CAN THE MARKET ALONE DELIVER EV CHARGEPOINTS?

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ABSTRACT

This paper focusses on identifying the market failures associated with electric vehicle charge point investment, and developing a methodology that helps identify locations where these market failures may pose particular barriers to investors in charge points. It presents analysis that has been carried out as part of the Charge Collective Network Innovation Allowance project.

There is broad consensus that a switch to low-carbon vehicles will be a critical part of the strategy to tackle climate change and to meet the Government's Net Zero target. Sales of new petrol and diesel cars will be phased out by 2030. A major effort therefore needs to be made this decade to accelerate the transition from conventionally fuelled vehicles.

Low provision of public charging infrastructure in the UK is widely seen as one of the main barriers to growth of the domestic EV market. Drivers are understandably concerned about battery capacity and the availability of conveniently located charging points. More than one-third of households in England do not have access to off-street parking and so will need to rely on public chargers.

The market failures directly associated with replacing petrol and diesel vehicles with EVs are well understood (including positive externalities from reductions in greenhouse gases and emissions affecting air quality). But there is also a series of market and policy failures specifically associated with the charge points themselves.

Investing in charge points can often involve high capital costs, including network reinforcement costs, sole-use connection assets and the charging infrastructure itself. Most of these costs are sunk. In this context, our analysis suggests there are three sets of barriers preventing the market alone from achieving a level of investment in chargers that is optimal for society:

- **Market failures – network externalities**. At low levels of charge point coverage and EV penetration, early investors in chargers have a first mover disadvantage compared to those who enter later. While their investment will tend to increase EV take-up and hence future charge point demand, these first movers cannot fully monetise that demand since the new EV users may decide to use other charge points once the market matures.
- **Policy uncertainty.** There is some uncertainty over the speed at which transport should be electrified in the 2020s. A delay of a few years in EV take-up could make a substantial difference to the business case for investing in chargers. There is also uncertainty on the extent to which the roll-out may be subsidised by central government. This uncertainty may in turn affect investment decisions.
- **Regulatory issues.** To the extent that network tariffs both signal forward looking costs and recover existing costs they may lead to investment at lower than optimal levels.[1]

[1] Ofgem (2019), *Targeted Charging Review*, https://www.ofgem.gov.uk/publications-and-updates/targeted-charging-review-decision-and-impact-assessment

In this paper, we describe these barriers and set out a methodology that can be used to help identify potential "cold spots" for investment. Cold spots are locations where the social benefits to charge point investments may be high, but the market failures pose barriers to investors.

1 INTRODUCTION

The Government has announced that it will end the sale of new petrol and diesel cars and vans from 2030.[2] Sales of electric vehicles (EVs) are increasing rapidly, however, they still make up only around 15% of new cars.[3] Therefore, a major effort needs to be made this decade to accelerate the transition from conventionally fuelled vehicles.

Low provision of public charging infrastructure in the UK is widely seen as one of the main barriers to growth of the domestic EV market.[4] Drivers are understandably concerned about battery capacity and the availability of conveniently located chargepoints (this concern is known as 'range anxiety'). Future demand for charging will likely have to be satisfied through a mix of different channels including charging at workplaces, along major roads, at supermarkets or at leisure centres.

Chargepoint provision in residential areas will likely also be key. Currently, the vast majority of chargepoints are installed on private driveways, allowing EV users to charge their cars whenever they want.[5] This also facilitated by OZEV's Electric Vehicle Homecharge Scheme, which provides a 75% contribution to the cost of each chargepoint and its installation.[6] However, one-third of households in England do not have access to off-street parking and so will need to rely on public chargers if they are to switch to EVs.[7] In UK Power Networks' area, this figure exceeds 50%.[8] Access to off-street parking is lowest for the most deprived groups**.** In the most deprived 20% of areas, more than 55% of individuals do not have access to private garages or off-street parking, in comparison to less than 15% in the least deprived 20% of areas.[9] At the same time, providers of public chargepoints face barriers to investment related to high capital costs (driven by network reinforcement and sole use asset costs) combined with a set of market failures, uncertainties around the policy landscape and regulatory rules. All these obstacles contribute to reducing investment in chargepoints to below optimal levels.

To help address this issue, UK Power Networks is undertaking the Charge Collective project (Box 1). Charge Collective is a Network Innovation Allowance (NIA) project that aims to design and trial a distribution network operator-led intervention to enable investment in public chargepoint infrastructure in a way that is fair to customers. The project focuses on fast (7-22kW) and rapid (43-50kW) chargepoints on residential streets, serving customers who charge on-street at

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2 BEIS (2020), *Powering Our Net Zero Future*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

3 https://innovation.ukpowernetworks.co.uk/market-intelligence/ f

4 As part of Charge Collective, UK Power Networks commissioned an online survey to understand future on-street charging needs and behaviours. Survey respondents perceived the lack of charging points at/near home and in public as the main barrier to owning an EV.

5 https://www.nao.org.uk/press-release/reducing-carbon-emissions-from-cars/

6 https://www.gov.uk/government/publications/customer-guidance-electric-vehicle-homecharge-scheme/electric-vehicle-homecharge-scheme-guidance-for-customers

7 English Housing Survey (2018), Table DA2202 (SST2.5): Parking and mains gas - areas, 2018.

8 UK Power Networks internal estimates

9 English Housing Survey (2018), Table DA2202 (SST2.5): Parking and mains gas - areas, 2018.

home. The intervention is being trialled in Cambridge, Norwich and Redbridge local authority (LA) areas. As well as delivering over 150 public chargepoints to these areas, the project will create learnings for the possible future roll-out of similar initiatives across Great Britain.

