RAC Foundation

Delivering a connected future for motoring - a case study of limited mobile signal coverage on public electric vehicle chargepoint use

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Foreword

Connectivity has become an ever-more prevalent feature of modern motoring and is set to grow in importance as our vehicles' ability to connect through digital networks impacts on their usability. Our connected cars transmit and receive data that informs drivers about the road ahead and auto companies about how their designs are performing. Automation is likely to require yet more reliable connectivity. Even when the car is sat still features such as over-the-air software updates rely on good connections.

Meanwhile, the signal coverage that enables connectivity is changing – generally improving, in speed and in terms of what is covered. As well it might, because coverage today in the UK is far from being uniformly available and consistently strong, even in our homes. Yet the transition to newer technologies is not straightforward.

That creates a challenge for the automotive industry – an industry which is all about mobility. Happily it is not an insurmountable challenge – there are workarounds that can be incorporated without breaking the bank. But the starting point must be to design around the signal coverage we're likely to have, near-term, not to assume a degree of coverage that is, for the moment at least, no more than a pipedream.

To that end, and because it can pose a particular problem both for drivers and for the attractiveness of adopting electric cars, we have chosen as an illustrative case-study looking at the reality and implications of signal coverage at electric car chargepoints. To risk stating the obvious, a chargepoint whose activation requires the driver to use their smartphone relies on that smartphone being able to connect. Where signal connectivity is a problem the driver could conclude the charger isn't working, but that won't get picked up in the new chargepoint reporting system. All of which can be fixed, but only if the problem is spotted in the first place.

Our analysis looked very specifically at a sample of 3.7kW to 7kW chargers run by major operators at locations in London and elsewhere in Great Britain; such chargers require a long-stay (e.g. overnight), account for approaching 60% of the UK total, and would typically need two working connections – one for the charger and one for the user. We assessed 3G as well as 4G coverage (the 3G switch-off being underway but not complete) using data from Teragence. And we looked at how many locations in our sample offered connectivity for all four mobile networks – anything less means that subscribers to one or more networks risk not getting a connection.

The picture that emerged looks like this:

- in Great Britain but outside London, only **33.4%** of chargers studied had all-network 4G coverage, **59.7%** of chargers studied were in a partial not-spot, and **6.7%** of chargers studied were in a total not-spot;
- in London, only **39.7%** of chargers studied had all-network 4G coverage, **57.8%** of chargers studied were in a partial not-spot, and **2.5%** of chargers studied were in a total not-spot;
- in Great Britain but outside London, only **33.4%** of chargers studied had all-network 4G and, failing that, 3G connectivity, **66.2%** of chargers studied were in a partial not-spot, and **0%** of chargers studied were in a total not-spot; and,
- in London, only **39.7%** of chargers studied had all-network 4G and, failing that, 3G connectivity, **60.3%** of chargers studied were in a partial not-spot, and **0%** of chargers studied were in a total not-spot.

Good, practical, user-friendly design is what we want to promote, and for that to happen we believe that government, the auto industry (including those involved in our increasingly electrified motoring future) and the telecoms world could and should be working together more actively to map and design around the reality of signal availability. That work should include establishment of a sensible measure of connectivity – coverage and strength – as relates to motoring (including the worlds of logistics and supply), looking beyond the very basic ability to contact the emergency services.

This isn't just a matter of convenience, it is a potentially significant issue for achievement of a number of government ambitions, including the path to net zero and the promotion of safer roads.

Steve Gooding

Director, RAC Foundation

1 Introduction

Connectivity has become a big, and growing, issue for the vehicles we drive on our roads and the technologies used by highway authorities to manage them. Our vehicles are marketed as 'connected', and as such they transmit and receive a host of data – importing a stream of real-time data about road and traffic condition that informs our satellite navigation systems, exporting data about the vehicle location and functionality. But signal coverage is not uniform across the road network – anyone who's tried to make a mobile phone call in a city street fronted by high-rise office or apartment blocks will know that this isn't simply an urban versus rural issue. Complexity mounts owing to the fact that there are different levels of connection – 2G, 3G, 4G, etc. – and four private companies providing mobile services that each offer different patterns of signal availability.

Is there a problem? After all, we mostly get our phones to work most of the time. Our Sat Nav service might disconnect in the course of a trip, but only briefly, with the on-screen map continuing to show the directions we should be following, just not a map that is 100% real-time accurate in its detection of traffic issues ahead. It is possible to design systems around signal availability. Of course, it would help to have a clear picture of exactly what that signal availability is – and is likely to be anytime soon. And it could be a problem if you experience a breakdown at a point where you don't have adequate coverage to call your breakdown service.

Perhaps the area of motoring that most immediately illustrates the connectivity challenge, though, is that for an electric vehicle driver trying to activate a public chargepoint. Even if the driver has the right subscription card to unlock and activate the charger or a contactless bank card for payment then the charger itself will still need one network connection – a mobile signal via one of the four service providers or a more direct link hard-wired or perhaps tethered to a nearby wi-fi hotspot. To use a smartphone app there would be a need for two connections – which might be to two separate service providers. If the driver is hoping for live information and a helpline, or if the vehicle itself is handling the payment that could mean a third connection, which could be via a third service provider (and this is the direction some car-makers are pursuing). It follows that the scope for experiencing a failed connection grows the more the number of connections required, and such a failure will give the driver the understandable impression that the charger is not working, when in reality it might be in fully functional condition but unable to work for that driver due to the absence of one or other of the mobile signal services required to close the circle of connectivity at that location.

This report looks specifically at one type of failed charging experience: when a charge is unable to be activated or completed at a charger owing to a lack of mobile phone connectivity. As the Public Charge

Point Regulations 2023[1] (hereafter, "the regulations") stipulate that there must be opportunity for contactless payment from 8kW upwards, this report focuses on the most-common type of non-rapid chargers in the UK, namely Type 2 chargers[2] greater than 3kW and less than 8kW (in effect, 3.7kW to 7kW), as these are most likely to demand *two* connections to the mobile network: one for the device, and one for the user's mobile phone app.

