Oxfordshire Electric Vehicle Infrastructure Strategy

1. Executive summary

All six of Oxfordshire's councils have declared climate emergencies. Supporting a transition to zero emission road transport is a key component in Oxfordshire's councils achieving their net zero carbon targets, and this has been reinforced by Oxfordshire County Council and Oxford City Councils' commitment to delivering the UK's first ZEZ in Oxford to reduce air pollution levels, tackle the climate emergency, and improve the health of residents, workers and visitors in Oxford and beyond.

Comprehensive, accessible and efficient charging infrastructure is essential in enabling the rapid adoption of electric vehicles, accelerated by the 2030 date for the end of petrol and diesel car sales in the UK.

In keeping with Oxfordshire's status as a centre of innovation, the Councils are at the forefront of delivering new solutions and sustainable models for EV charging across the county. Drawing on partnerships with Oxford's academic institutions and technology firms Oxfordshire is delivering projects at the cutting edge of zero emissions mobilities. The Energy Superhub Oxford project will see large scale battery storage technology supporting a super-rapid EV charging hub in Oxford, while Local Energy Oxfordshire is exploring how local renewable energy generation can support decentralisation of the grid, and how EVs can play a part in new energy systems. Oxfordshire's V2GO project has examined the potential for EV fleets to support the grid through acting as energy storage units, and the ongoing Go Ultra Low Oxford and Park and Charge projects are examining new technologies and models to support EV drivers without access to off-road parking and charging.

This pipeline of projects across the county already is delivering up to 432 charging points by June 2022 in partnership with Government and the private sector.

The Oxfordshire Electric Vehicle Infrastructure Strategy (OEVIS) sets out the policies and plans to realise our vision for EV charging in Oxfordshire, whereby:

- *Residents, businesses and visitors in Oxfordshire will be confident they can recharge EVs conveniently, and in a manner appropriate for their needs.*
- *Oxfordshire's EV charging provision will develop to meet the needs of users now and in the future, and in doing so support Oxfordshire's transition to decarbonising transport and improving air quality.*

It has been a true collaborative piece of work between the County, City and District Councils and has been informed through the lessons learnt from the innovative EV charging projects already being delivered.

The Oxfordshire Electric Vehicle Infrastructure strategy will put Oxfordshire's councils in a strong position to ensure that those wishing to purchase an EV can access convenient charging; providing an operational approach to enabling and deploying charging infrastructure in Oxfordshire, and laying the foundations for future projects.

1.1. Policies at a glance:

Policy Area	Policy
Targets for EV charging	**Policy EVI 1:** The Councils will collaborate to enable and encourage deployment of public EV chargepoints in Oxfordshire towards meeting predicted demand by 2025 in line with national targets and with reference to European directives.
Funding public EV chargers	**Policy EVI 2:** The Councils will collaborate to seek funding for EV infrastructure and support the development of a self-sustaining EV charging network for Oxfordshire which relies less heavily on continuing public finance support in the future and minimises the impact on existing and future Council budgets
Public Charging in local authority car parks	**Policy EVI 3:** The Councils will aspire to reach or exceed a target of converting 7.5% of local authority managed public car park spaces, to fast or rapid EV charging by 2025.
	Policy EVI 4: The Councils will manage parking bays for EV charging in local authority car parks to encourage both destination and overnight EV charging and for all types of EV ownership, including private vehicles, shared or car club vehicles, and business vehicles where appropriate
Charging at Council sites	**Policy EVI 5:**The Councils will support staff and visitors to access electric vehicle charging at Council premises where appropriate
Charging without off-road parking	**Policy EVI 6:** Recognising that lack of off-road parking may be a significant barrier to EV take-up, Oxfordshire County Council will promote a hierarchy of solutions to EV charging for residents, businesses and shared vehicles without access to off-road parking, which prioritises off-street charging hubs, and other solutions which avoid generating additional street clutter or surrounding maintenance and management challenges.
Charging in New Developments	**Policy EVI 7:** The Councils will seek to include statements and policies supportive of EV charging infrastructure and, where appropriate, references to the Oxfordshire Electric Vehicle Infrastructure Strategy in their planning standards and guidance
	Policy EVI 8: The Councils will benchmark nationally, and between themselves, each seeking to set minimum standards for the quantity of EV charging to be provided in developments in their planning requirements
	Policy EVI 9: The Councils will seek to provide support and guidance on EV charging provision to Town and Parish Councils, and other groups writing Neighbourhood Plans

EV Charging in Historic Areas	**Policy EVI 10:** In order to manage the impact of EV chargers without restricting access to EV charging, the Councils will define and communicate the design features of EV chargers which will have the most positive impact on the character of our cities towns and villages, and ensure that where there are specific heritage conservation needs, these are met by the charging equipment deployed.
Commercial car parks	**Policy EVI 11:** The Councils will seek opportunities to encourage organisations, businesses and other owners of commercial public and customer car parks to deploy public EV charging infrastructure where it is appropriate
Communal residential car parks	**Policy EVI 12:** The Councils will explore opportunities to encourage owners and managers of housing stock of all types of tenure to deploy EV charging infrastructure for residents where it is appropriate
Workplace Charging	**Policy EVI 13:** The Councils will explore opportunities to encourage uptake of EV charging at workplaces and business premises where it is appropriate
Rapid charging on strategic roads	**Policy EVI 14:** The Councils will seek to improve the availability of rapid and ultra-rapid EV charging on and near the strategic road network and important link roads across Oxfordshire
Charging standards for Oxon	**Policy EVI 15:** The Councils will encourage the deployment of a high quality, reliable, open, value for money, future-proofed and truly instant access EV charging network for Oxfordshire by setting high standards which seek to reach 'above and beyond' minimum legal requirements
Managing Energy Impacts	**Policy EVI 16:** The Councils will seek to increase the emissions reduction benefits of electric vehicles, and mitigate the impact of EV charging infrastructure on the local and national grid by encouraging and promoting the use of renewable energy for EV charging, encourage 'off-peak' use of EV chargers, and exploring technical options to manage grid demand from EV charging infrastructure.
Promoting EVs & Infrastructure	**Policy EVI 17:** The Councils will promote information about public EV charging in Oxfordshire, and awareness of the benefits of EVs to the public through their online and other communications channels

2. Introduction and context

2.1. Introduction

2.1.1. Fossil fuels are the principal source of carbon emissions driving the anthropogenic climate change that will create devastating impacts for our living world. Recognising the critical importance of keeping global warming to 1.5 degrees C in line with the 2015 Paris Climate Agreement, all of Oxfordshire's Councils have recognised the climate emergency. Supporting a transition to zero emission road transport is a key component in Oxfordshire's Councils achieving their net zero carbon targets. Comprehensive, accessible and efficient charging infrastructure is essential in enabling the rapid adoption of electric vehicles. This strategy sets out the policies and plans to realise this goal.

2.1.2. Oxfordshire is a place of real innovation – the county is home to Europe's largest concentration of multi-million-pound science research facilities, underpinning our leading position in advanced engineering and manufacturing, energy systems, and vehicle and mobility technologies. Oxfordshire is also growing. The Oxfordshire Growth Board, through the emerging Joint Statutory Spatial Plan (JSSP), is planning for 100,000 new homes to be built in our county by 2031. An expected 86,500 new jobs are also being created. The Local Industrial Strategy for Oxfordshire sets out Oxfordshire's ambitions to be a pioneer for clean and sustainable growth driven by our science and innovation.[i]

2.1.3. Oxfordshire is home to the University of Oxford, the global number one ranked university and Oxford Brookes University, one of the UK's leading modern universities. Oxford University's School of Geography and the Environment and Department of Engineering Science host research centres with world-leading expertise in EV and battery production, energy and future mobilities systems. The Energy and Power Group are experts in the impact of EVs on the grid. The Transport Studies Unit (TSU) has expertise in understanding EV driving and charging patterns. Oxford Brookes' Sustainable Vehicle Engineering Centre is training next generation EV engineers, with strong links to the county's motorsports and vehicle industries.

2.1.4. Williams Advanced Engineering, based in Oxfordshire, create high-performance batteries in the Formula E programme, at the cutting edge of battery performance and management. Oxford is home to the BMW mini plant, where the all-electric MINI is built for the UK and European market. The Faraday Institution on the Harwell Campus is the independent institute for electrochemical energy storage science, research and technology. The institute and Oxford University are leading projects which could revolutionise the way EV batteries are manufactured.

2.1.5. Drawing on partnerships with Oxford's academic institutions and technology firms Oxfordshire is delivering projects at the cutting edge of zero emissions mobilities, hosting world-firsts for battery storage for EV charging, and EV infrastructure delivery. The Energy Superhub Oxford project will see large scale

battery storage technology supporting a super-rapid EV charging hub in Oxford, while Local Energy Oxfordshire is exploring how local renewable energy generation can support decentralisation of the grid, and how EVs can play a part in new energy systems. Oxfordshire's V2GO project examines the potential for EV fleets to support the grid through acting as energy storage units. The ongoing Go Ultra Low Oxford and Park and Charge projects are examining in depth the technologies available to support EV drivers without access to off-road parking and charging.

2.1.6. Oxfordshire is also leading the country in policy making to reduce urban transport emissions; in the pipeline is the UK's first Zero Emission Zone in Oxford from 2021, championed by Oxfordshire County Council and Oxford City Council.

2.1.7. The Oxfordshire Electric Vehicle Infrastructure strategy has been a true collaborative piece of work between the County, City and District Councils. It has taken the lessons learnt from all these, and other, innovative EV charging projects, to provide an operational approach to enabling and deploying charging infrastructure in Oxfordshire, and lay the foundations for future projects.

2.2. What is the Oxfordshire EV Infrastructure Strategy about?

2.2.1. Clean Growth is at the heart of the UK Industrial strategy, and the government sees growth in the EV industry as essential to the UK's clean industrial future and National Infrastructure Strategy[ii]. The Road to Zero strategy sets out the governments ambitions to end the sales of internal combustion engine (ICE) vehicles, which has recently been brought forward by 10 years to 2030, and its ambitions for a world-class EV charging network for the UK.

Figure 1 - EV Charging in national policy

The Road to Zero Strategy (2018)

The Government's Road to Zero Strategy outlines how the government will support the transition to zero emission road transport and reduce emissions from conventional vehicles during the transition. The document includes a target to end the sale of new conventional petrol and diesel vehicles by 2040. The UK government has since brought this date forward to 2030.

A key part of the Road to Zero Strategy focusses on measures to support the development of world class EV charging infrastructure network through;

- The Automated and Electric Vehicles Act (2018) which provide a legislative basis for provision of, and standards in EV charging infrastructure.
- Ensuring that new developments are EV ready, and that all new homes, where appropriate, should have a charging point available, through changes to Buildings Regulations, and the now revised National Planning Policy Framework (NPPF) (revised February 2019) to support local authorities in writing local planning policies which incorporate facilities for charging EVs

2.2.2. In this document we use the term EV to refer to all 'plug-in' vehicles including pure Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles, and Extended Range Electric Vehicles (REEVs) as all require charging to travel using their zero emissions capabilities.

2.2.3. Car use in Oxfordshire is high; over 4 billion miles were travelled by car or taxi in Oxfordshire in 2019[iii]. Road transport emissions contribute around 33% of carbon emissions nationally[iv] and generate significant issues for air quality; in 2019, 68% of NO_x emissions in Oxford were caused by road traffic[v] and 22 places in Oxfordshire found to be breaching air pollution limits.

2.2.4. The current Connecting Oxfordshire[vi] Local Transport Plan 4 shapes our transport policy and sets out Oxfordshire County Council's policy and strategy for developing the transport system in Oxfordshire to 2031. It has been developed with these over-arching transport goals:

- *To support jobs and housing growth and economic vitality;*
- *To reduce transport emissions and meet our obligations to Government;*
- *To protect, and where possible enhance Oxfordshire's environment and improve quality of life;*
- *To improve public health, air quality, safety and individual wellbeing.*

2.2.5. The Oxfordshire Electric Vehicle Infrastructure Strategy (OEVIS) has strong ties with the Oxfordshire Energy Strategy[vii] which seeks to integrate EVs into a smart and zero carbon energy infrastructure, and the Oxfordshire 2050 Plan to promote future-proofed development in the planned growth across Oxfordshire. The strategy also links closely with each of the collaborating Councils' Climate Emergency declarations and net zero carbon targets, and Oxfordshire County Council's Climate Action Framework, where it will act as a supporting strategy to facilitate delivery of recommended actions, and support the drive to meet local and national emissions reductions targets.

2.2.6. The OEVIS has further strong links with the development of the emerging Connecting Oxfordshire Local Transport and Connectivity Plan, which sets out a vision for a net-zero Oxfordshire transport system that enables the county to thrive as one of the world's leading innovation economies, whilst supporting clean growth, protecting our rich and varied natural and historic environment and being better for health and well-being, social inclusivity and education. This EV Infrastructure Strategy aims to compliment and support this vision, by reducing emissions from shared transport through promoting EV infrastructure for shared transport, and reducing emission from private road transport where active and public transport is not an option.

2.2.7. Oxfordshire's Councils have an opportunity to encourage uptake of EVs by working together to enable the development of a high quality EV charging network. The Oxfordshire EV Infrastructure Strategy draws on significant expertise

and experience across Oxfordshire to further enable reduction in transport emissions through enabling quality EV charging provision.

2.2.8. Through our Oxfordshire Electric Vehicle Infrastructure Strategy, we identify:

- *The opportunities and challenges for the EV charging network in Oxfordshire*
- *The likely uptake of EVs across Oxfordshire and the centres of demand for EV charging in Oxfordshire*
- *How we will contribute to and accelerate local deployment of EV charging infrastructure to ensure high quality EV charging is accessible in our county*
- *A framework of EV charging options for residents without access to private off-road parking*
- *Opportunities to work with landowners and businesses to further increase EV charging provision*
- *Opportunities to further support the decarbonisation of road transport and manage the impact of EV charging on the grid.*
- *How we will increase awareness of public EV charging infrastructure and promote uptake of EVs*

2.2.9. The strategy will inform our operational policies and processes, to ensure that EV charging is accessible and convenient in Oxfordshire. It will set a foundation for project development, establish a consistent approach to delivering and enabling EV charging across Oxfordshire, and support the developing EV market, and local businesses in the EV sector.

2.3. Our vision and objectives

2.3.1. Our vision for EV charging in Oxfordshire is:

- *Residents, businesses and visitors in Oxfordshire will be confident they can recharge EVs conveniently, and in a manner appropriate for their needs.*
- *Oxfordshire's EV charging provision will develop to meet the needs of users now and in the future, and in doing so support Oxfordshire's transition to decarbonising transport and improving air quality.*

2.3.2. The OEVIS will provide an operational approach to enabling and deploying charging infrastructure in Oxfordshire. In the short-term (2020-2025), our objectives are to:

- *Enable and deliver public EV charging across Oxfordshire*
- *Adopt a common approach to managing EV charging in Council car parks*
- *Enable residents without access to private off-road parking to access a range of options for EV charging*

- *Encourage new developments to include high quality EV charging infrastructure*
- *Set standards for the quality of public EV charging in Oxfordshire which supports development of a network which is high quality, open and accessible*

2.4. The development of the Oxfordshire EV Infrastructure Strategy

2.4.1. This strategy has been developed collaboratively with significant subject matter expert input from each of Oxfordshire's five District and City Councils, and a steering board of members from each. We have also engaged with external stakeholder groups including Parish and Town Councils and the EV charging industry. A full list of our steering group and workshop attendees can be found in Annex 1: Stakeholders.

2.5. The scope of the Oxfordshire EV Infrastructure Strategy

2.5.1. This strategy covers the administrative area of Oxfordshire County Council and includes the administrative areas of each of the five District Councils. It focusses on EV charging for cars, car-based vans, and taxis (hackney carriage and private hire vehicles) for three user groups with differing needs for EV charging:

- *Oxfordshire residents*
- *Local businesses, their employees, taxis, logistics operations and car clubs*
- *Visitors to Oxfordshire*

2.5.2. The strategy does not cover EV charging for buses or large goods and service vehicles. Large EVs such as buses and medium/large trucks are still in development, and charging requirements are currently uncertain. At the time of writing, Oxford's expression of interest in becoming Britain's first All-Electric Bus Town has been shortlisted by the Department for Transport and we anticipate that EV Bus charging infrastructure will be further developed as part of this project, if funded. As uptake of these vehicle types is likely to be low in the short term, they are not deemed a priority for this strategy. At this time charging for e-bikes and other micro-mobility solutions are not included in this strategy but like trucks and buses may form the basis for future consideration.

2.6. Delivering the strategy

2.6.1. This strategy includes many measures which will require dedicated resourcing, funding and the collaboration of external partners to complete delivery. Key actions for delivery are outlined under each policy. While budgets are constrained and future budgets are uncertain, especially in light of the Covid-19 pandemic, and our targets and commitments must be considered aspirational, Oxfordshire's Councils will use their best endeavours to deliver on the commitments made in this document, using existing project funding, future

Government funding opportunities and partnerships with the private sector which deliver an EV charging network for Oxfordshire with minimal impact on existing Council budgets.

3. EV charging background

3.1. Types of EV charging infrastructure

3.1.1. EV charging infrastructure can be broadly split into 4 types: slow, fast, rapid and ultra-rapid, based on power output and speed of charging. Each have factors which make them suitable for different charging settings and use cases; home, workplace, on-street, destination and en-route.

- **Slow:** up to 3kW AC – between 6-12 hours to fully charge a battery EV, less for a plug-in hybrid
- **Fast:** 7 to 22kW AC power outputs, and typically fully charge a battery EV in 3-4 hours. Frequently these are 'smart' chargers; able to communicate with a CPMS or back office to manage time and rate of charging[viii]
- **Rapid:** Typically, rapid AC chargers are rated at 43kW, while rapid DC are typically 50kW. Will typically charge a BEV to 80% in around 30-40 minutes.
- **Ultra-rapid:** Superchargers and high-powered charging at 100-350kW DC are becoming increasingly relevant for battery EV drivers, though current EV models may be limited in the charging power they can accept. Will typically charge an EV to 80% in 15 to 25 minutes dependent on power output.

3.1.2. Further details on types of EV charging and where they are most suitably deployed can be found in annex 3.

Chargers and Chargepoints

3.1.3. In this document we refer to an EV charging unit as an EV charger. EV chargers may have one or more sockets which allow connection to an EV to charge. These sockets are referred to in this document as EV chargepoints.

3.2. Challenges and opportunities for EV charging

3.2.1. In general, EVs and the charging infrastructure needed to support them present a series of challenges and opportunities to EV drivers and landowners. As local authorities, the County and District Councils can work together to support EV growth.

3.2.2. Table 1 summarises factors which were considered in developing our county-wide EV Infrastructure Strategy.

Table 1 - Opportunities and challenges for developing a public EV charging network

General	
Opportunities	**Challenges**
• Encouraging drivers to switch from petrol/diesel to EV will benefit local air quality, and decarbonise transport as energy generation progresses from fossil fuels to renewable sources. • Demand for chargers in Oxfordshire is likely to be higher than other regions • Chargers may attract EV users to an area and stimulate nearby shops and the local economy • Increased EV usage will stimulate the EV technology sector in Oxfordshire. • Charge Point Operators (CPOs) offer concession contracts for chargers at little or no cost to local authorities and which may provide a revenue opportunity in the future. • District Councils own car parks located in urban centres close to both businesses and residential properties which have limited off road parking.	• Available power capacity on the electricity network varies across the county and is limited in some areas. • Costs of upgrading the local electricity network for charging capacity are often high. • Some charger sites can be constrained by planning/heritage restrictions. • Access to working public EV charging is a key concern for EV drivers. • Instant access to EV charging networks often requires use of apps, roaming across charger networks is limited. • Owning and operating chargers generates costs for local authorities at a time when funding is constrained. • Management of EV charger contracts can be an additional resource burden for councils. • The business case for CPOs remains challenging whilst demand for EVs is still growing.
On the Highway	
Opportunities	**Challenges**
• Oxfordshire County Council has control of highways land assets on major roads which could provide opportunities for rapid charging stops. • On-street charging infrastructure at appropriate locations may offer locations for users to charge where there is no off-road alternative.	• Over 30% of households in Oxfordshire have limited or no access to home EV charging as they park on the street. • On-street chargers require space on the public highway. Some locations may present an obstruction to pedestrians. • Some operators are reluctant to offer concessions in on-street settings where usage is low, and cost of maintenance is high. • On-street parking bays are limited in certain areas. Reserving bays for EV users may increase pressure on parking and require resources for the traffic order.

4. This is Oxfordshire

4.1. EV uptake in Oxfordshire

4.1.1. To support the drive to reach net zero carbon emissions by 2050, the UK government has set out its ambitions to end the sale of new petrol and diesel cars by 2030, bringing the end date forward by 10 years from that proposed in the Road to Zero.

4.1.2. At the end of August 2020, there were 4,381 ultra-low emissions vehicles (ULEVs)[1] in Oxfordshire[ix], 2,200 of which were BEVs. Socio-economic factors mean Oxfordshire is likely to have faster growth in EV sales than the national average; research from the University of Oxford indicates that EV sales are likely to reach approximately 70% of new vehicle sales by 2025 (Figure 2). In absolute numbers, the university's predictions mean that by 2025 by 2025 there could be over 25,000 EVs on Oxfordshire's roads, and over 44,000 by 2027.

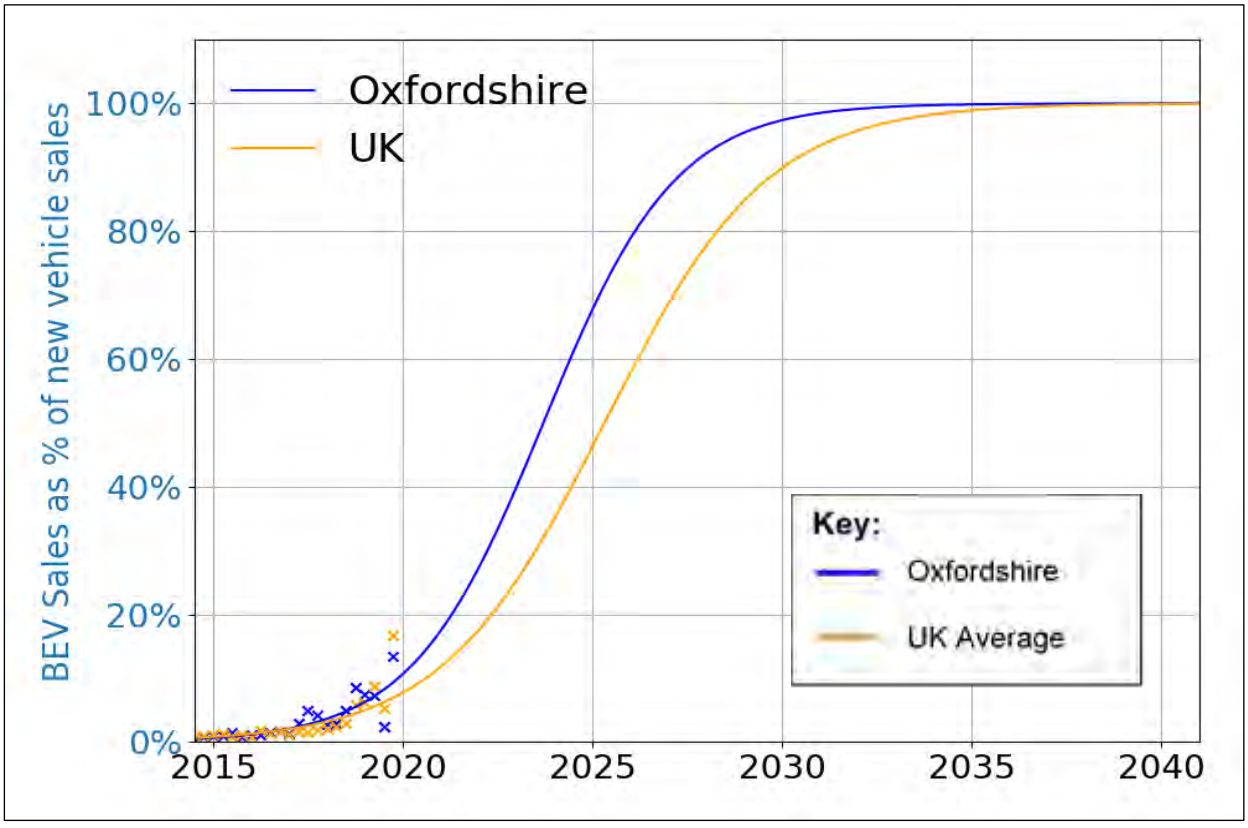


Figure 2 - Predicted Growth of EVs as a percentage of new vehicle sales in Oxfordshire. Based on DfT vehicle licensing data from Q4 2011- Q3 2020[x]. *Qualifications: Based on historic data; external influences & policy changes may affect growth. DfT has split the Ultra Low Emission Vehicle Data into Battery Electric Vehicles (BEV) and Plug-in hybrids (PHEV). As regulation now promotes BEV over PHEV, it was felt appropriate to use BEV data to forecast EV growth.*

[1] ULEVs emit less than 75g of carbon dioxide (CO2) from the tailpipe per km travelled; typically refers to battery electric, plug-in hybrid electric and fuel cell EVs

4.2. Current EV charging provision

4.2.1. Public EV charging infrastructure in Oxfordshire is currently limited and patchy, with most centred in urban areas and little provision in smaller market towns or more rural areas. While the network across the UK is growing rapidly, Oxfordshire is in danger of falling behind in infrastructure provision which could inhibit the forecast speed of transition.

4.2.2. The county has 448 public EV chargepoints, distributed over 123 charging sites. Numbers of chargers at sites range from a single chargepoint to over 40, and sites may contain chargepoints of different speeds.

