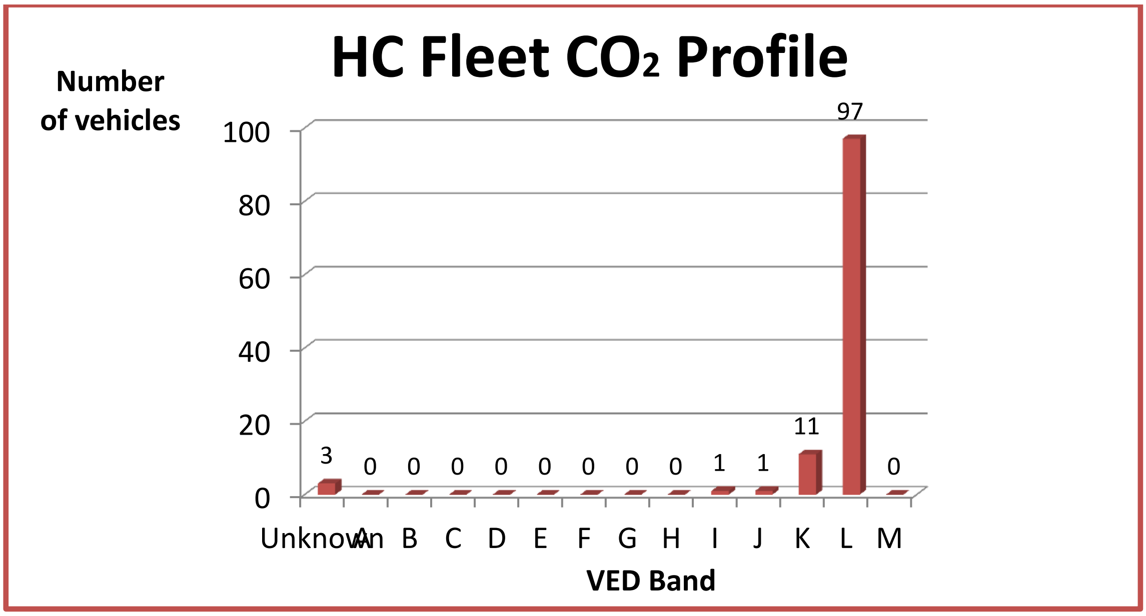
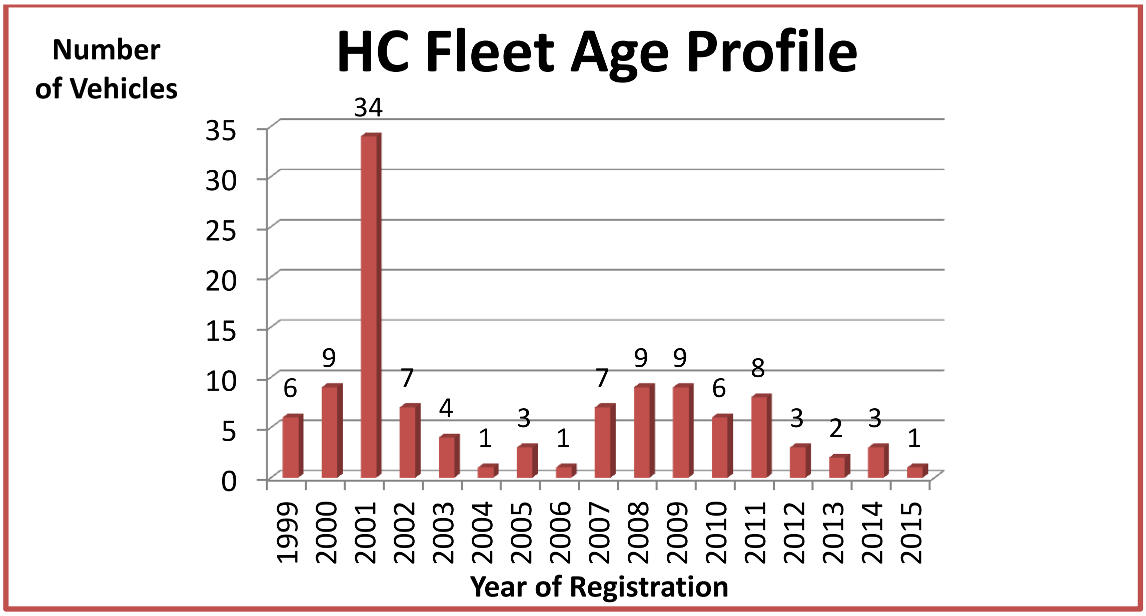
[1] https://www.oxford.gov.uk/info/20131/population/467/students_in_oxford
[2] https://en.wikipedia.org/wiki/Oxford#Transport
[3] http://www.ons.gov.uk/ons/rel/census/2011-census-analysis/cycling-to-work/2011-census-analysis---cycling-to-work.html

The current fleet has average official CO_2 emissions of 230 g/km, with individual vehicles ranging from 172 to 248 g/km.



The average taxi is 10.8 years old, which is relatively old, compared to many areas of the UK.