Figure 1: *A public 7kW charger*

These sorts of chargers have a low customer throughput, because each user must stay plugged in for a long time to get a meaningful amount of charge. These are not the ultra-rapid chargers aimed at replicating the speed of refuelling offered by a traditional petrol pump, however these slower chargers are important for a number of reasons:

[1] see https://www.legislation.gov.uk/uksi/2023/1168/

[2] Charging connectors for electric vehicles take a number of forms. In the UK, at the most basic, there is the domestic three-pin plug (as you would find in any home). Slower (3kW to 22kW) charging is almost exclusively via Type 2 connections, which you would see in cases like domestic 7kW chargers and chargers at long-stay car parks. These are AC connections. DC connectors are for more rapid charging (e.g., 50kW and above), and include CCS and CHAdeMO systems. Type 2 connectors are therefore facilitating the *vast* bulk of sub-50kW charging.

- As of 1 January 2024, there were 53,677 charging devices installed in the UK, with 31,910 having a maximum speed of 3kW up to 8kW - this represents 59% of all charging devices, and a greater proportion of charging sockets[3],
- they are not covered under the regulations that mandate operators to provision of certain levels of service,
- they are the only economically efficient infrastructure for certain types of longer-dwell-time parking (railway station car parks, workplace parking, hotels, etc.),
- because they are common, they are the shop-window to charging for any prospective new EV driver. It is vital that they work well - reliably and easily, and
- for those without off-street parking, successful access to the slower end of on-street charging is the only way to minimise price differentials (pence per mile) between those with only public charging available to them and those with off-street charging on much lower domestic tarrifs (e.g., motorists with driveways), and between EV users and ICE drivers. For the next wave of EV adoption, keeping pence per mile costs low will be important.

In the next stage of EV adoption, it will be critical that any charging experience is as straightforward as possible. This report is based on the following assumptions[4]: (a) that at a slower charger, activation is likely to be app-based, and therefore likely dependent on multiple phone connections, (b) a motorist should be able to have the same confidence of a successful transaction at any charger as they would at any petrol filling station. For this to be true, amongst other technical challenges outside of the scope of this report, all of these chargers will need reliable connectivity, and because 3G is being switched off, this needs to be 4G or above for all networks[5]. Therefore, it considers two questions: how much of the charger network made up of these charger types has all-network 4G coverage (i.e., how much is future-ready) and how much of the network has all network coverage if one includes 3G as a fallback where 4G is not available?

Taking a sample of the small-area (0.002 km^2) data that is currently commercially available via the Teragence Signal Checker API[6], we have mapped connectivity for known locations of public EV chargepoints for a representative random sample of locations across Great Britain. The purpose of this report is to act as a demonstration that this analysis can – and *should* – be done by those with ready access to the most granular data so that the industry can manage and plan around the provision that

[3] see https://www.gov.uk/government/statistics/electric-vehicle-charging-device-statistics-january-2024

[4] NB: This report avoids, at this point, getting into a debate about whether everything will or should be app-based.

[5] In December 2021, the industry and Government issued a statement committing to turning off all 2G and 3G networks by 2033 at the latest. Vodafone has already turned off its 3G network (by early 2024). EE and Three will turn off 3G "in 2024". O2 will turn of 3G by 2025.

[6] see https://teragence.com

exists. Our sample reveals that signal connectivity could be an issue at the very least intermittently for as many as 66.6% of these chargepoints, in the event that either the user or the charger cannot get a signal for their network and there is no alternative option available for accessing a charge. It is hard to say whether or not this is a precise representation of the national picture, not least because it is a picture that is changing as more chargepoints are installed, because mobile network coverage is improving (both in land-mass coverage and in quality of service), and because coverage fluctuates with changing conditions in local areas (e.g., weather, density of users at a given time for a given cell tower). However, it is a significant sample based on real-world user experience.

The London analysis is based on a 7% random sample of the *locations* where chargers of this sort from major operators (BP Pulse, POD Point, GeniePoint, char.gy, Mer, blink, ubitricity, Connected Kerb, Source London) could be found, resulting in an effective sample of charging *devices* of 6.9%[7]. For the analysis of chargers outside of London (BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb), the equivalent numbers are 14% and 13.2%. The sampling method used samples hexes with chargers in them, and therefore any hex with multiple chargers results in this difference between sampled locations and sampled chargers.

It is also important to remember that the analysis looks at connectivity across the 4G network, and then how well 3G serves to provide backup connectivity where 4G fails. While phone-based access to chargers currently relies on a minimum of 3G access, 3G switch-off in the UK has already commenced (Vodafone began in 2022 and has already completed as of March 2024), hence 4G access is effectively the new minimum standard going forward.

In an ideal world the answer might lie in a vast improvement to the level and spread of mobile signal coverage for all service providers. For various commercial reasons that does not look to be on the cards – improvements will be made, but not on a scale that would entirely eliminate the EV chargepoint conundrum.

The connectivity required for the future of motoring presents distinct connectivity challenges, as so much of driving and related tasks (e.g., charging) occur at locations which otherwise have a poor case for network improvement because of very low and/or very inconsistent population densities.

The good news is that there are other eminently practical workarounds available to chargepoint providers so long as the strength and nature of signal coverage at each chargepoint location is checked. It is out of scope here to set out exactly which solutions should be used, however, there are a number

[7] These two numbers differ because the sampling is based on a random subset all hexes with 1 or more chargers within it, and the resulting group of chargers studied is all chargers within those hexes. If the sampled hexes have more than the average number of chargers per hex, a greater percentage of chargers end up in the sample than the percentage of hexes sampled. If the sampled hexes have a lower average, the opposite occurs.

of comparatively affordable and small-scale adjustments that can be made to the current ways of working that would help alleviate this problem for motorists. These might include:

- signposting the availability of a limited wi-fi hotspot for drivers to use (e.g. in the on-charger instructions for use) if the chargepoint's connection is robust but the motorist's might not be;
- use of roaming SIM cards (i.e., from other countries), which have become increasingly common in the Internet of Things (IoT) sector, so that connectivity can adjust by roaming to whichever mobile network is most robust at a given moment;
- use of external and/or directional antennae for more reliable data connections;
- make more use of external fixed antennae on vehicles (e.g., through Android Auto, or standards like ISO15118 - "Plug & Charge"), and less use of mobile phones that might not be optimised for the use-case;
- making 'roaming' RFID[8] cards more widely (and freely) available (i.e., to remove the motorist's phone from the equation);
- improvements to signal quality through the "Single Rural Network" (SRN) programme of mast sharing between mobile network operators;
- satellite internet provision from operators like Starlink and OneWeb; and,
- as a fallback, when the issue is an unresolveable signal connectivity failure, the charger itself could be set to default to provide a free charge up to a limit that would at least guard against a potential breakdown for lack of a sufficiently charged battery.