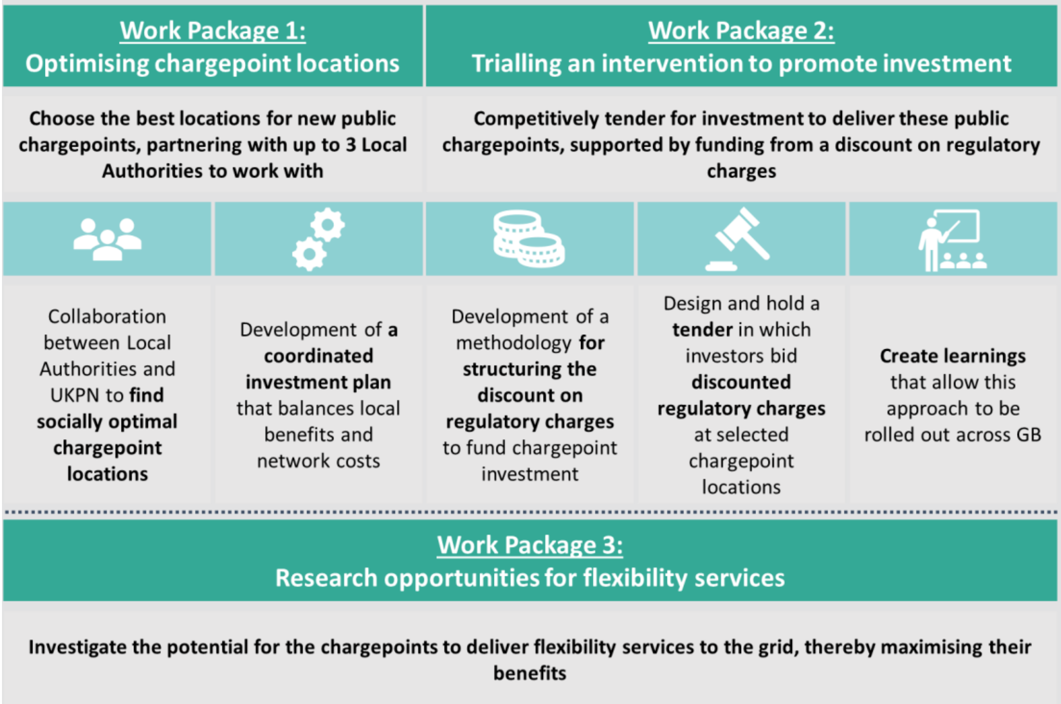
BOX 1: CHARGE COLLECTIVE

Charge Collective aims to develop a methodology that would allow DNOs to facilitate the delivery of on-street chargepoints in their areas.

The project covers identifying Local Authority partners right through to delivery of the network upgrades for the chargepoint investments. The work is organised under three work packages as outlined in Figure 1 below.

The key deliverables are learnings in relation to processes and practical tools to help DNOs and LAs to cost-effectively enable chargepoint investment in areas prone to market failures.

Figure 1 Charge Collective work packages



Source: UK Power Networks

This paper is structured as follows:

- Section 2 describes the market failures associated with chargepoint investment
- Section 3 sets out a methodology for finding socially optimal chargepoint locations
- Section 4 presents our conclusions

2 RATIONALE FOR INTERVENTION

To support the transition to Net Zero, the UK will need to develop a network of public chargepoints for EVs. A proportion of the required infrastructure will be delivered competitively by the market. However, other areas may require some support. In this section we describe why this support may be needed.

2.1 Barriers to optimal chargepoint investment

There are several barriers to the market alone reaching an optimal outcome on public chargepoint investment.

- **Market failures.**
  - **Network externalities ("chicken-and-egg problem")**. The market for EVs and investment in charging infrastructure are interdependent. Current low take up of EVs means potential developers are more hesitant to invest. At the same time, there is a lot of evidence that EV demand is largely influenced by consumers' perceived access to charging, and without this investment, EV take up may remain low.[10] The market failure arises because early investors have a first-mover disadvantage: while deployment of new chargepoints should induce more EVs, the investors may not be able to capture the returns since the new EV users may decide to use other chargepoints once the market matures.
  - **Coordination failure**. In an ideal world, network charges and other signals would incentivise chargepoint investors to act in a way which minimises network costs, for example by a greater exploitation of economies of scale in network reinforcement. However, in reality such co-ordination is difficult to achieve and costs are higher than they could be.
  - **Other externalities**. In areas with high air pollution, EV take-up is likely to lead to higher benefits to society. However, while there are some policy measures which relate to air quality (e.g. the London Ultra Low Emission Zone), there is no universal price on emissions, and therefore EV users in polluted areas cannot privatise the full benefits that their actions create. As such, there may be less investment in chargepoints in these areas than is socially optimal.
- **Policy uncertainty**. Although there is a clear overarching long term climate policy target, investors face significant policy uncertainty with respect to, for example, the extent of subsidised roll-out of EVs or ability to monetise additional revenue streams (e.g. from flexibility services). This can lead to a reduction in charging infrastructure.