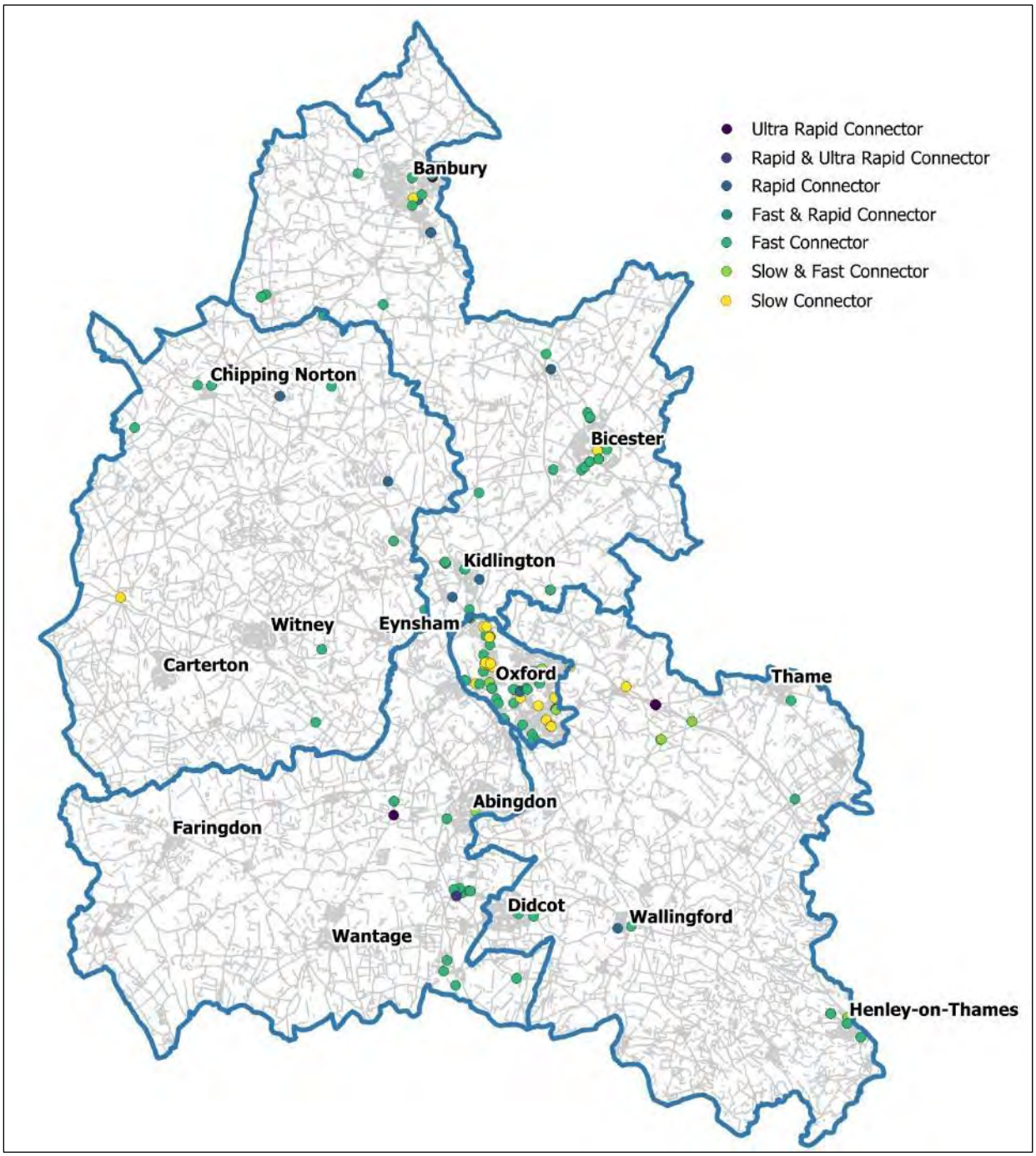


Figure 3 - EV Charging infrastructure in Oxfordshire. Source: Zap-Map (2020).

4.2.3. Large areas of the county have little or no public EV charging provision. Oxford City Council's administrative area is the most densely covered, reflecting the work Oxford City Council undertook, in partnership with Oxfordshire County Council, on the Go Ultra Low Oxford On-street Project. The project installed over 30 fast on-street EV chargers in a trial of charging solutions for residents without access to off-road parking.

4.2.4. There are EV chargers in only 8 of Oxfordshire's 98 local authority owned and managed public car parks, with the remaining chargers hosted by commercial entities; including supermarkets and retail parks, hotels and car dealerships.

4.2.5. Public rapid charging is dispersed around the county, with four charging sites at service stations adjacent strategic road network, and the remaining rapid charging sites again found at hotels and car dealerships. Ultra-Rapid charging is limited to 5 sites, the largest of which is the Tesla Charging hub at the Milton interchange, which hosts 32 ultra-rapid chargepoints available only to Tesla Drivers.

Chargepoint speed	Number of sites	Number of chargepoints
Ultra-Rapid	5	55
Rapid	20	60
Fast	85	281
Slow	35	52
Total	N/A	448

Table 2 - Public EV chargers in Oxfordshire by speed

4.3. The Oxford Zero Emission Zone

4.3.1. Oxfordshire County Council and Oxford City Council are proposing to create a Zero Emission Zone (ZEZ) pilot in Oxford city centre, starting in August 2021, and based on a road user charging scheme. This pilot, and any future implementation and expansion, may generate additional need and demand for EV charging for road user groups, not just within the zone, but also across the county, from where journeys into the zone may originate.

4.4. Taxis: Hackney Carriage and Private Hire Vehicles

4.4.1. In addition to the requirements for vehicles travelling in Oxford's Zero Emission Zone, from 2022 all newly licensed Hackney Carriage Vehicles licenced by Oxford City Council must be Ultra Low Emissions Taxis (ULEVs) meeting the UK government's definition which typically refers to battery electric, plug-in hybrid electric and fuel cell EVs. Across the county EVs are already starting to enter the Hackney Carriage and Private Hire Vehicle fleet. The usage patterns of both forms of taxi mean that access to Rapid and Ultra-Rapid charging are important in allowing drivers to maximise their productive work time, and that charging infrastructure at company premises, and close to popular routes or ranks are beneficial to supporting the EV taxi business case. While it is not within the scope of this strategy to define specific locations for charging for electric taxis, the strategy aims to ensure that public EV charging is available to all user types, including taxis.

4.5. Social inclusion

4.5.1. While many areas of Oxfordshire are affluent, and likely to be among the first to see early mass adoption of EVs, there are significant areas of Oxfordshire where income is low. Lower income households are often disproportionately affected by poor air quality, and also the sector of society least able to adopt EVs early.

4.5.2. While the Councils are limited in the actions they can take to support low income households with the purchase of EVs, action can be taken to ensure equitable access to EV charging. Car club vehicles may also provide a more affordable alternative to private EV ownership, with the potential to give wider access to clean vehicles, and support reductions in private vehicle ownership in line with the aims of Connecting Oxfordshire. Electric car clubs and the chargers needed to power them are therefore included as a valuable measure to improve social inclusion in Oxfordshire's EV ready future.

4.6. On-street parking

4.6.1. Over 34% of households in Oxfordshire are unlikely to have private off-road parking, and as such have limited or no access to home charging. Not everyone without off-road parking has a vehicle, but there are indications that around 25% of all cars nationally are parked on streets overnight[xi]. Most on-street parking in Oxfordshire can be seen in the city of Oxford and other urban centres, where terraced properties and high-density housing are key features of the urban landscape, and where air quality concerns are most acute. However, this situation is also seen in many more rural areas such as historic market towns (Figure 4).

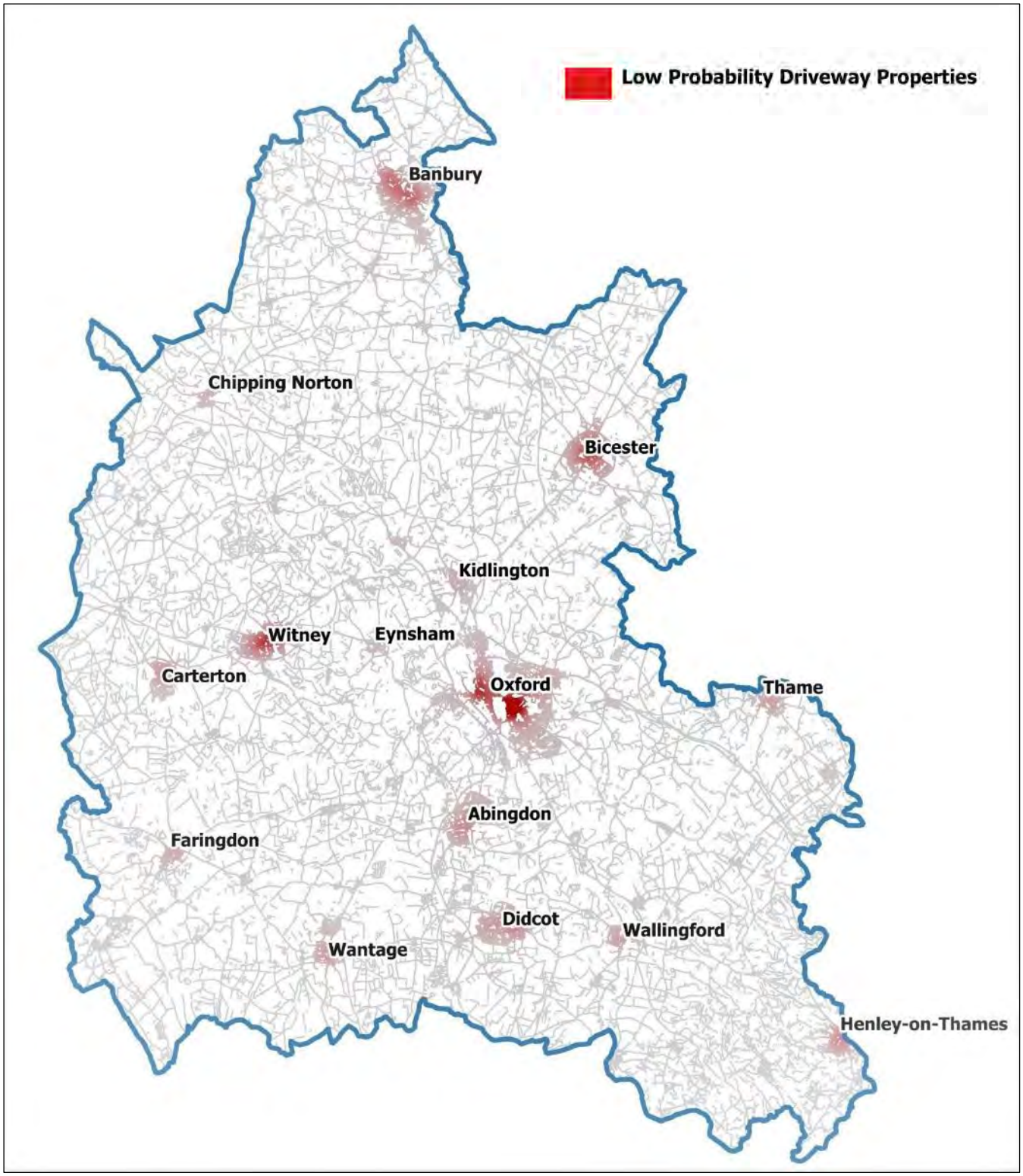


Figure 4 - Oxfordshire hotspots for properties with low probability of a driveway. Source: Energeo 2020 & EMU 2018. *Higher colour intensity indicates higher density of occurrence. Properties with low probability of a driveway are defined as those with less than or equal to 3 metres distance between the front elevation of the property and the nearest edge of the public highway, inclusive of the pedestrian footway where this is present.*

5. Where are chargers needed first?

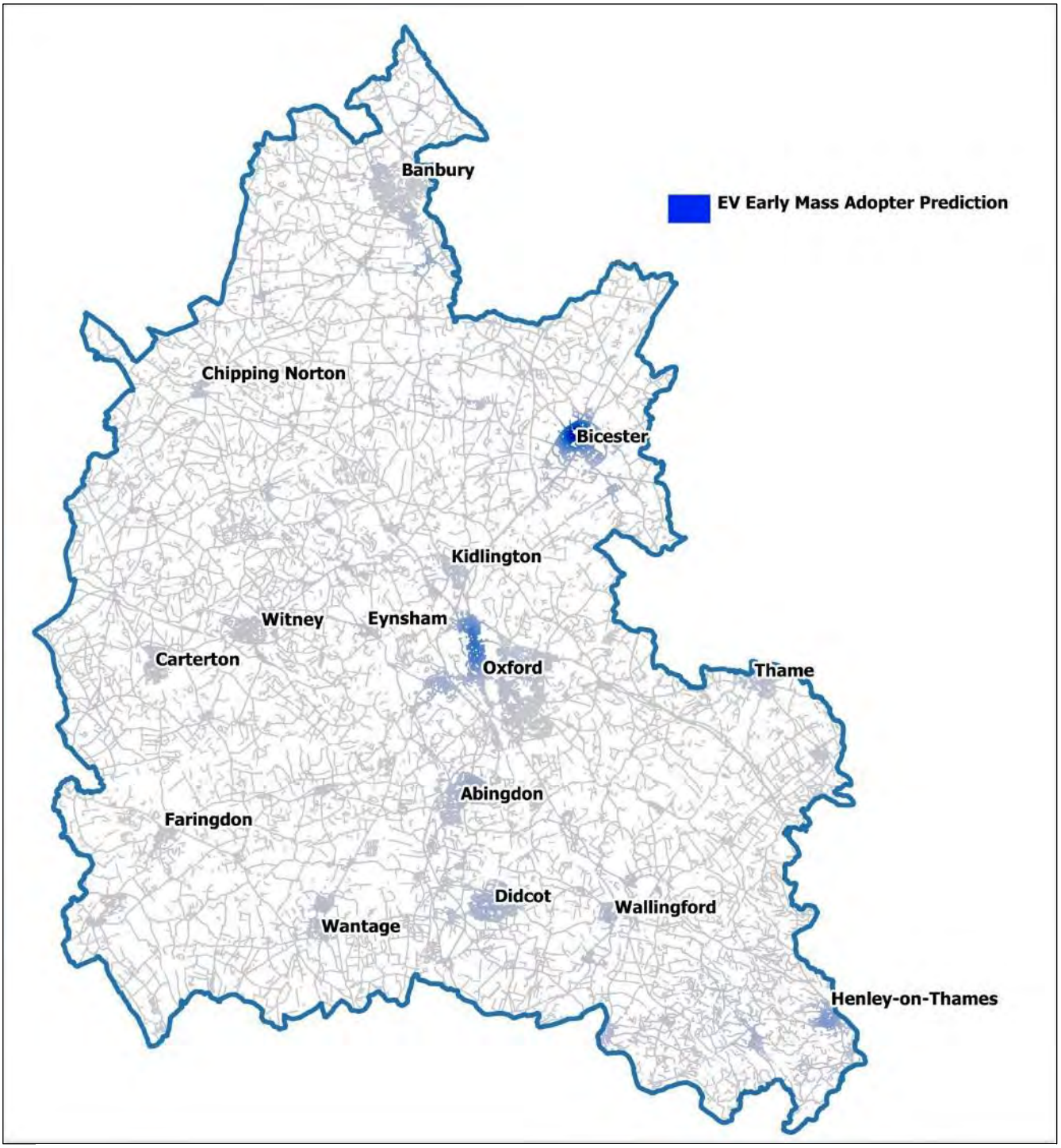


Figure 5 - Oxfordshire hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. *Higher colour intensity indicates higher density of occurrence. Households likely to be early mass adopters were defined as households in categories 1-10,15-16,18,22-24,26&29, located proximate to an existing ULEV registration.*

5.1. Analysing demand

5.1.1. While most EV charging is done at home (around 80%)[xii], a network of public chargers is essential for drivers who do high mileage, travel long distances and/or have no access to chargers at home or work. The UK is home to around 19,500 public chargepoints and has one of the largest, and most comprehensive rapid networks in Europe, but more is needed to meet demand.

5.1.2. Chargers must be located in areas which are convenient to drivers, and have the space, energy and network connections to make installations feasible. In this section we examine where demand is likely to grow fastest, and where support is needed to help residents on lower incomes adopt cleaner vehicles.

5.1.3. Analysis of likely centres of EV adoption as uptake in Oxfordshire moves from 'early adoption' to 'early mass adoption' has been carried out using demographic characterisations of people likely to be in these groups across Oxfordshire, and combined with data on existing electric vehicle registrations, which are used as a predictor of 'neighbourhood influence' to give a picture of the hotspots for likely uptake over the coming 5 years (Figure 5).

5.1.4. The outputs show dense areas of likely uptake in Bicester, the North and West of Oxford, and larger market towns such as Abingdon, Didcot and Henley. Likely uptake in and around Banbury is more diffuse, and further investigation may be required to understand the likely cause of slower uptake.

5.1.5. When EV uptake hotspots are overlaid with areas of high on-street parking, the councils can begin to identify key areas for early action on EV charging infrastructure (Figure 6).

5.1.6. More detailed heatmaps of EV uptake hotspots for each of the districts and key towns can be seen in Annex 4: Geospatial Analysis.

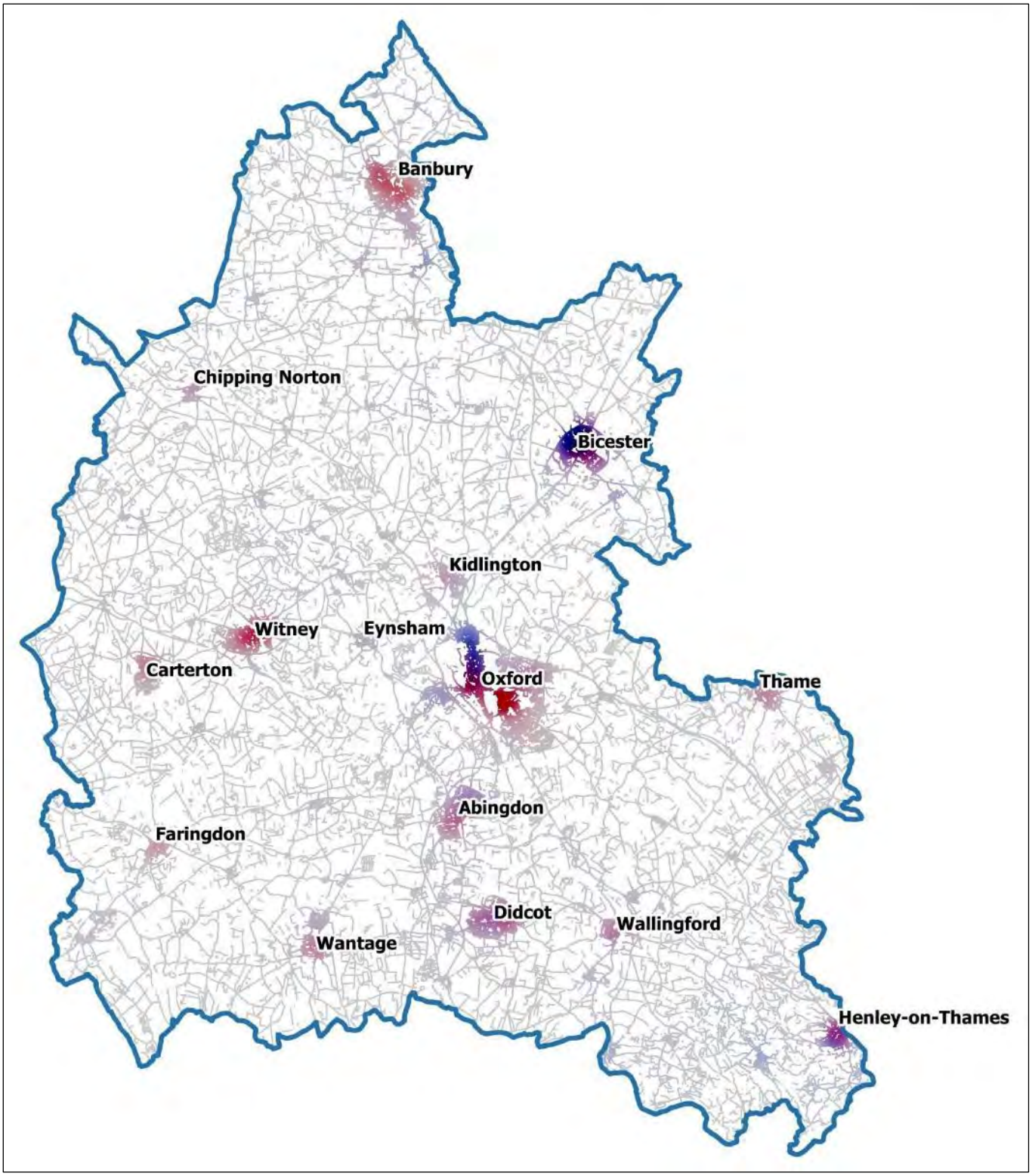


Figure 6 - Oxfordshire hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. *Higher colour intensity indicates higher density of occurrence.*

5.2. The Councils' influence (where can we act?)

5.2.1. The Oxfordshire Electric Vehicle Infrastructure Strategy will focus on the measures and policies the Councils can either carry out directly or influence:

- **Direct control** – measures to improve EV infrastructure provision on the Council's own estate defined as the Council's own operational buildings or at Council owned or managed public parking, and through the procurement or licensing of EV charging infrastructure.

5.2.2. The Councils also have extensive direct and indirect spheres of influence:

- **Direct influence** – measures that will have a direct impact on the EV infrastructure provided by others through planning and infrastructure policies;
- **Wider influence** – through partnerships, advice, lobbying and leadership.

5.2.3. Viewing the challenges for EV charging infrastructure through these three lenses gives us an indication of what actions the Councils can take, how they can be prioritised, and what impact they are likely to have on the development of EV charging infrastructure over the coming five years.

6. Quantity of EV charging

6.1. Targets for EV charging in Oxfordshire

6.1.1. Predicting the absolute number of EV chargers that will be needed in the future is highly complex; rapidly changing vehicle and charging technologies, economic factors and dependence on public behaviour change means there is a great deal of uncertainty.

6.1.2. A European directive[xiii] on the deployment of alternative fuels infrastructure recommended in 2014 that "the appropriate average number of recharging points should be equivalent to at least one recharging point per 10 cars". This ratio applies to public chargers and does not include home chargers. Using this ratio, we would need at least 2,500 to 3,000 public charge points across the county in order to meet the charging need for the 25,000 to 30,000 EVs on Oxfordshire roads by 2025 predicted by the University of Oxford[xiv].

6.1.3. This simple metric does not differentiate between the different speeds of chargers, or how accessible they are. A rapid 50kW charger may serve 4 to 5 times the number of EVs in a day that a standard 3-7kW charger can, and a charger which is open to the public for 12 hours of the day, can notionally serve half as many vehicles as one which is available 24/7. However, the higher costs of rapid and ultra-rapid EV charger installation can often be passed on to the end user in higher tariffs, and so this must be taken into consideration when designing a strategy for EV Infrastructure which promotes value for money. The assumptions upon which the original metric was based may no longer be relevant; the number of chargers needed may not require the same level of increase in line

with projected increases in EV uptake, given longer battery ranges, new charging technologies and a greater proportion of EVs able to use faster rapid charging technologies[xv]. For these reasons, campaign groups are calling for the metric to be reviewed as part of the review of the Alternative Fuels Infrastructure directive in 2020. It is recommended that when establishing the number of new chargers required in Oxfordshire to meet future demand, the Councils' approach follows the weighting method proposed by T&E.

Figure 7 - The Transport & Environment Charger Weighting Metric

Transport & Environment (T&E), a European clean transport campaign group, has designed a new metric. Instead of simply counting each charger as one, this metric weighs the energy they can provide to the EV fleet and how available they are to the public. The T&E ratio model proposed gives each different charging speed a weighting:

- 1 for single phase 3-7 kW Slow Charger
- 2 for tri-phase 7-22 kW Fast Charger
- 4 for 43 kW AC Rapid Charger
- 5 for 50 kW DC Rapid Charger
- 10 for 150 kW and above Ultra-rapid Charger

If we accept the EU's recommended ratio of 1 charger per 10 cars as a base line for 3-7kW chargers, then higher power chargers can be weighed against the target according to the equivalent number of 3-7kW chargers they represent. For example, if Oxfordshire were to rely solely on rapid charging at 50kW per hour, the equivalent of the recommended EU ratio could be met by 800 rapid charge points.

6.1.4. With the current public EV charging provision providing the equivalent of approximately 1,464 3-7kW chargepoints, and the pipeline of the Council's EV charging projects planned over the next two years providing the equivalent of over 900 3-7kW chargepoints, the equivalent of **1,636** further 3-7kW public chargepoints could be required to meet potential demand.

Table 3 – Oxfordshire's planned pipeline of EV charger installations

Project	Number of chargepoints	Chargepoint Speed	T&E Weighting	3-7kW chargepoint equivalents
Park and Charge	280	7-22kW	2	560
Go Ultra Low Oxford: On-street	100+	Up to 7kW	1	100
Energy Superhub Oxford	18 4 20	150kW+ 50kW 22kW	10 5 2	180 20 40
West Oxfordshire EV Charger project	10	7kW	1	10
Total	**432**	**N/A**	**N/A**	**910**

Policy EVI 1: The Councils will collaborate to enable and encourage deployment of public EV chargepoints in Oxfordshire towards meeting predicted demand by 2025 in line with national targets and with reference to European directives.

Key actions:

- ✓ The Councils will use their best endeavours to enable a geographically and socially inclusive EV charging network which promotes equal access to EV charging for those in rural and remote locations and areas of deprivation based on available evidence of EV charging need.
- ✓ The Councils will collaborate to share project learnings, access to charging demand and charger locations data and tools amongst themselves where legally permitted to do so with each other.
- ✓ New data agreements will be developed to allow data sharing and tools access between the two tiers in regard to charging demand and locations data.
- ✓ The Councils will continue the collaborative approach used in the development of the Oxfordshire EV Infrastructure Strategy through regular meetings of a Working Group of officers involved in EV infrastructure and other EV related projects.

6.2. Funding public EV chargers

6.2.1. EV charging is a developing market, and business models for successful operation of charging networks are evolving rapidly.

6.2.2. The costs of installing and operating EV charging equipment require both upfront capital and ongoing revenue funding. The bulk of capital funding is spent in the connection of the EV charger to the energy network, and remains fairly static, while chargers themselves have significantly reduced in cost as technology has developed and demand increased. Ongoing and essential inspection and maintenance of chargers represent the bulk of revenue costs, with back-office and data connection fees taking a smaller part.

6.2.3. Local authorities have taken various approaches to the funding and ownership of EV charging infrastructure. During the first wave of infrastructure deployment, several authorities, including Bristol City Council and Transport for London, invested in procuring EV chargers which were owned and operated by the authorities, who received revenue from the chargers, and committed ongoing funding to support the contract management, maintenance and operation of the charging network. This approach saw local authorities acting as Charge Point Operators (CPOs) and required significant resourcing to manage the network.

6.2.4. A financial model developed for the Councils, based on owning and operating EV charging in house, demonstrates that in car parks Councils could reach

breakeven on operating costs for fast chargers after 4 years (including potential loss of income from parking fees, where they apply) if charger utilisation is high at 6 charging events per day. However, if utilisation drops below this point to levels more usually indicated by market engagement, the ongoing revenue losses will be considerable, leaving the Councils with significant ongoing funding commitments for several years.

6.2.5. The high cost of installing and managing EV charging equipment in house means that it is unlikely that Councils will be able to fund this without ongoing government funding and private investment.

6.2.6. CPOs frequently offer investment via a concession model, whereby local authorities can 'host' chargers operated and managed by the CPO at little or no cost to the local authority, while revenue from charging is retained by the operator or shared with the host. The larger scale of the networks operated by commercial businesses allow them to benefit from savings in operating costs which are not readily accessible to Councils running smaller networks in-house. This model has been successfully used around the country, including Oxfordshire, in areas where usage and turnover are high, such as in car parks or charging hubs, where the investment can be recouped relatively quickly.

6.2.7. In instances where usage and turnover of EV chargers are low, particularly on-street EV charging in residential areas, the business case for operators is more challenging. The government's On-Street Residential Chargepoint Scheme (ORCS) provides capital match funding for local authorities up to £6,500 per charger, but as it does not provide revenue funding for the ongoing operation and maintenance of the chargers. Therefore, the business case for operators may still be less attractive where return on investment is uncertain.

6.2.8. This may lead to challenges for Councils in encouraging CPOs to install in less economically viable areas without funding aspects of operation and maintenance, or entering into very long agreements, which limits their ability to request charger upgrades or seek new providers if the incumbent is under-performing.

