


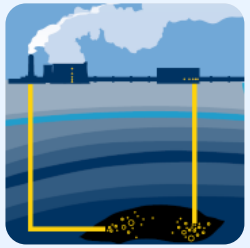



Subsurface Technology for Electric Pathways (STEP) Project Final Report

Innovate UK

September 2022

Office for Zero Emission Vehicles

UKRI Innovate UK

elementenergy
an ERM Group company

Sarah Clements
Sam Reeves
Oliver Robinson
Celine Cluzel

Subsurface Technology for Electric Pathways (STEP) project

Report Overview

- Trojan Energy has designed a novel chargepoint that sits flat and flush with the pavement
  - Residents can charge their electric vehicles (EVs) on the street outside their home without permanent infrastructure at the pavement edge
- In 2019, Trojan Energy and project partners won funding from OZEV/IUK for the design, manufacture and first real-world trial of 150 chargepoints – the Subsurface Technology for Electric Pathways (STEP) project
- The trial is now live throughout the London Boroughs of Brent and Camden
  - The trial is being monitored on an ongoing basis
  - Feedback from the trial so far has been overwhelmingly positive
- Results from the trial and resulting consumer research will feed into Trojan Energy's future strategy
- This report summarises the project and results so far

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75% of private vehicle charging is done at home as it is cheap and convenient
This raises the question – how can we ensure those without off-street parking aren't disadvantaged?

Charging methods: ***Primary "home" chargepoint types***

Charging type	Home off-street charging	Residential on-street charging	Residential charging hub	En-route charging	Destination charging	Workplace charging
Use case	Charging at home in a private driveway, garage, or residential car park, typically overnight	Charging at a public on-street chargepoint near to the driver's house, typically overnight	Charging at public chargepoints in the driver's local area. Can be fast (overnight) or rapid (similar to petrol refueling)	Charging along major routes or main roads in urban areas. Rapid charging means quick turnaround times	Charging in car parks at the end of an outward journey	Charging while parked at workplace
Typical location	Driveway, garage, residential car park	On residential roads	Along urban roads, public car parks, forecourts etc.	Forecourts at services and other sites near main roads	Public car park, supermarket, shopping centre etc.	Employee car park
Typical charging speed	Slow (3-7kW)	Slow - Fast (3-22kW)	Fast & rapid (7-50kW)	Rapid (50kW+)	Slow, fast & rapid (3-50kW+)	Slow (3-7kW)
Who is deployment led by?	Homeowner	Council	Council or private sector	Private sector, some Council involvement	Private sector, some Council involvement	Employer

Trojan Energy offers a solution for those without off-street parking to charge at home with their novel, low-profile on-street charging technology being trialled in the STEP project

Source: Element Energy

Trojan Energy has designed a novel on-street charging solution for customers who cannot charge at home – the STEP project involves the first demonstration trial of the technology