The new consumer regulations approved by Parliament[9] recently should help with overall user experience at many chargers. However, the regulations do not target the sub-8kW network, nor do the reporting requirements of the regulations catch this signal-related type of failed charging experience in the new reliability metrics. This is because the charger is *not activated* properly in the first place, and therefore leaves no trace of the event in the data.

2 Methods & data sources

An individual's ability to access the mobile network is dependent on their mobile service provider (hereafter, "MNO", or mobile network operator) offering a service to their location. Other than for 999 calls, the UK does not allow roaming between UK networks. So, if a phone is on network A, but

[8] RFID means "radio frequency identification". RFID cards are often credit card sized pieces of plastic that use a form of radio communication to identify the card to a reader (in this case, built into a charger). They are often seen in offices and gyms to open doors. They require no batteries and no mobile connectivity.

[9] see https://www.gov.uk/guidance/regulations-public-charge-points

only network B serves the location of that phone, the phone will not connect beyond a 999 service. The situation is different, of course, for phones on non-UK networks working in the UK: those phones are able to roam between each UK network as required. So, this report covers the UK experience for UK-based devices; it does not consider UK roaming (e.g., motorists with foreign phones, or devices on specialist foreign IoT sim cards).

This report uses two terms to describe the provision of adequate signal coverage: a *total not-spot* is where no MNOs operate at a given level (e.g., 4G) and a *partial not-spot* is where not all MNOs operate. This is an important distinction, especially for vehicle-based and roadside services, where a user is unlikely to know the MNOs involved, and will certainly have no opportunity to switch to a better MNO for the area. Therefore, it is provision of *all* network coverage (i.e., neither a total nor a partial not-spot) that is important for an equitable provision for road users, especially where some interactions may involve multiple connected devices (e.g., vehicle, phone, EV charger), all possibly on differing networks.

There are multiple usable sources for charger location data. This report uses the National Chargepoint Registry (NCR) (accessed on 9 March 2024). From that source, specific charging devices are isolated. A charging device can have multiple plugs/sockets, including different connector types (CCS, Type 2, etc.) and different charging speeds (measured in kW). The chargers selected must:

- not have provision at the device for speeds at 8kW or greater - chargers at this speed or higher must offer contactless payment and are therefore less reliant on mobile connectivity,
- be run by one of the major operators (BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb, Source London). This is to focus on critical parts of the network, where access is known to be via the mobile network (i.e., not simpler small scale operations at workplaces, B&Bs etc.),
- be located in one of the regions/nations of Great Britain, by matching posted location to OS BoundaryLine data,
- have at least one Type 2 connector, and
- provide more than 3kW.

The Teragence API provides small area data based on a discrete global grid system called H3, developed by Uber. This system divides the world into standardised grid of hexagons and there are a number of levels (or, “zoom levels”) that provide hexagons of differing granularities. The Teragence API provides data using H3 zoom level 11.

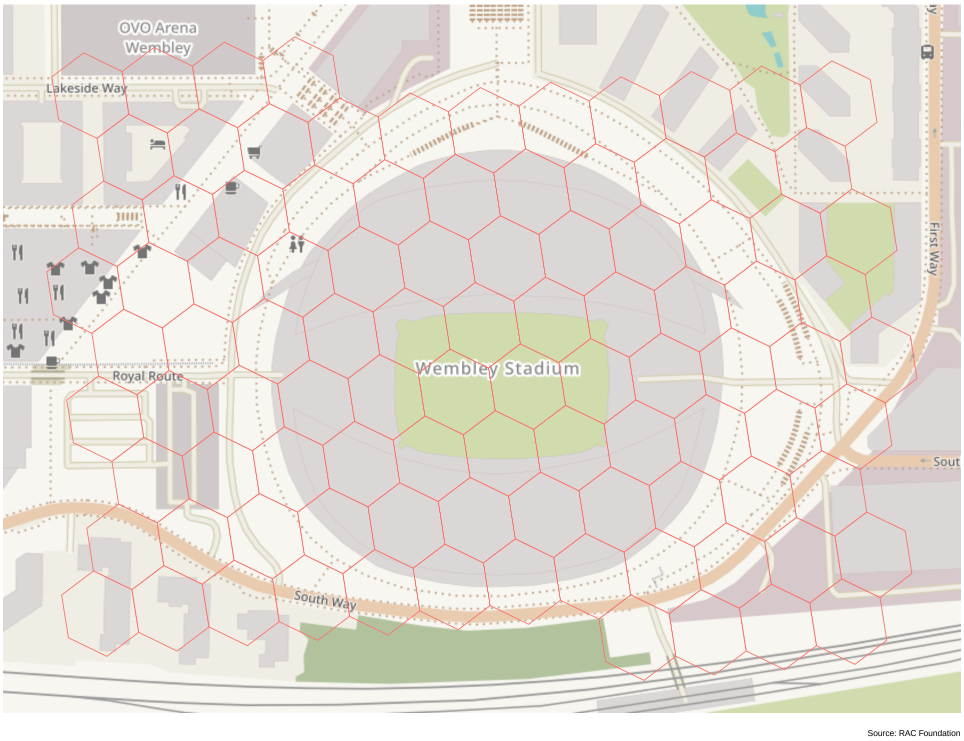

Figure 2: *An example of the H3 hex grid at zoom level 11, Wembley Stadium, London.*

Figure 2 shows the size of the areas for which we have coverage data, comparing hex size at zoom level 11 to Wembley Stadium in London. It is clear from this that the data is very small-area, and in fact offers more granularity than the data used by Ofcom in their *Connected Nations* report series[10] and in their public Ofcom API[11].