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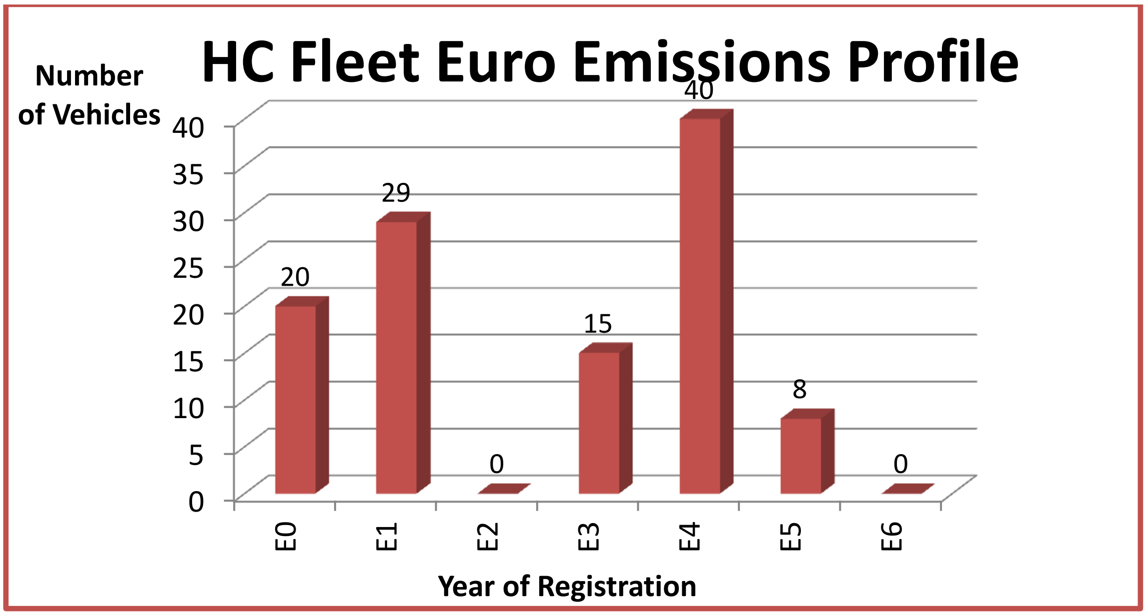
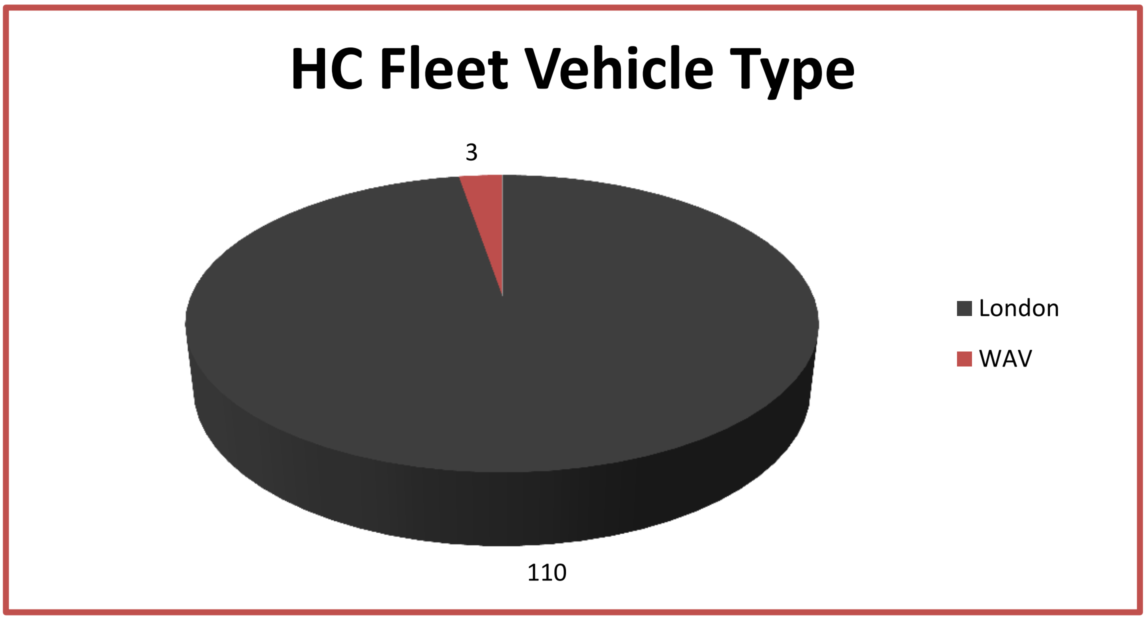
None of the taxis meet the most recent (September 2015) Euro 6 emissions standard; 7% meet Euro 5 (2010); 36% Euro 4 (2005); 13% Euro 3 (2000), 26% Euro 1 (1992) and 18% pre-dated the Euro standards.[4]



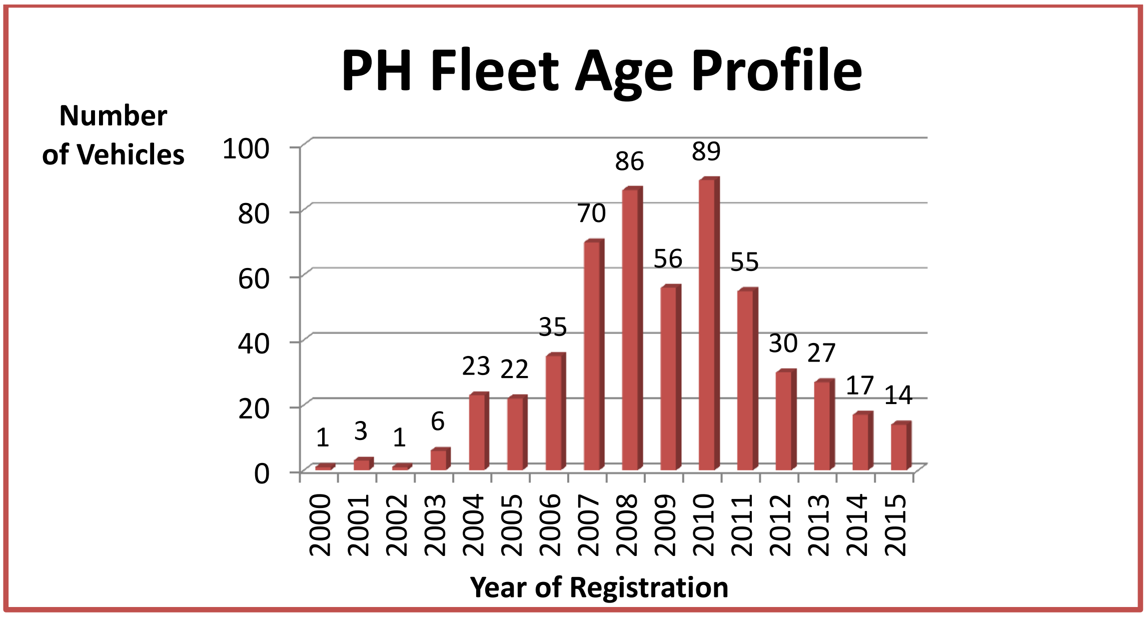
The hackney carriage fleet in Oxford is entirely comprised of wheelchair accessible vehicles (WAVs), of which the vast majority (97%) conform to the London standard conditions of fitness.