Trojan Energy technology

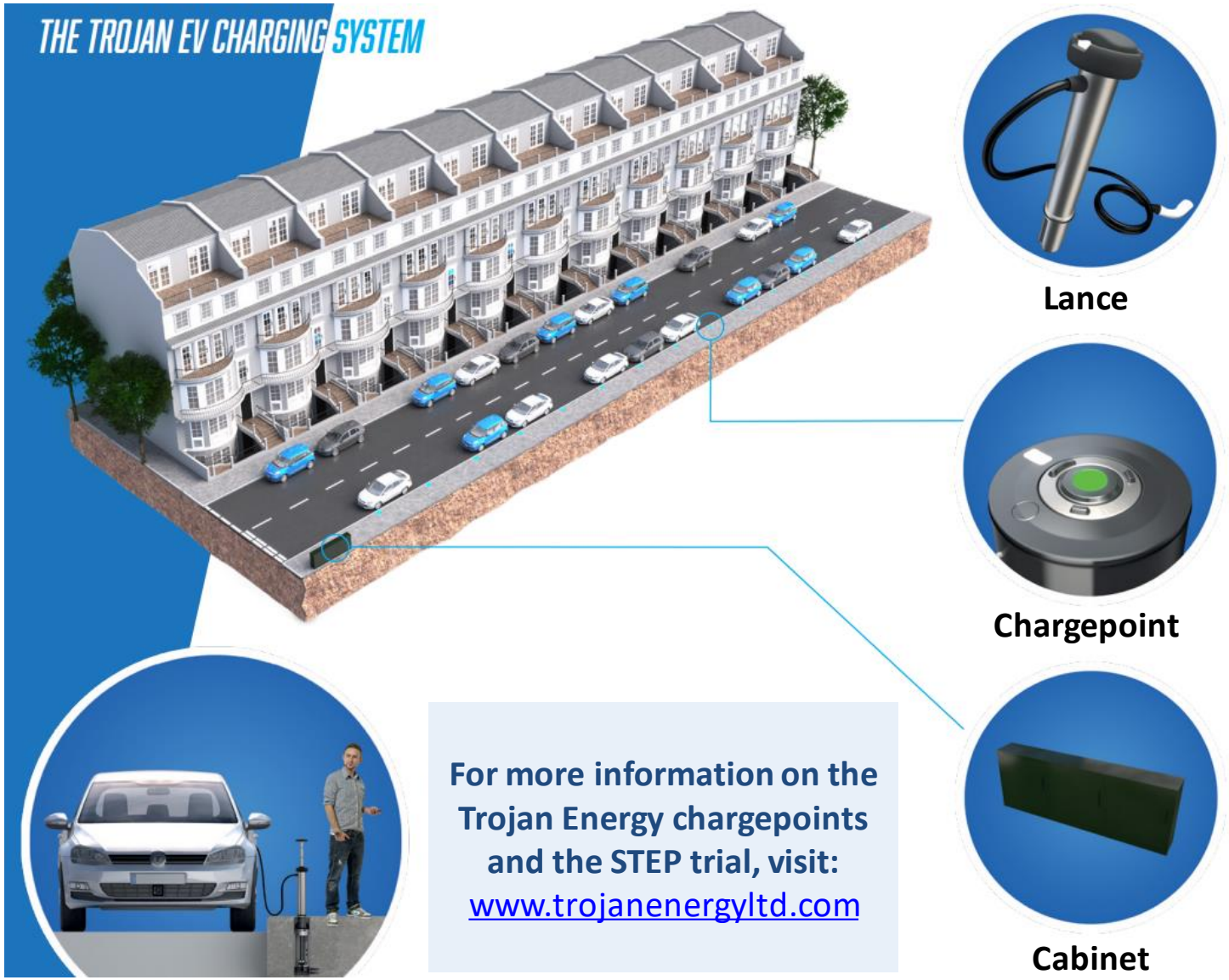
- The Trojan Energy chargepoint **sits flat and flush with the pavement**, meaning there is **no additional permanent street furniture**
- Each **EV Driver receives their own lance** which is inserted into the chargepoint and plugged into the car to start charging
- Up to **15 chargepoints can be installed in parallel** – covering entire streets and removing the need for dedicated EV parking bays
- The charging system has been designed **with input from Disability Rights UK and the Royal National Institute of Blind People** to ensure pavements remain accessible for all road users
- The STEP project is the **first real-world demonstration** of Trojan Energy's flat and flush chargepoints

The flat and flush chargepoint

The lance plugged into a chargepoint

For more information on the Trojan Energy chargepoints and the STEP trial, visit:
www.trojanenergyltd.com

The Trojan Energy technology provides significant benefits compared to traditional on-street chargepoints including the lack of permanent street furniture



For more information on the Trojan Energy chargepoints and the STEP trial, visit: www.trojanenergyltd.com

Key aspects of the Trojan Energy technology

The chargepoint:

- The system consists of a **chargepoint** that is installed flat and flush with the pavement and a **'lance'** which the user inserts into the connector
- **15 chargepoints** are deployed along a stretch of street, via one grid connection
- **Fast charging** up to 22kW
- Anyone can park in these bays – **no dedicated bays** for EV charging

The Lance:

- Everyone in the trial receives their own lance
- This is inserted into the chargepoint and plugged into the car to start charging
- The **lance is removed and stored** in the user's car or home so that when no vehicles are charging there is **no additional street clutter at the kerbside**

The Portal:

- Allows customers to control their charging online (currently online only but will be moving to a downloadable App)