[10] See: House of Commons, "Electric vehicles: driving the transition", Fourteenth Report of Session 2017 – 19, page 25 (https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf), Screeton, J., et al. (2013). Assessing the Role of the Plug-in Car Grant and Plugged-in Places Scheme in Electric Vehicle Take-up in England, (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/236749/research-exec-summary.pdf), Engel, H., et al. (2018). Charging ahead: Electric-vehicle infrastructure demand. McKinsey & Company, (https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand), PWC Strategy& report (2019). Consumer Research Into Rapid Charging (https://www.nationalgrid.com/document/124756/download)

- **Regulatory choices**. Ofgem determines the upfront connection costs and use of system charges that are paid by investors in chargepoint infrastructure. To the extent that these charges and tariffs reflect costs, an efficient outcome should ensue (absent other market failures). However, tariffs both signal forward looking costs and recover existing costs. Ofgem recognises that recovering existing costs from users who are very price sensitive has the potential to distort behaviour, and therefore to lead to an inefficient outcome.[11] This issue is likely to affect chargepoint investors, who will tend to be price sensitive (especially given the market failures described above) and lead them to provide fewer chargepoints than optimal.

In June 2021, Ofgem published its minded-to-position to move to a shallow connection charging boundary (i.e. to remove from the upfront connection charge the contribution to reinforcement for demand customers).[12] Ofgem is currently indicating the change in the connection charging boundary would come into effect in 2023, although there is a clear risk of this slipping further into the future.

If Ofgem's minded-to-position is implemented, it will reduce the upfront capital costs for some chargepoint locations (i.e. in sites where the majority of the upfront connection costs relates to reinforcement costs). For these sites, the impact of the market failures on investment will be less significant (although they may still have some impact). However, we understand from UK Power Networks that there will be sites that require significant extension assets and whose upfront connection costs might not therefore be reduced significantly. For such sites, market failures are likely to remain a relevant concern.

2.2 The importance of connection costs

The presence of these failures can drive a wedge between the return investors get in the market (the private return) and the return society as a whole gets from the investment (the social return).

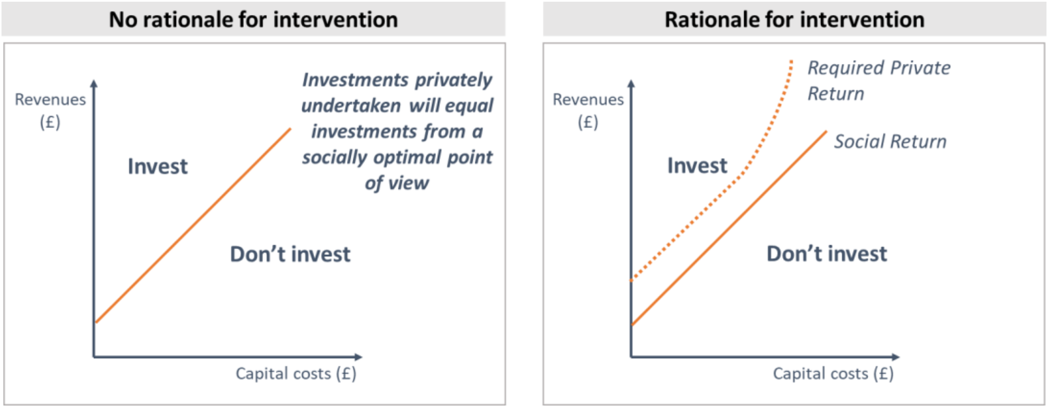
Because chargepoints can deliver greater benefits to the society as a whole than to the private investor, the market will underdeliver. The size of the shortfall will be largest where the difference between social and private return is greatest.

The underinvestment from a social point of view takes place in the area between the lines in Figure 2 below.

[11] Ofgem (2019), *Targeted Charging Review*, https://www.ofgem.gov.uk/publications-and-updates/targeted-charging-review-decision-and-impact-assessment

[12] Ofgem (2021), Access SCR – Consultation on Minded to Positions, https://www.ofgem.gov.uk/sites/default/files/2021-06/%281%29%20Ofgem%20Access%20SCR%20-%20Consultation%20on%20Minded%20to%20Positions.pdf

Figure 2 Rationale for intervention



Source: Frontier Economics

The drivers of the gap between the required private return and the social return are described in Figure 3.

Figure 3 Drivers of the gap between private and social returns

	Impact of market failures, regulatory choices and policy uncertainty
Capital costs	Higher than socially optimal level due to coordination failures
Revenues	Lower than they should be due to: ▪ unpriced externalities ▪ network externalities/"chicken-and-egg problem" ▪ regulatory choices
Cost of capital[13] (determines the private return for a given capital cost and revenue)	Higher than socially optimal level due to policy uncertainty

Source: Frontier Economics

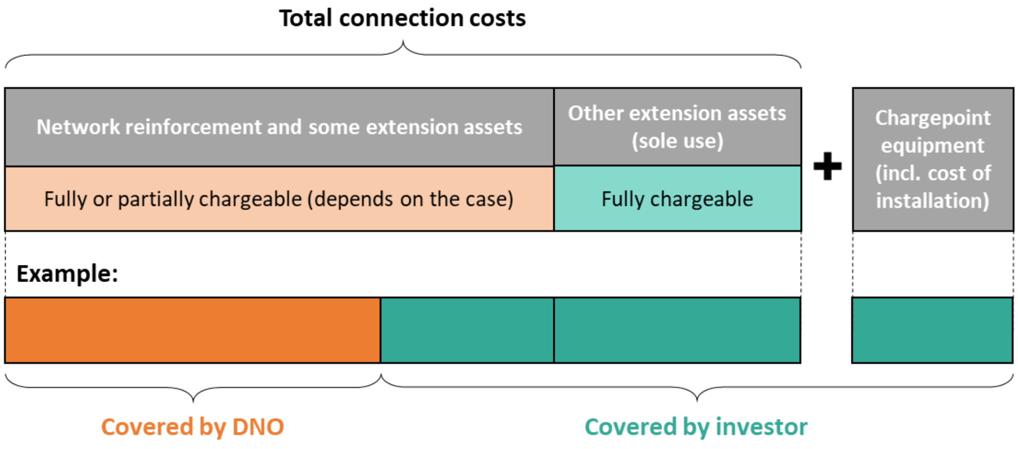
As illustrated in Figure 2, the extent of the sunk capital costs (connection costs and chargepoint kit) can interact with these failures. In particular, the gap between private returns and social returns is biggest where capital costs are higher. This is because for higher capital costs, the level of required private returns increases when there is policy uncertainty or other market failures. This means that the wedge between the required private return and the social return will be particularly high for the most capital-intense investments.