6.2.9. The economics for on-street residential charging will continue to be challenging until the tipping point for EV adoption is closer, and analysis of and improvements in deployment costs, commercial models and actual asset utilisation can be assessed and addressed more fully. This may continue to require government grant funding to help de-risk EV charger deployment. Government has committed funding to support the development of new business models for 'on-street' residential EV charging; Oxfordshire's Councils are involved in three projects which explore new business models for delivering EV charging access by lowering costs, avoiding the higher costs of charging at the roadside, developing new models of asset ownership and opportunities for alternative funding streams.

6.2.10. In order to facilitate deployment of a high quality EV charger network for Oxfordshire, we need to continue to be at the forefront of working with the private sector and exploring funding models for EV charging while the market is still evolving.

Policy EVI 2: The Councils will collaborate to seek funding for EV infrastructure and support the development of a self-sustaining EV charging network for Oxfordshire which relies less heavily on continuing public finance support in the future and minimises the impact on existing and future Council budgets.

Key Actions:

- ✓ The Councils will collaborate to seek government and other funding for, and private investment in, Oxfordshire's public EV charging network
- ✓ Oxfordshire County Council's EV Integration team, working in partnership with industry and the District & City Councils where appropriate, will continue to seek project or other funding to explore sustainable business models for EV charging

7. Delivering EV charging

7.1. Public charging in local authority car parks

Setting targets for EV charging spaces

7.1.1. Oxfordshire's local authorities have direct control of over 90 off-road car parks and 'Park and Ride' sites located across the county, in addition to other car parking at leisure and community centres. The County Council also manages larger areas of on-street parking laid out in car park style at Broad Street and St. Giles in Oxford, which for the purposes of target setting in this document we will include under the definition of car parks.

7.1.2. Car parks controlled by the six local authorities provide over 14,000 car parking spaces to local residents, businesses, visitors and travellers in Oxfordshire. As discussed in section 6.1, to meet destination charging demand from the expected number of EVs on Oxfordshire's roads by 2025, the recommended number of 3-7kW equivalent chargepoints calculated using the T&E metric is 2,500 – 3,000.

7.1.3. Charging in public car parks and park and ride sites can be a valuable resource for users charging their vehicles while visiting other amenities in the local area – known as destination charging - but can also have great value for local residents without access to a private driveway or garage where they can charge from their home power supply. This dual use helps to maximise usage of the chargers and supports the business case for charger deployment as discussed in section 6.2.

7.1.4. Oxfordshire's local authorities therefore have an opportunity to make a large contribution to the public EV charging network by introducing EV charging into their own public car parks and park and ride sites.

7.1.5. If 7.5% of Oxfordshire's local authority-controlled car park spaces were provided with EV charging, this would total over 1100 spaces dedicated to EV charging. If the chargers provided were all 7-22kW 'fast' chargers or greater, this would meet all of Oxfordshire's likely destination charging needs for 2025 and over 70% of the predicted need up to the end of 2027. If carefully located, these chargers can also be used to support residents without off-road parking.

7.1.6. Oxfordshire's Councils are already actively deploying EV charging in their car parks across the county. Here we show how many charging spaces will be made available. The Councils' two major car park based EV charging projects will enable the Councils to reach over 40% of the 710-space target by June 2022.

Project	EV charging spaces	Expected completion
Park and Charge	280	March 2022
Energy Superhub Oxford	42	June 2022
Total	312	

Policy EVI 3: The Councils will aspire to reach or exceed a target of converting 7.5% of local authority managed public car park spaces, to fast or rapid EV charging by 2025.

This target will apply across each Council's entire parking estate to allow for challenges in very small or isolated car parks, and include some of Oxfordshire County Council's 'car park style' on-road public car parking where appropriate.

Key Actions:

- ✓ The Park and Charge project will be completed by March 2022 and will deliver up to 280 charging spaces
- ✓ The Energy Superhub Oxford Project will be completed by June 2022 and will deliver up to 42 charging spaces
- ✓ The Councils will collaborate to deliver further EV charging projects to reach or exceed the target by end of 2025
- ✓ The Councils will continue to monitor plug-in vehicle uptake in Oxfordshire and usage of the Councils' EV charger network annually to assess if the 7.5% chargepoint target is appropriate. The target will be formally reviewed in 2023

Managing EV charging in our car parks

7.1.7. In order to ensure that EV drivers have a consistent and positive experience of using EV chargers, the Councils also have the opportunity to align policies for the management and deployment of EV charging at their sites.

7.1.8. EV drivers frequently report that EV chargers are blocked by petrol or diesel cars inappropriately using EV charging bays (known as ICE-ing). Drivers also report frustration at finding EV charging bays blocked by EVs which have finished charging, but which have not been moved. Reservation of bays adjacent to EV chargers, setting maximum stay times which are appropriate to the speed of charging and use of the car park, and appropriate and regular enforcement of the car park rules can all help to improve the customer experience and increase usage of charging points.

Policy EVI 4: The Councils will manage parking bays for EV charging in local authority car parks to encourage both destination and overnight EV charging and for all types of EV ownership, including private vehicles, shared or car club vehicles, and business vehicles where appropriate

Key Actions:

- ✓ The Councils will use enforceable Parking Orders to reserve parking bays with EV chargers for charging EVs or specific car club vehicles only in order to prevent and enforce against their misuse
- ✓ The Councils will embed charging time limits for EV charging bays during peak hours in enforceable parking orders to maximise user access to chargers. These will be appropriate to the type of charging and usage of the car park. To encourage overnight use of EV chargers for drivers without home charging access these charging time limits will not apply during night-time or off-peak hours
- ✓ The Councils will ensure that where these requirements are implemented, enforcement officers will be well briefed on how EV bays are to be enforced, and where appropriate the Councils will consider the use of technical options to support enforcement i.e. bay sensors, cameras or ANPR cameras
- ✓ To encourage overnight use of EV chargers for drivers without home charging access, those Councils which charge an over-night parking fee will seek ways to remove or reduce parking fees for those unable to charge at home. Parking fees at other times of day will continue to apply (where appropriate) when vehicles are charging
- ✓ To ensure customers are confident in using EV charging bays across Oxfordshire the Councils may seek to agree consistent EV charging bay markings in line with UK government and industry standards

7.2. Visitor and workplace charging at Council sites

7.2.1. The Councils have direct control over the provision of EV charging at their own premises, including workplace parking at Council offices. This section addresses the Councils' approach to providing workplace charging for visitors and staff. This strategy will not seek to set out the Councils' approach to fleet vehicle charging as this is covered by Council fleet managers within the different organisations.

7.2.2. Commuter traffic contributes significantly to carbon and NO_x emissions in Oxfordshire, as well as generating significant issues of congestion around major centres of employment. A key aim for the Oxfordshire Local Transport and Connectivity Plan 5: Connecting Oxfordshire, is to reduce harmful emissions from commuter traffic by supporting sustainable alternatives such as public and active transport.

7.2.3. The Councils are each encouraging the reduction of workplace parking and actively promoting the use of public and active transport for staff and visitors. Parking is limited at many Council sites, in particular those in Oxford. Where public and active transport are not an option, the Councils have an opportunity to set an example to businesses around the county by providing EV charging for staff and visitors, where parking is already provided.

7.2.4. The Government's Workplace Charging Scheme provides a grant to support charging infrastructure at workplaces of 75% of the purchase and installation costs of a charger capped at a maximum of £350 per socket (a maximum of 40 sockets per organisation), which hundreds of companies across the UK have used to install EV chargers for their employees and fleets. The government has also legislated so that no benefit in kind liability arises for employees who charge their own electric and plug-in hybrid vehicles at work.

7.2.5. Where feasible, workplace charging installed at Council premises could also act as EV charging hubs if accessible to the public overnight – this is being considered at WODCs Council premises as part of the Park and Charge project. In this case, it may also be possible to attract investment from CPOs into concession contracts.

Policy EVI 5: The Councils will support staff and visitors to access electric vehicle charging at Council premises where appropriate

Key Actions:

- ✓ Where visitor parking is provided at Council sites, the Councils will explore options to license or deploy EV charging
- ✓ The Councils will monitor demand for staff and contractor EV charging and seek options to provide access where necessary

7.3. Charging without off-road parking

7.3.1. As shown in section 4.6, many households in Oxfordshire have no access to private off-road parking, and subsequently have limited or no access to home charging. This is a significant barrier to EV uptake for many households.

7.3.2. Without support, some drivers may attempt their own fixes; we have seen examples of EV drivers trailing cables across the public footway to charge vehicles from their homes. This presents a significant trip hazard, is detrimental to inclusive mobility and may contravene the Highways Act (1980).

7.3.3. Providing safe alternative access to EV charging for people who must park their car on the street is therefore critical to the UK's transition to EVs, and the protection of inclusive mobility for road users with additional needs.

7.3.4. Oxfordshire County Council, as the local highways authority, recognises the need to enable safe access to EV charging for residents who must park their car on the public highway, and will seek to enable the market to provide charging access to these users in a safe and responsible manner.

7.3.5. Oxford and Oxfordshire have led the UK in attempting to address this challenge; the Go Ultra Low Oxford Project led by Oxford City Council in partnership with Oxfordshire County Council was a world first, piloting technical solutions to the challenges of on-street EV charging. The Park and Charge Project (Figure 9) has enabled Oxfordshire County Council and several of Oxfordshire's District Councils to explore an alternative to roadside EV charging; the use of public car parks in residential areas to provide access to EV charging for local people without a home EV charger.

Table 4 – Feasibility of EV charging options for residents without off-road parking

Option	Impact on streetscape & mobility	Complexity & cost	Commercial Sustainability	Scalability
Off-road fast charging hubs	Nil	Medium	High	High
Cable Gullies	Low	Low	High	High
Off-road rapid & super-rapid hubs	Nil	High	Medium	Low
Street-light charging	Low	Medium	Medium	Medium
Free-standing on-street chargers	High	High	Low	Low
Rising bollards	Medium	High	Low	Low

7.3.6. Experience from these and other Oxfordshire projects provides valuable learning, which has been instrumental in designing the approach described in this strategy. Table 4 summarises performance of different charging options for those who park on the street against four key feasibility factors.

7.3.7. Key learnings from the Go Ultra Low Oxford On-street (O-GULO) project demonstrate that installing electrical on-street EV charging infrastructure is complex, time consuming and costly to install and manage. Costly electrical/data connections and maintenance create a challenging business case for investment and limited choice for local authorities and consumers, as discussed in section 6.2. The installation of EV chargers on the public highway, if not carefully managed, may also generate street clutter and create negative impacts for road users; in particular, pedestrians and those with disabilities, potentially compromising the Council's commitment to inclusive mobility.

7.3.8. Our learnings give a strong indication that where it is possible to avoid on-street electrical infrastructure by creating off-road fast charging hubs, this is desirable, and can support better use of infrastructure and a stronger case to attract private investment. The potential to provide safe access to charge an EV with a home charger using a 'cable gully' as piloted in the O-GULO project may help us to support on-street EV charging at mass scale, simply and cost effectively.

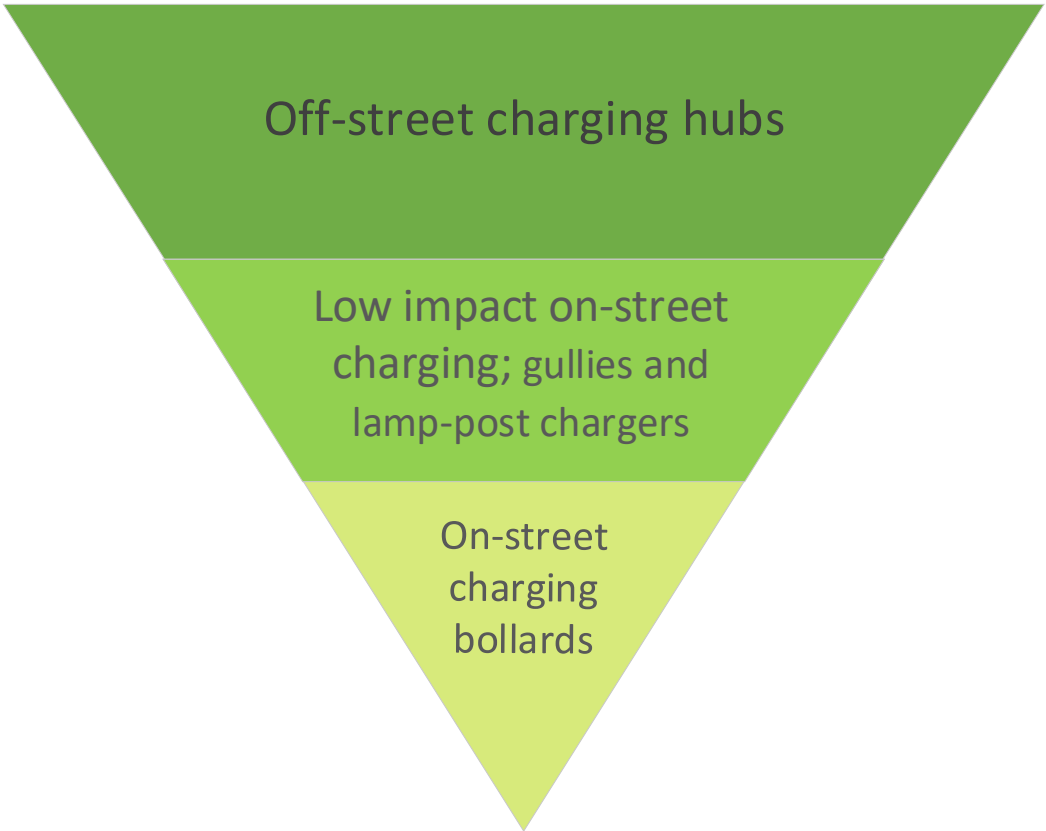


Figure 8 - Priorities for supporting charging without off-street parking

7.3.10. The Councils therefore consider that in the framework of options for supporting drivers without off-street parking, these opportunities are key priorities for deployment (Figure 8). The Councils also recognise that in some cases, there may be no alternative to providing on-street EV charger installations, and will continue to support these installations where necessary due to;

- Lack of suitable land for off-road EV charging hubs in the local area
- Disability status which would preclude an individual user from accessing an off-road charging hub.

7.3.11. A recent study by specialists in geo-spatial mapping indicates that where on-street EV charging is deployed, appropriate siting in areas of high need can reduce the number of on-street EV chargers required[xvi]. Funding for the Ox Gul-e project (Figure 10), which is investigating the feasibility of cable gullies, will enable Oxfordshire County Council to develop tailored site analysis tools to support staff making decisions on appropriate locations for on-street EV charging.

Policy EVI 6: Recognising that lack of off-road parking may be a significant barrier to EV take-up, Oxfordshire County Council will promote a hierarchy of solutions to EV charging for residents, businesses and shared vehicles without access to off-road parking, which prioritises off-street charging hubs, and other solutions which avoid generating additional street clutter or surrounding maintenance and management challenges.

Key actions:

- ✓ Develop and publish detailed policy for the deployment of safe, convenient and accessible chargepoints on the public highway for residents, businesses, and shared vehicles where there is no option to avoid on-street chargepoints, while considering inclusive mobility and the needs of pedestrians and other road users.
- ✓ Develop a scheme to license the deployment of on-street EV charging infrastructure and its ongoing management, maintenance and future-proofing, which meets the requirements of this policy by appropriate and competent organisations
- ✓ Develop a customer service process for the management of requests for on street EV charging, and implement a centralised database of requests to inform future deployment of EV charging hubs and on-street EV charging
- ✓ Work with partners to fund and deliver specific projects exploring new technologies, business models and opportunities to enable access to EV charging for residents and businesses without access to private off-road parking, for example Park and Charge, Ox Gul-e, Go Ultra Low Oxford On-street and other future opportunities

Figure 9 - Park & Charge Oxfordshire

The Park and Charge Project is an Innovate UK funded partnership involving SSE Utilities, Zeta Group and others, designed to explore a new model of providing EV charging for those without off-street parking at local 'over-night charging hubs.'

This project aims to demonstrate the potential for the over-night hub model with a pilot to install up to 280 chargepoints in Council car parks in areas where demand for on-street charging is likely to be high.

Local people will be able to use the over-night hubs at a discounted rate, before moving their car the following day, freeing up the charger for use by other drivers.

The Electric Vehicle Supply Equipment (EVSE) used will be 'fast' 7-22kWh chargers enabling them to be used at higher power during peak hours if the necessary power is available.

The model has the advantage of reducing the need for local authorities to install more chargers on the public highway, and the greater risk, cost and complexity associated with this approach.

Figure 10 - Spotlight on Ox Gul-e

Ox Gul-e is a £160,000 Innovate UK funded industrial research and feasibility project which will in will enable Oxfordshire County Council and Oxford Direct Services to build on the cable gully concept originally piloted in Oxford as part of the Go Ultra Low Oxford Project led by Oxford City Council and Oxfordshire County Council.

Current on-street EV charging infrastructure is complex, costly to install and manage. Visually unappealing, current charging points tend to clutter streets and costly electrical and data connections coupled with constant maintenance creates a weak business case for investment. This has led to limited choice for local authorities and consumers.

The project will deliver a prototype design for a purpose-built cable gully, explore how new EV charging solutions can be funded sustainably in the future, and develop the processes and policies to roll the new solution out across Oxfordshire and further afield.

8. Using the planning system

8.1. EV charging in new developments

8.1.1. Local planning policies in England are guided by the National Planning Policy Framework (NPPF)[xvii] which plays an important role in future proofing new developments. The planning system should help to shape places in ways that contribute to radical reductions in greenhouse gas emissions, and infrastructure to mitigate climate impacts and support renewable and low carbon energy and infrastructure. The NPPF states in paragraph 105.e that:

> *"If setting local parking standards for residential and non-residential development, policies should take into account: a) the accessibility of the development; b) the type, mix and use of development; c) the availability of and opportunities for public transport; d) local car ownership levels; and e) the need to ensure an adequate provision of spaces for charging plug-in and other ultra-low emission vehicles."*

8.1.2. And in 110.e that applications for development should:

> *"be designed to enable charging of plug-in and other ultra-low emission vehicles in safe, accessible and convenient locations"*

8.1.3. Through the planning system, the Councils have the opportunity to use their direct influence on developments to improve provision of EV charging via strategic infrastructure and transport planning, local plans, guidance and conditions.

8.1.4. The Oxfordshire District Councils currently have a variety of planning policy requirements covering climate change, air quality and zero and ultra-low emission transport. All the District Councils include statements supportive of sustainable transport and some specifically encourage improved EV charging provision. Oxford City Council's recently adopted Oxford Local Plan 2016-2036 and the emerging Area Action Plan for the Salt Cross development in West Oxfordshire also set out planning conditions for the quantity of EV chargers to be provide in new developments. These standards are set out in Policy EVI 8: below.

8.1.5. South Oxfordshire District Council's recently adopted Local Plan 2035 (Policy Trans 5) requires proposals for all types of development to be designed to enable the charging of plug-in and low emission vehicles and to provide facilities to support the take up of electric and/or low emission vehicles. Further guidance will be provided in the District's forthcoming Design Guide (Supplementary Planning Document). The Cherwell District Council Local Plan and Vale of White Horse District Council Local Plan are due for or in the process of review and the Councils are currently considering options.

8.1.6. The government has consulted on proposed changes to the English Building Regulations regarding EV charging provision in new developments, which it is believed will serve as the national minimum acceptable standard. Further details of the proposed changes can be seen in Figure 11.

Figure 11 - The Governments Proposed Changes to Buildings Regulations

In July 2019 the government launched a consultation on its proposals to set minimum requirements for EV charging infrastructure in new and existing residential and non-residential buildings. The consultation proposed the creation of a new part to the English Building Regulations requiring EV charging infrastructure in new buildings and buildings undergoing material change of use and major renovation.

Policy position: Residential Buildings
The government proposes requiring every new residential building or residential building undergoing major renovation with more than 10 car parking spaces to have cable routes for EV chargers in every car parking space.

Policy position: Non-Residential Buildings
The government proposes every new non-residential building and every non-residential building undergoing a major renovation with more than 10 car parking spaces to have one charger and cable routes for an EV charger for one in five spaces. The government proposes a requirement of at least one charger in existing non-residential buildings with more than 20 car parking spaces from 2025.

8.1.7. The quantity of EV charging proposed by the government fall below those set locally by Oxford City Council and other local authorities in the UK in their local plans. The Councils have a desire to stretch beyond these base standards to ensure new developments are future proofed for the predicted rapid uptake of EVs in Oxfordshire.

8.1.8. The Councils recognise that the quality of EV charging for residents and businesses in Oxfordshire is also critically important for EV charging infrastructure to function as desired. In section we set out the Councils' ambitions for a high quality EV charging network for Oxfordshire, and the standards we will set to enable this.

8.1.9. In some cases, developers may lack the resourcing or expertise to understand how EV charging could be implemented or funded in communal car parks. The problem may be particularly acute for registered social landlords, where budgets are constrained.

8.1.10. In order to ensure that new developments also reach these standards consistently across Oxfordshire, it is vital to provide developers and planning

officers and developers with clear and concise information on best practice and the quality standards we expect for EV charging across the county. In addition, it is important to signpost to national and local organisations which can provide guidance on low or zero capex options for EV charging deployment and provide low cost access to clean electric vehicles through electric car clubs.

8.1.11. The policies below set out the Councils' ambitions to stretch beyond the Governments proposed changes to the English Buildings Regulations, align planning policy requirements for EV charging infrastructure in local plans, and support the local planning system through development of clear guidelines on EV charging for both developers and planning officers.

Policy EVI 7: The Councils will seek to include statements and policies supportive of EV charging infrastructure and, where appropriate, references to the Oxfordshire Electric Vehicle Infrastructure Strategy in their planning standards and guidance.

Key Actions:

- ✓ Oxfordshire County Council will include statements and policies supportive of EV charging infrastructure in:
  - o The Oxfordshire Plan 2050
  - o Connecting Oxfordshire: Local Transport and Connectivity Plan
  - o Highways Asset Management Plan and Network Management Plan
  - o Other relevant planning documents
- ✓ The Councils will collaborate to develop a Technical Advice Note for developers and planning officers which will;
- ✓ Share knowledge of best practise and promote the Oxfordshire Standards for EV charging deployment, on-going management, and maintenance, and future-proofing
- ✓ Signpost to organisations who can provide guidance on funding and delivering EV charging
- ✓ Promote electric car clubs in new developments

Policy EVI 8: ***The Councils will benchmark nationally, and between themselves, each seeking to set minimum standards for the quantity of EV charging to be provided in developments in their planning requirements.***

The standards set will seek to meet or exceed those set in the Oxford City Council Local Plan (2016-2035) which state that;

- ***Where parking is to be provided, planning permission will only be granted for developments if:***
  - ***Provision is made for EV charging points for each residential unit with an allocated parking space; and***
  - ***Non-allocated spaces are provided with at least 25% (with a minimum of 2) having electric charging points installed.***
- ***Planning permission will only be granted for non-residential development that includes parking spaces if a minimum of 25% of the spaces are provided with electric charging points.***

Key Actions:

- ✓ Oxfordshire County Council will include minimum standards on the quantity of EV charging points to be provided in new developments in the Oxfordshire County Council Street Design Guide and Oxfordshire Parking Standards.
- ✓ The District and City Councils will include minimum standards on the quantity of EV charging points to be provided in Local Plans when these are reviewed; and Supplementary Planning Documents and Air Quality Action Plans if appropriate to provide additional detail.

Policy EVI 9: ***The Councils will seek to provide support and guidance on EV charging provision to Town and Parish Councils, and other groups writing Neighbourhood Plans***

Key Actions:

- ✓ Oxfordshire County Council will include guidance on EV charging and links to the OEVIS and on-street EV charging policy in the Oxfordshire County Council Neighbourhood Planning Guide
- ✓ The Councils will respond to queries from those preparing Neighbourhood Plans in order to share knowledge of best practice for EV charging infrastructure.

8.2. EV charging in historic areas

8.2.1. Installing an EV charger at an existing private property or in car parks, is generally classed as permitted development under the General Permitted Development Order[xviii]. For on-street parking, the General Permitted Development Order grants planning permission to development by local authorities including EV charging[xix].

8.2.2. These permitted development rights can be suspended in designated conservation areas by means of an Article 4 Direction, and do not apply in the curtilage of a listed building or Scheduled Monument. Those wishing to install an EV charger at a listed building or in a designated conservation area may need to apply for listed building consent. If restrictive Article 4 directions were introduced in Oxfordshire, this could impact significant areas of the county (see Table 5 below) potentially creating significant challenges for:

- Residents wishing to install home EV chargers
- The deployment of on-street EV charging infrastructure, and EV charging in public car parks.

Table 5 - Listed buildings and conservation areas in Oxfordshire

Local Authority Area	Listed Buildings	Conservation Areas
Cherwell	2300	60
Oxford	1500	18
South Oxfordshire	3500	72
Vale of White Horse	2000	52
West Oxfordshire	3254	51
Oxfordshire Total	12554	253

8.2.3. There are no current Article 4 directions specific to EV chargers in conservation areas in Oxfordshire. However, management of street furniture is noted as an important factor in several of Oxfordshire's conservation areas. As charger infrastructure becomes more common, there may be a need or desire to manage EV charging in historic areas in order to protect their appearance and character. In response to the needs of local authorities, the market is developing more varied and elegant designs, some specifically tailored to blend in with a historic environment; in Oxford the GULO project piloted a charging socket installed into a heritage style bollard[xx].

Policy EVI 10: ***In order to manage the impact of EV chargers without restricting access to EV charging, the Councils will define and communicate the design features of EV chargers which will have the most positive impact on the character of our cities towns and villages, and ensure that where there are specific heritage conservation needs, these are met by the charging equipment deployed.***

Key Actions:

- ✓ The Councils will collaborate to develop an information sheet for officers and the public giving examples of EV charging equipment used around the UK in conservation areas and on or near listed buildings, and signposting to guidance from organisations such as Historic England.
- ✓ Where there are any local heritage concerns for the Councils, the proposals for the EV Infrastructure will be carefully assessed in relation to its immediate setting and surroundings and its impact on streetscape quality. Any harm will be weighed against public benefit in accordance with local planning policies and the NPPF
- ✓ Where Article 4 directions in conservation areas are introduced to manage EV charger installation, Oxfordshire County Council will require all EV charging infrastructure deployed on the public highway to meet local planning requirements for heritage conservation.

9. Influencing others

9.1. Commercial car parks

9.1.1. As identified in section 7.1, the have a pipeline of planned EV charging projects, and will commit to convert 7.5% of the county's 14,000 local authority owned/managed off-road car park spaces to EV charging spaces with 7-22kW chargers. This will make a significant contribution towards providing for Oxfordshire's EV charging needs, but will still leave more EV charging point equivalents required to future-proof for the demand predicted in section 6.1.

9.1.2. Using the EU recommended ratio of chargers as a benchmark, we can see that to meet the predicted demand for over owners and managers of other car parks also need to deliver EV charging.

9.1.3. Public car parking at large retailers, supermarkets, shopping centres and transport hubs such as railway stations present an opportunity to provide EV charging for users of these amenities, and like car parks owned by local authorities, could provide vital support with EV charging for those unable to charge an EV at home or off-road at business premises. Across the UK, commercial organisations are installing rapid and fast charging at many of their

sites[xxi], including a large scale EV charging hub with 50 fast EV chargers at the Westgate Centre in Oxford. A review of EV charging at UK supermarkets from 2017 indicated that on-site EV charger deployment was increasing amongst supermarket retailers[xxii], since then several large companies have announced plans to boost EV charging at their stores across the country in the last 3 years[xxiii]. Other commercial organisations such as pub and restaurant chains and hotels are also beginning to offer EV charging to customers[xxiv]. However, many smaller, locally based companies are equally well located to provide EV charging, but lack the resourcing or funds to take up the opportunity.