STEP project overview

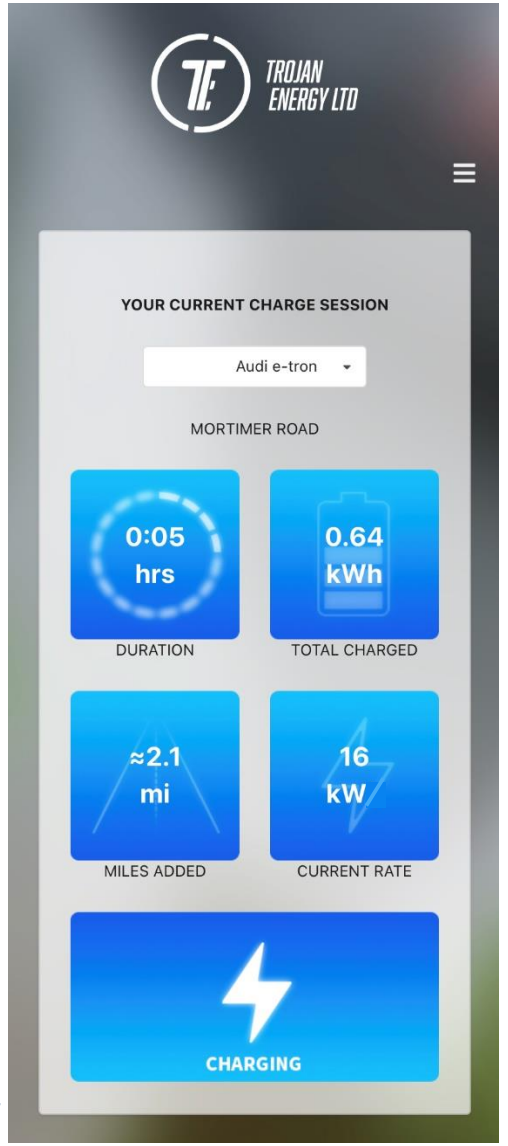
For a full overview of the STEP project watch the showcase video here

STEP Project - Showcase Video (vimeo.com)

To make charging easier for customers, Trojan Energy developed an online portal through which users can control and monitor their charging

Trojan Energy portal

- Trojan Energy have **developed an online portal** where users can control and monitor their charging
- On the portal, users can:
  - Monitor current charging sessions (duration, energy charged, estimated miles added and charging speed)
  - Check past charging sessions including downloadable monthly bills
- The portal currently only exists online and **will be developed into a downloadable app** in the near future
- There is **no requirement to use the Trojan Energy portal in order to charge** – plugging the lance into a car automatically starts charging



Example portal display

The team: delivery of the STEP project has been achieved by 8 partners each with a unique role and responsibility

Partner	Role	Tasks
elementenergy an ERM Group company	**Project manager, lead on public engagement & commercialisation**	Coordinated with the project team to ensure smooth communication and consistent project progress
TROJAN ENERGY LTD	**Chargepoint manufacturer and operator**	Designed, manufactured and installed the chargepoints Oversaw communication with subcontractors Developed commercial opportunities
Brent	**Host of EVCPs, lead local authority**	Oversaw installation of the 90 chargepoints in Brent, ensuring local requirements are met
Camden	**Host of EVCPs**	Oversaw installation of the 60 chargepoints in Camden, ensuring local requirements are met
UK Power Networks Delivering your electricity	**Distribution Network Operator**	Provided insight into the installations from DNO perspective Connected chargepoints to the electricity grid
UNIVERSITY OF LEEDS	**Consumer Research Lead**	Developed and analysed pre-trial and post-trial surveys for consumers
octopus energy	**Energy supplier for trial**	Provided insight from electricity supplier perspective Supplied electricity for the trial
Birmingham City Council	**Research partner for potential future installations**	Provided insight into how on-street charging infrastructure differs outside of London

In the STEP project, Trojan Energy chargepoints are being trialled across the London Boroughs of Brent and Camden