Sunk capital costs are particularly significant for fast (7-22kW) and rapid (43-50kW) chargepoints, as these may require substantial connection works. The charging equipment itself is also more expensive for higher charger speeds.

Figure 4 demonstrates a simplified split of the costs. Under the business-as-usual approach, the chargepoint investor pays for the charging equipment, the sole use network assets, some further network extension assets and for a portion of the network reinforcement work. The remainder is typically covered by the DNO.

[13] By cost of capital, we mean the cost of debt and equity.

Figure 4 Simplified visualisation of costs to connect



Source: UK Power Networks, Frontier Economics

The cost of the chargepoint equipment ranges from £1.5k for the cheapest fast chargers to £40k for the most expensive rapid chargers. Based on typical connection costs in areas with high network utilisation, UK Power Networks estimate that the full upfront connection costs incurred by investors varies depending on local factors, but can reach high levels that can impede investment.

2.3 Tackling market failures

In a first-best world, faced with the market failures, policy uncertainty and regulatory choices described above, interventions would tackle them directly, for example via charges targeted at externalities, and measures to reduce policy uncertainty. This would allow the market to deliver the socially optimal level of chargepoint investment. However, tackling these issues directly would require complex actions from multiple institutions working in energy policy.

An alternative option is to design an intervention which can:

- identify locations with high social return;
- reduce capital costs by delivering multiple investments in a coordinated way; and
- incentivise investors with a discount on capital costs that closes the remaining wedge between the social returns and the required private returns.

This can help to:

- reduce the impact of market failures and policy uncertainty on charge point investment;
- directly resolve distortions to the price signals from the cost recovery elements of charges (i.e. recovery of sunk costs); and
- bring economies of scale and network benefits from upgrading the network once and futureproofing.

In the next section we describe a methodology for identifying locations with a high social return and for assessing the social benefits of intervening in such locations.

3 A METHODOLOGY FOR FINDING SOCIALLY OPTIMAL CHARGEPOINT LOCATIONS

As outlined above, where there is a wedge between investors' private and social return, the market will underprovide chargepoints. However, this wedge will not be present at all sites. In selecting sites for the intervention, the aim was to identify "cold spots" where investments that would have a high social return were not occurring.

The gap between private and social return from chargepoint investment is primarily driven by the presence of externalities (such as air pollution) in a given local area and how many EVs the investment can encourage by overcoming the network externalities (or "chicken-and-egg" problem). These two factors can interact with each other: the more EVs that the intervention can bring on to replace ICE cars, the more externalities are likely to be reduced.

Figure 5 Location choice: identifying areas where support could bring considerable social benefits

1. In which locations are chargepoints most likely to **encourage greater take up of EVs?**

2. In which of these locations are chargepoints most likely to **deliver substantial wider benefits?**

Source: Frontier Economics

This can be translated into two objectives for location choice, which are the focus of this paper:

- **Maximise the impact on EV take up**. Locate the chargepoints where they are most likely to encourage customers to switch to EVs.
- **Deliver substantial wider benefits**. These would be benefits from reducing air pollution where the problems are most acute, serving vulnerable customers [14], and helping ensure a fair distribution of intervention benefits among UK Power Networks' customers.

From a public policy perspective, it is also crucial that the support to investors is provided only in areas where public chargepoints are required and would not occur in the absence of the intervention.[15] This objective can be largely delivered through the design of a competitive procurement process that uses a competitive auction to elicit the amount of funding that investors would require to make their investment viable and provides funding equal to that amount. Charge Collective is designing

[14] https://www.ofgem.gov.uk/system/files/docs/2021/04/riio-ed2_business_plan_guidance_-_april_2021.pdf

[15] HMT (2018) *Green Book*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

and implementing such a process (though this is not discussed further in this paper).

3.1 Selecting areas: indicators

To identify locations for supporting chargepoints, the project first looked for areas within the partner LAs that were most likely to satisfy the selection criteria. Because residential on-street chargepoints typically serve EV users who live within a very small radius, the areas needed to be granular enough to accurately represent the population affected by the intervention. On the other hand, more data is publicly available for larger geographies. To strike this balance, Charge Collective focused on Lower Super Output Areas (LSOAs).

This section further describes the specific rationale behind each criterion and introduces indicators that were used to assess whether an intervention in an LSOA is likely to deliver substantial social benefits. Example maps from Cambridge LA have been included for reference.

Impact on EV uptake

The aim is to identify areas with a large number of people who are currently inhibited from purchasing EVs due to insufficient charging options. Two sets of factors have been considered for this: area-specific factors and customer-specific factors.