9.1.4. The Councils also have established relationships with organisations such as OXLEP, the Low Carbon Hub and Oxfordshire Greentech, which could be leveraged to encourage workplace EV charging in Oxford and more widely across Oxfordshire. The latter two organisations already work with commercial organisations across Oxfordshire to deliver low carbon infrastructure and renewables projects and have established relationships with many organisations keen to support EV charging.

9.1.5. Funding opportunities from the government may enable future projects to take place in partnership with businesses and landowners which could support resourcing at the Councils to deliver this engagement and the potential projects.

9.1.6. EV charging provided by commercial organisations for their customers is a useful step towards supporting those drivers who already have access to a charger at home, but significantly greater benefits could be realised if those charger assets were made available to local people without access to off-road EV charging at home.

9.1.7. As discussed in section 7, the Park and Charge project is piloting the dual use of EV charging hubs in car parks for both destination charging and as overnight EV charging hubs, providing evidence which could help to influence owners or managers of private car parks to provide more public EV charging, and to open it up to local users outside of regular customer hours.

Policy EVI 11: The Councils will seek opportunities to encourage organisations, businesses and other owners of commercial public and customer car parks to deploy public EV charging infrastructure where it is appropriate

Key Actions:

- ✓ The Councils will seek opportunities to signpost commercial organisations and businesses to local and national partner organisations to promote the deployment of EV charging in commercially owned car parks.
- ✓ The Councils will seek funding opportunities to support resourcing of engagement with commercial organisations to encourage EV charging in privately owned car parks.
- ✓ Oxfordshire County Council will disseminate learning from the Park and Charge project to encourage the suitable development of overnight EV charging hubs in commercially owned car parks.
- ✓ EV charging infrastructure in commercial car parking at new developments will be required through the development planning process as per Policy EVI 8

9.2. Communal residential car parks

9.2.1. Existing high-density housing developments often have communal parking areas for residents. These are usually separated from individual households, preventing residents installing home EV chargers or accessing the governments home charging grant. Residents who have contacted the Councils for support with EV charging indicate that in some cases housing management companies or landowners may lack the resourcing or expertise to understand how EV charging could be implemented or funded in communal car parks. The problem may be particularly acute for registered social landlords, where budgets are constrained.

9.2.2. As described in section 4.5, car clubs offer an opportunity to give wider access to clean vehicles, and reduce private car ownership in residential areas, which applies equally to both new and existing development.

9.2.3. Through our established relationships with OXLEP, the Low Carbon Hub, Oxfordshire Greentech and others, the Councils could encourage and signpost owners and managers of housing stock to available and affordable options to support tenants and leaseholders with EV charging and affordable access to clean vehicles in Oxfordshire.

9.2.4. Funding opportunities from the government may also enable future projects to take place in partnership with owners and managers of housing stock which could support resourcing at the Councils to deliver this engagement and potential future projects.

Policy EVI 12: The Councils will explore opportunities to encourage owners and managers of housing stock of all types of tenure to deploy EV charging infrastructure for residents where it is appropriate

Key Actions:

- ✓ The Councils will seek opportunities to signpost owners and managers of housing stock to our existing partner organisations to promote the deployment of EV charging and electric car clubs in communal residential car parks across all types of tenure.
- ✓ The Councils will seek funding opportunities to support resourcing of engagement with owners and managers of housing stock to encourage EV charging in privately owned car parks and electric car clubs in communal residential car parks across all types of tenure.
- ✓ EV charging infrastructure in residential car parking at new developments will be required through the development planning process as per Policy EVI 8

9.3. Workplace & business charging

9.3.1. As discussed in section 7.2, workplace EV charging, provided where public and active transport is not an option, can support commuters to switch to EVs. Workplace charging can also support businesses to switch their fleets to EVs.

9.3.2. The Councils have committed to take steps to support EV charging for visitors and staff at their own sites, but as some Councils provide very limited parking for staff, other employers across Oxfordshire must act on commuter emissions.

9.3.3. In order to further support reduction in commuter transport emissions, the Councils can act to encourage employers across Oxfordshire who provide workplace parking to offer EV charging for their staff and visitors; Workplace charging can support drivers without off-street parking at home, and can enable plug-in hybrid and range extender drivers to travel further within the electric zero emissions capability of their vehicle.

9.3.4. Oxford is the largest employment centre in Oxfordshire, attracting 45,000 private cars to the morning rush hour daily[xxv]. As part of Connecting Oxfordshire, Oxfordshire County Council and Oxford City Council are working together to develop and implement Connecting Oxford, a plan to transform public transport, walking and cycling in Oxford, including better connectivity to places of work. This will be achieved by reducing traffic levels in Oxford, prioritising bus movements and investing in new services, and freeing up more road space for pedestrians and cyclists. Less traffic and more people using public transport and active travel modes will also have air quality benefits. Included in this is improved air quality, by reducing the number of cars travelling into and around the city and encouraging more people to travel by public transport, and active transport. The proposals

include traffic filters across the city and a workplace parking levy (WPL) in the city's Eastern Arc - an area outside the city centre that links parts of north Oxford, Marston, Headington and Cowley. Those affected by the proposed WPL, including employers and their employees, could directly benefit from investment in new bus services, grants for onsite sustainable travel improvements, parking management, discounts on bus fares, park & ride buses and parking.

9.3.5. The Oxfordshire County and Oxford City Councils are currently developing a business case required to assess the full impacts of the proposals. Extensive public and stakeholder engagement and consultation is also planned to help develop and refine the Connecting Oxford proposals, with implementation currently programmed from 2023. have endorsed a full feasibility study for the introduction of the Connecting Oxford transport proposals. This feasibility study and the proposals of Connecting Oxfordshire presents direct opportunities to engage employers and encourage more workplace EV charging infrastructure in the city.

9.3.6. As described above in section 9.1, the Councils also have relationships with organisations such who are well equipped to encourage and provide support for businesses wishing to install EV charging for staff and visitors.

Policy EVI 13: The Councils will explore opportunities to encourage uptake of EV charging at workplaces and business premises where it is appropriate

Key Actions:

- ✓ Oxfordshire County Council will explore opportunities to encourage uptake of EV charging at workplaces through the developing transport plans for Oxfordshire, including through engagement with employers on the Connecting Oxford plan.
- ✓ The Councils will seek opportunities to signpost commercial organisations and businesses to our existing partner organisations engage to promote the deployment of EV charging in workplace car parks.
- ✓ The Councils will seek funding opportunities to support resourcing of engagement with commercial organisations to encourage EV charging in workplace and business premises car parks.
- ✓ EV charging infrastructure in workplace car parking at new developments will be required through the development planning process as per Policy EVI 8

9.4. Rapid charging on the strategic road network

9.4.1. The UK has one of the largest, and most comprehensive rapid networks in Europe including more than 3,500 rapid chargers [xxvi,xxvii]. The government wants to encourage and leverage private sector investment to build and operate a self-sustaining public network including rapid charging. To meet long-distance, en-route rapid charging requirements, and maximise carbon emission reductions, the number of rapid chargers located near the major roads network needs to expand to 1,170 by 2030[xxviii].

9.4.2. Highways England are the responsible authority for managing the deployment of rapid EV charging at sites on the strategic road network, including Oxfordshire's strategic road network such as the A34 and M40. The organisation has recently been awarded funding from the government and announced its commitment to ensure 95% of its motorways and major 'A' roads are within 20 miles of a charge point by the end of 2020.

9.4.3. However, there are still few public rapid or ultra-rapid chargers at sites on the strategic road network in Oxfordshire: as shown in section 4.2, only 8 are located at service or fuel stations close to major roads in the county.

9.4.4. Oxford City Council are developing a rapid and ultra-rapid charging hub at the Redbridge Park and Ride site, close to the A34 in Oxford, which will significantly boost access to high-speed EV charging for users in the county travelling via Oxford. Further rapid charging close to major roads is still required to support more rural communities and travellers in other parts of the county (see Figure 13).

9.4.5. Oxfordshire County Council has an established relationship with Highways England as the highway authority for the A34 and M40 in Oxfordshire, and with the Office for Low Emission Vehicles, and may be able to make the case for encourage deployment of rapid and ultra-rapid EV charging funded by Highways England at sites in Oxfordshire.

9.4.6. As the Highway authority for Oxfordshire, Oxfordshire County Council also has responsibility for highways land assets, including important link roads across the county and their associated lay-bys. Some of these lay-bys are large and underutilised, giving them potential for use as rapid charging stops where grid connections and space allow.

Policy EVI 14: The Councils will seek to improve the availability of rapid and ultra-rapid EV charging on and near the strategic road network and important link roads across Oxfordshire

Key Actions:

- ✓ The Oxford City Council ESO project will be delivered to meet the need for rapid and super-rapid charging for residents, businesses and travellers in and around Oxford.
- ✓ The Councils will engage with HM Government departments and agencies responsible for the roll out of EV charging infrastructure on the strategic road network.
- ✓ Oxfordshire County Council will explore options to engage the market in assessing the potential use of large laybys and other highways land assets such as Park & Rise sites for rapid and ultra-rapid EV charging across Oxfordshire.

Figure 12 - Spotlight on Energy Superhub Oxford

Oxford City Council is part of **Energy Superhub Oxford (ESO)** a £41m project to trial the world's largest hybrid battery technology in the city to support rapid and ultra-rapid EV charging, and low-carbon heat networking.

The project will see the trialling of the 50MW hybrid battery system, connected to the Cowley substation in Oxford, and will both store and re-supply electricity directly back to the grid. The battery will store and deliver power to electricity suppliers and will help to balance the local requirements for National Grid by storing electricity at times of low demand and re-supplying at peak demand. The technology will be able to shift the demand to periods of low prices, minimise bills and overcome local network constraints.

The project will enable the use of spare capacity energy to power an EV 'superhub' at the Redbridge Park and Ride site, helping to minimise the impact of large scale rapid and ultra-rapid charging on the grid. Technology from the battery will optimise time-of-day charging, with capabilities for overnight charging.

Public chargers to be installed under the project include:

- Over 20 rapid and ultra-rapid EV chargers
- At least 10 fast (22kW) chargers at the Redbridge site and another 10 at Seacourt Park and Ride.

The funding will also support the Council to work with a partner offering a 'Trial before you Buy' programme for Hackney Carriage Vehicle drivers in Oxford, and support the council in converting its fleet to electric.

10. Securing open, accessible and reliable EV charging

10.1. National legislation, standards and quality challenges

10.1.1. National and European standards give minimum quality and safety standards for EV chargers, their installation and the interface with customers.

10.1.2. The standards are set out in European and UK legislation, regulations and standards, and are adhered to by professional manufacturers, installers and operators of EV charging infrastructure. Table 6 gives a high-level description of some of the key standards, and a comprehensive review can be seen in Annex 3.

10.1.3. Any chargers funded by OLEV On-street Residential Charging Scheme (ORCS), or Workplace Charging Scheme must also meet further specific requirements.[xxix,xxx]

10.1.4. These are the minimum baselines which all EV charging must meet. However, reliability, ease of use and access, and the customer experience continue to be a concern for users.

10.2. Reliability

10.2.1. Reliability of EV charging has improved since the first wave of EV infrastructure funding saw first-generation chargers installed under the governments plugged-in places schemes, but consumers still rate reliability as their overriding consideration[xxxi], and 21% of public EV charging network users have had negative experiences when using the charging network[xxxii].

10.2.2. Technical standards for equipment which reach above and beyond those set at the European or national minimum levels can help to increase the reliability of EV charging equipment. Chargers which enable remote fixes to technical failures reduce the need for engineer callouts and thus 'downtime' for EV chargers, and modular design which allows a section of the charger unit to be replaced, rather than a small component or the entire unit, can speed up repairs when an engineer is needed.

10.2.3. Reliability of EV chargers is also strongly linked to their operation and maintenance. To ensure that chargers function as desired, they must be operated and regularly maintained by a competent contractor. Experience from GULO projects show that where this is not the case, incidence of charger failure and safety breaches are high.

10.2.4. Well-designed and thorough contractual arrangements for maintenance and operation of charging points by a competent contractor are necessary to meet customer needs and avoid poor reliability of charging networks. Resources for the management of contracts or licences to operate EV charging equipment are also essential to ensure that operators meet their obligations[xxxiii].

10.2.5. A plan for the renewal of assets at the end of their lifetime is also critical to ensuring the reliability of the network continues as technology changes and improves.

Table 6 - Key Regulations & Standards

Legislation, regulation standard	High-Level Description
The Alternative Fuels Infrastructure Regulations 2017	Key requirements which are not already captured in other standards: • Infrastructure operators must provide to any person ad-hoc access to charge • Equipment must incorporate an intelligent metering system
Autonomous and Electric Vehicles Act 2018	Gives the government powers to impose regulations on: • Public charging or refuelling points: access, standards and connection • Provision of specific information for users of public charging or refuelling points • Transmission of data relating to charge points
OCPP Open Charge Alliance Open Charge Point Protocol	Open industry standard that enables charger sellers and network operators to "mix and match" interoperable hardware and software: • Compliant hardware can be used across a range of different cloud based back end software. • All chargers should be OCPP 1.6+ compliant.
Electricity Safety, Quality and Continuity Regulations (ESQCR)	Statutory legislation that governs the supply of electricity to users: • All installations must comply. • Relevant elements for the EV charger installer are interpreted into BS7671.
BS7671:2018 (+A1:2020) Electrical Installations (IET Wiring Regulations)	The UK standard to which all electrical installations must conform. • The 18th Edition IET Wiring Regulations contains important new information for all electrical installers and engineers. • Section 722 relates specifically to the installation of EV supply equipment.
IET Code of Practice for EV Charging Equipment Installation 4th Edition	An overview of EV charging equipment installation considerations on: • Physical installation requirements • Relevant electrical installation requirements of the updated BS 7671:2020 • Specific requirements when installing EV chargers in locations such as dwellings, on-street, commercial and industrial premises.
BS 8300: 2018 Design of an accessible and inclusive built environment.	Standards for accommodating users with the widest range of characteristics and capabilities: • Defines the height from the ground of the socket outlet (also stated in BS7671 & IET CoP) • Includes clearances for wheelchairs around street furniture.

10.3. Instant access

10.3.1. The early development of the UK public EV charging market led to the creation of 'closed' EV charging networks, where access to charge was limited to subscribers or members. In the United Kingdom, EV drivers carry on average 3.19 charging network cards. Open access to roam across networks with a single card is seen as an important point for future improvements to the EV charging network by consumers[xxxiv].

10.3.2. The government has taken steps to increase access to EV charging on an 'ad hoc' basis via the Alternative Fuels Directive which demands that infrastructure operators provide to any person ad-hoc access to charge without need for a membership. The easiest interpretation of this is to allow credit/debit card payments, and some operators are now enabling contactless or NFC payment (Apple Pay, Google Pay etc.), but many other charging networks are slow to deploy these technologies unless they are specifically requested. Some operators have made the case that if their App can be downloaded at any time and a driver can then immediately access the charger once they have setup up the App, then this can be considered ad-hoc access. However, this requires access to a smart phone and makes ad hoc charging more time consuming and complex than many consumers prefer.

10.4. Charging standards for Oxfordshire

10.4.1. Oxfordshire's ambitions for an EV charging network include creating a truly open network, which ensures easy, consistent access to anyone wishing to use a charge-point across Oxfordshire. To achieve the high quality EV charging network we are striving for, the Councils have collaborated to develop a set of minimum standards for EV charging equipment deployed on-street and in local authority car parks, which will also form the basis of advice for advice on EV charging in new developments.

Policy EVI 15: The Councils will encourage the deployment of a high quality, reliable, open, value for money, future-proofed and truly instant access EV charging network for Oxfordshire by setting high standards which seek to reach 'above and beyond' minimum legal requirements

Key Actions:

- ✓ Procure, license or otherwise deploy only EV charging which meets or exceeds the national standards and the Oxfordshire EV Charging Standards detailed in Annex 3: EV Charging Standards
- ✓ Review the Oxfordshire EV Charging Standards on a regular basis and as technologies and business models develop.
- ✓ Seek the best value for users by using the procurement and licensing processes to encourage CPOs to offer opportunities to benefit target groups, such as those

who must park on the street, taxi drivers and operators, or other businesses through different rates for EV charging over-night and during daytime hours, or other measures which incentivise take up amongst target groups.

- ✓ Encourage developers, and other stakeholders to meet or exceed the same standards when deploying EV charging infrastructure through planning guidance and wider engagement.

11. Powering EV charging for the future: Managing energy impacts

11.1. Impacts on the grid

11.1.1. EV charging relies on energy supply through connection to networks or lighting circuits, generating challenges in connecting EV chargers and providing sufficient power to operate.

11.1.2. Rapid charging hubs and ultra-rapid charging take huge amounts of energy out of the grid at busy times, which can lead to expensive upgrading of the local electrical grid, including new substations or transformers. Neither rapid or ultra-rapid charging can be considered truly 'smart'; the chargers are controlled by and communicate with a back office, but due to their nature of delivering large amounts of energy very quickly there is limited opportunity to manage the delivery of energy across off-peak hours in order to protect the grid. Even fast charger installations can require upgrades or reinforcement of networks in areas where the local network can only support small increases. The cost of these works can be prohibitive.

11.1.3. The My Electric Avenue report for SSE concluded that without managed charging, EVs could cost £2.2 billion in UK grid infrastructure[xxxv]. Traditionally, these findings would mean the replacement of underground cables in the public highway.

11.1.4. However, the government has recognised that the previous system of centralised generation of electricity transported through to the end user is changing to a more decentralised system[xxxvi] with increasing levels of low carbon and renewable generation, often connected at the local distribution network and behind the meter.

11.1.5. EVs necessarily reduce CO_2 and other harmful emissions from the tailpipe, positively benefitting the drive to reduce transport emissions. These environmental benefits can be increased if upstream carbon emissions are also tackled when EVs are charged from renewable sources.

11.1.6. To enable these changes in generation and minimise the need for conventional network reinforcement, the system is adapting to become more flexible and smarter in order to better manage the new flows in power. The

Oxfordshire Energy Strategy[xxxvii], developed by OxLEP in partnership with all local Councils, University of Oxford, Low Carbon Hub, the Distribution Network Operator and other stakeholders, and endorsed by the Growth Board in November 2018, sets objectives to:

- secure a smart, modern, clean energy infrastructure which will support planned housing, industrial and commercial growth.
- Lead nationally and internationally to reduce countywide emissions by 50% by 2030, on 2008 levels, and set a pathway to achieve zero carbon growth by 2050

11.1.7. EVs could offer new opportunities for the power system as part of this smarter, cleaner and more flexible energy system for Oxfordshire system. Projects such as the Energy Superhub Oxford, Local Energy Oxfordshire and Vehicle to Grid Oxfordshire are already examining the part EVs could play in Oxfordshire. The EV Infrastructure Strategy has a role in ensuring that our EV infrastructure supports the aims of the Energy Strategy, minimises negative impacts on the electrical grid and is ready to respond to the learning generated in the county.

11.2. Smart EV charging

11.2.1. Smart charging, during off-peak periods and when demand and network congestion is otherwise low, means consumers can potentially benefit from cheaper pricing when charging, avoid triggering future network reinforcement, use their EVs to power their homes or businesses or sell energy back to the grid [xxxviii].

11.2.2. Since 2019 all government funded charger installations must have smart functionality. The Automated and Electric Vehicles Act (2018) also gave government the powers to ensure that all chargers sold or installed in the UK will have smart functionality.

11.2.3. In deploying or licensing privately funded EV charging infrastructure in Oxfordshire, the Councils have opportunities to require charger operators to meet the same standards set by government for smart charging. The Councils also have the opportunity to guide developers deploying EV charging to opt for smart chargers though planning advice and the proposed technical advice note to be developed.

11.3. Renewable energy, on-site renewable generation and storage

11.3.1. As the UK energy network continues to decarbonise, and charge point operators increasingly commit to buying energy from renewable sources, these upstream carbon emissions will naturally reduce. The ESO project demonstrates the potential for large scale storage to support the grid, but other projects across the UK have also made use of smaller scale battery storage, stand-alone or combined with on-site photo-voltaic generation to support EV charging.

11.3.2. The Councils could increase the use of renewables in the EV charging network, and mitigate against challenges in energy supply, by promoting the installation of on-site renewable generation and storage where EV chargers are deployed in significant numbers.

11.3.3. Designing developments with sufficient and appropriately located lower power EV charging equipment from the outset, with sufficient energy capacity to meet predicted future demand, will help to manage grid impact, meeting the EV charging infrastructure needs of residents and businesses now and in the future, efficiently and cost effectively.

11.3.4. Where properties have access only to unallocated parking on the public highway, the government wishes to encourage the use of integrated street-lighting and EV charging to avoid street clutter. Historically, street lighting circuit designs and power capacity have not been required to take into account the need for additional load from EV charging. New developments using traditional processes to design street lighting without consideration of EV charging will require costly and complex retrofitting to meet the energy demand of EV charging. This can be avoided by designing in and ensuring adequate power capacity for EV charging from the outset. Exemptions to the above requirements may be made for specific sites where planning restrictions apply.

Policy EVI 16: The Councils will seek to increase the emissions reduction benefits of electric vehicles, and mitigate the impact of EV charging infrastructure on the local and national grid by encouraging and promoting the use of renewable energy for EV charging, encourage 'off-peak' use of EV chargers, and exploring technical options to manage grid demand from EV charging infrastructure.

Key Actions:

- ✓ The Oxfordshire Standards set by the Councils for EV charger quality will include requirements for EV chargers to have smart functionality in line with government funding standards.
- ✓ Where it is feasible, the Councils will explore technical options to support grid management and greater reductions in transport emissions such as on-site renewable generation and energy storage.
- ✓ The Councils will encourage developers to consider the use of on-site generation and storage to support EV charging through the jointly developed Technical Advice note on EV charging in new developments.
- ✓ The Councils will set parking policies which encourage use of EV charging infrastructure in Council car parks and on the highway over-night and at other 'off-peak' times as per Policy EVI 4:

12. Promoting EVs and infrastructure

12.1.1. Given that EVs are still a relatively new phenomenon, a broader challenge beyond public charger infrastructure is the level of information and general understanding that people have regarding EVs. The Councils recognise that they are able to contribute towards information provision to help overcome this.

12.1.2. Increasing knowledge, understanding and experience of EVs can help break down the barriers to EV ownership, challenge perceptions, and give people the encouragement and reassurance they need to make the shift to a cleaner vehicle[xxxix]. Awareness of available EV charging infrastructure is also a factor in driving EV adoption[xl]. The Councils have opportunities to use their existing online presence to signpost current and potential EV drivers toward existing sources of information on chargers, and to use resources from our projects to promote EVs and a cleaner transport choice.

12.1.3. As part of the Park and Charge project, Oxfordshire County Council is spending £150,000 on a county-wide communications and education package to engage Oxfordshire residents as well as visitors and commuters to the area. This communications campaign will go beyond simply promoting the Park and Charge project and charging hubs, and will communicate much more widely about Oxfordshire's transition to EVs as a lower-carbon and cleaner way to travel. Oxfordshire County Council will work very closely with the district councils, as well as with other local initiatives such as Energy Super Hub Oxford, EV car clubs, car dealerships and local community action groups to promote the local initiatives and resources that are combining to make EVs more accessible within Oxfordshire.

12.1.4. In October 2020, Oxfordshire County Council launched an online survey to gain a greater understanding of local people's knowledge, experiences, attitudes and intentions around the use of electric vehicles and charging facilities in the area. This has provided essential insights to help effectively target communications and create the impactful messaging needed to unlock barriers and successfully steer people towards choosing electric vehicles in Oxfordshire. The survey will be repeated in late 2021 to evaluate success of the Park and Charge communications activities and inform future messaging to maintain/gather momentum in the future.

Policy EVI 17: The Councils will promote information about public EV charging in Oxfordshire, and awareness of the benefits of EVs to the public through their online and other communications channels

Key Actions:

- ✓ The Councils will promote EVs and awareness of EV infrastructure in Oxfordshire through the Park and Charge project public communications and engagement campaign, ensuring communications regarding other current EV infrastructure projects are closely linked.
- ✓ The Councils will seek to provide the public with information on public EV charging in Oxfordshire via their online communications channels, signposting to national sources of information where relevant (i.e. zap-map and government information sources).
- ✓ The Councils will seek opportunities to promote their activities around EVs and EV charging infrastructure where appropriate through project communications and other appropriate channels.

13. Annex 1: Stakeholders

13.1. The Oxfordshire Energy Strategy Steering Group Members

A member steering board made up of representatives from each of the Council's has been engaged in the development of this strategy:

Name	Council Role
Cllr Yvonne Constance	Oxfordshire County Council Cabinet Member for Environment (including Transport)
Cllr Dan Sames	Cherwell District Council Lead Member for Clean and Green
Cllr Tom Hayes	Oxford City Council Cabinet Member for Zero Carbon Oxford
Cllr Caroline Newton	South Oxfordshire District Council Climate Emergency Advisory Committee Member
Cllr Catherine Webber	Vale of White Horse District Council Cabinet Member for the Climate Emergency and the Environment
Cllr David Harvey	West Oxfordshire District Council Cabinet Member for Climate Change

13.2. External organisations represented at workshops

Town Councils, Parish Councils and Community Groups		
Adderbury Parish Council	Eynsham Parish Council	Souldern Parish Council
Bampton Parish Council	Faringdon Town Council	South Oxford Community Association
Banbury Town Council	Garsington Parish Council	Thame Green Living
Bicester Town Council	Henley-on Thames Town Council	Thame Town Council
Charlbury Town Council	Kennington Parish Council	Wallingford Town Council
Deddington Parish Council	Kidlington Parish Council	Witney Town Council
Didcot Town Council	Little Coxwell Parish Council	

Charging Industry Stakeholders
EB Charging
EZ Charge
JojuSolar
Urban Electric

14. Annex 2: Evaluation of charging options for residents without private off-road parking

Option	Streetscape & Mobility Impact	Complexity & cost of deployment	Commercial Sustainability	Scalability
Off-road fast charging hubs	**Nil** ▪ Avoids street clutter	**Medium** ▪ High density installations enable efficiencies ▪ Reduced interaction with utilities and parking regulations: deployment less complex	**High** ▪ Multiple charger installations enable cost savings ▪ ORCS funding can be accessed ▪ Use by residents and car park visitors generates higher usage and income ▪ Opportunities for private investment and concession agreements	**High** ▪ Opportunities to deploy in publicly or privately owned car parks
Cable Gullies	**Low** ▪ Integrates well into existing streetscape	**Low** ▪ Low tech and simple: reduces costs of installation significantly	**High** ▪ Potential for self-funding by residents ▪ Low maintenance requirements mean very low ongoing costs	**High** ▪ Very few limitations on where cable gullies can be deployed
Off-road rapid and super-rapid charging hubs	**Nil** ▪ Avoids street clutter entirely	**High** ▪ Multiple charger installations can enable efficiencies in deployment ▪ Reduced interaction with utilities and parking regulations makes deployment process less complex ▪ High power needs of rapid and super-rapid charging can create complexities and significant costs in securing power supply	**Medium** ▪ Higher usage across groups generates greater income for operator ▪ This is balanced by significant upfront costs for installation ▪ Opportunities for private investment and concession or hosting agreements with landowners	**Low** ▪ Suitable sites with appropriate power supplies are challenging to secure ▪ High numbers of rapid and super-rapid chargers generate significant challenges for local and national electrical grid

Street-light integrated charging	**Low** ▪ Integrates well into existing streetscape	**Medium** ▪ Relatively simple installation ▪ ORCS funding can be accessed.	**Medium** ▪ Low cost of technology and installation ▪ CPOs moving away from concession models including maintenance	**Medium** ▪ Deployment limited to areas where street-light position is at leading edge of footway ▪ Deployment limited by lighting network capacity
Free-standing on-street charger bollards	**High** ▪ Generates street clutter from charger pillar and electrical supply cabinet	**High** ▪ Dedicated electrical supply is required ▪ Low density installations: cost savings cannot be realised ▪ ORCS funding can be accessed	**Low** ▪ Higher costs of installation and low utilisation mean that residential on-street locations are less commercially viable in the near term (5-10 years) ▪ CPOs moving away from concession models including maintenance	**Low** ▪ Deployment limited by grid capacity and pavement width ▪ Lack of commercial sustainability means operators by be reluctant to install in areas likely to see low usage without subsidy
Rising bollards	**Medium** ▪ Stored below pavement surface when not in use. ▪ Some clutter impact when in use	**High** ▪ Deep excavation required, generating complexity with existing utilities and archaeological sites ▪ Dedicated electrical supply is required ▪ Costs are higher for installation. ▪ ORCS funding can be accessed	**Low** ▪ Higher costs of installation and low utilisation mean that residential on-street locations are less commercially viable in the near term (5-10 years) ▪ Charger operators moving away from concession models including maintenance	**Low** ▪ Deployment limited by grid capacity, pavement width and underground utilities ▪ Lack of commercial sustainability means operators by be reluctant to install in areas likely to see low usage without subsidy

15. Annex 3: EV charging standards

15.1. EV charger types

Slow charging at 2.4-3kW AC is most useful in home or workplace settings, where the user can charge over a longer period, and can be carried out with a standard 3-pin plug. However, it is not recommended for regular use as the UK domestic plug and socket connection was not designed for continuous loads of 10-13 amps as used by an electric car. Charger sockets of up to 5kW can also be integrated into existing electrical assets on the street, such as lighting columns.