This report therefore treats all chargers in the same hexagon as having the same mobile phone connectivity, and given how small the hexagons are (11 are needed to cover the entire turf at Wembley Stadium), this is a reasonable assumption to make. As this report is meant to serve as a demonstrator, the report uses sampling of chargers to provide indicative results on the issue of mobile connectivity at chargers and to demonstrate the practicality of the methods used. So, from the NCR, two sample cuts of the data are produced:

- a sample of London that is based on all the EV chargers within a random 7% sample of all the H3 hexes (at zoom level 11) in London that have 3.7kW to 7kW Type 2 chargers (from BP Pulse, POD Point, GeniePoint, char.gy, Mer, blink, ubitricity, Connected Kerb, Source London), and
- a sample of Great Britain (excluding London) that is based on all the EV chargers within a random 14% sample of all the H3 hexes (at zoom level 11) in that area with 3.7kW to 7kW Type

[10] see https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research
[11] see https://api.ofcom.org.uk

2 chargers (from BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb).

In other words, take all National Chargepoint Registry (NCR) chargers of interest (3.7kW to 7kW, from BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb, Source London), isolate which hexagons contain these chargers, and then randomly sample those hexagons. The resultant data analysed in what follows is comprised of all of those chargers within sampled hexagons.

The provision of charging in London is significantly better than in other regions. This difference is largely influenced by pockets of *very* high density lamp post charging in certain parts of London (i.e., certain streets in certain London local authority areas). To make sure a sample of the NCR data was not distorted by certain pockets of London provision, this report uses two separate samples, which result in effective samples of charging devices (rather than H3 hexes) of 6.9% for London and 13.2% for the rest of Great Britain (see Figure 3 and Figure 5, respectively).

From these two samples, a list of all unique H3 hex IDs is produced, and this list is then run through the Teragence API. This produces, for each API call, a full account of real-world, crowd-sourced data for a given MNO at a given location for 4G, including maximum, minimum and mean signal strength (in dBm[12]), the number of devices contributing to that result, and the distance from that site to the location of any data used for interpolation (for locations where data is interpolated). For locations where inadequate 4G is found, the state of 3G for that operator is accessed via the same API.

The standard measure for 4G signal strength is RSRP (" Reference Signal Received Power") and for 3G it is RSCP ("Received Signal Code Power"). It is expressed in dBm and it correlates to people's intuitive understanding of coverage, i.e. the bars on their phone. As with the bars, the higher the value, the better the signal. While RSRP and RSCP are the main metric, radio professionals will point out that in addition to the power of a connection, consideration should be given to its quality as well to get a 100% complete picture. This report takes signal strength as the indicative measure of user experience, but it is not the only factor in user experience.

There is currently a lack of clarity on how good signal must be to have a reliable experience at a charge point. As a proxy, this report uses -105dBm for 4G and -105dBm for 3G, on the basis of discussion with industry experts. However, this is open to some debate, and the Teragence data is provided in dBm to zero decimal places, so the analysis could be repeated with another measure of adequacy if required. Of course, it is not the case that below that dBm value there will necessarily

[12] dBm is "decible-milliwatts", a unit to indicate power level in radio communication.

be *no* service from a given MNO. Rather, it is the boundary between acceptable and unacceptable provision, the latter of which will be either poor or no signal.

At the moment, the sector lacks clarity or agreement on exactly where the boundary should be set. It is certainly the case that for this issue to be addressed by policy or service level KPIs, a level that is judged to be an adequate and reliable mobile data connection needs to be determined, not least because connectivity can shift significantly with topography, weather and the amount of traffic on the mobile network at that place and time.

It should be noted that the source data includes both chargepoint operators and MNOs - this report is not about the relative merits of one company or another, but about the broader user experience and policy issues relating to mobile network coverage and chargepoint access. Therefore, there is no analysis in what follows that names operators of either specific chargepoints or mobile networks (though the input data would permit such analysis), nor are small-area maps provided as this would enable matching of operators by exact geographical location.

3 London

The London sample is 6.9% of all chargers of interest in London, representing 809 charging devices and 922 Type 2 connectors.

Figure 3 and Figure 4 set out the geographical spread of 4G and 4G and, failing that 3G provision in Greater London respectively; namely:

- where provision is good - chargepoints are in neither a partial nor a total not-spot.
- where provision is inadequate - chargepoints are in either a partial or a total not-spot, excluding at least some motorists from access to charging.

Tables with detailed data for each local authority is in the annex.