Area-specific factors

- Public chargepoints could be expected to enable greater take up in areas that currently offer very few options for charging. This will be areas which either have a low density of chargepoints and/or have little off-street parking – this is because where private parking is available, EV users can install their own chargepoints.[16]
- Areas with high population density should on average be more likely to have more potential EV users.
- Local incentives and rules can also play a part in encouraging take up. For example, exemption from local congestion charges or parking benefits for EVs may be an important factor when choosing a new car. This will be particularly important in London which includes both clean air and congestion zones whose rules and extent may change over time.[17]

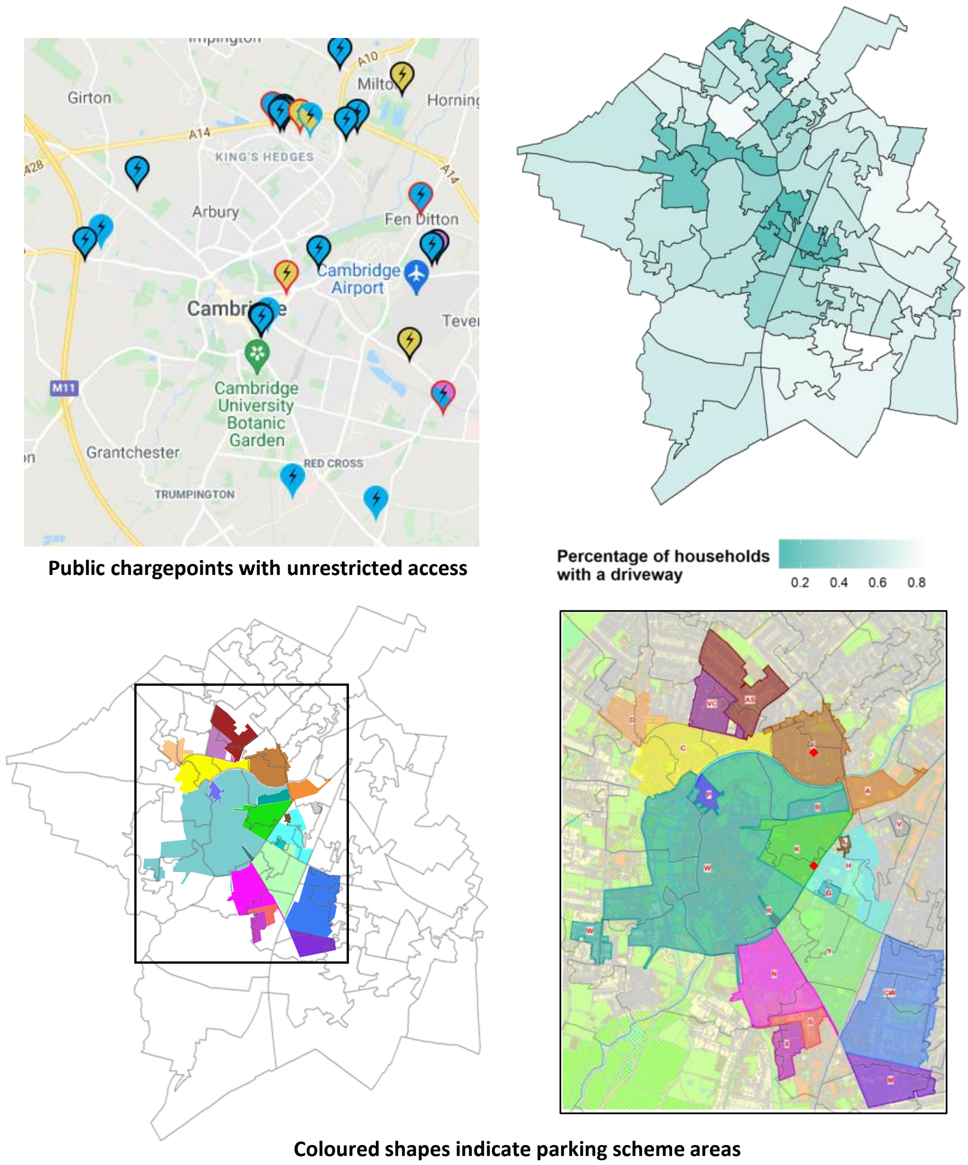
Figure 6 illustrates some of these indicators for Cambridge. The first map shows that there are few public chargepoints available apart from one charging cluster in the north. This suggests that most EV users across the LA without access to off-street parking will struggle to charge their cars and that potential users may be discouraged from making the switch. The map to the right confirms that there is

[16] Barriers to private installation are low. The government offers funding and guidance through the Electric Vehicle Homecharge Scheme Funding. See more at https://www.gov.uk/government/publications/customer-guidance-electric-vehicle-homecharge-scheme/electric-vehicle-homecharge-scheme-guidance-for-customers.

[17] In fact, Redbridge which is one of the partners LA for Charge Collective, will be partly covered by the Ultra Low Emission Zone from October 2021. It is likely that this may encourage drivers to switch to EVs, provided that sufficient charging options are made available (e.g. through Charge Collective).

little availability of off-street parking in the most central areas of Cambridge. Finally, the bottom maps show the locations of parking scheme areas in the LA. These were assessed together with information about the numbers and types of permit holders in each area. This showed where cars may be expected to be parked for longer periods of time and confirmed where Cambridge residents most heavily rely on on-street parking.

Figure 6 Example maps from Cambridge LA: impact on EV uptake 1



Coloured shapes indicate parking scheme areas

Source: Zap-Map, Frontier Economics and Cambridge LA. Based on data from ONS and Cambridge LA.