Fast charging can range from 7.4 kW to 22kW AC is the most common type of EV charging, suitable for home, workplace, destination and on-street EV charging. Most public EV charging infrastructure is 7.4 kW though more modern chargers may be able to achieve 22kW. It should be noted that domestic household chargers are only able to deliver the lower end of this range as higher rates require 3-phase energy supply. Fast chargers can be wall or floor mounted, and most are 'smart'; able to communicate with a charger management system or 'back office' and manage the time and rate of charging to minimise the impact of EV charging on the electrical grid[xli].

Rapid charging occurs at 43kW and 50kW, and typically provides an 80% charge in 30 to 60 minutes. Units can usually supply AC (43kW) or DC (50kW) energy but not always both at the same time. Rapid charger units are most often floor mounted, larger than fast chargers and have tethered cables for each of the three vehicle input sockets used for rapid charging EVs. Rapid charging is most suitable for en-route charging and workplace charging where rapid delivery of energy is required to complete a journey or enable continued use of commercial vehicles such as delivery vans or taxis. It can also provide a useful back up for domestic users when EV charging at a slower speed is not available or feasible. Rapid charging is often seen at motorway service stations.

Ultra-Rapid charging occurs at rates above 50kW, and is only provided via DC. Ultra-rapid charging is limited by the small number of EVs in the UK which can accept charging at this level of power, however it is likely that in the future, ultra-rapid charging will replace rapid charging as the most suitable for en-route and business needs. Tesla provided the first ultra-rapid charging in the UK and others are now providing chargers which can supply energy at up to 350kW though the range of 100-150kW is more typical. Most manufacturers use one of two standard input sockets; CCS or CHAdeMO.

Table 7 gives details of EV charging types, connection types and site suitability (adapted from UK EVSE Procurement Guide, UK EVSE 2019)

Table 7- EV charging types, connection types and site suitability (adapted from UK EVSE Procurement Guide, UK EVSE 2019

Charging Type	Power Output (Kw)	Approximate time to full charge*	Miles of range per 20 minutes of charging**	Charger Socket Type	Suitable Locations
Slow	2.4-3.4 kW AC	16 Hours	2.4-3	Standard Three Pin Plug	Home*** and workplace (adhoc/emergency use)
	3.7-5 Kw AC	13.5 hours	2.7-7	Seven Pin 'Type 2' Plug	Specialist lamp column charging – on street
Fast	7-11Kw AC	5-7.5 hours	3.7-11	Seven Pin 'Type 2' Plug or tethered lead with Five Pin 'Type 1/J1772' Plug or Seven Pin 'Type 2' Plug	Home***, workplace, on street, public car parks
	11-22 Kw AC	2.5-4.5 hours	11-22		
Rapid	43Kw AC	45 minutes (to 80%)	43	Tethered lead with Seven Pin "Type 2" Plug	Workplace, en-route at motorway service stations, charging hubs, public car parks, on-street for specific use cases.
	50 Kw DC	35 minutes (80%)	20-50	Tethered lead with Heavy Duty 'JEVS G105' Plug or Heavy Duty 'Combo 2 CCS' Plug	
Ultra-Rapid	120-147 Kw DC	25 minutes (to 80%)	120-147	Tethered lead with Tesla adapted 'Type2' Plug	En-route at motorway service stations, charging hubs, public car parks
	150 Kw DC	25 minutes (to 80%)	150	Tethered lead with Heavy Duty 'JEVS G105' Plug or Heavy Duty 'Combo 2 CCS' Plug	
	350 Kw DC	15 minutes (to 80%)	350	Tethered lead with Heavy Duty 'Combo 2 CCS' Plug	

* Based on a typical EV with a 50kWh battery

**Range added per 20 minutes of charging calculated assuming a 3 mile/kWh vehicle efficiency.

*** Up to 7kW single phase only at 32 Amps AC output from a typical household single phase AC energy supply

15.2. Standards, regulations and best practice

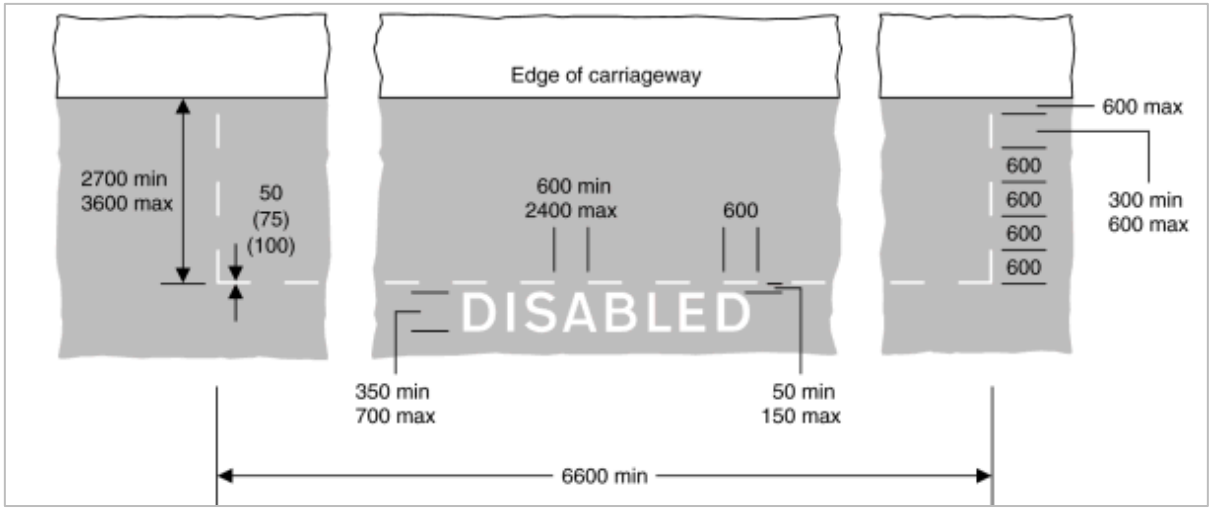
Relevant regulations: Overall deployment (2020)

Standard or Requirement	Formal Description	Commentary	Review Date
The Alternative Fuels Infrastructure Regulations 2017	Regulates alternative fuels (electricity and hydrogen) to ensure the way they are supplied to vehicles is consistent across the EU. This will reduce dependence on oil and the environmental impact of transport, while contributing to a low carbon economy. Specific standards will be mandatory for electrical vehicle recharging points. In effect, this will provide electrical and hydrogen vehicle users the ability to connect and recharge throughout Europe.	• All equipment installed must meet these high-level requirements which form a pan EU policy. Key requirements not already captured in other standards: • Equipment must incorporate an intelligent metering system – in general this is interpreted as the inclusion of a MID compliant revenue grade meter and a data collection system (Cellular/Wi-Fi/Ethernet) to send meter data to back end software for billing and presentation to the driver, generally via a smart phone App. • Infrastructure operators must provide to any person ad-hoc access – easiest interpretation of this is to allow credit/debit card payments. • Many operators are now enabling contactless or NFC (Apple Pay, Google Pay). However, some operators have made the case that if their App can be downloaded and any time and a driver can then immediately access the charger once they have setup up the App then this can be considered ad-hoc access. Generally, drivers don't see this as an ideal solution.	2022
Electricity Safety, Quality and Continuity Regulations (ESQCR)	Regulates quality and supply continuity as well as specifying safety standards. Compliance to ESQCR is a statutory requirement for distribution network operators (DNO's).	• This is the statutory legislation that governs the supply of electricity to users in the UK. All installations must to comply. In practice, relevant elements for the installer are interpreted into BS7671.	N/A
Traffic Signs Regulations and General Directions 2016-2018	Prescribes the designs and conditions of use for traffic signs to be lawfully placed on or near roads in England, Scotland and Wales.	Where there are designated EV charging bays, signage may be required: • Bays should be marked with TSRGD sign 660.9 with the permitted variant "Electric vehicle recharging point only" • Bays should also be marked, taking account of TSRGD sign 1028.3/ 1028.4/ 1032 with permitted variations "ELECTRIC VEHICLES", "ELECTRIC VEHS ONLY" or "ELECTRIC VEHS" for on road bays. • Bays in car parks should be painted green, where appropriate.	TBC

Relevant regulations: Overall deployment

660.9
Parking place with facilities for charging electric vehicles reserved for permit holders

Other



Relevant standards & legislation

Standard or Requirement	Formal Description	Commentary	Review Date
Local Planning Requirements	Specific regulation varies from one regional planning authority to next and so would need to be considered at a regional level across the UK.	• Experience of deployment by local authorities is that planning issues associated with conservation / heritage areas are often encountered. • This may result in special solutions to suit local area, e.g. all the charging equipment being coloured black.	N/A

Autonomous and Electric Vehicles Act 2018	The purpose of this legislation is both to amend the existing compulsory third party insurance framework by extending it to cover the use of automated vehicles and deal with electric and hydrogen powered vehicle charging infrastructure	• The act gives the government powers to impose regulations on the following relevant topics:
		  • Public charging or refuelling points: access, standards and connection
		  • Large fuel retailers etc: to require provision of public charging or refuelling point
		  • Provision of specific information for users of public charging or refuelling points
		  • Transmission of data relating to charge points
			N/A

Relevant standards & best practice: EV charging equipment technical standards (2020)

Standard or Requirement	Formal Description	Commentary	Review Date
IEC/EN 61851-1:2017 Electric vehicle conductive charging system - Part 1: General requirements* ***EV charging equipment must be CE marked, meeting IEC/EN 61851 can be used to demonstrate this**	Applies to EV supply equipment for charging electric road vehicles, with a rated supply voltage up to 1000V AC. The aspects covered in this standard include: • characteristics and operating conditions of the EV supply equipment; • specification of the connection between the EV supply equipment and the EV • requirements for electrical safety for the EV supply equipment. All requirements from IEC 61851-22 have been moved to this standard.	• EV supply equipment manufacturers typically claim compliance with these standards in their product literature. • Ideally products should be third party certified, but is not widespread; it's likely that many don't fully comply. • Products that show compliance with BS EN 60335-1 for Household and similar electrical appliances, rather than IEC/EN 61851, have debatable compliance. This BS does not cover all aspects of the equipment for EV charging. • Certification would include product safety (LVD) and EMC compliance to support CE marking. • The standard also defines the basic communication protocol between the vehicle and charging equipment.	2021
IEC/EN 62196-1:2014 Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of EVs	Applicable to plugs, socket-outlets, vehicle connectors, vehicle inlets and cable assemblies for EVs intended for use in conductive charging systems which incorporate control means, with a rated operating voltage not over 690V AC 50 Hz to 60 Hz, at a rated current not exceeding 250A.	• All Type 1 and Type 2 EV plugs and sockets used in EV supply equipment, cables and accessories should show compliance with this standard. • EV supply equipment products will not achieve certification to IEC/EN 61851-1:2017 if the plug/socket used does not meet this standard.	2020

Relevant standards & best practice: EV charging equipment technical standards (2020)

Standard or Requirement	Formal Description	Commentary	Review Date

ISO 15118-1:2019 Road vehicles — Vehicle to grid communication interface — Part 1: General information and use-case definition	This document replaces ISO/EN 15118-1:2013 Road vehicles - Vehicle to grid communication interface
	
	The document specifies terms and definitions, general requirements and use cases as the basis for the other parts of ISO 15118
	
	Specifies the communication between EVs, including Battery EVs and Plug-In Hybrid EVs, and the Electric Vehicle Supply Equipment (EVSE).
	Describes the communication between the EV Communication Controller (EVCC) and the Supply Equipment Communication Controller (SECC).
		• This relates to future Plug and Charge and AC V2G features.
		• This standard defines the high-level powerline communication protocol used for Plug and Charge and V2G applications. It operates alongside the basic communication protocol used to manage the charging session.
		• Plug and Charge removes the need for driver authentication (RFID, QR codes etc).
		• The Basic IEC/EN 61851-1 protocol can operate on its own but the high-level ISO/EN 15118-1 protocol requires both protocols to be in operation.
		• The main changes from the previous document are:
		  • New use cases and requirements for wireless communication, wireless power transfer, automatic connection devices and bidirectional power transfer have been added; and
		  • As usage of private data and cyber security are becoming an important concern for users, requirements for more traceability and data privacy have also been added
		• Car communicates with charger using ISO15118-1 protocol to identify itself and handle driver billing automatically – functionality that is not possible with the basic protocol. Mercedes, BMW and VW already support this technology.
		• Links to specific standard documents in the series which form requirements of part 1:
		  • ISO 15118-2:201: Network & application protocol requirements
		  • ISO 15118-3:2015- Physical and data link layer requirements
		  • ISO 15118-8:2018 - Physical layer and data link layer requirements for wireless communication
		  • ISO 15118-20: 2nd generation network and application protocol requirements
			2024

OCPP Open Charge Alliance Open Charge Point Protocol – OCPP 1.6 or higher	Freely available open standard that enables component vendors and network operators to "mix and match" interoperable hardware and software. New versions of OCPP are collaboratively defined within an open industry alliance to ensure that the protocol continues to meet evolving market requirements. Charging network operators and service providers in more than 50 countries rely on OCPP to manage more than 10,000 charging stations.	• All hardware should be OCPP 1.6+ compliant. • This is the industry agreed standard API that allows flexibility for hardware to be used across a range of different cloud based back end software. Both hardware and back end need to be OCPP compliant. • OCPP handles all the control, driver authentication and billing processes between the charging equipment and the back end. It can also handle some advanced features for load management and V2G.	TBC
ISO/IEC 14443-1:2018 Cards and security devices for personal identification - Contactless proximity objects - Part 1: Physical characteristics	Defines the physical characteristics of proximity cards and is intended to be used in conjunction with other parts of ISO/IEC 14443.	• General standard that defines RFID and NFC applications.	2023

Relevant standards & best practice: Overall installation (2020)

Standard or Requirement	Formal Description	Commentary	Review Date
BS 7671:2018 (+A1:2020) Requirements for Electrical Installations (IET Wiring Regulations)	The national standard to which all UK electrical installations should conform. The 18th Edition IET Wiring Regulations contains important new information for all electrical installers and engineers. The international standard, IEC 60364 forms the basis of this UK regulation. Section 722 relates specifically to the installation of EV supply equipment.	• Installations will be required to meet all general requirements of BS7671 & the IET CoP. • The 2020 amendment to section 722 modifies the general requirements for protection against electric shock and includes specific requirements for PME systems socket outlets and connectors, external influences, isolation and switching and RCD protection. • BS7671 Section 722 states special requirements that will need to be noted, specifically: • Earthing arrangements – Regulation 722.411.4.1 concerning the use of protective multiple earthing (PME) supply has been changed to increase the ability for an installer to use PME on EV charging equipment installations. • Does not allow PME to be used to supply an EV charging point unless one of the methods described in the regulation is used. • Equipment should include 6mA DC leakage protection allowing installations to use a lower cost Type A RCD. Without this a costly dedicated Type B RCD will be required for every outlet. • To reliably charge all vehicles, high immunity RCDs should be used that are tolerant to the harmonics in some vehicle types. • Installers must ensure adequacy of supply - without load management no diversity can be applied. This means that the site supply must always be able to supply 100% of the load, irrespective of all the socket outlets being in use or otherwise. Using load management will overcome this concern by varying the charge rates based on usage. • For 3-phase installations, consideration should be made to ensure load balancing to maintain neutral current at close to zero. Phase rotation of charging outlets should be employed at 3-phase outlets.	TBC
IET Code of Practice for Electric Vehicle Charging Equipment Installation 4th Edition	Provides an overview of EV charging equipment, considerations needed prior to installation. This includes physical installation requirements, relevant electrical installation requirements of the updated BS 7671:2020 and specific requirements when installing EV charging equipment in locations such as dwellings, on-street locations, commercial and industrial premises.		

Relevant standards & best practice: Overall installation (2020)

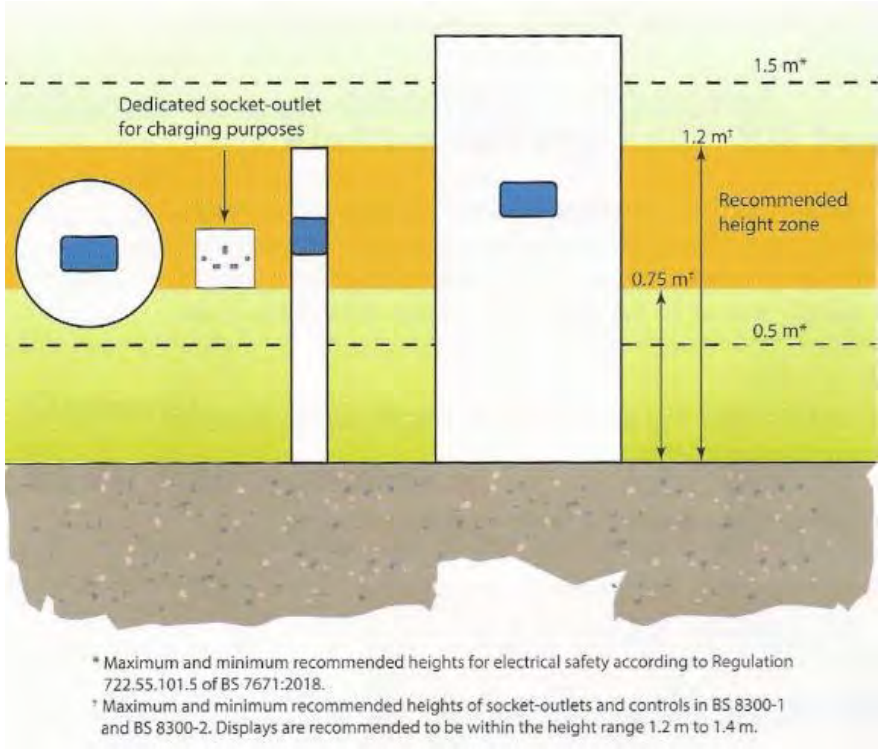


Figure 1: Recommended Heights for Socket Outlets, Payment Terminals and Displays

Source: IET Code of Practice

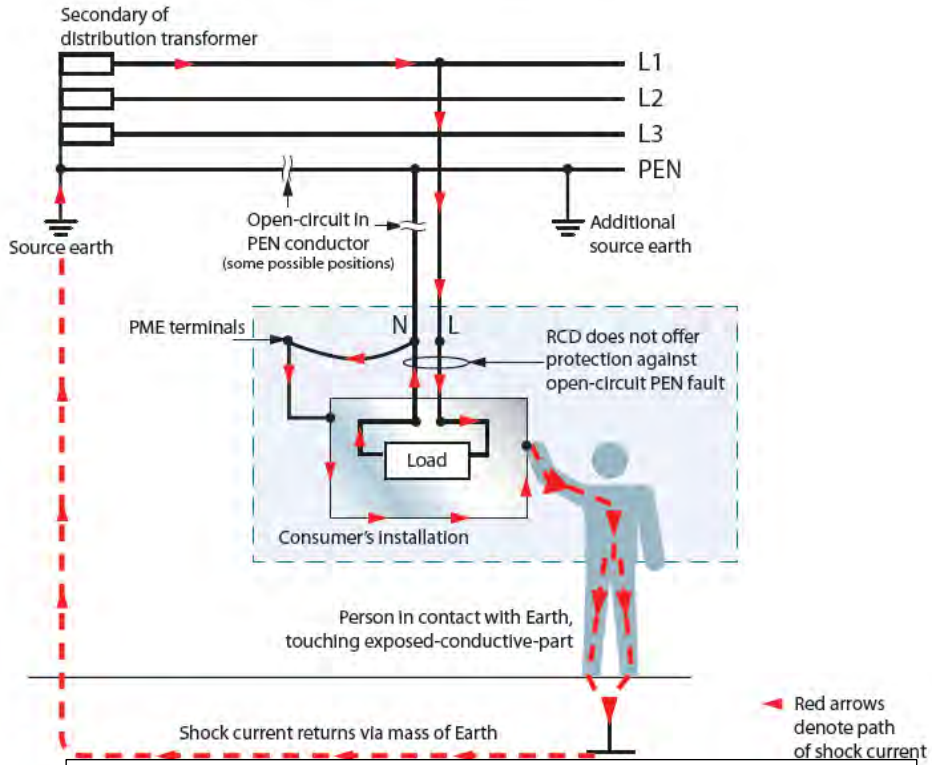


Figure 2: Electric Shock Risk Due to Open Circuit Fault in the Supply Neutral PEN Conductor

Source: NICEIC

Relevant standards & best practice: Overall installation (2020)

Standard or Requirement	Formal Description	Commentary	Review Date
IEC 62955:2018 Residual direct current detecting device (RDC-DD) to be used for mode 3 charging of EVs	Applies to residual direct current detecting devices (RDC-DD) for permanently connected AC EV charging stations referred to as RDC-MD (residual direct current monitoring device) or RDC-PD (residual direct current protective device), for rated voltages not exceeding 440 V AC with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz and rated currents not exceeding 125 A.	• Defines the device requirements for the 6mA DC leakage protection feature needed to meet the requirements of BS7671 installation requirements where a Type A RCD can be used.	2020
IEC 61008-1:2010+AMD1:2012+AMD2:2013 CSV - Consolidated version Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) -Part1: General rules	Applies to residual current operated circuit-breakers functionally independent of, or functionally dependent on, line voltage, for household and similar uses, not incorporating overcurrent protection (hereafter referred to as RCCBs), for rated voltages not exceeding 440V AC. with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz and rated currents not exceeding 125 A, intended principally for protection against shock hazard. This consolidated version consists of the third edition (2010), its amendment 1 (2012), its amendment 2 (2013) and the corrigendum of January 2014.	• Includes definitions, requirements and tests, covering all types of RCCBs. For the applicability to a specific type this part applies in conjunction with the relevant part, as follows: • Part 2-1: Applicability of the general rules to RCCBs functionally independent of line voltage. • Part 2-2: Applicability of the general rules to RCCBs functionally dependent online voltage. • Defines the device requirements for the Type A or Type B RCD earth leakage protection needed to meet BS7671 installation requirements.	2020

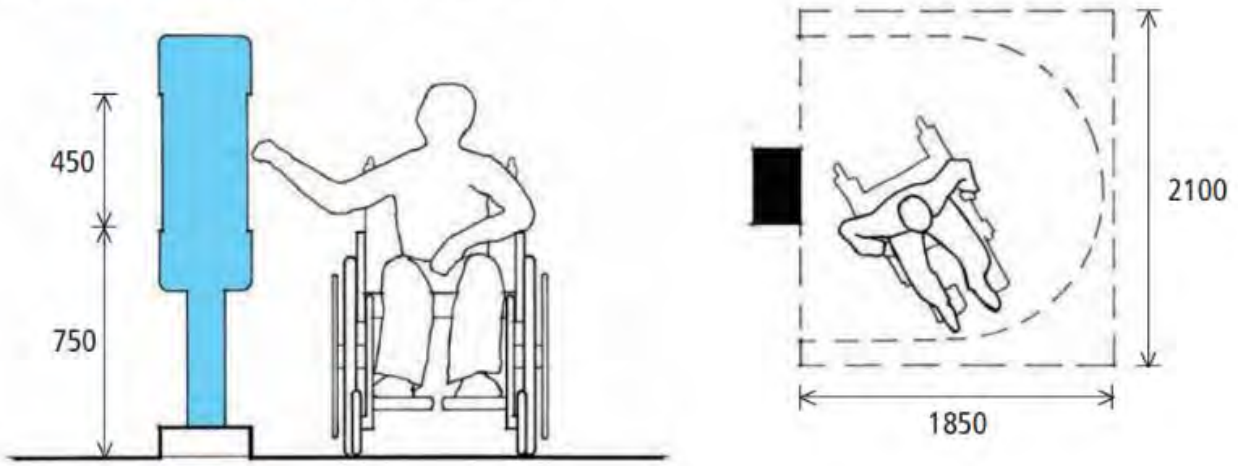
Relevant standards & best practice: Overall installation (2020)

Standard or Requirement	Formal Description	• Commentary	Review Date
BS EN 61009-1:2012+A12:2016 Residual current operated circuit-breakers with integral overcurrent protection (RCBOs).	Applies to residual current operated circuit breakers with integral overcurrent protection functionally independent of, or functionally dependent on, line voltage for household and similar uses (RCBOs), for rated voltages not exceeding 440 V AC with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz and rated currents not exceeding 125 A and rated short circuit capacities not exceeding 25 000 A for operation at 50 Hz or 60 Hz.	• Defines the device requirements for the Type A or Type B RCBO earth leakage protection combined with over current protection suitable to meet BS7671 installation requirements.	TBC
ENA ER G12 Issue 4 Requirements for the Application of Protective Multiple Earthing to Low Voltage Networks	Sets out the requirements to be adopted when Protective Multiple Earthing (PME) is applied to DNO overhead and underground low voltage distribution systems and to other public distribution systems connected to those systems under the Distribution Code. These requirements may be supplemented by each Company's own PME code of practice in respect of the detailed engineering and technical requirements of PME application. The document also considers situations where PME should not normally be used.	• Specifically, section 6.2.15. • Defines UK DNO recommendations for connecting to the low voltage network and includes specific requirements for EV charging. • Note that some DNOs have their own specific guidance that should be referenced (WPD, UKPN). • Largely these documents duplicate BS7671 in content but clearly set out areas of concern for DNOs with regard to EV charging. •	TBC