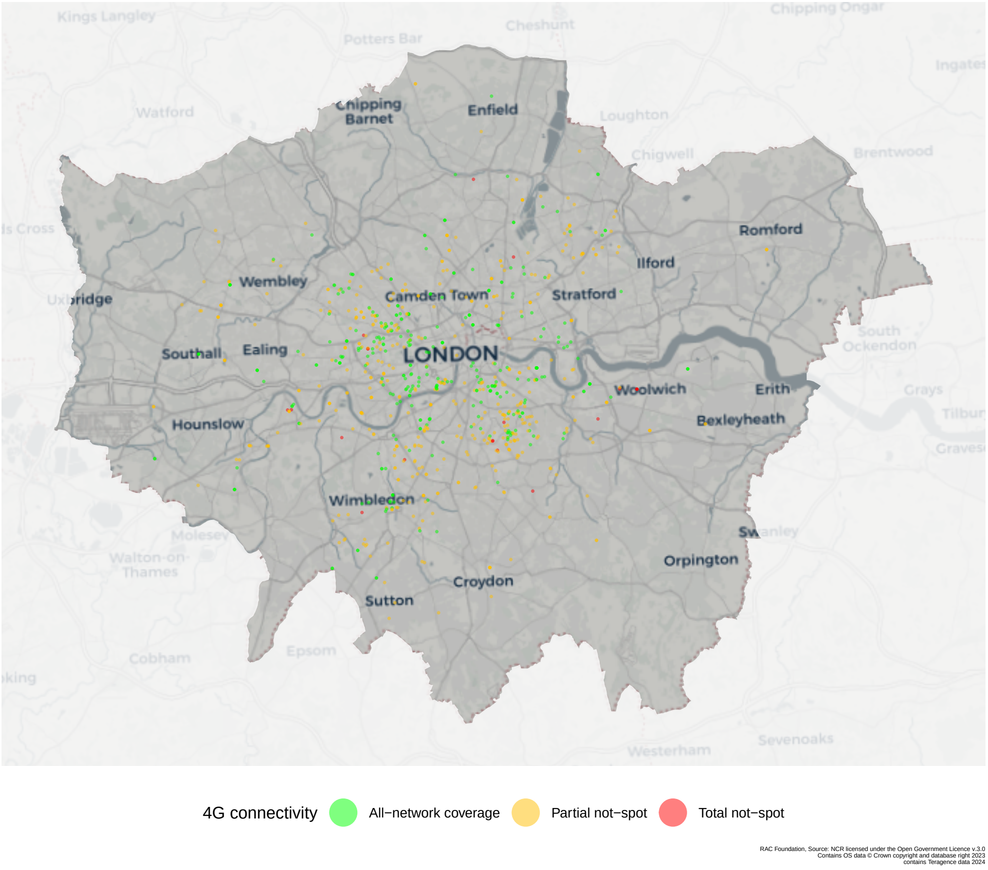

Figure 3: *4G connectivity at EV chargers in London (3.7kW to 7kW, BP Pulse, POD Point, GeniePoint, char.gy, Mer, blink, ubitricity, Connected Kerb, Source London).*

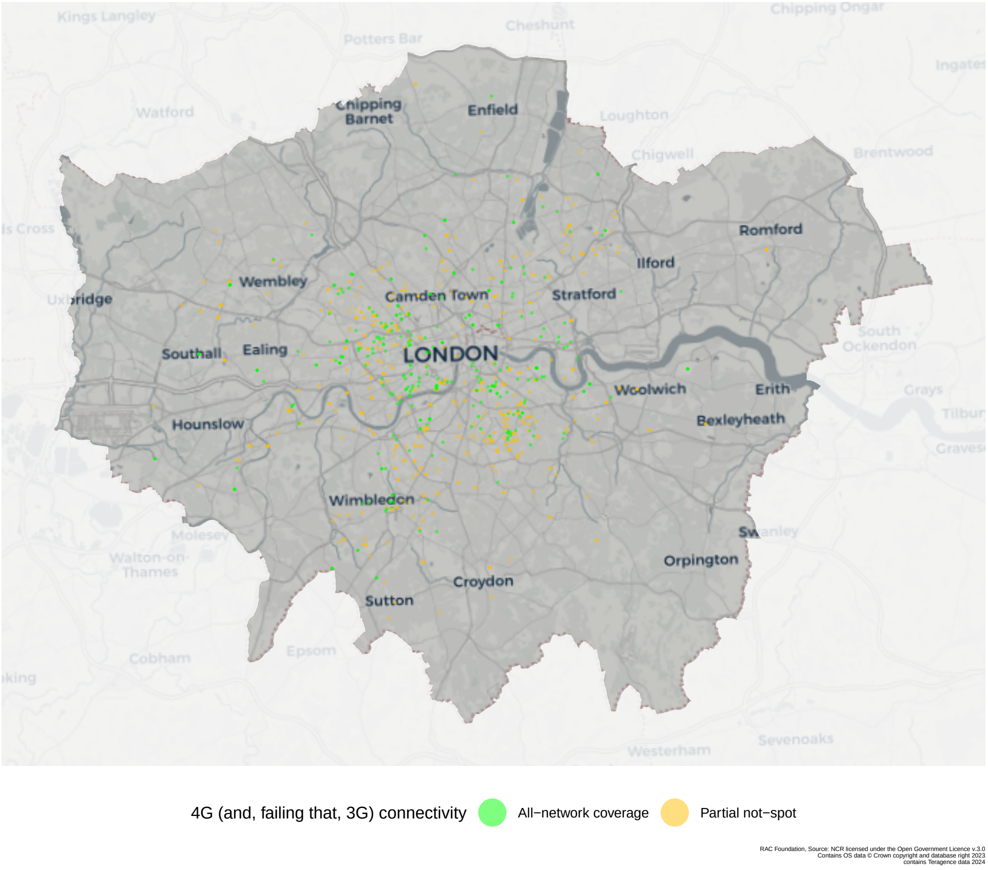

Figure 4: *4G (and, failing that, 3G) connectivity at EV chargers in London (3.7kW to 7kW, BP Pulse, POD Point, GeniePoint, char.gy, Mer, blink, ubitricity, Connected Kerb, Source London).*

4 Great Britain

The sample for Great Britain excluding London is 13.2% of all chargers of interest, representing 1250 charging devices and 1787 Type 2 connectors.

Figure 5 and Figure 6 set out the geographical spread of 4G and 4G and, failing that 3G provision in Great Britain (excluding London); namely:

- where provision is good - chargepoints are in neither a partial nor a total not-spot.
- where provision is inadequate - chargepoints are in either a partial or a total not-spot, excluding at least some motorists from access to charging.

Tables with detailed data for each GB region/nation is in the annex.