Key metrics:	STEP (Brent + Camden)	Brent – lead local authority (LA)	Camden
	TROJAN ENERGY LTD	Brent	Camden
No. of chargepoints	• **150 chargepoints** total across **10 hubs** - 15 chargepoints installed per hub	• **90 chargepoints** across **6 hubs** - Two recruitment areas	• **60 chargepoints** across **4 hubs** - Two recruitment areas
No. of trial participants	• **150 EV Driver** trial participants - **Significantly exceeded overall target** - One EV Driver per chargepoint • **171 additional Observer** trial participants: local residents providing feedback on the trial - Observers are affected by the chargepoints in their local area but don't use them	• **40 EV Driver** trial participants • **70 Observer** trial participants	• **110 EV Driver** trial participants: High demand for chargepoints due to high EV ownership • **101 Observer** trial participants
Additional offerings	• **Additional technology offerings:** - **Smart charging** in Brent - **De-ICEr** software in Camden • **Future work:** - Integration of chargepoints with car clubs - Merging charging and home electricity bills for Octopus Energy customers	• **Smart charging** trialling in Brent through BEIS funded trial • Customers can access cheaper electricity costs by charging overnight	• **De-ICEr** software allows users to check availability of chargepoints via the Trojan Energy online portal • Funded outside of this project

Note: the terminology "hub" refers to 1 set of 15 chargepoints and 1 grid connection. Hubs can be split across two adjacent streets

BEIS – Department for Business, Energy and Industrial Strategy

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Acronyms

STEP trial streets were selected based on a wide range of criteria including demand for chargepoints and suitability of sites

Draft list of streets

- An initial draft list of streets was developed early on in the project
- The streets were selected based on a variety of factors:
  - Local **demand for chargepoints**[1]
  - **Controlled Parking Zones** (CPZ)
  - Data on **local EV ownership**, provided by the local authority
  - Consideration of **Heritage status** of some areas in Camden and the requirements for installation within these areas
- The recruitment areas were finalised based on CPZs and trial streets were required to be within these areas

Final streets

- Using the draft list of streets, **site assessments** were completed to determine the **suitability for Trojan Energy chargepoints**
- Site assessments involve:
  - Assessment of **other street furniture** (e.g. lampposts, benches) **and trees** to determine current levels of clutter on streets
  - **Ground Penetrating Radar** was used to reveal congestion with utilities underground
  - UKPN helped to determine **grid connection suitability**
- The final outcome resulted in a list **of 10 streets**

Chargepoint locations

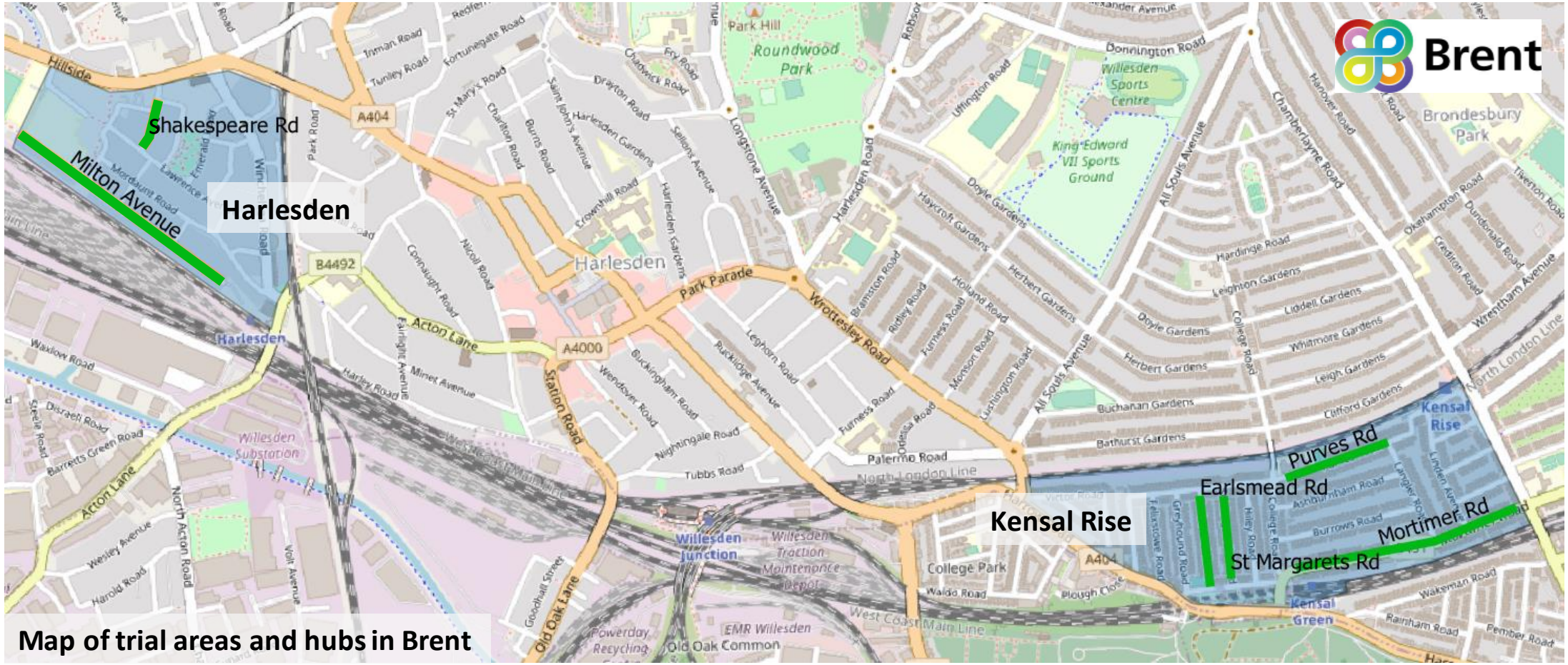
- Within these final streets, the location of the chargepoints was determined by further analysis, including:
  - Additional **Ground Penetrating Radar and site digging** to find areas with no congestion with utilities underground
  - Deciding **location of the Trojan Energy cabinet** to minimise disruption of the local area
- During this process, it was decided that **some charging hubs** would be **split across two streets**