Relevant standards & best practice: Overall Installation (2020)

Standard or Requirement	Formal Description	Commentary	Review Date
BS 8300: 2018 Design of an accessible and inclusive built environment. External environment.	Recommendations on designing buildings to accommodate users with the widest range of characteristics and capabilities. It applies to: • External features of a building or group of buildings, such as entrances, outward opening doors and windows, where they affect external access routes, and • Interiors of buildings such as entrances and reception facilities, horizontal and vertical movement, and facilities in the building	• Defines the height from the ground of the socket outlet (also stated in BS7671 & IET CoP) • Includes clearances for wheelchairs around street furniture - should be considered for physical layout of equipment on the footway and for wheelchair access to the socket outlets for disabled drivers. • See below for diagrams	TBC

Accessible ticket-dispensing machines



15.3. EV charging standards for Oxfordshire

Standard area	Background	National regulations and standards	Oxfordshire 'above and beyond' standard
Technical standards for charger hardware	• There are minimum standards set out in legislation by central govt on charger hardware. • National and European standards give minimum quality and safety standards for EV chargers • Any chargers funded by OLEV On-street Residential Charging Scheme (ORCS), or Workplace Charging Scheme must meet more detailed standards.	Charger hardware should meet all relevant regulations and standards; • The Alternative Fuels Infrastructure Regulations 2017, • Automated and Electric vehicles Act (2018), • IEC/EN 61851-1:2017 , • IEC/EN 62196-1:2014; • OCPP Open Charge Alliance Open Charge Point Protocol – OCPP 1.6 or higher; • ISO/IEC 14443-1:2018	• Free-standing charging equipment should allow full servicing and replacement without disturbance of the pavement or hardstanding surface; no civil work should be required • Charger units should be modular in design: in the event of equipment failure the design should allow a module or section to be replaced, rather than a discrete component or the entire unit. • Charger design should make the most efficient use of available space per installation: where feasible all free-standing chargers should be double units capable of charging two vehicles simultaneously to their full rated power output. • Equipment with an independent power supply should be fitted with auto-resetting RCDs: Standard RCDs will need to be manually reset in the cabinet, should any vehicle cause a trip. Auto resetting RCDs could reduce maintenance visits just to reset RCDs. • Exemptions to the above standards may be made for specific sites where planning restrictions apply.
Technical Standards for Installation	• National and European standards give minimum quality and safety standards for EV charger installations. • Evidence from local and national projects indicates that where chargers are installed, additional cable	Installations of chargers and related electrical supply equipment must meet all relevant regulations and standards for installation; • BS 7671:2018 (+A1:2020) Requirements for Electrical Installations (IET Wiring Regulations); • IET Code of Practice for Electric Vehicle	• Installation of chargers should be designed to minimise the requirement for disruption should additional chargers be required in the future. • Where chargers with a dedicated power supply are installed, cable routes to supply support future installations should be considered to future-proof installations for additional chargers as demand increases.

	ducting to support further EV chargers is useful in reducing disruption caused by additional future installations.	• Charging Equipment Installation 4th Edition; • IEC 62955:2018; • IEC 61008-1:2010+AMD1:2012+AMD2:2013 CSV, • BS EN 61009-1:2012+A12:2016, • ENA ER G12 Issue 4 ; • BS 8300: 2018 Design of an accessible and inclusive built environment.	• Exemptions to the above standards may be made for specific sites where planning restrictions apply.
Technical Standards for Back Office and User interface	• National law demands open access to all public chargers without need for subscription. • Research shows that users find multiple subscriptions to EV charger networks, with multiple RFID cards and apps unappealing. • Some CPOs claim to meet open access using apps which can be downloaded; however, this is unappealing to customers – Roaming across multiple networks or credit/debit card access is preferred • Roaming access currently limited in UK, although Automated and Electric vehicles act gives govt. powers to require this if market does not develop.	All chargers must be operated a Charge Point Management System or 'back office' which meets all national relevant regulations and standards; • The Alternative Fuels Infrastructure Regulations 2017, • Automated and Electric vehicles Act (2018) • OCPP Open Charge Alliance Open Charge Point Protocol – OCPP 1.6 or higher;	Payment options for customers should include: • Provides users with instant access via credit/debit card payment • Permits users to 'roam' across charger networks
Management & Maintenance of	• There are no current national standards for the	All EVCPS and associated electrical supply equipment must be subject to an ongoing routine	• All chargers must be operated and maintained by a competent contractor. A competent

EV charging Networks	overall management of EV charging networks • National standards for the maintenance and inspection of electrical equipment, including EV chargers are detailed in the British Standards and the IET wiring regulations (18th edition)	and responsive maintenance plan which meets all relevant standards & regulations. This must include periodic electrical safety inspection • Under BS:7671 'condition reporting', electrical equipment must be tested periodically. The period of inspections is subject to review of the previous inspection and test results to determine the rate of degradation, if any, of the electrical equipment, • Testing of EV charging must be carried out in accordance with the IET wiring regulations (18th edition) and at least annually for untethered chargers and 6-monthly for tethered chargers. • All operatives carrying out maintenance and testing of on-street EVCPs and associated electrical or other equipment must be competent to carry out works in the highway and hold relevant training and certification, including NRWSA training certification, HERS registration and with an Electrotechnical Certification Card (ECS).	contractor should hold as a minimum: • Proof of membership of an Electricians' Association. • Proof of public liability insurance. • Proof that staff are trained to install and maintain electric vehicle chargers. • Proof that the contractor is approved to install and maintain the chargers by the manufacturer. • Proof that the contractor holds the relevant licences to operate the charger CPMS or back-office. • The routine and responsive maintenance plan must include an emergency response plan with appropriate response times and action procedures to remove risk to life, person or property. • The routine and responsive maintenance plan must include SLAs which define a minimum of 3 levels of fault severity, with appropriate response and fault rectification times for each (see Table 8 for best practice routine and responsive maintenance SLAs). • The CPO must have appropriate measures in place for asset renewal or removal at the end the life of the EVCP.

Table 8 - Recommended Best Practice Maintenance SLAs

Service	Action	Response and Remedy Time
Annual/Biannual inspection	Including physical inspection of the charger unit, feeder pillar, their wiring, weather seals, circuit protection devices and earth continuity to British Standard BS7671. Visual check for sticker and signage issues. Report from inspection to include description of the units checked including serial number, full address, date of installation and last test and pass or fail status with itemised fail list if the unit has failed.	Annual, within 15 Working Days of anniversary.
Remote monitoring	Remote monitoring service for identification of faults to be linked with ticketing system for equipment faults and error reporting.	Seven (7) days per week, fifty-two (52) weeks a year, twenty-four (24) hour remote monitoring is essential.
Remote reboot and restart facilities	Remote reboot and restart facilities to be used where appropriate for issues reported by the remote monitoring system, charger engineers, the Council or Customers.	Seven (7) days per week, fifty-two (52) weeks a year, twenty-four (24) hour availability is essential.
Attend equipment & resolve severity one incident. *Definition: Requires emergency isolation to prevent risk to life, person, or property.*	Investigate, call the emergency services and make safe. Carry out emergency isolation and rectification works.	Call emergency services immediately after identification of severity one incident. Attend and complete isolation within one (1) hour from notification. Once isolated and made safe, incident is moved to Severity Two
Attend equipment & resolve severity two incident. *Definition: Requires action to make the charger/s operational: i.e. component failure*	Investigate and carry out operational rectification works.	Incident rectified and charger/s operational within twenty-four (24) hours from notification.
Attend equipment & resolve severity three incident. *Definition: Requires cosmetic action: i.e. graffiti, soiling etc.*	Carry out cosmetic rectification works.	Incident rectified within five (5) days from notification.
Customer and Council issue telephone and/or app-based helpline. *Definition: First line response for customer issues whilst customer is at Charger*	Answer calls from the customer and guide them through possible remedies that do not require an engineer at site (e.g. trapped plug or other error). Includes remote reboot and restart facilities.	Seven (7) days per week, fifty-two weeks a year, twenty-four (24) hour helpline is essential

16. Annex 4: Geospatial Analysis

16.1. Spatial analysis of residential properties in Oxfordshire with low probability of a driveway

Figure 14 - Oxfordshire hotspots for properties with low probability of a driveway. Source: Energeo 2020 & EMU 2018. Higher colour intensity indicates higher density of occurrenceto Figure 19 illustrate hotspots for on-street parking in Oxfordshire indicated by the number of properties with low probability of a driveway on which a vehicle can be parked. Properties with low probability of a driveway were defined as those with less than or equal to 3 metres

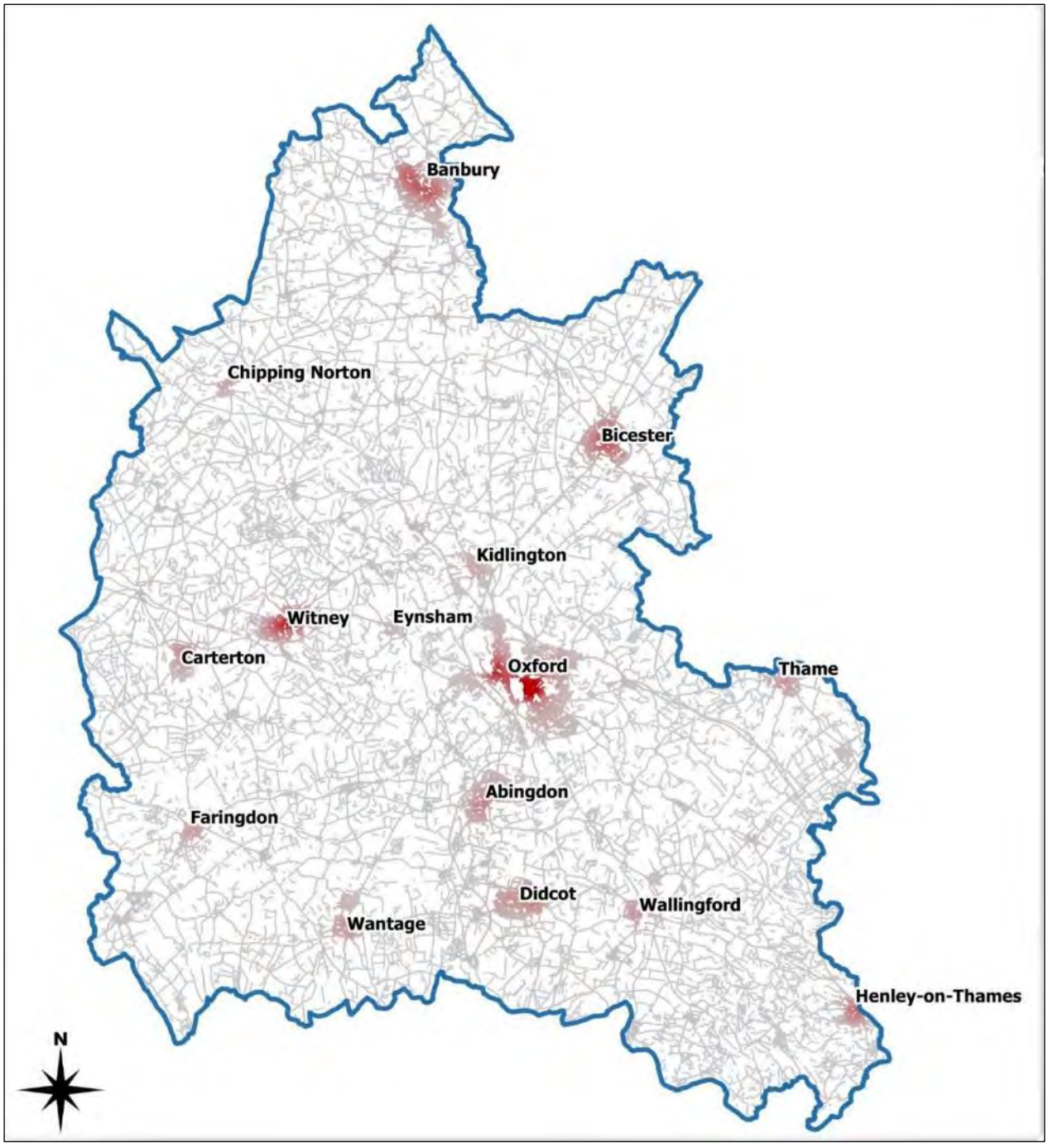


Figure 13 - Oxfordshire hotspots for properties with low probability of a driveway. Source: Energeo 2020 & EMU 2018. Higher colour intensity indicates higher density of occurrence

distance between the front elevation of the property and the nearest edge of the public highway, inclusive of the pedestrian footway where this is present.

Figure 14 - Cherwell District hotspots for properties with low probability of a driveway. Higher colour intensity indicates higher density of occurrence.

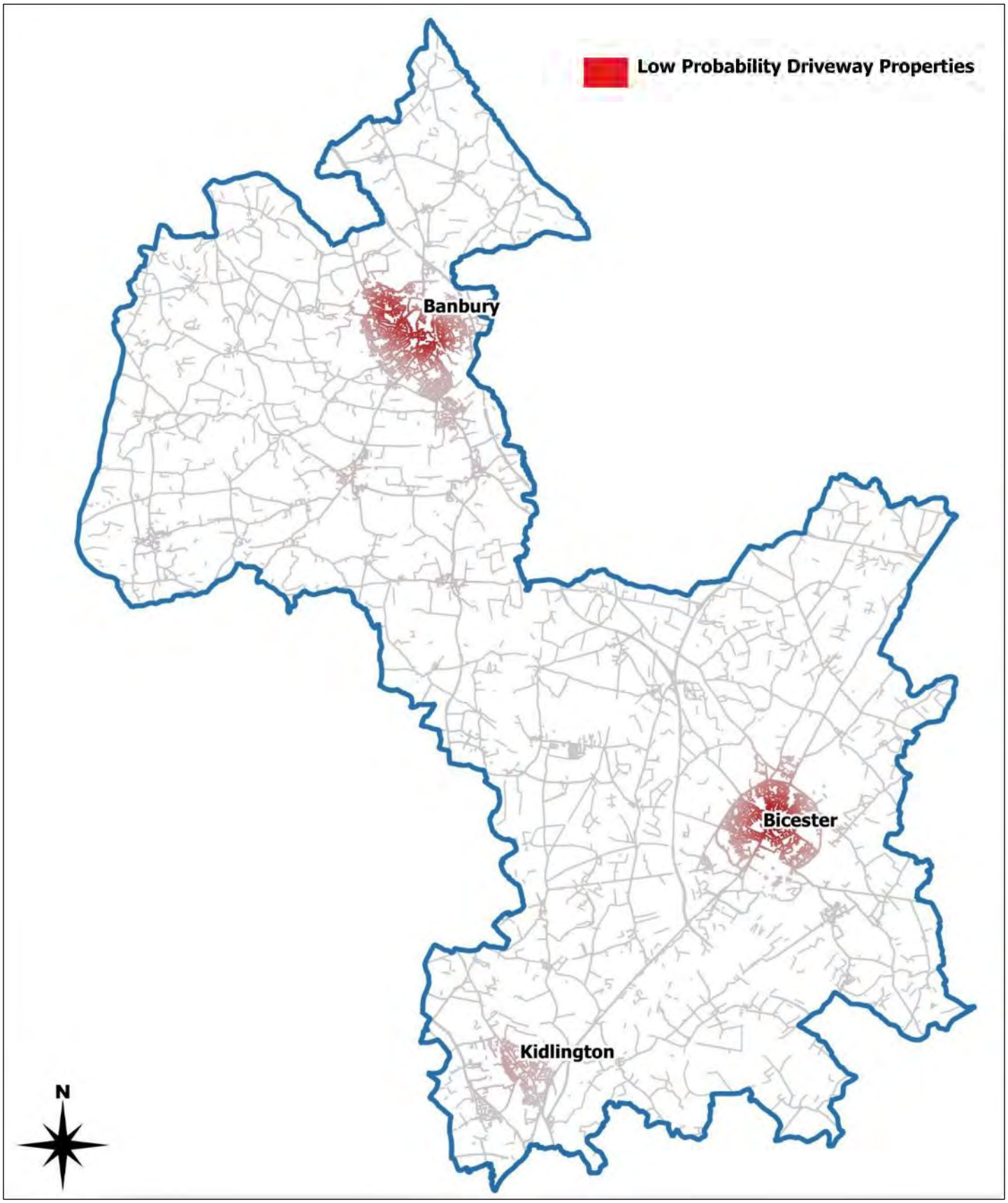


Figure 15 - Oxford City hotspots for properties with low probability of a driveway. Higher colour intensity indicates higher density of occurrence.

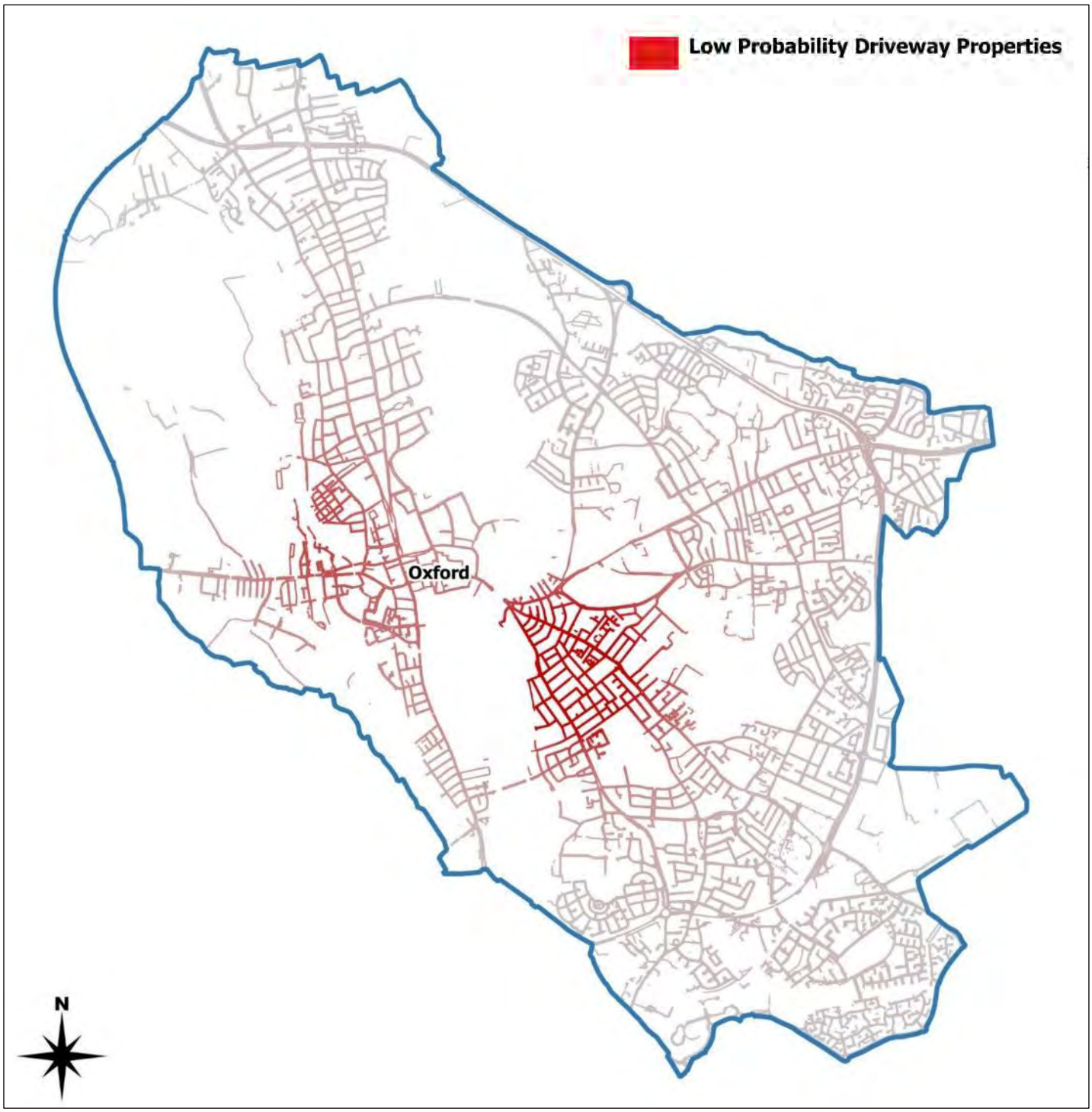


Figure 16 - South Oxfordshire hotspots for properties with low probability of a driveway. Higher colour intensity indicates higher density of occurrence.

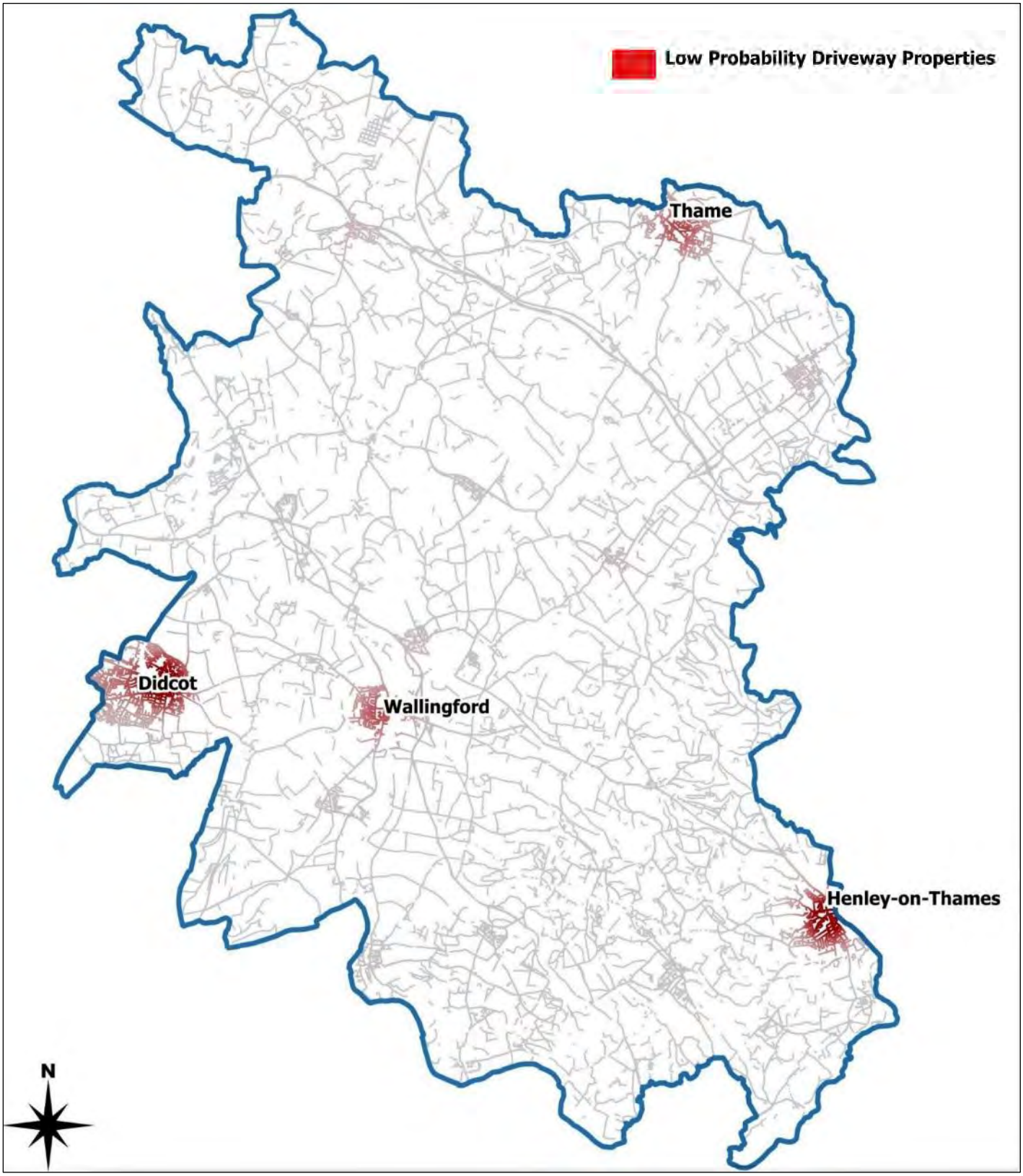


Figure 17 - Vale of White Horse hotspots for properties with low probability of a driveway. Higher colour intensity indicates higher density of occurrence