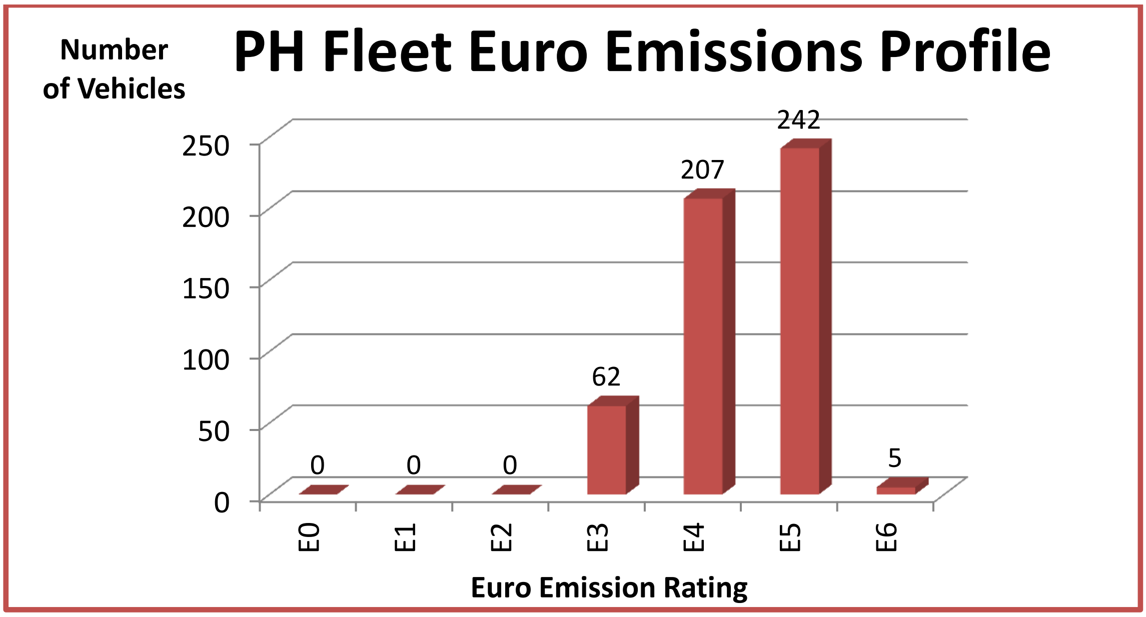
[4] Based on 112 vehicles. Euro standard data not available for one vehicle but from its age (2015) it is likely to be Euro 5 or 6

Private hire fleet profile

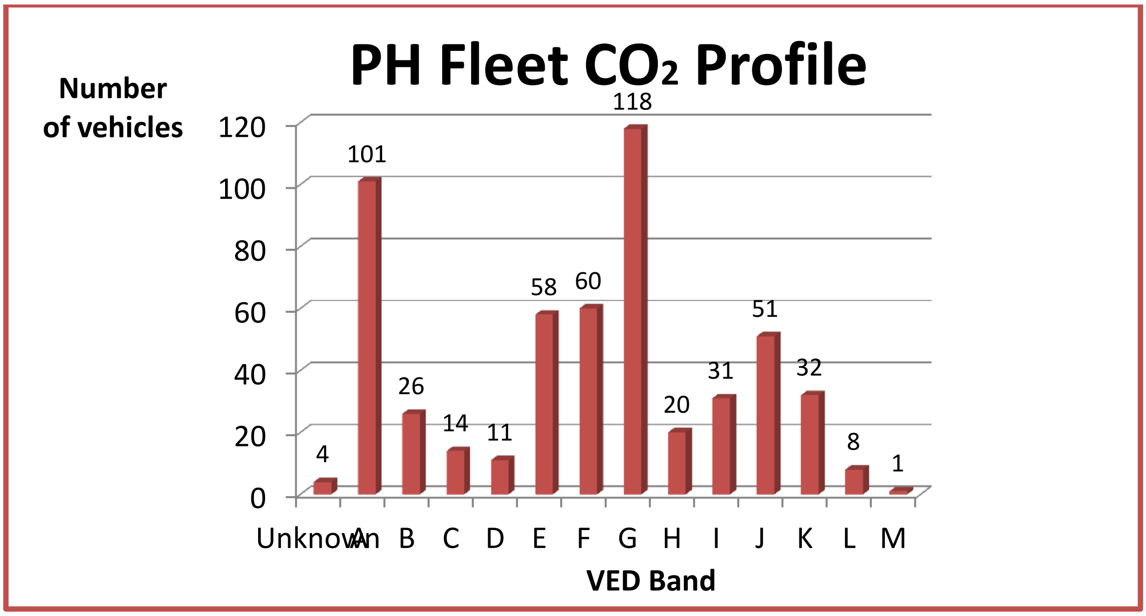
Although there is no maximum age limit in the city the average age of the vehicles is relatively young at 4.7 years, however there is a long “tail“ of registrations with the oldest being 15 years old. 30 private hire vehicles in Oxford are two years old or newer. Oxford’s private hire fleet includes 126 petrol-electric hybrid vehicles (not plug-in hybrids) all of which are Toyota Prius except one Mercedes E class.



Euro emissions standard data was available for 516 private hire vehicles. Of these, 1% met the latest (2015) Euro 6 standard; 47% Euro 5; 40% Euro 4; and 12% Euro 3.



The CO_2 profile of the vehicles is relatively low, with average CO_2 emissions of 145 g/km.



With 23 per cent of the fleet petrol electric hybrid and the range of models available from manufacturers growing rapidly, uptake of pure electric and plug in hybrid vehicles should be relatively straightforward as charging infrastructure is installed.

Air quality in Oxford

Oxford declared its first Air Quality Management Area (AQMA) in 2001 and is currently covered by an AQMA covering the whole of the city, declared in 2010 due to exceedances in permitted levels of nitrogen dioxide[5].

Road transport is the main source of air pollution in Oxford[6] so the adoption of ULEV taxi and private hire vehicles would bring a clear public health benefit for those who live and work in the city.

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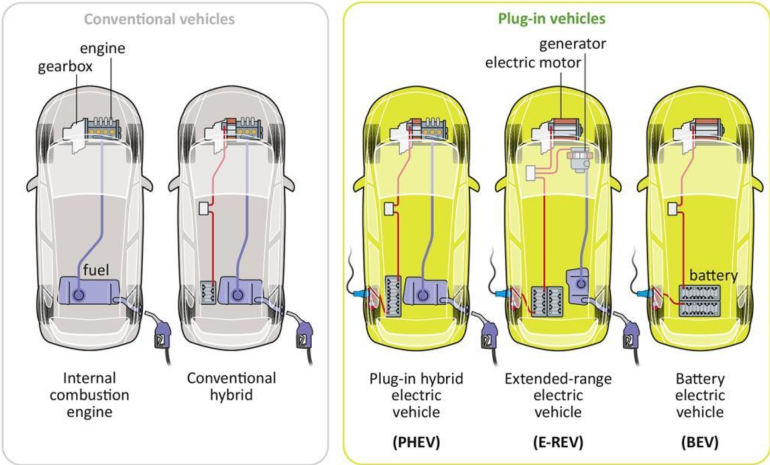
[5] http://uk-air.defra.gov.uk/aqma/local-authorities?la_id=193
[6] http://uk-air.defra.gov.uk/aqma/details?aqma_id=249

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).