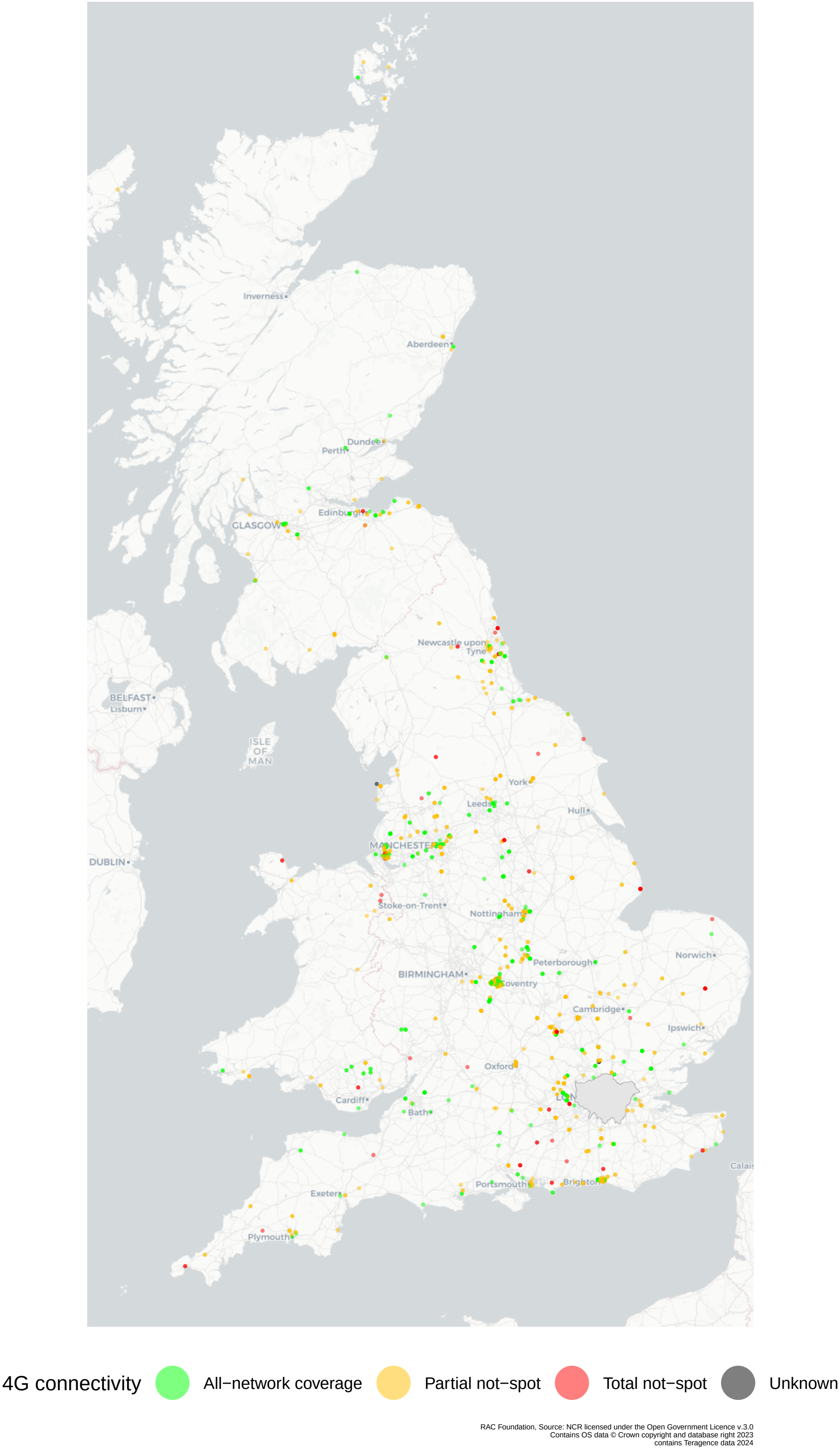

Figure 5: *4G connectivity at EV chargers in Great Britain, excluding London (3.7kW to 7kW, BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb).*