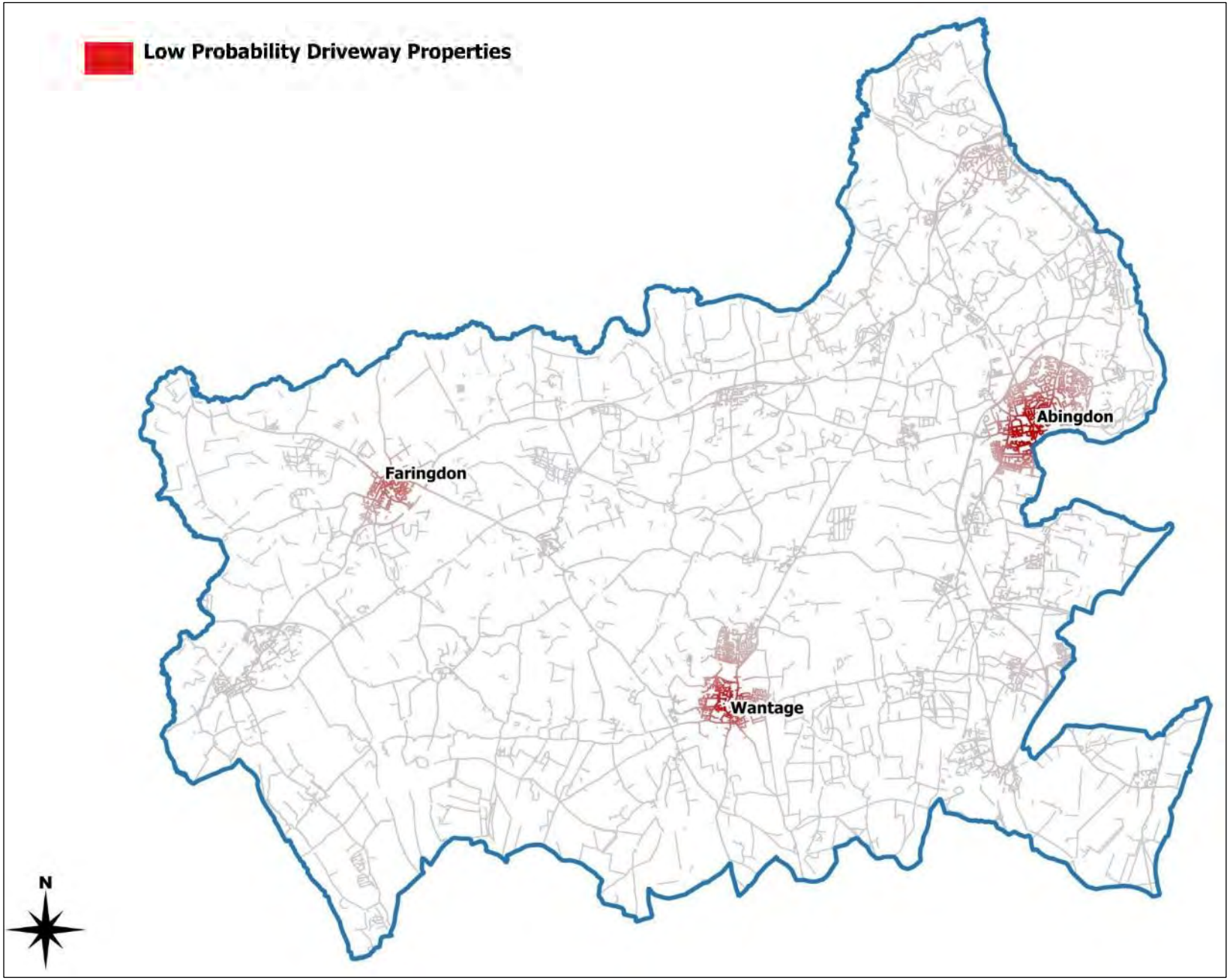
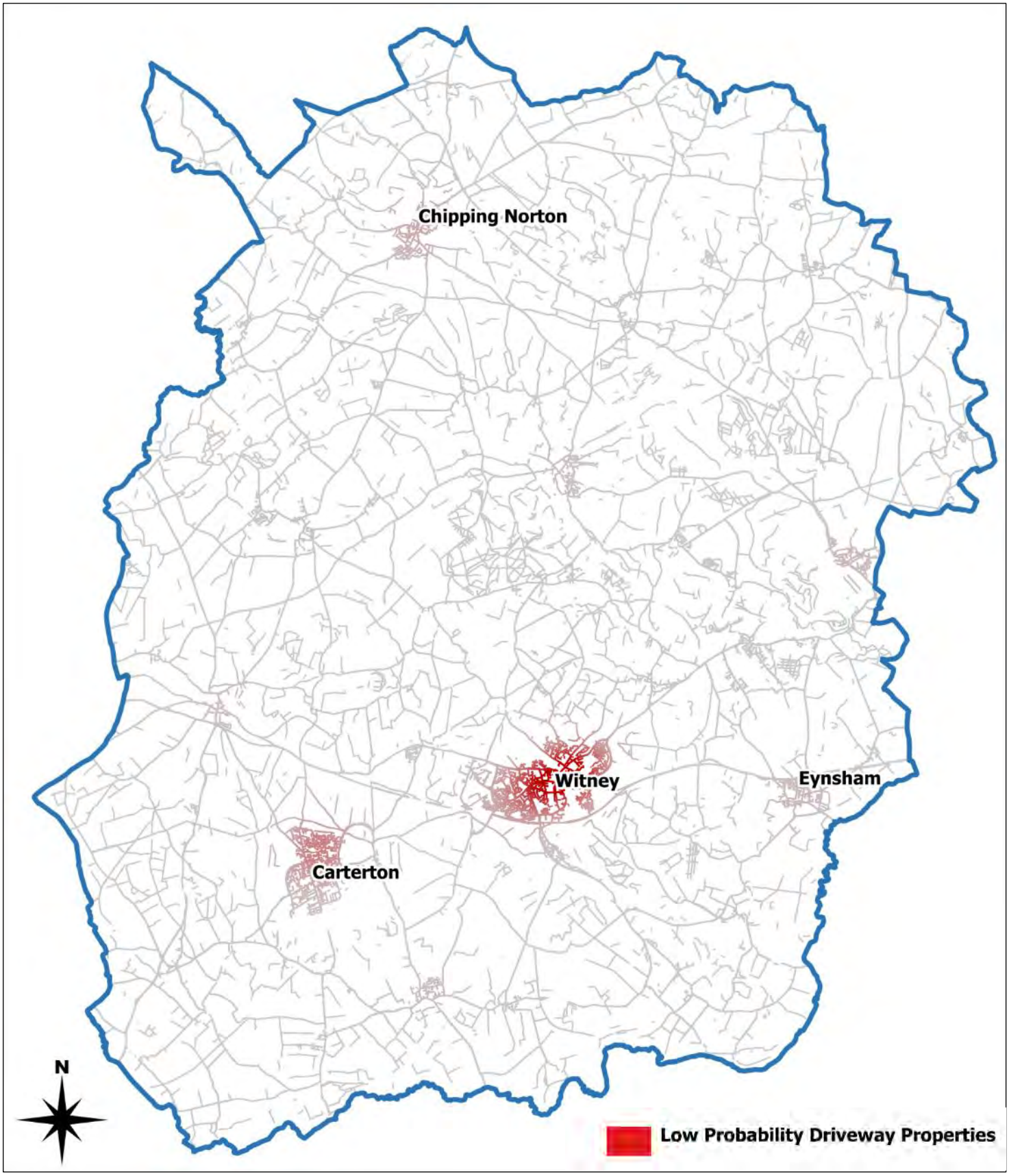


Figure 18 - West Oxfordshire hotspots for properties with low probability of a driveway. Higher colour intensity indicates higher density of occurrence



16.2. Spatial analysis of predicted early mass EV adoption in Oxfordshire

Figure 19 to Figure 25 illustrate hotspots for early mass adoption of EVs in Oxfordshire. Households likely to be early mass adopters were defined as households in categories 1-10,15-16,18,22-24,26&29, located proximate to an existing ULEV registration.

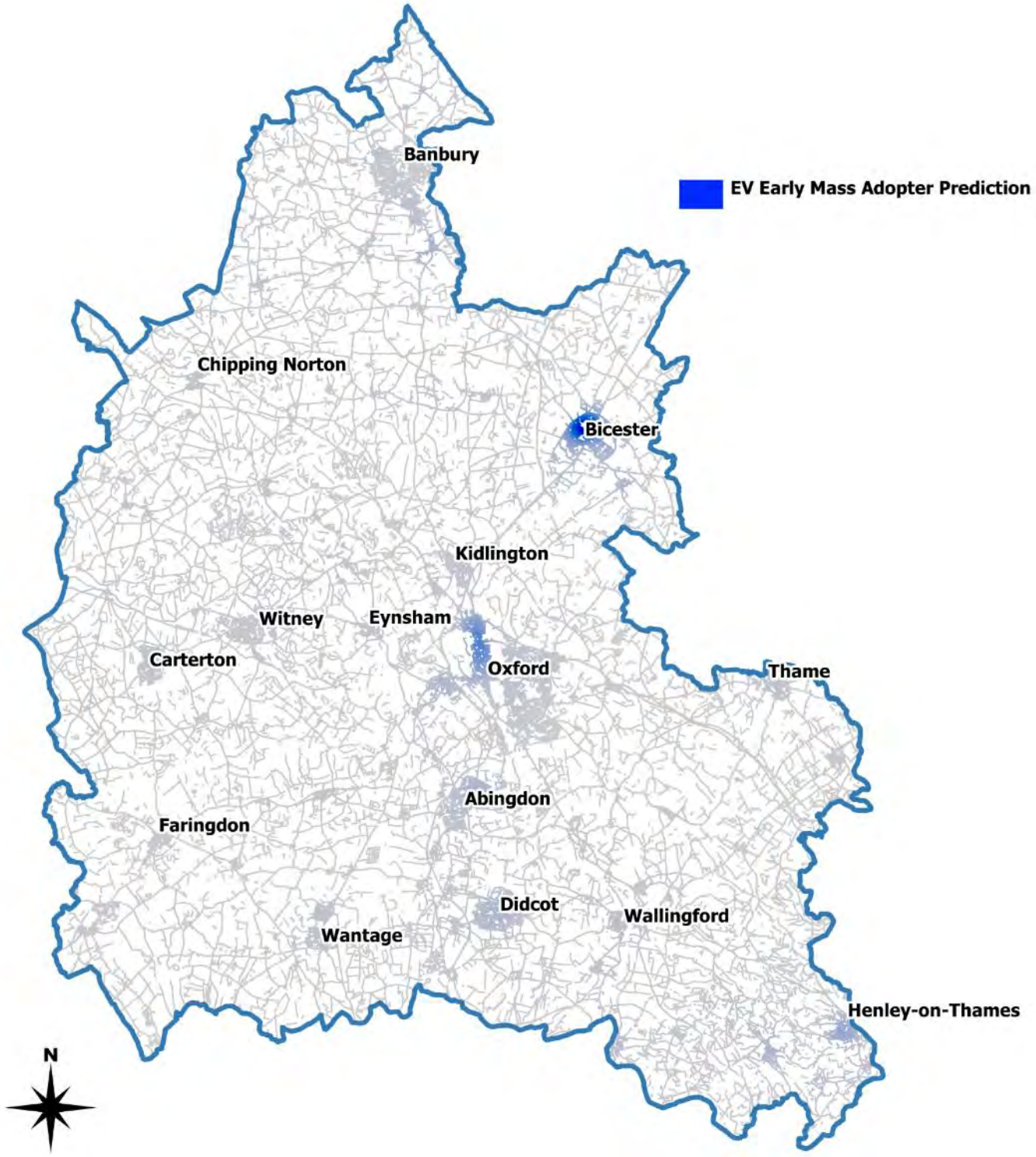


Figure 19 - Oxfordshire hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

Figure 20 - Cherwell hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

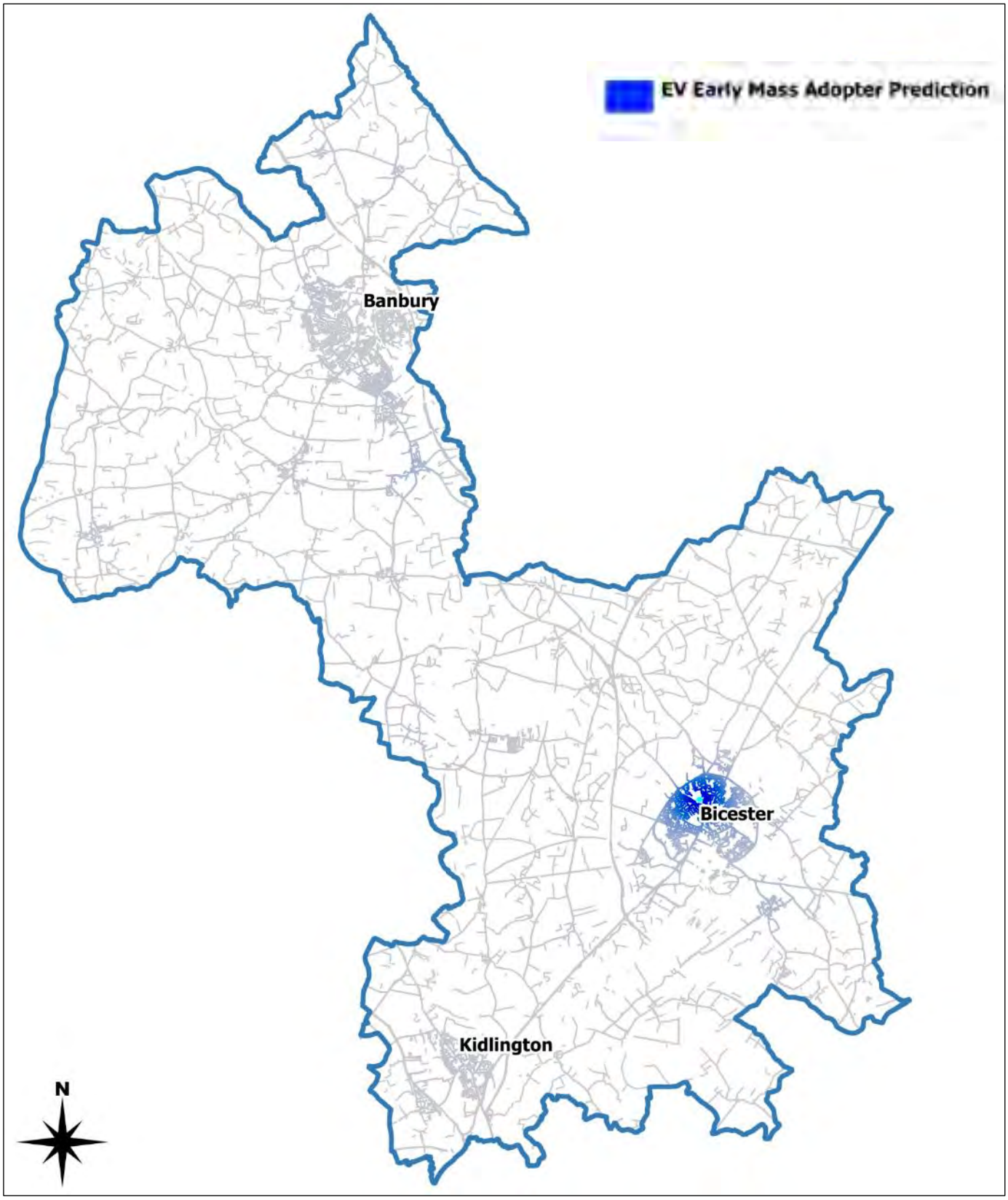


Figure 21 - Oxford hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

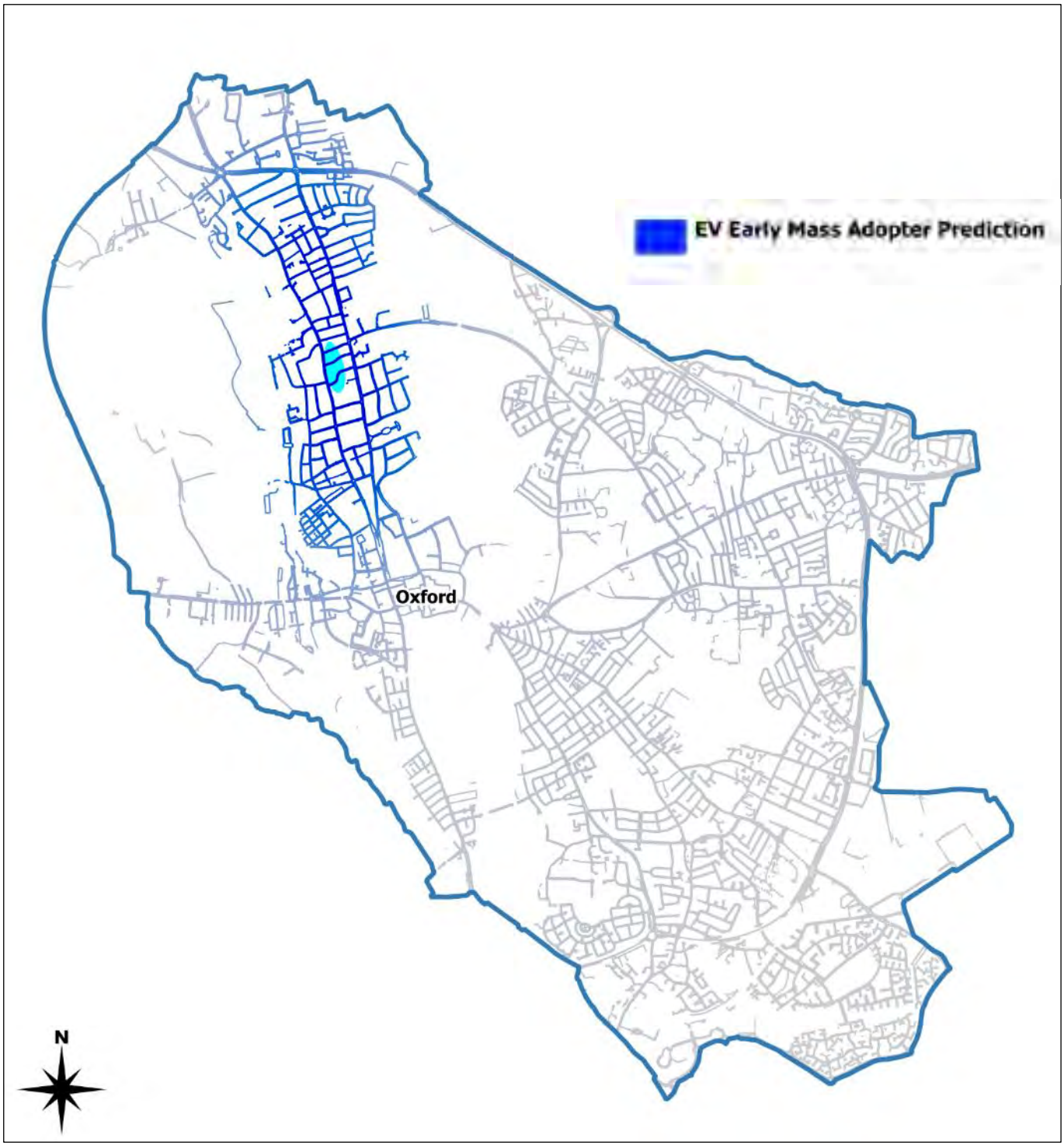


Figure 22 - South Oxfordshire hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

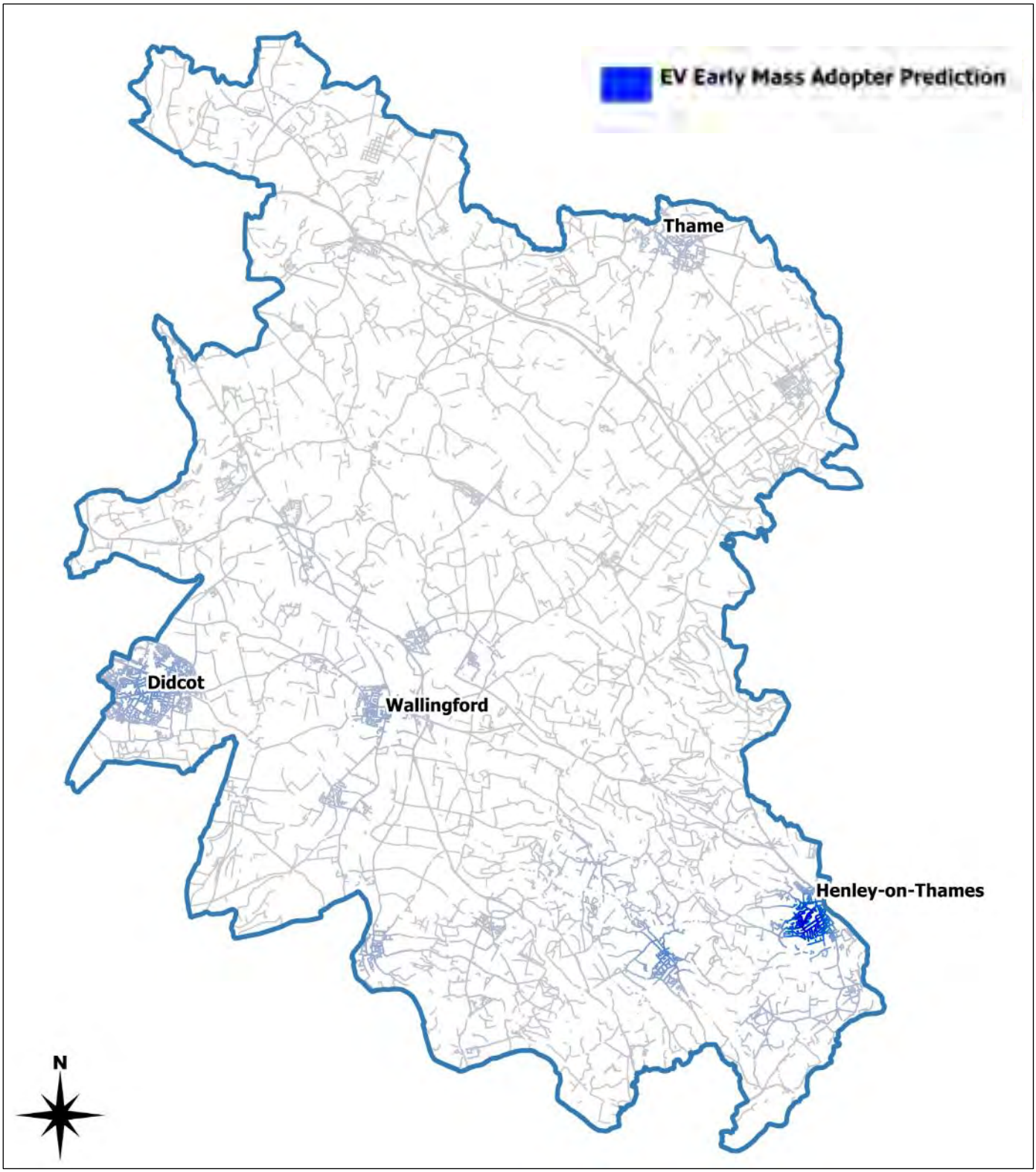


Figure 23 - Vale of White Horse hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

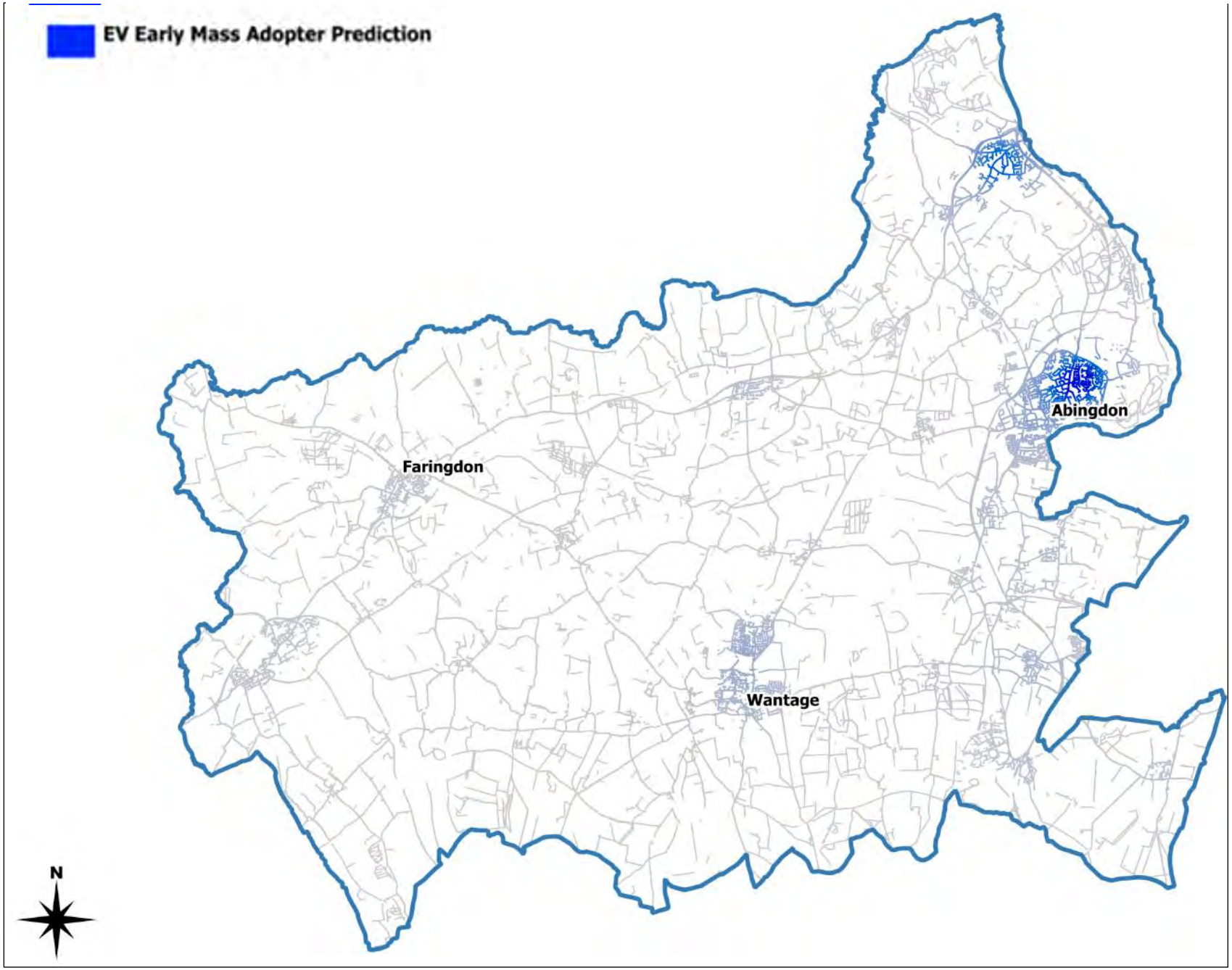
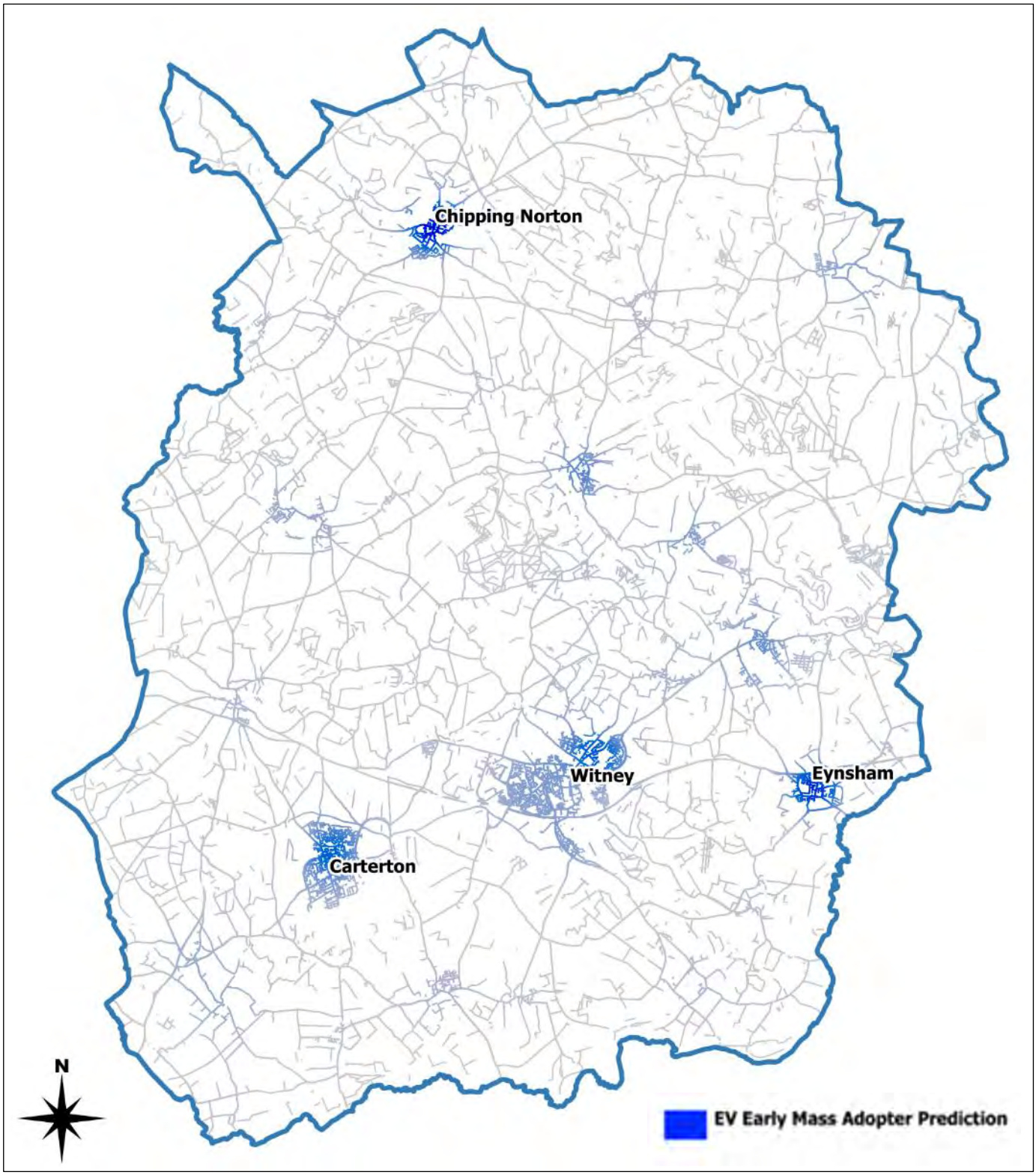


Figure 24 - West Oxfordshire hotspots for predicted early mass EV adoption. Sources: Energeo 2020, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.