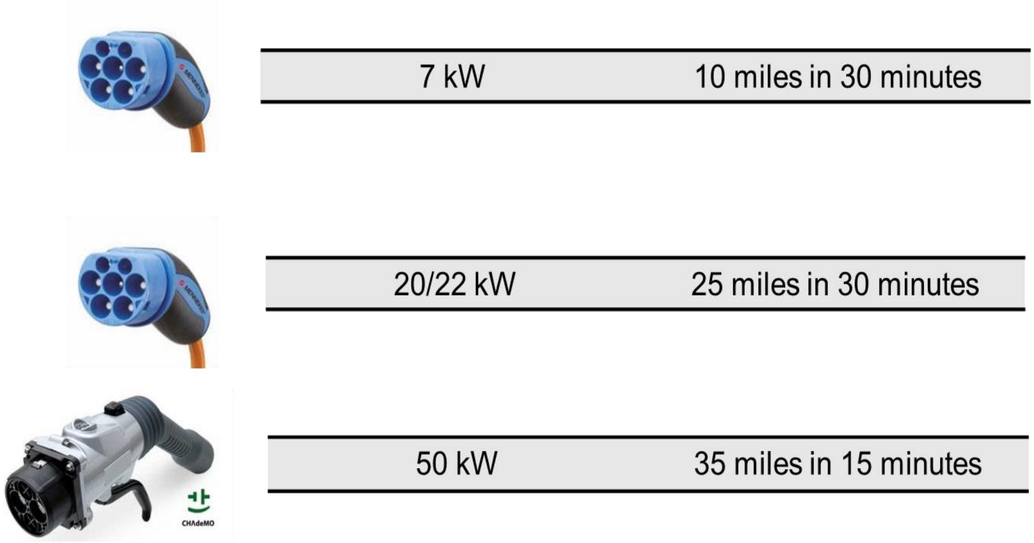
Plug-in hybrid electric vehicle (PHEV): Combine a battery, electric motor and ICE like a conventional hybrid, a larger battery provides a longer electric only driving range. The battery can be recharged from a charge point reducing the amount of fuel consumed over a given distance. The vehicle reverts 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[7].



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 charging8. 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[9].

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

[8] 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.

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

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.
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 Oxford standard saloon cars and people carriers are not able to be licenced as hackney carriages, however a range of plug-in hybrid and pure electric vehicles are available from mainstream manufacturers which would be suitable for the private hire market. 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

Oxford City Council provided registration data for the 538 licenced vehicles in the city. The maximum age for first licencing a private hire vehicle is the same as for hackney carriages at five years and similarly no maximum age limit is in place. There is no requirement for wheelchair accessible vehicles.

There are four larger operators in the City and 24 smaller ones, many of whom are engaged in offering chauffeur services.

Meetings with trade representatives

A face to face meeting was held with a representative from ABC Radio Taxis who operate a fleet of 70 cars, most of which are driven by owner drivers and not owned by the company. A telephone conference was held with Royal Cars who operate a fleet of 300 vehicles, 70-80 of which are owned by the company and rented to drivers. This is a business model they wish to expand. 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 and where charging infrastructure should be located were sought, taking into account the anticipated performance of vehicles currently on the market. Their willingness to complete a survey and engage with the project in 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 a reply from Royal Cars. The engagement with the trade 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. 58 licenced taxi drivers, some of whom are vehicle owners completed the survey, a sufficiently high proportion (30% of licence holders) 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[10].

	Daily Working Mileage	Total Daily Mileage (Commuting & Working)
Average (Median / Mean)	**69 miles / 68 miles**	**92 miles / 72 miles**
<= 60 miles per day	44%	13%
<= 80 miles per day	76%	42%
<= 100 miles per day	90%	71%
<= 120 miles per day	92%	87%
<= 140 miles per day	94%	92%
<= 160 miles per day	94%	94%

[10] Based on 52 drivers that responded in full to questions about commuting & working mileages

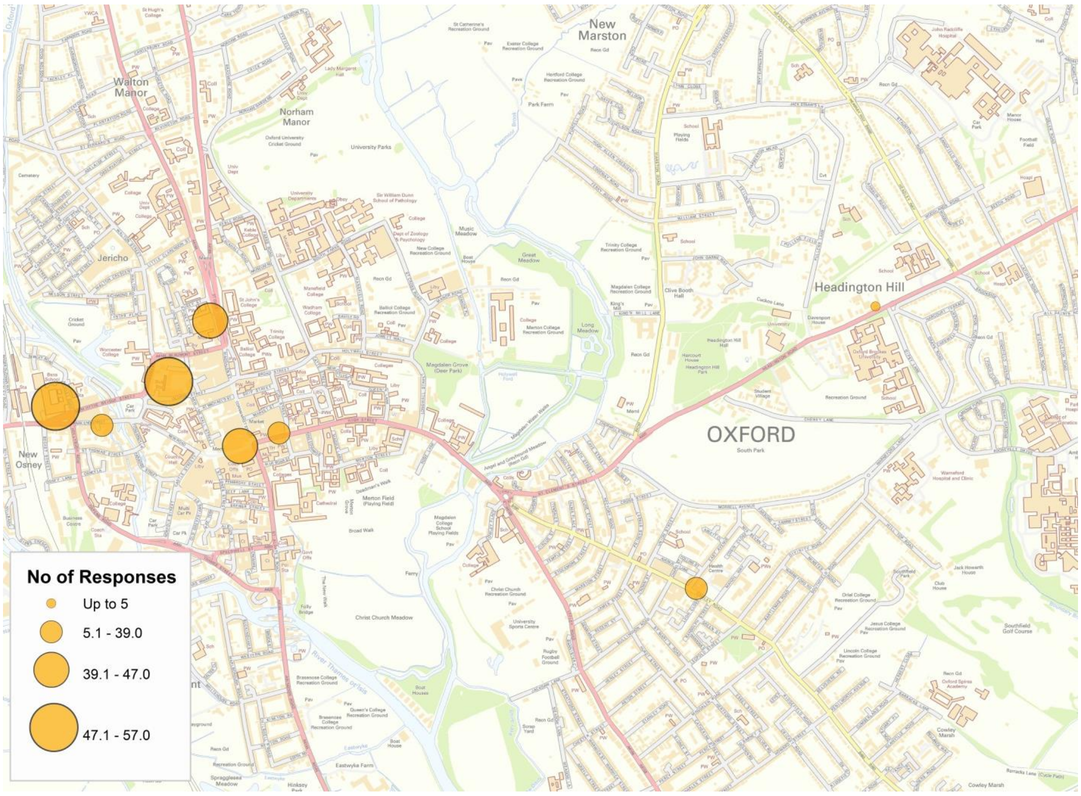
Break durations

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

	Proportion of Drivers
At least one break of any duration	93%
At least one break of more than 15 minutes	83%
At least one break of more than 30 minutes	21%

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
Oxford Railway Station	57
Gloucester Green	53
Queen Street	46
Park End Street	35
St. Giles	47
High Street	39
Cowley Road	39
London Road	10

Drivers were asked how many times a week accept fares to locations outside of Oxford. The results are shown below:

Trips outside of Oxford per week	No Trips	1-5	6-10	>10
Proportion of Drivers	4%	75%	16%	5%

Drivers were also asked where they typically take breaks, to which the most common responses were on ranks and at home. No other locations were seen to be suggested frequently enough for them to be significant.