Note: The maps show some of the indicators that were considered in assessing whether a given area is likely to respond to deployment of chargepoints by switching to EVs.

Customer-specific factors

Current Ultra Low Emission Vehicle (ULEV)[18] buyers tend to be "middle-aged, male, well-educated, affluent, and live in urban areas with households containing two or more cars and with the ability to charge at home" and this socio-demographic profile is "not likely to change significantly" in the near future.[19] Charge Collective is therefore most likely to initially encourage a switch to EVs by customers who have the above features but do not have the ability to charge at home. The most effective way to encourage take up of EVs is to focus on customers who:

- □ have a high income;
- □ live in urban (or densely populated) areas;
- □ already own a car (and would purchase and EV as a replacement); and
- □ have no access to off-street parking.

- Requests made by residents to their Local Authority for chargepoint deployment are also likely to be an useful indicator of latent demand for EVs.

The importance of affluence in the likelihood of switching to EVs is largely driven by the high costs of these cars relative to conventional ones. As these fall closer to parity, high income can be expected to become a weaker determinant of switching. Although initial responsiveness to the intervention is important for unlocking other benefits (e.g. reducing pollution externalities), Charge Collective aims to futureproof the provision of on-street charging and ensure that other demographics are not left behind. This is addressed further in the remainder of this section.

Figure 7 illustrates some of this data for Cambridge. This shows that LSOAs to the east have a smaller proportion of high earners than other areas. This means that customers there may be less responsive (less likely to switch to EVs) to better access to chargepoints because the cost of the car itself may be a barrier for them. The map to the right shows that a lot of Cambridge residents own a car, apart from a few central LSOAs. The bottom-left map on the other hand shows the percentage of households thar have access to a driveway. Although car ownership is high in most areas in Cambridge, those located further away from the centre have better access to off-street parking. Users in central LSOAs are therefore most likely to rely on on-street chargepoints. The final map in bottom-right confirms this finding and shows that certain areas have a large proportion of cars for only a small number of driveways.

[18] Ultra Low Emission Vehicles (ULEV) are presently defined as emitting less than 75 gCO2/km from the tail pipe. This definition is expected to change to 50 gCO2/km in the near future: https://www.vehicle-certification-agency.gov.uk/fuel-consumption-co2/fuel-consumption-guide/zero-and-ultra-low-emission-vehicles-ulevs/.

[19] Uptake of Ultra Low Emission Vehicles in the UK (2015)

Figure 7 Example maps from Cambridge LA: impact on EV uptake 2

Source: *Frontier Economics. Based on data from ONS, DfT and UK Power Networks.*

Note: *Darker shades indicate more desirable values of the metric. For example, the bottom-left chart shows the percentage of households with access to a private driveway. The lower the percentage, the more likely it is that EV users in these areas will rely on public on-street chargepoints.*

Wider societal benefits

It is also important to understand where the intervention has the potential to deliver wider social benefits. Moreover, as costs are to be recovered from all customers, the intervention must consider a fair allocation of chargepoints to all UK Power Networks' customers.

Externalities, coming mainly from pollution, will contribute to the disparity between the social and private return to investment. As such, the intervention should target areas where these are greatest. The additional benefit of reducing pollution externalities will likely be largest in more deprived areas with the worst air quality. This is because deprived communities are disproportionately affected by air pollution due to higher chance of having existing medical conditions, living in areas with poorer outdoor and indoor environment or having less access to healthy food.[20]

The intervention should also ensure that vulnerable customers are not left behind. Ofgem defines vulnerability as "when a consumer's personal circumstances and characteristics combine with aspects of the market to create situations where he or she is: (i) significantly less able than a typical domestic consumer to protect or represent his or her interests; and/or (ii) significantly more likely than a typical domestic consumer to suffer detriment or that detriment is likely to be more substantial".[21] This intervention considers a range of measures of deprivation in order to assess whether an area is likely to bring benefits to vulnerable or less well-off customers.

The previous section suggested that more affluent areas may be more suitable for intervention as their residents would be more likely to purchase an EV. This does not necessarily have to contradict the objective of serving vulnerable customers. Affluent areas can at the same time have high levels of deprivation. We nonetheless recognise that there may be some trade-offs between the different objectives.

Figure 8 illustrates these indicators for Cambridge Local Authority. The first map shows the proportion of high-emission cars in the LSOA. Where the proportion is high, it is more likely that a switch to an EV will be made by a user of a high-emission car which could bring greater environmental benefits than a switch from a relatively low-emission car. The map shows that such cars are most popular in the west of Cambridge. The remaining three maps are based on the Index of Multiple Deprivation (IMD) and show how the LSOA ranks compared to all LSOAs in England in terms of: outdoors living environment, health deprivation and disability, and overall deprivation. The lower the decile the worse off the LSOA is. Although the IMD is not a perfect measure as it can only provide information about the relative ranking between different areas, it can be treated as a rough indicator.[22] The maps show that different areas struggle with different deprivation types. For example, most of Cambridge ranks poorly in terms of the quality of outdoors environment in particular the central LSOAs. On the other hand, health deprivation and disability is relatively worse in the west of the LA.