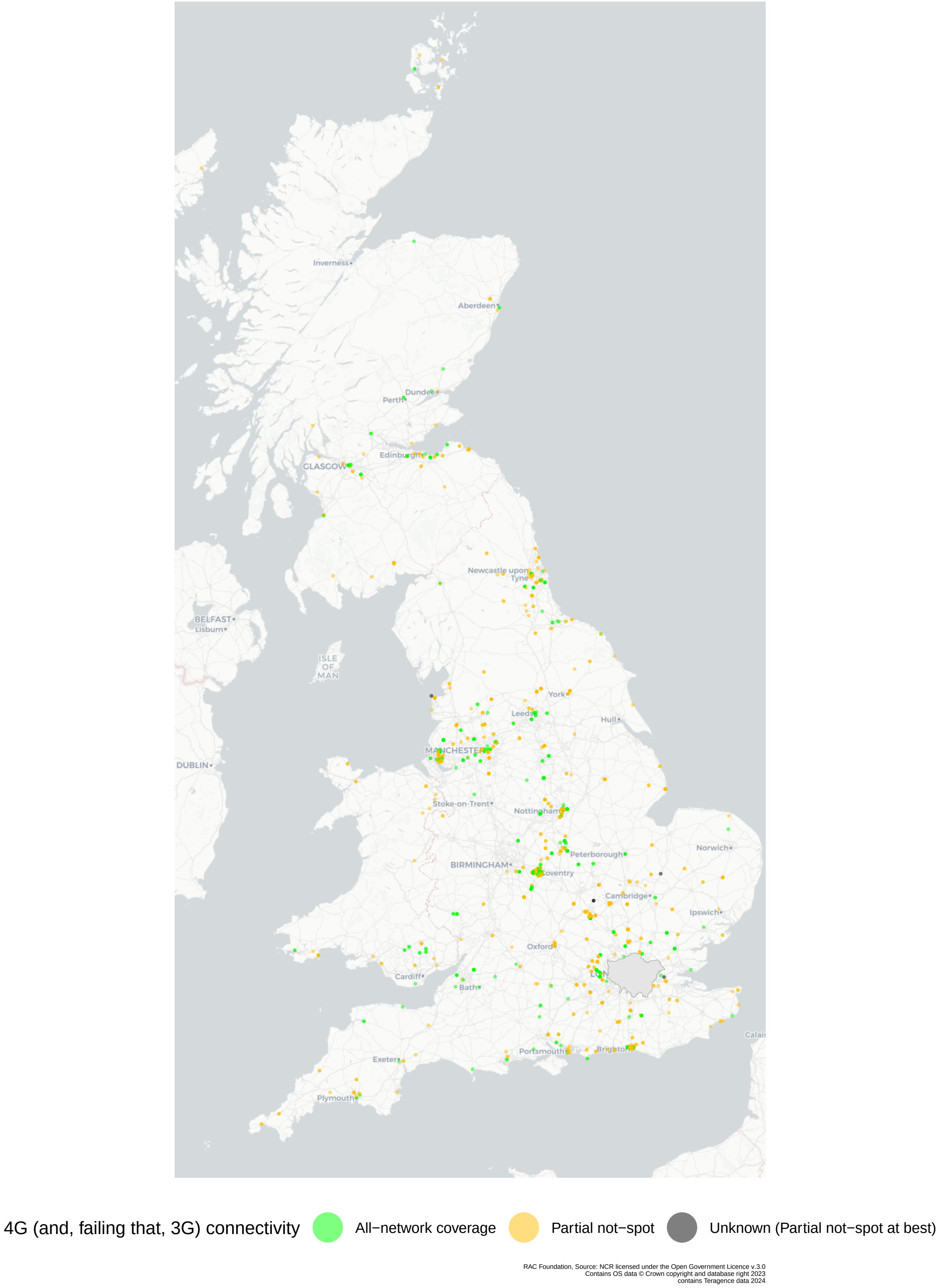

Figure 6: *4G (and, failing that, 3G) connectivity at EV chargers in Great Britain, excluding London (3.7kW to 7kW, BP Pulse, Mer, blink, ChargePlace Scotland, POD Point, GeniePoint, char.gy, ubitricity, Connected Kerb).*

5 Conclusion

This report provides an indicative account of the state of mobile coverage at 3.7kW to 7kW EV chargers in Great Britain. By using the -105dBm signal standard (and -105dBm for 3G), and by looking at total and partial not-spots for 4G rather than any other measure of signal (like provision of 5G, or maximum data speed across all available MNOs), this report highlights where a decent user experience can be expected and where activation of internet-linked (mostly app-based) chargers will be problematic - for some if not all users.

Because of the sampling approach taken (see the chapter *Methods & data sources* for explanation of sampling London and elsewhere differently), it is not possible to give a single overall national picture for connectivity at EV chargers. It is possible to say the following:

- in Great Britain but outside London, only 33.4% of chargers studied had all-network 4G coverage, 59.7% of chargers studied were in a partial not-spot, and 6.7% of chargers studied were in a total not-spot;
- in London, only 39.7% of chargers studied had all-network 4G coverage, 57.8% of chargers studied were in a partial not-spot, and 2.5% of chargers studied were in a total not-spot;
- in Great Britain but outside London, only 33.4% of chargers studied had all-network 4G and, failing that, 3G connectivity, 66.2% of chargers studied were in a partial not-spot, and 0% of chargers studied were in a total not-spot;
- in London, only 39.7% of chargers studied had all-network 4G and, failing that, 3G connectivity, 60.3% of chargers studied were in a partial not-spot, and 0% of chargers studied were in a total not-spot; and
- clearly, including 3G does not *improve* the number of chargers meeting the standard we have set. Rather, because Vodafone has *already* completed 3G turn-off, adding in 3G access to our assessment simply reduces the number of chargers with the very worst connectivity (total not-spots) and turns those sites into partial not-spots.

Although the charger network is complex, and the methods of access to it are varied, an adequate, appropriate standard for sub-8kW chargers that serves all motorists reliably would certainly require all-network 4G mobile connectivity going forward.

For EV adoption to accelerate, we would argue that motorists should be able to travel to *any* charger, with *any* mobile phone, and have a reasonable expectation of a connection made and transaction completed, as this is in line with what we expect from petrol stations and internal combustion engine vehicles.

There are, of course, many elements at play that determine whether or not electricity ends up successfully being bought when one tries to charge an EV. But mobile connectivity is part of that, and it is an issue not fully capturable through analysis of charger data, as those transactions which are attempted but fail because of a connectivity problem never get logged. It is clear from the work done here that more work remains to be done to deliver a consistent experience for all motorists across Great Britain.

This report highlights an important gap in the current analysis conducted by Government and industry to ensure the good use of infrastructure and good user experience. Our analysis has been conducted with open-source software, open data and transparent paid-for APIs, using a shareable, repeatable and reproducible script[13]. Government analysts could replace the paid-for API component with granular data already available to them and use it to focus policy to maximise the utility of existing and future charging infrastructure.

Of course, adequate connectivity at chargepoints is not the only area where modern motoring relies on mobile phone provision. The scenario here is just one of many ways in which motoring now needs connectivity. Real-time driving information (e.g., traffic, diversions, etc.), eCall and 999, calling for breakdown assistance (with fewer and fewer available landline phones on the road), logistics management, real-time bus information, and over-the-air updates are further examples - the total is sure to grow. All of these examples warrant similar analysis and similar interventions to ensure fair, adequate and safe provision and so support delivery of the benefits promised by our ever more connected motoring future.

[13]Any reader interested in replicating some or all of this analysis should contact the author.

Annex

Table 1: *Sampled London chargers by Local Authority, 4G connectivity*

Lower Tier	Count of sampled charging devices	Number of sampled devices with good all-network 4G	Number of sampled devices in a 4G partial not-spot	Number of sampled devices in a 4G total not-spot	Percent of sampled devices with good all-network 4G	Percent of sampled devices in a 4G partial not-spot	Percent of sampled devices in a 4G total not-spot
Barking and Dagenham	3	0	3	0	0.0	100.0	0.0
Barnet	1	0	1	0	0.0	100.0	0.0
Bexley	2	0	2	0	0.0	100.0	0.0
Brent	37	15	22	0	40.5	59.5	0.0
Bromley	4	0	4	0	0.0	100.0	0.0
Camden	25	7	18	0	28.0	72.0	0.0
City of Westminster	96	54	42	0	56.2	43.8	0.0
Croydon	6	0	6	0	0.0	100.0	0.0
Ealing	32	14	18	0	43.8	56.2	0.0
Enfield	8	3	4	1	37.5	50.0	12.5
Greenwich	23	10	9	4	43.5	39.1	17.4
Hackney	26	9	16	1	34.6	61.5	3.8
Hammersmith and Fulham	29	11	18	0	37.9	62.1	0.0
Haringey	16	7	9	0	43.8	56.2	0.0
Harrow	2	0	2	0	0.0	100.0	0.0
Hounslow	7	2	5	0	28.6	71.4	0.0
Islington	31	15	16	0	48.4	51.6	0.0
Kensington and Chelsea	58	31	24	3	53.4	41.4	5.2
Kingston upon Thames	2	2	0	0	100.0	0.0	0.0
Lambeth	28	7	21	0	25.0	75.0	0.0
Lewisham	13	2	9	2	15.4	69.2	15.4
Merton	44	19	24	1	43.2	54.5	2.3
Newham	1	1	0	0	100.0	0.0	0.0
Redbridge	8	3	5	0	37.5	62.5	0.0
Richmond upon Thames	33	9	22	2	27.3	66.7	6.1
Southwark	157	68	85	4	43.3	54.1	2.5
Sutton	8	2	6	0	25.0	75.0	0.0
Tower Hamlets	21	11	10	0	52.4	47.6	0.0
Waltham Forest	28	5	23	0	17.9	82.1	0.0
Wandsworth	60	14	44	2	23.3	73.3	3.3