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%	50%	10%	2%
Unlikely	21%	18%	15%	5%
Likely	17%	5%	38%	26%
Very likely	24%	3%	15%	51%
Don't know	26%	24%	23%	16%

- 53% of respondents are likely or very likely to consider a pure electric taxi when they next replace their vehicle.
- 77% 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 69% and the proportion likely or very likely to consider a plug-in hybrid taxi rises to 92%.

Drivers were also asked about their perceived barriers to operating ULEV taxis. The results are presented below:

Perceived barrier	Proportion of sample
High lease / purchase cost	72%
Charging during the day would impact on my productive working time	58%
The technology is new and unreliable	56%
Insufficient range (in miles) between charges	47%
Nowhere to charge between shifts	47%
Nowhere to charge during shifts	42%
None	4%
Other	2%

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. Oxford 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 107 hackney carriage licenses.

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 Oxford City Council 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, Oxford City Council 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 polluting taxis. In doing this, Oxford City Council 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.

Oxfordshire County Council & Oxford City Council 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, the Councils could **work with operators of local transport hubs such as Oxford Station 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. The Councils 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, Oxford City Council 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 Oxford City Council and Oxfordshire County Council 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. The Councils 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

Oxford City Council's taxi licensing policy currently prevents vehicles older than five years from being granted a new license. However, unlike some other local authorities of a similar size, Oxford City Council does not impose any age limit on license renewals. The effect of this policy can be seen in the hackney carriage fleet age graph in section 01, which shows a broad preference for older vehicles (15 years old being the most common age).

We would recommend that an eighteen year age limit is imposed, after which no hackney carriage license will be permitted. The reason for this is two-fold. Firstly, this will generate a pipeline of hackney carriage owners/operators that will need to purchase a newer vehicle, at which point they will have the option to purchase a ULEV. Secondly, this will ensure that the oldest, most polluting vehicles are removed from the fleet first, maximising the positive impact on air quality.

Eighteen years is an ideal limit to set for hackney carriages in Oxford City Council, as it avoids any abrupt changes to the fleet in favour of a more phased in approach. This will reduce the likelihood of relationships with the trade being compromised and 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
16	49	7	4	1
17	15	34	7	4
18	6	9	34	7
19	0	6	9	34
20	0	0	6	9

As is displayed above, imposing age limit of sixteen years would result in a larger group of ineligible vehicles leaving the group in 2017, as this would include all vehicles first registered from 1997 to 2002. On the other hand, imposing alimit of twenty years would result in a small number of vehicles becoming ineligible as there are very few vehicles in Oxford City Council's hackney carriage fleet which currently, or will soon, exceed this age. Between the remaining three options, an eighteen year limit would strike a balance between ambition and practicality.

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 preferences shown in the drivers' survey:

1. **Low.** An eighteen year cap is imposed to remove the oldest vehicles from fleet; voluntary uptake (supported by top-up grants) of a proportion of taxis older than eighteen years, with that proportion being based on "*very likely*" responses to survey question on whether their 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 eighteen 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 imposing a modest 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	1	2	8	2	13
Medium	4	6	24	5	39
High	6	9	34	7	56

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	1	0.9	3	2.8	11	10.3	13	12.1
Medium	4	3.7	10	9.3	34	31.8	39	36.4
High	6	5.6	15	14.0	49	45.8	56	52.3

Based on these numbers and a range of assumptions[11] 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	0	0	**0**	0	0	**0**	1	0	**1**	0	0	**0**	1	0	**1**
Medium	0	0	**0**	1	0	**1**	3	0	**3**	0	0	**0**	4	0	**4**
High	1	0	**1**	1	0	**1**	3	0	**3**	1	0	**1**	6	0	**6**

[11] Average daily working and total mileages are 68 and 76 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.

The total chargepoint requirement is relatively low for Oxford City Council. This is, in part, due to the fleet being of a fairly small size but also because the average mileage, as expressed in the drivers' survey, falls within the range of many pure-electric vehicles. We also anticipate that this mileage will also fall into the range of the next generation zero-emission capable London-style taxis. For this reason, the need for public infrastructure is less as drivers may undertake their daily workload after a single charge, at home or elsewhere.

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	0	0	1	1
Medium	0	1	4	4
High	1	2	5	6

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 Oxford 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	27	5%	3	0	3
Medium	161	30%	12	3	15
High	269	50%	13	12	25

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 Oxford City Council's hackney carriage fleet is 0.626g/km. This is high compared to other local authority areas, and is primarily the result of Oxford City Council's relatively ageing hackney carriage fleet. On average the fleet itself, only qualifies for a Euro 2 classification.

The average daily mileage of the hackney carriage fleet (combined working and commuting mileage), as indicated by the drivers' survey is 76 miles. Assuming a six day working week, the approximate total NOx emissions of Oxford City Council's hackney carriage fleet is 2.7 tonnes per annum. The table below shows how NOx output would be improved by the various ULEV uptake scenarios described in the previous sub-section.

	Present	Low	Medium	High
NOx Ave. g/km	0.626	0.430	0.359	0.316
Total NOx (g)	2,708,458	1,859,726	1,555,129	1,366,213
Total NOx Change (g)		848,732	1,153,329	1,342,245
Percentage Change		**31%**	**43%**	**50%**

Depending on which scenario is achieved, Oxford City Council could reduce its annual taxi-attributable NOx output by between approximately 0.85 tons per year and 1.34 tons per year. This would represent a reduction of 31% to 50%, assuming that the hackney carriage fleet remains the same size.

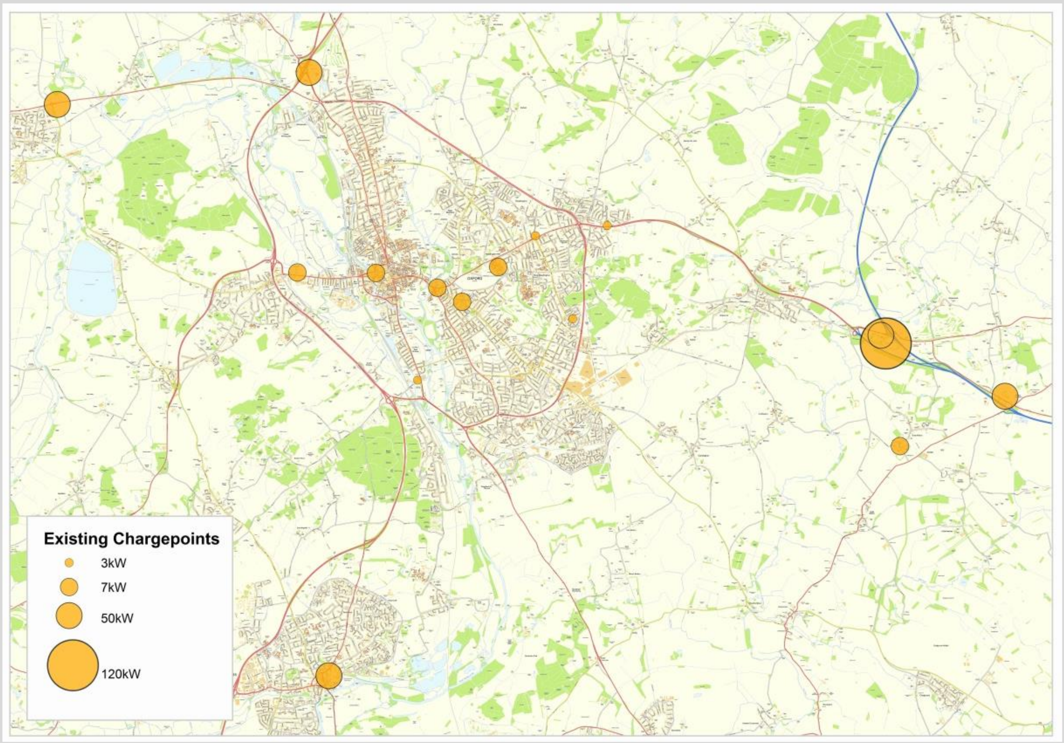
Any direct correlations between percentage change in NO_x emissions and improvements in localised air quality cannot be assumed without further research as localised air quality is also impacted by other factors including driver behaviour and areas of work, as well as atmospheric conditions and street layout. . 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