16.3. Co-incidence of low driveway probability households with early mass adoption

Figure 26 to Figure 31 illustrate the co-incidence of hotspots for low driveway probability households and early mass adoption predictions of EVs in Oxfordshire. Where the two types of hotspot overlap the colour purple in the figures indicates areas for early action to support potential EV drivers without access to home charging.

Figure 25 - Oxfordshire hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

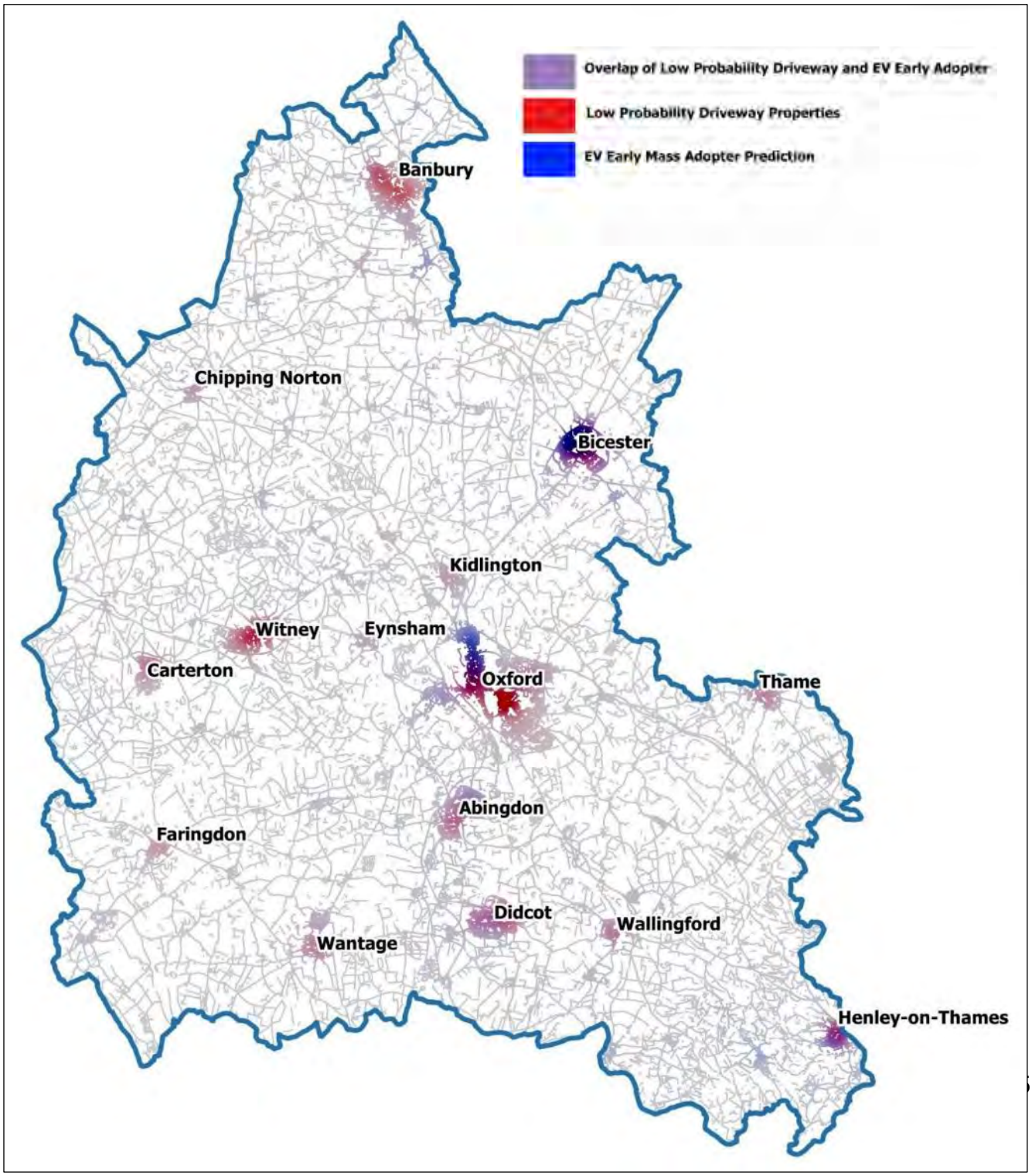


Figure 26 - Cherwell hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

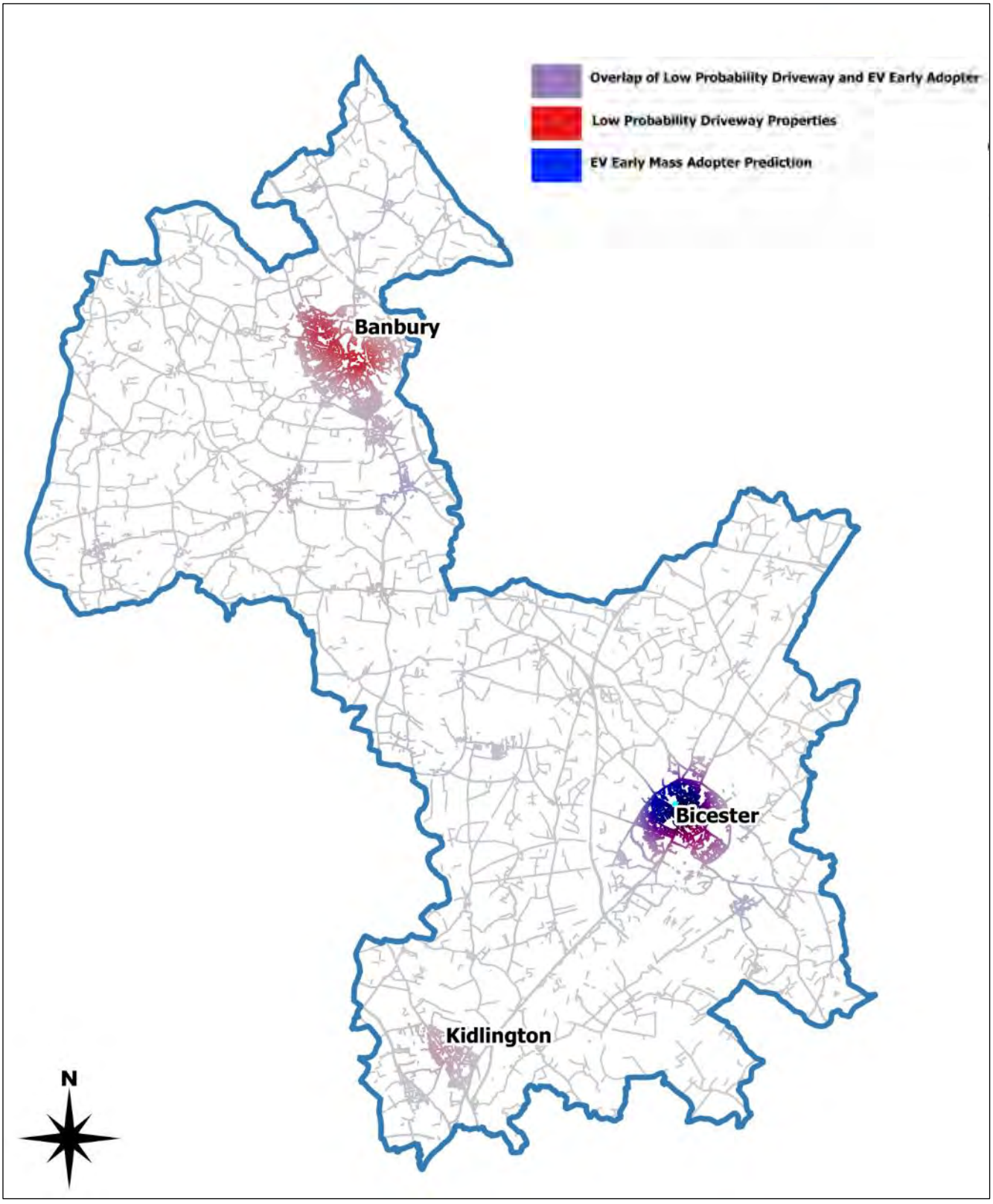


Figure 27 – Oxford hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

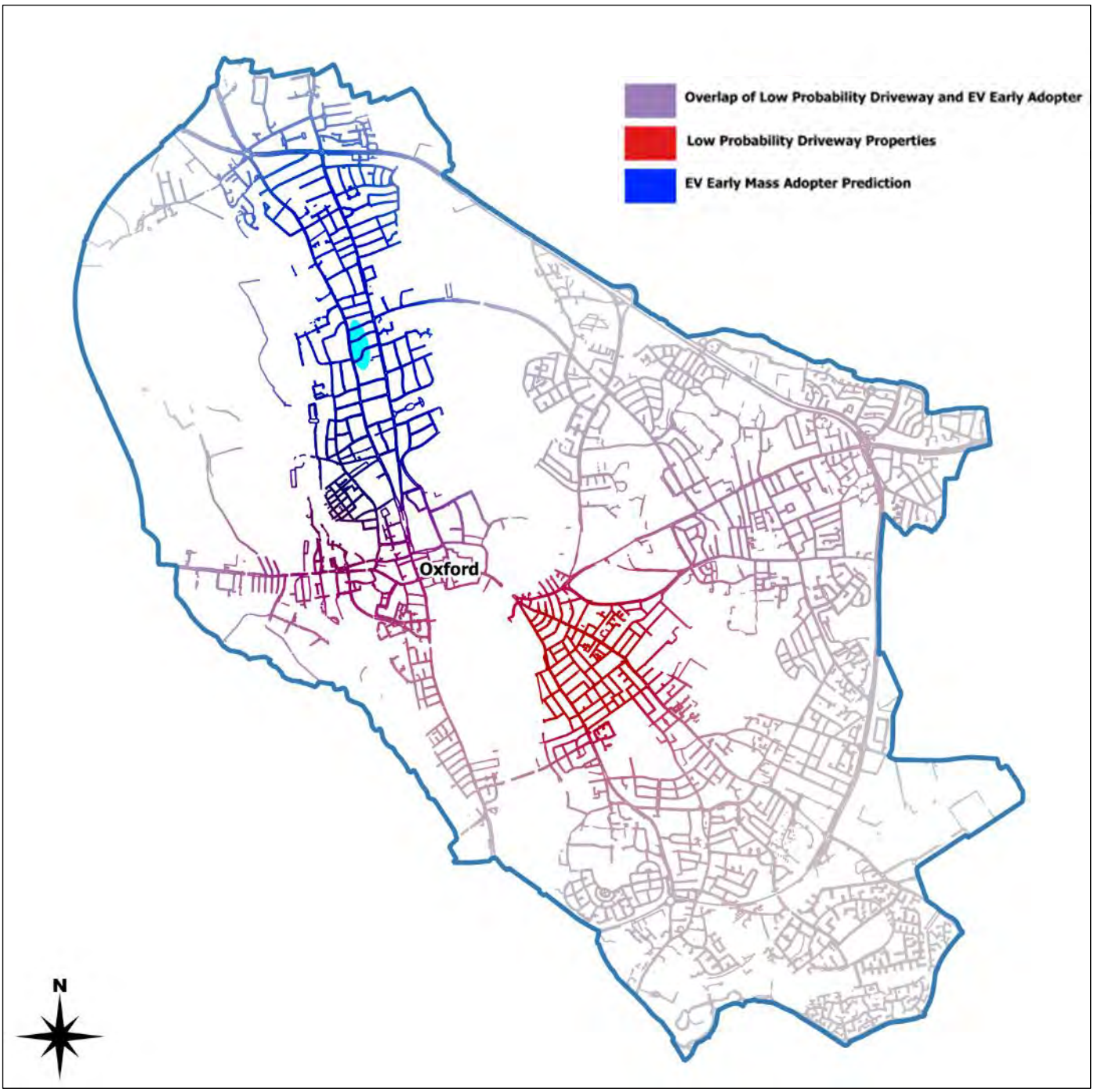


Figure 28 - South Oxfordshire hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

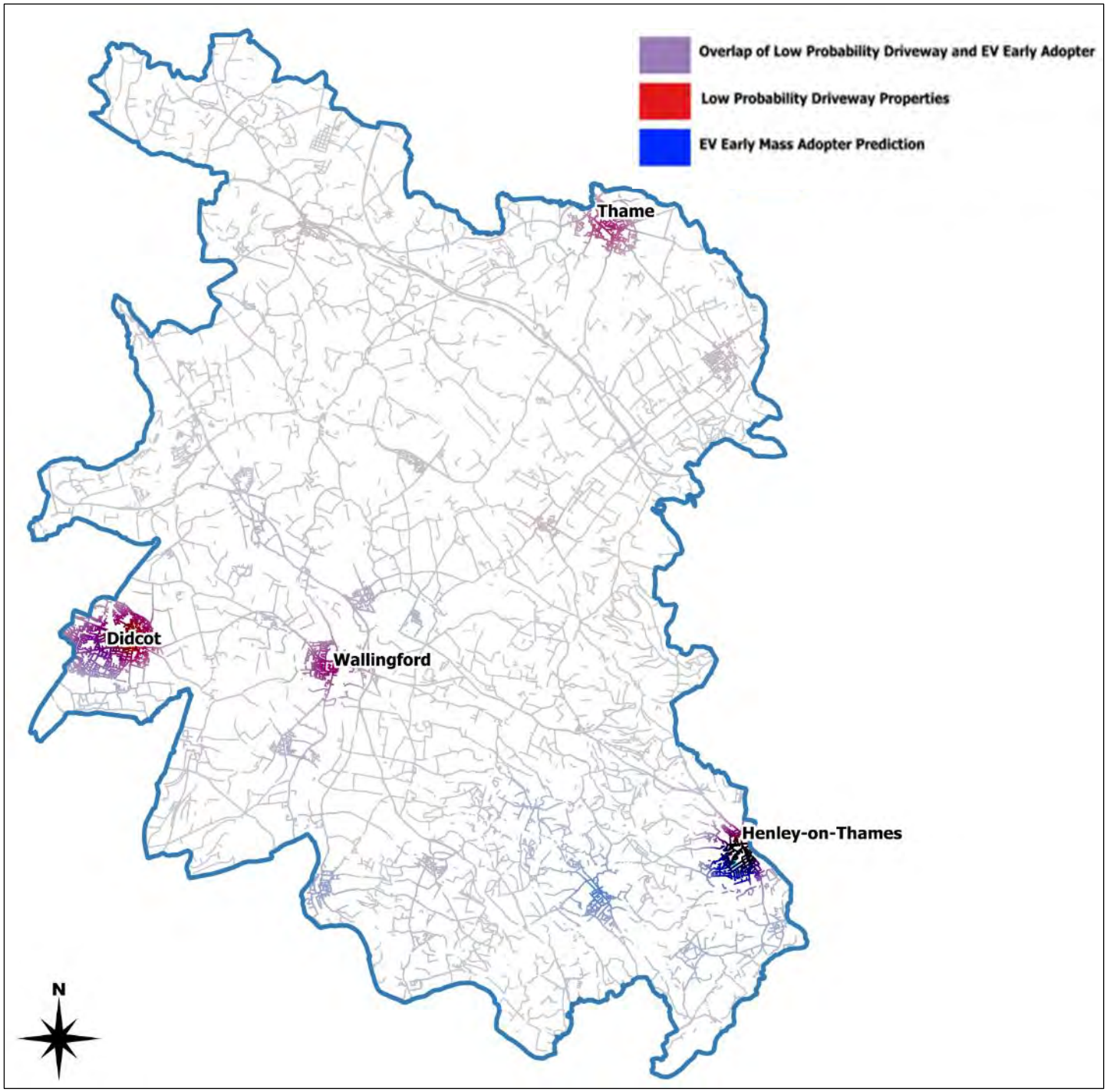


Figure 29 - Vale of White Horse hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.

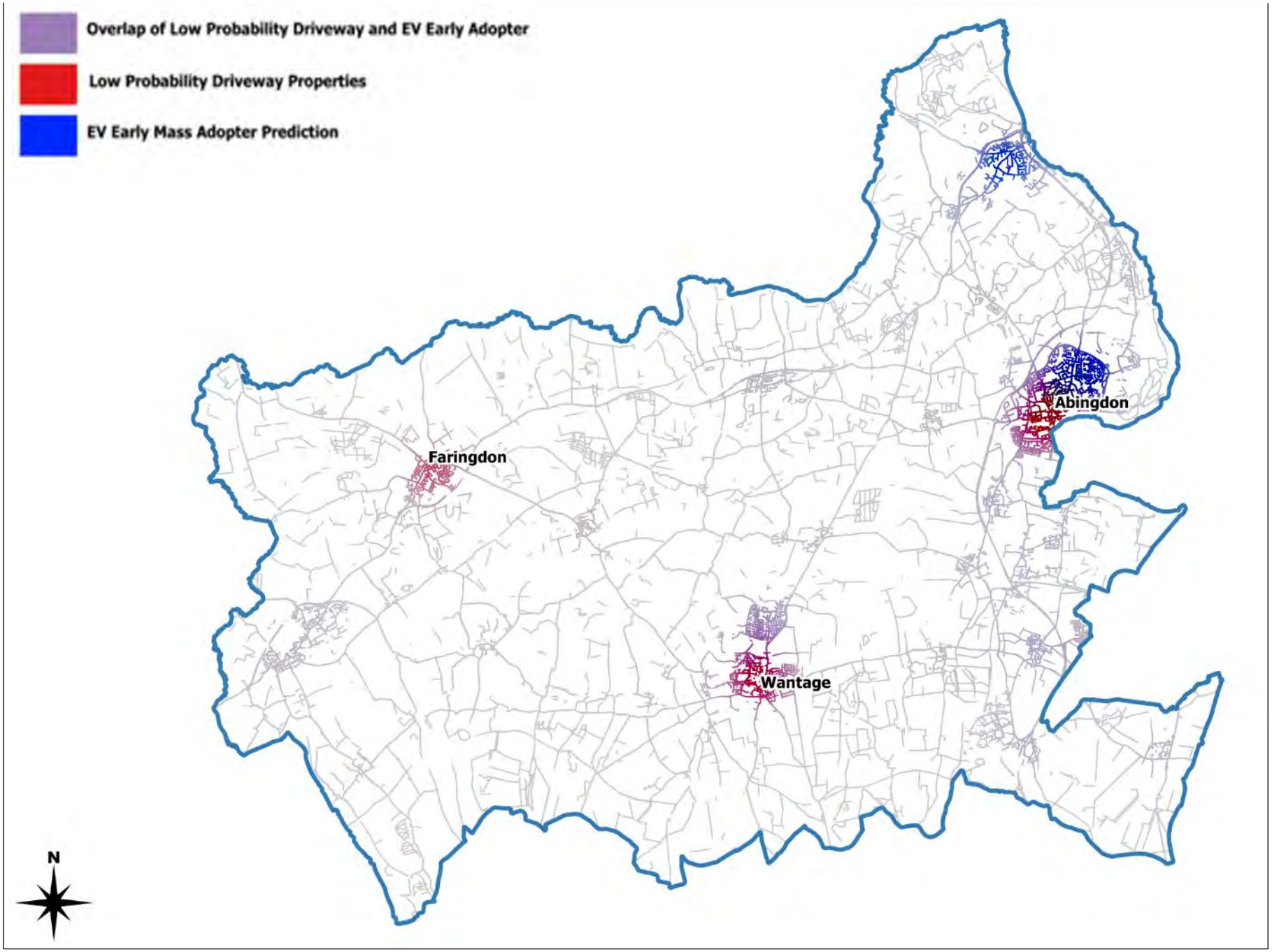
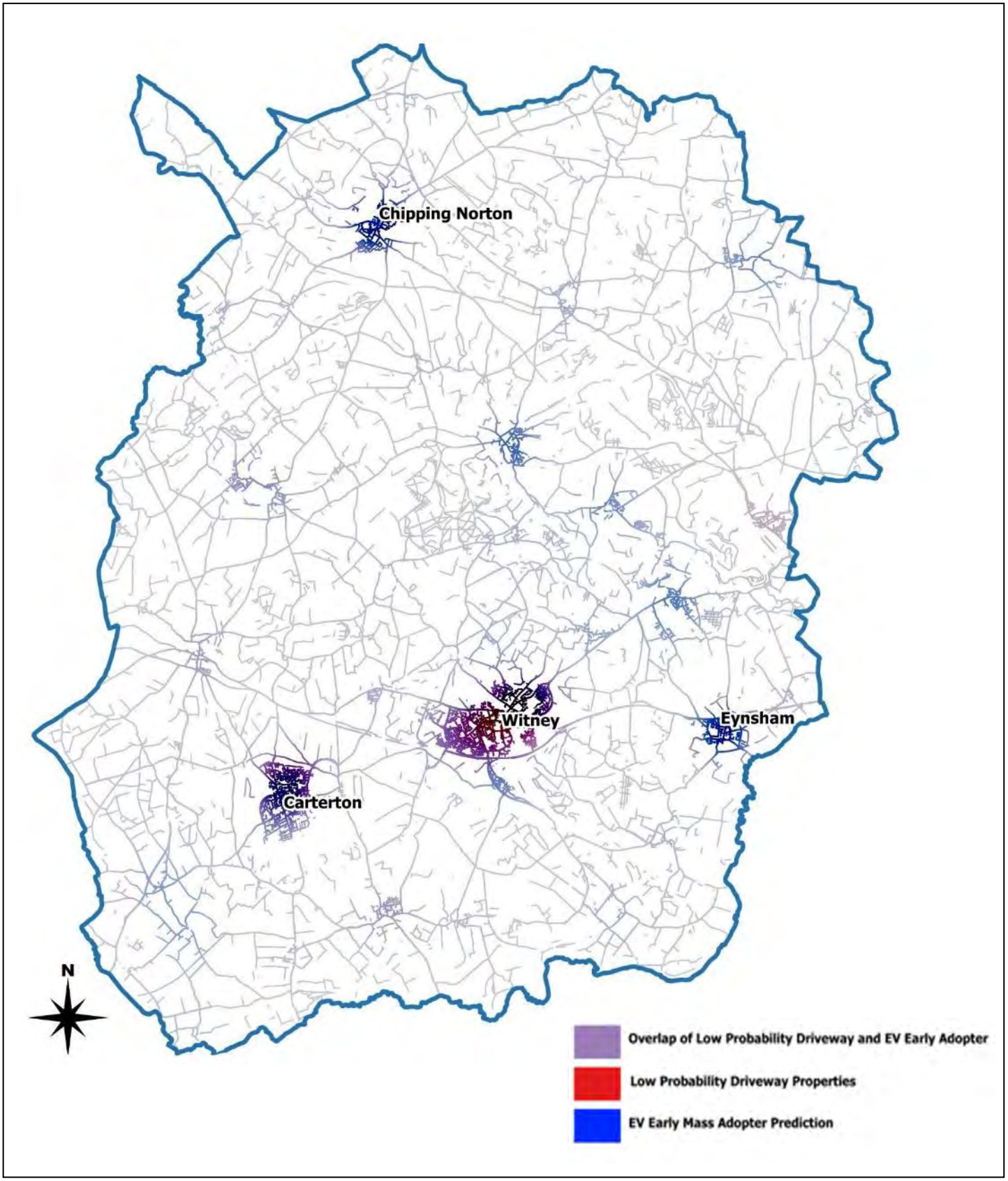


Figure 30 - West Oxfordshire hotspots for predicted early mass EV adoption & low driveway probability. Sources: Energeo 2020, EMU 2018, ACORN 2020, DfT 2020. Higher colour intensity indicates higher density of occurrence.



References

i Oxfordshire Local Industrial Strategy

ii The UK National Infrastructure Strategy, HM Treasury, 2020

iii DfT, 2019

iv 2018 UK Greenhouse Gas Emissions, BEIS, 2019

v Air Quality Annual Status Report 2019, Oxford City Council, 2020

vi Connecting Oxfordshire

vii Oxfordshire Energy Strategy

viii Part 3, Road to Zero Strategy (2018), DfT

ix DfT, 2020

x *The image is licensed under Creative Commons ShareAlike International license 4.0. It is attributed to Sivapriya M. Bhagavathy, Constance Crozier and Malcolm McCulloch, University of Oxford and was developed for an internal report of the Park and Charge project.*

xi National Travel Survey Table NTS0908 DfT (2015)

xii Electric Vehicle Charging in Residential and Non-Residential Buildings, DfT 2019

xiii Directive 2014/94/EU of the European Parliament and of the Council 22/10/2014

xiv https://epg.eng.ox.ac.uk/our-research/park-and-charge/

xv Plugging the gap: An assessment of future demand for Britain's electric vehicle public charging network

xvi On-Street Households: The next EV Challenge and Opportunity. Field Dynamics. 2020

xvii Section 9, National Planning Policy Framework (Revised) (Feb 2019), MHCLG

xviii The Town and Country Planning (General Permitted Development) Order 2015, Schedule 2, Part 2

xix The Town and Country Planning (General Permitted Development) Order 2015, Schedule 2, Part 12

xx X-Last EV Charging Bollard, Oxford

xxi EV charging points to installed at 10 major shopping hubs, Edie.net

xxii Supermarkets analysis, Zap-Map

xxiii Thousands of free EV charge points to be installed at Tesco sites, Fleet News

xxiv EV charging at Greene King Pubs, The Independent

xxv Connecting Oxford Brochure (2020) Connecting Oxford Brochure (2020)

[xxvi] European Alternative Fuels Observatory (2018). Electric vehicle charging infrastructure

[xxvii] https://www.zap-map.com/statistics/

[xxviii] The Road to Zero (2018)

[xxix] On-street Residential Chargepoint Scheme guidance for local authorities

[xxx] Workplace Charging Scheme: guidance for applicants, chargepoint installers and manufacturers

[xxxi] https://www.zap-map.com/zap-map-user-survey-reveals-top-10-ev-charging-networks/

[xxxii] REA/Zap-Map finds 21% of public EV charging network users experience issues, Fleet News, 2020

[xxxiii] https://www.tsu.ox.ac.uk/pubs/2019-GULO-Phase-1-Final-Report.pdf

[xxxiv] https://assets.ctfassets.net/ulfvrpf1itxm/3gNS3F5NPiiU2W7tA62QqH/f6269e4852bb147bc7e29709e2383989/EV_driver_survey_report_2020_EN.pdf

[xxxv] My Electric Avenue

[xxxvi] Upgrading our Energy system: Smart Systems and Flexibility Plan (July 2017), BEIS

[xxxvii] Oxfordshire Energy Strategy (Nov 2018) OxLEP

[xxxviii] Part 3, Road to Zero Strategy (2018), DfT

[xxxix] Electric Nation, Transport Scotland, 2018

[xl] Driving and accelerating the adoption of electric vehicles in the UK, DfT, 2020

[xli] Part 3, Road to Zero Strategy (2018), DfT