1 – Local resident group surveyed 100 residents and 95% said they wanted more chargepoints in the Willoughby Road area

The STEP trial includes 6 hubs in Brent, each with 15 chargepoints installed, across 6 streets

Brent

Trojan installation streets in Brent across two areas, Harlesden and Kensal Rise



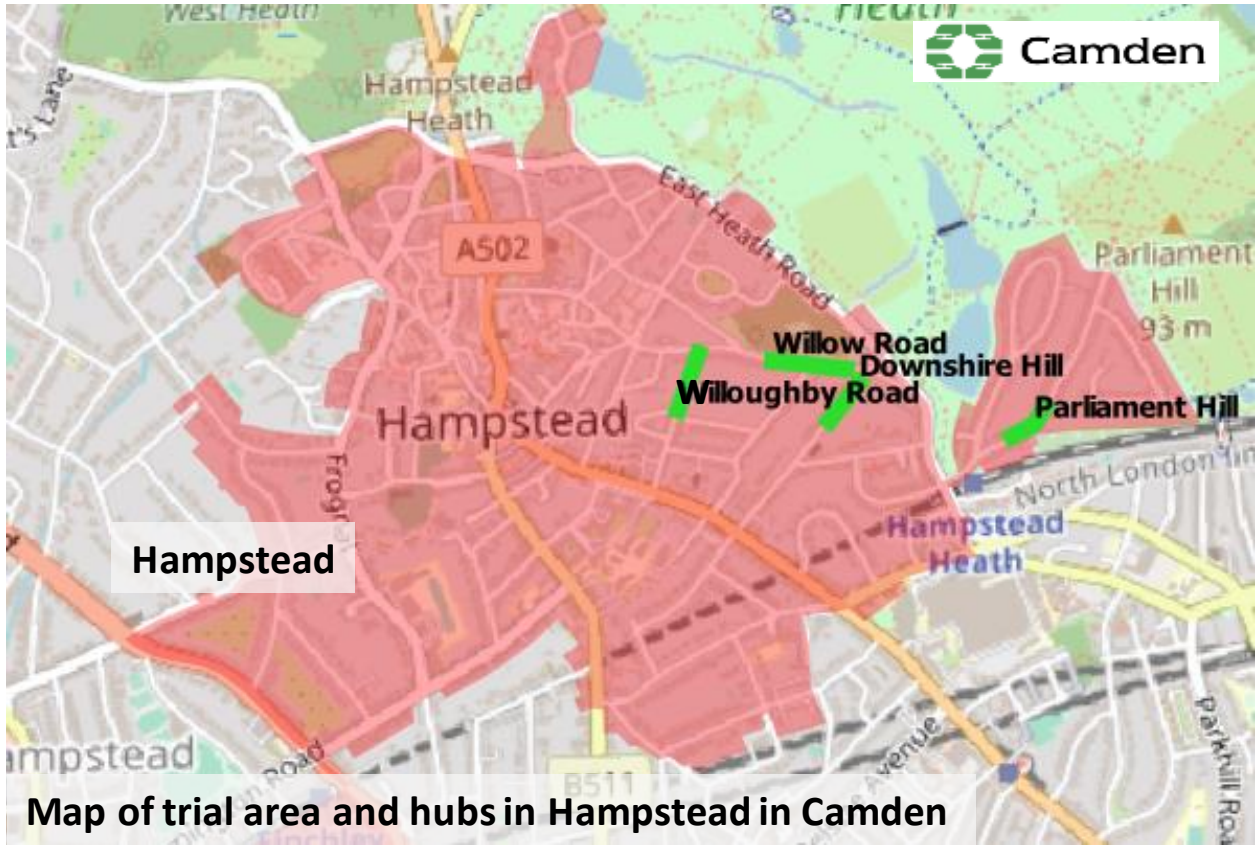
Map of trial areas and hubs in Brent