Recommendations for chargepoint locations

Existing chargepoint network

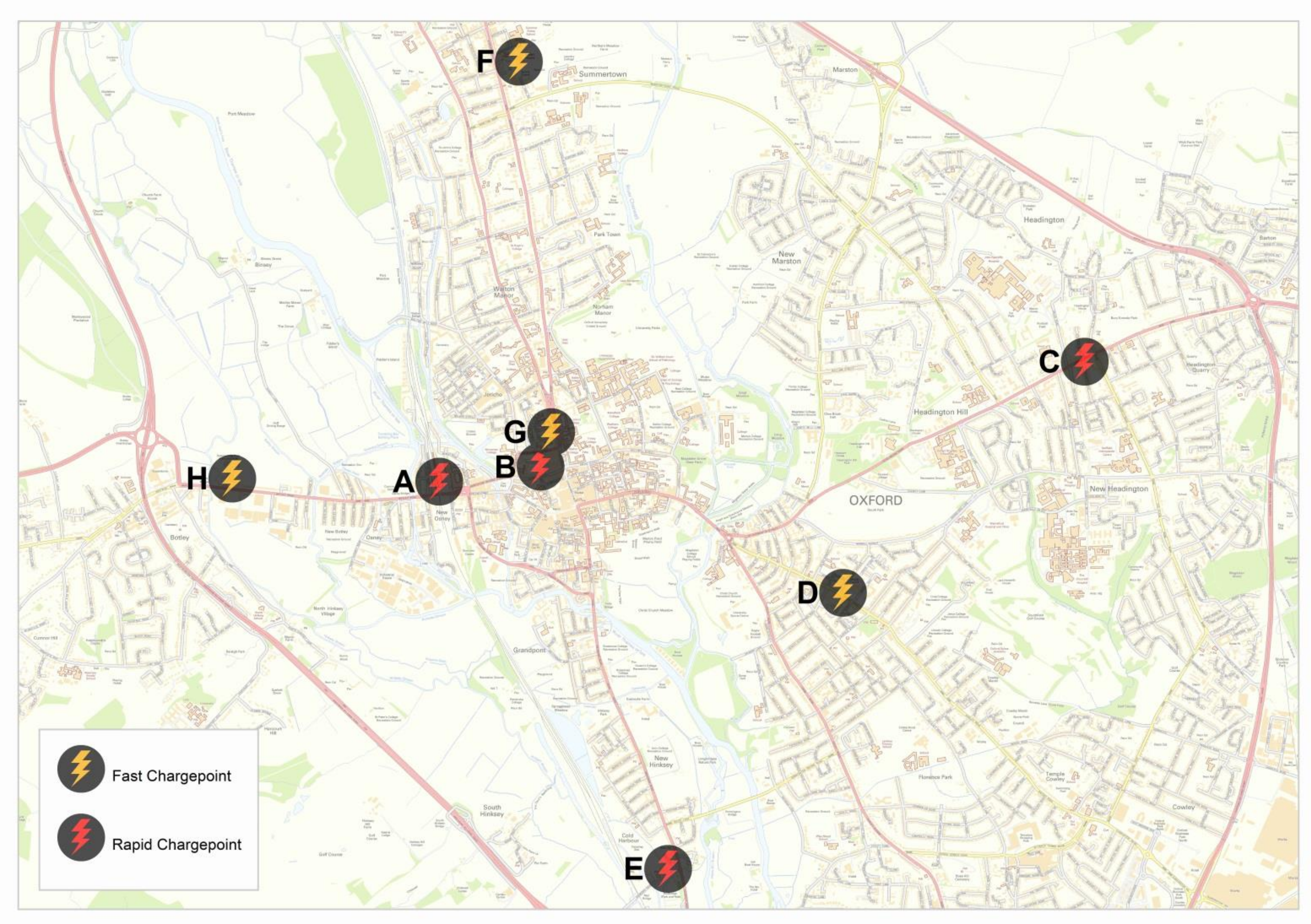
The map below displays the chargepoints in the Oxford area which provide 3kW/7kW (slow) or 43kW/50kW (rapid) rates of recharging. The full list of these chargepoints is available in the annex. Currently there are insufficient chargepoints providing an appropriate rate of charge to support the introduction of plug-in taxis. However, there are several rapid charging points available outside Oxford city centre; therefore infrastructure works should focus more on the area within the ring road.



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 H 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
Oxford Railway Station	A	Rapid
Gloucester Green	B	Rapid
London Road	C	Rapid
Cowley Road	D	Fast
Redbridge Park and Ride	E	Rapid
Summertown Car Park	F	Fast
St. Giles	G	Fast
Seacourt Park and Ride	H	Fast



The highest priority points (A & B) are at Oxford Railway Station and Gloucester Green, respectively. These two locations were shown to be very popular in the drivers' survey, with practically every hackney carriage driver completing the survey claiming to use one or both of the ranks on these sites. The two sites are centrally located, they both appear to be relatively practical locations to install chargepoints and both are appropriate places to take breaks (owing to local amenities). For these reasons, rapid charging infrastructure is recommended at these two locations.

Point C, located on or near the taxi rank on London Road, is also recommended for rapid charge. This location was found to be ideal for charging infrastructure due to several factors. Firstly in that several drivers stated in the drivers' survey that they use the London Road taxi rank (despite it not being a specific option on the survey). More importantly than this, point C is located roughly equidistant from John Radcliffe Hospital and Churchill Hospital, which were equally the most popular pick-up/drop-off locations specified in the drivers' survey. This location also provides some geographical coverage to areas east of Oxford city centre.