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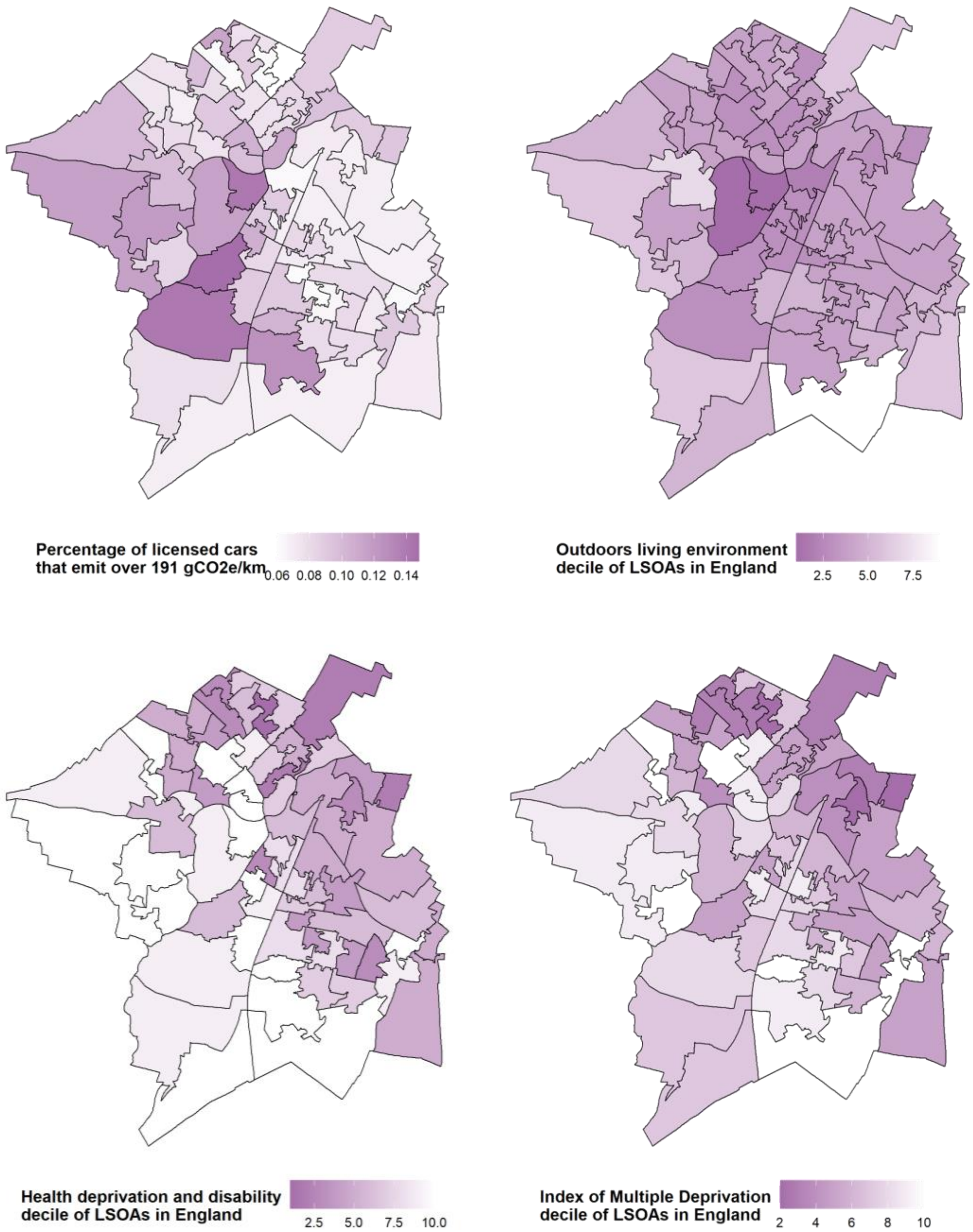
[20] https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution

[21] Consumer Vulnerability strategy 2025, Ofgem (2019)

[22] The IMD is a relative measure. An LSOA may for example, be very deprived but rank much higher than another very deprived area. Similarly, two LSOAs may be close in ranking but their deprivation may differ significantly.

Figure 8 Example maps from Cambridge LA: wider societal benefits



Source: Frontier Economics. Based on data from ONS and DfT.

Note: Darker shades indicate more desirable values of the metric. For example, the intervention aims to target areas with worse outdoor living environment. In the map on top-right, LSOAs which rank poorly (are in lower deciles of LSOAs in England) are darker. On the other hand, the map on top-left shows the proportion of high-emission cars in the LSOAs. The greater the proportion, the darker the area.

Combining indicators

Not all indicators should be treated equally in assessing how likely an intervention in the area is to encourage EV switch or deliver wider benefits. For example, higher population density in a given area will, on average, imply more potential EV users. However if residents in that area have access to off-street parking, the intervention will have little impact on their decision. Moreover, some indicators will point to opposite areas. For example, while a wealthier LSOA is more likely to be ready to switch to EVs, it is also less likely to have vulnerable residents and be at risk of being "left behind" in the transition to Net Zero.

To help simplify the selection process, we prioritised a set of features in our decision making process:

- **Priority features** were:
  - presence of high income earners,
  - low availability of off-street parking,
  - high car ownership and
  - deprivation.
- **Secondary features** were:
  - high population density,
  - local consumer sentiment,
  - low density of chargepoints,[23]
  - high air pollution.[24]

Figure 9 demonstrates these features on an example set of LSOAs in Cambridge that were shortlisted for the project and considered in more detail. The values are categorised according to a RAG rating – green tile indicates a desirable value of a metric while a red indicates a poor score. For example, LSOA 3 ranks highly in terms of social benefits such as high deprivation level and poor outdoor environment. However, its residents have a very good access to off-street parking which overall, makes it a less favourable choice. On the other hand, LSOA 7 ranks quite highly across both the likelihood to encourage take up of EVs and in terms of delivering wider societal benefits. The area was selected for the trial.