Table 2: *Sampled London chargers by Local Authority, 4G (and, failing that, 3G) connectivity*

Lower Tier	Count of sampled charging devices	Number of sampled devices with good all-network coverage	Number of sampled devices in a partial not-spot	Number of sampled devices in a total not-spot	Percent of sampled devices with good all-network coverage	Percent of sampled devices in a partial not-spot	Percent of sampled devices in a total not-spot
Barking and Dagenham	3	0	3	0	0.0	100.0	0
Barnet	1	0	1	0	0.0	100.0	0
Bexley	2	0	2	0	0.0	100.0	0
Brent	37	15	22	0	40.5	59.5	0
Bromley	4	0	4	0	0.0	100.0	0
Camden	25	7	18	0	28.0	72.0	0
City of Westminster	96	54	42	0	56.2	43.8	0
Croydon	6	0	6	0	0.0	100.0	0
Ealing	32	14	18	0	43.8	56.2	0
Enfield	8	3	5	0	37.5	62.5	0
Greenwich	23	10	13	0	43.5	56.5	0
Hackney	26	9	17	0	34.6	65.4	0
Hammersmith and Fulham	29	11	18	0	37.9	62.1	0
Haringey	16	7	9	0	43.8	56.2	0
Harrow	2	0	2	0	0.0	100.0	0
Hounslow	7	2	5	0	28.6	71.4	0
Islington	31	15	16	0	48.4	51.6	0
Kensington and Chelsea	58	31	27	0	53.4	46.6	0
Kingston upon Thames	2	2	0	0	100.0	0.0	0
Lambeth	28	7	21	0	25.0	75.0	0
Lewisham	13	2	11	0	15.4	84.6	0
Merton	44	19	25	0	43.2	56.8	0
Newham	1	1	0	0	100.0	0.0	0
Redbridge	8	3	5	0	37.5	62.5	0
Richmond upon Thames	33	9	24	0	27.3	72.7	0
Southwark	157	68	89	0	43.3	56.7	0
Sutton	8	2	6	0	25.0	75.0	0
Tower Hamlets	21	11	10	0	52.4	47.6	0
Waltham Forest	28	5	23	0	17.9	82.1	0
Wandsworth	60	14	46	0	23.3	76.7	0

Table 3: *Sampled chargers (for Great Britain excluding London) by nation/region*

Nation/Region	Count of sampled charging devices	Number of sampled devices with good all-network 4G	Number of sampled devices in a 4G partial not-spot	Number of sampled devices in a 4G total not-spot	Percent of sampled devices with good all-network 4G	Percent of sampled devices in a 4G partial not-spot	Percent of sampled devices in a 4G total not-spot
East Midlands	174	65	99	10	37.4	56.9	5.7
Eastern	113	36	68	7	31.9	60.2	6.2
North East	84	26	48	10	31.0	57.1	11.9
North West	186	69	112	4	37.1	60.2	2.2
Scotland	99	41	55	3	41.4	55.6	3.0
South East	258	54	178	26	20.9	69.0	10.1
South West	65	35	24	6	53.8	36.9	9.2
Wales	39	13	20	6	33.3	51.3	15.4
West Midlands	168	56	108	4	33.3	64.3	2.4
Yorkshire and the Humber	64	22	34	8	34.4	53.1	12.5

Table 4: *Sampled chargers (for Great Britain excluding London) by nation/region, 4G (and, failing that, 3G) connectivity*

Nation/Region	Count of sampled charging devices	Number of sampled devices with good all-network coverage	Number of sampled devices in a partial not-spot	Number of sampled devices in a total not-spot	Percent of sampled devices with good all-network coverage	Percent of sampled devices in a partial not-spot	Percent of sampled devices in a total not-spot
East Midlands	174	65	109	0	37.4	62.6	0
Eastern	113	36	75	0	31.9	66.4	0
North East	84	26	58	0	31.0	69.0	0
North West	186	69	116	0	37.1	62.4	0
Scotland	99	41	58	0	41.4	58.6	0
South East	258	54	202	0	20.9	78.3	0
South West	65	35	30	0	53.8	46.2	0
Wales	39	13	26	0	33.3	66.7	0
West Midlands	168	56	112	0	33.3	66.7	0
Yorkshire and the Humber	64	22	42	0	34.4	65.6	0

Table 5: *Sampled chargers, London and Great Britain excluding London, 4G connectivity*

Nation/Region	Count of sampled charging devices	Number of sampled devices with good all-network coverage	Number of sampled devices in a partial not-spot	Number of sampled devices in a total not-spot	Percent of sampled devices with good all-network coverage	Percent of sampled devices in a partial not-spot	Percent of sampled devices in a total not-spot
Great Britain excluding London	1250	417	746	84	33.4	59.7	6.7
London	809	321	468	20	39.7	57.8	2.5

Table 6: *Sampled chargers, London and Great Britain excluding London, 4G (and, failing that, 3G) connectivity*

Nation/Region	Count of sampled charging devices	Number of sampled devices with good all-network coverage	Number of sampled devices in a partial not-spot	Number of sampled devices in a total not-spot	Percent of sampled devices with good all-network coverage	Percent of sampled devices in a partial not-spot	Percent of sampled devices in a total not-spot
Great Britain excluding London	1250	417	828	0	33.4	66.2	0
London	809	321	488	0	39.7	60.3	0