Point D on Cowley Road is located on or near a popular taxi rank. This site was also seen to be a popular pick-up/drop-off location for hackney carriage drivers and is close to many shops and amenities, making it an ideal place to take breaks. The site also provides geographical coverage southeast of Oxford city centre. Cowley Road is recommended for fast charge infrastructure, in order to simplify installation on the roadside, to limit costs and owing to it being a convenient break location.

Point E is located at the Redbridge Park and Ride. This location provides coverage to the south of Oxford city centre, is located on a public transport hub and is also relatively close to the popular pick-up/drop-off destinations of Oxford Business Park and Oxford Science Park. There is also space available at this site to ensure the installation of charging infrastructure is comparatively simple and undisruptive. For this reason, we recommend that rapid charge be installed at Redbridge Park and Ride.

Fast charge is recommended for installation at point F, in or near Summertown Car Park. Summertown was suggested by drivers as being both a frequent pick-up/drop-off destination and an area where charging infrastructure would be useful. Further to this, Summertown is an ideal location to provide charging coverage for the area north of Oxford city centre. Fast charge is suggested here in order to limit costs and simplify installation in a location which is well suited to taking breaks.

Point G at the St. Giles rank is also recommended for fast charge. This site is ideal for charging infrastructure in the sense that it is a very frequently used rank in a central location. However, the rank itself is located between two opposing lanes of traffic, possibly causing some issues with regards to ease of installation and road safety for rapid charging infrastructure. For this reason, we recommend that this site be fitted with fast charge infrastructure to simplify installation. Due to the practical considerations, this site is of a lower priority than the other central sites proposed (A/B).

Finally, point H at the Seacourt Park and Ride is recommended for fast charging infrastructure, owing to its proximity to some local amenities making it an ideal site to take breaks. This location provides some geographical coverage to areas west of Oxford city centre and is located at a public transport hub.

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. Oxford City Council should use the chargepoint locations and number of chargepoints required to provide location and capacity details to Scottish and Southern Electric (SSE) the Distribution Network Operator (DNO) covering Oxford, 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. SSE do not anticipate major issues in the City.

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 SSE for a free initial budget estimate, providing details of the location and the required power. SSE 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[12] guidance on the impact of street furniture on traffic management and streetscapes.
5. Request a free formal quotation from SSE 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.

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

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

SSE 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 SSE.

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[13] (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)[14]. 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 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.

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

- 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

Whilst there are some rapid charge options available in the areas around Oxford, the majority of ULEV charging infrastructure presently available in Oxford City Centre is of a slow charge speed (3-7kW). In practice, this would be inappropriate for use by the local TPH trade. This is because too much working time would be lost whilst charging, considering that an 80% charge takes several hours on a slow charger. Responses from the drivers' survey show that losing working time in this manner is the second most frequently expressed concern (behind upfront cost), in utilising ULEVs in Oxford's TPH industry. By comparison, an 80% charge would take roughly 30 minutes on a typical rapid charger.

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[15]. The table below compares this to the cost per mile of using a 20kW 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

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.

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

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 is 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

A number of very positive factors emerged from the drivers' survey. 76% of drivers expressed that they would be likely or very likely to purchase an ULEV for use. as a Hackney Carriage. Range anxiety is less of a concern than expected, most probably due to average mileage being lower in Oxford than many other urban areas. However significant concern was expressed about the upfront cost of purchasing an ULEV taxi and in the potential impact that charging may have on working time. Both of these concerns are related specifically to the business case for ULEVs in the TPH industry and present a challenge to Oxford City Council regarding how to incentivise them to the local trade.

Another notable concern expressed in the drivers' survey was that, as ULEVs are new to the market, their reliability is yet to be firmly established in a TPH setting. This concern is an understandable one, as taxi vehicles will commonly travel several hundred thousand miles over their operating lifespan. However, the perception that ULEVs are unreliable is a common misconception. In fact, for a number of reasons, ULEVs (especially pure electric models with only an electric motor) generally possess greater reliability than conventional vehicles. This is because they are mechanically simpler and have fewer moving parts (electric motors have one moving part and do not require multi-speed transmissions). The vehicles also feature regenerative braking technology, which uses the electric motor as a generator to slow the rotation of the wheels whilst reclaiming kinetic energy to charge the battery. The result of this is that brake discs and pads should need replacing less frequently than on conventional vehicles. The singular costly element of an electric vehicle which may require replacement is the battery, for which some manufacturers offer battery leasing options to mitigate and spread the cost. The disparity between the actual and the perceived reliability of ULEVs expressed in the drivers' survey presents Oxford City Council with the challenge of educating drivers to understand the strengths and weaknesses of modern ULEVs.

Current regulatory framework

The most significant challenge presented by Oxford's taxi licensing policy is that, in not imposing any age limit on vehicles, it provides little incentive for hackney carriage drivers to purchase brand new vehicles. In the context of ULEVs, this is particularly challenging as the used vehicle market has yet to develop and likely will not develop for several years, as ULEV hackney carriage models – such as the LTC TX5 and Metrocab – are not scheduled to be released until 2017-18. The effect of this regulation is that conventionally fuelled hackney carriages will be considerably more competitive with their brand new ULEV equivalents than they would be were an age cap to be considered. This is magnified by the drivers' concerns regarding upfront purchase cost of ULEVs, which was the most frequently cited concern in the drivers' survey.

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	£39,000	£30,000	£90,000	**£159,000**
Medium	£117,000	£120,000	£405,000	**£642,000**
High	£168,000	£180,000	£570,000	**£918,000**

The following table shows the total amount of grant funding required between 2017 and 2020, in order to achieve ULEV hackney carriage uptake targets across the three uptake scenarios, 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	£3,000	£3,000	£6,000	£9,000	£54,000	£63,000	£6,000	£69,000
Medium	£12,000	£12,000	£48,000	£60,000	£162,000	£222,000	£15,000	£237,000
High	£48,000	£48,000	£57,000	£105,000	£192,000	£297,000	£51,000	£348,000

Hackney carriage top-up grants

Taxi top-up grants are available specifically for purpose-built, wheelchair accessible taxis. The predicted number and cost[16] of taxi top-up grants are as follows:

Scenario	2017		2018		2019		2020	
	Grants	Cost	Grants	Cost	Grants	Cost	Grants	Cost
Low	1	£3,000	2	£6,000	8	£24,000	2	£6,000
Medium	4	£12,000	6	£18,000	24	£72,000	5	£15,000
High	6	£18,000	9	£27,000	34	£102,000	7	£21,000

[16] 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.

Oxford City Council presently only licenses purpose-built taxi vehicles in its hackney carriage fleet. Therefore the projections for ULEV adoption in the hackney carriage fleet (as shown in section five) are assumed to directly influence the amount of top-up grant funding required.