The table shows that in practice, filtering results can be mixed. Some areas will score highly in some metrics and lower in others which can make it difficult to unambiguously determine whether they are a suitable choice for intervention or not. To resolve this, selection in Charge Collective took into account (i) whether an area ranked particularly strongly against at least one objective (impact on EV uptake or wider societal benefits), and (ii) how the portfolio of chosen areas ranked against the objectives. For example, in Cambridge, the choice of more affluent areas was balanced by including an area which scored more highly on deprivation.

[23] All of the partner LAs had low density of existing chargepoints. As the transition to electric vehicles progresses, we expect this feature to gain in importance.

[24] Charge Collective focused on urban areas which are naturally characterised by worse air quality. As such, air pollution was not an important differentiator between the LSOAs. If choosing between more varied areas, air pollution should be considered as a priority feature.

Figure 9 Filtering assessment for an example set of LSOAs in Cambridge

			LSOA 1	LSOA 2	LSOA 3	LSOA 4	LSOA 5	LSOA 6	LSOA 7	LSOA 8
Priority	Income	**Income 40k** (% of hh earning >£40k)	18.3%	6.1%	4.1%	20.3%	23.7%	21.1%	11.0%	20.3%
		Income 60k (% of hh earning >£60k)	6.7%	1.4%	0.6%	7.2%	12.7%	7.1%	3.3%	7.9%
	Car ownership	**Car ownership** (cars per person)	0.45	0.38	0.34	0.29	0.27	0.28	0.19	0.27
	Parking	**Parking** (% hh with a driveway)	61.0%	55.0%	60.0%	38.0%	43.0%	11.0%	9.0%	15.0%
		Cars per driveway	1.37	2.46	1.50	1.59	1.38	5.55	7.38	5.28
	Deprivation	**IMD** (decile of LSOAs)	7	5	3	8	8	9	5	9
Secondary	Population density	**Population density** (pop/km2)	1659	5810	4090	5194	6316	8977	7677	8611
	Health deprivation	**Poor health & disability** (decile of LSOAs)	9	4	3	8	9	8	3	9
	Air quality	**Outdoor environment** (decile of LSOAs)	6	3	4	3	3	4	3	4
		Car pollution (% of cars with high emissions*)	7.7%	7.8%	6.2%	6.7%	8.1%	8.2%	8.8%	8.6%
		Car density (cars per sqkm)	740	2217	1392	1508	1718	2524	1423	2350

Source: *Frontier Economics. Based on data from ONS, DfT and UK Power Networks.*

Note: *The table shows the indicator results for an example set of LSOAs. The values are categorised according to a RAG rating – a green tile indicates a favourable value, a red tile indicates an unfavourable one.*

3.2 Choice of parking bays

The choice of exact locations within the selected LSOAs was left to LA representatives. The LAs took into account the visual impact and accessibility of chargepoints. The features which were most commonly searched for were:

- parts of the streets with flank walls;
- road buildouts which could accommodate a chargepoint;
- suitable traffic regulations (for example, restricted waiting time zones were considered very suitable for rapid chargepoints);
- car club bays that could be converted into EV bays (only where not already allocated to a car club car) or spots that could serve a car club bay and a regular adjacent bay;
- spots adjacent to disabled bays; and
- other local arrangements, such as parking permit zones.

In some cases, the engagement between the connections teams at UK Power Networks and the LAs led to a change in the choice of selected parking bays because of connection constraints. This was the case for example, where the connection required major road works, such as when cables needed to cross a road, or where there were other issues like the risk of flooding.

4 CONCLUSIONS

Market failures mean that, in some locations, support is required to deliver charge points

There are three sets of barriers preventing the market alone from achieving a level of investment in chargers that is optimal for society:

- **Market failure:**
  - **Network externalities**. At low levels of charge point coverage and EV penetration, early investors in chargers have a first mover disadvantage compared to those who enter later.
  - **Coordination failure**. In an ideal world, network charges and other signals would incentivise chargepoint investors to act in a way which minimises network costs, for example by a greater exploitation of economies of scale in network reinforcement. However, in reality such co-ordination is difficult to achieve .
  - **Other externalities**. EV users in areas with high levels of air pollution cannot privatise the full benefits that their actions create.
- **Policy uncertainty.** There is some uncertainty over the speed at which transport should be electrified in the 2020s. A delay of a few years in EV take-up could make a substantial difference to the business case for investing in chargers. This uncertainty may in turn affect investment decisions.
- **Regulatory.** To the extent that network tariffs both signal forward looking costs and recover existing costs they may lead to investment at lower than optimal levels.[25]

These market failures mean that support for investments in some locations could yield social benefits.

We have defined a process for identifying investment "cold spots"

Investment does not need to be supported in all locations. We have developed a site selection process which relies on both statistical indicators and local knowledge.

The indicators played a part in ensuring that the process was systematic and objective. They served as good prompts for discussion with LA representatives and guaranteed that promising areas were not omitted. However, the data was considered at the level of LSOAs – while these tend to be quite small and cover populations of ~1500 people, it was possible that the indicators did not capture the true heterogeneity of the areas. Conversations with LAs helped confirm data validity and added other important local factors such as parking regime, typical parking stress or existing demand for chargepoints.

[25] Ofgem (2019), *Targeted Charging Review*, https://www.ofgem.gov.uk/publications-and-updates/targeted-charging-review-decision-and-impact-assessment