Hackney carriage numbers

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

Scenario	2017				2018				2019				2020			
	R	F	T	Cost	R	F	T	Cost	R	F	T	Cost	R	F	T	Cost
Low	0	0	**0**	-	0	0	**0**	-	1	0	**1**	£30,000	0	0	**0**	-
Medium	0	0	**0**	-	1	0	**1**	£30,000	3	0	**3**	£90,000	0	0	**0**	-
High	1	0	**1**	£30,000	1	0	**1**	£30,000	3	0	**3**	£90,000	1	0	**1**	£30,000

This study recommends that the required number of chargepoints (as described in "Chargepoint recommendations" section, page 13) 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 Oxford City Council 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 SSE. Further engagement with the Great Western Railways (operator of Oxford Railway Station) is required to ensure that infrastructure can be installed at Oxford Railway Station, where it is likely to be most required. Oxford City Council could also raise awareness about the rapid charge facilities that are available in the areas around Oxford, to ensure drivers are confident that they will still be able to undertake journeys beyond Oxford's ring road.

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 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. Oxford City Council 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 Universities and NHS trusts 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

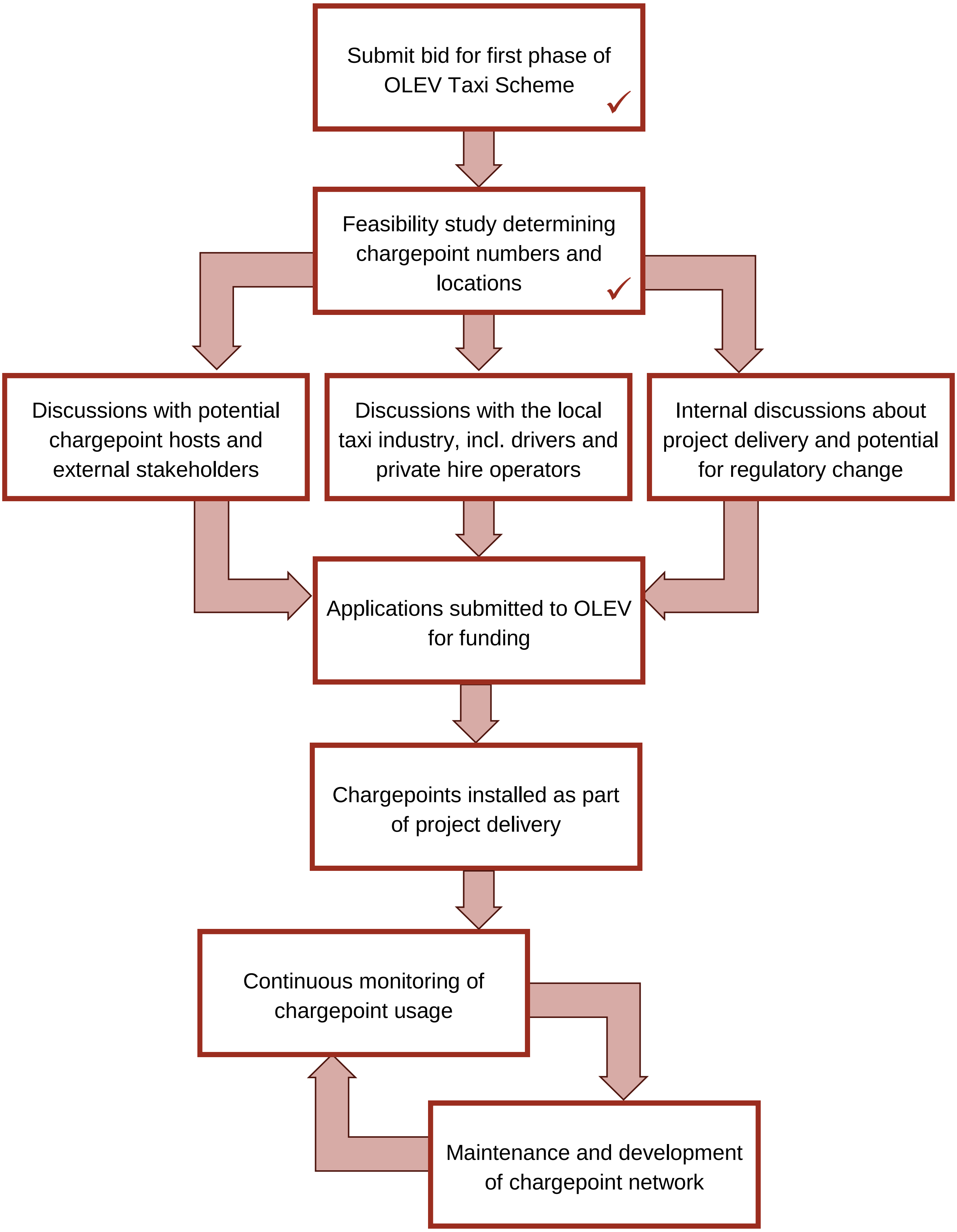
The councils should engage with LTC in particular once the specifications and costs of the TX5 are known. By providing drivers and their representatives with whole life vehicle running cost predictions and access to cost effective driver training in the operation of the vehicles will help overcome many of the negative perceptions, certainly regarding cost. It is recommended that the private hire trade should be encouraged to obtain vehicle demonstrators to determine real world range and costs; Oxford City Council can play a central part in this process. The councils could also consider providing some degree of education and/or training for prospective ULEV purchasers. Delivering this with manufacturers may also allow for test drives and the gaining of other experience to help address some of the more negative perceptions of TPH drivers in Oxford.

Current regulatory framework

Oxford City Council must consider how its existing TPH regulatory framework could be adapted to encourage the uptake of ULEVs. It is strongly recommended that the first step towards this goal is to begin discussing the implementation of an upper age limit, beyond which hackney carriages will no longer be licensed. More ambitious measures could also be implemented, such as enforcing that all new hackney carriages and/or private hire vehicles must be ULEV. However, measures of this nature should only be undertaken in consultation with the local TPH trade, to ensure that they are received positively and are ultimately effective.

Next steps

The flowchart below illustrates the next steps for Oxford 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
OX3 9JT	Public	3kW
OX3 8DP	Public	3kW
OX3 7JQ	Public	3kW
OX1 4XG	Public	3kW
OX2 0HP	Public	7kW
OX1 2BQ	Public	7kW
OX4 1AB	Public	7kW
OX4 1UT	Retailer	7kW
OX3 0BP	Public	7kW
OX2 8JD	Public	7kW
OX44 7PD	Retailer	7kW
OX2 8JZ	Hotel	50kW
OX29 4EN	Public	50kW
OX33 1JN	Hotel	50kW
OX9 2JW	Hotel	50kW
OX14 3HL	Retailer	50kW
OX33 1LJ	Public	120kW