Note: Streets in Kensal Rise are within a Controlled Parking Zone (CPZ). Only participants with the correct CPZ permit are able to use these chargepoints
Streets in Harlesden are not within a CPZ and are therefore open to all EV Driver participants

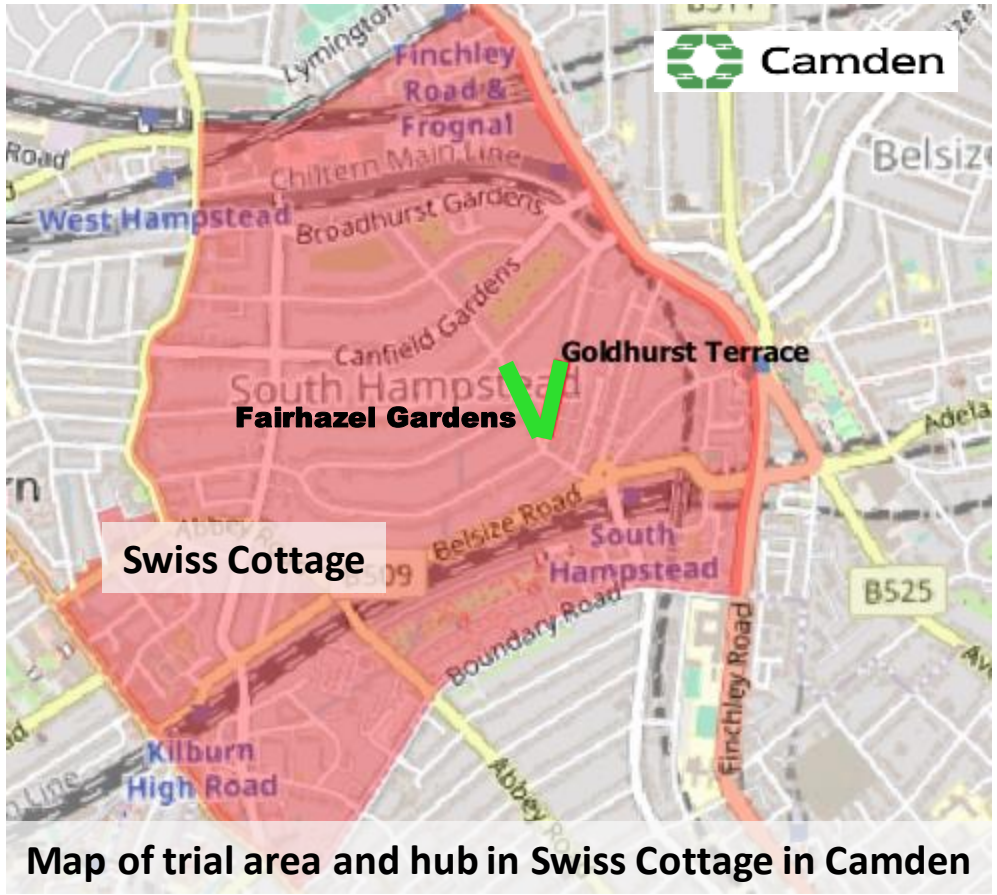
The STEP trial includes 4 hubs in Camden, each with 15 chargepoints installed, across 6 streets (Willow Road/Downshire Hill and Goldhurst Terrace/Fairhazel Gardens hubs are split across two streets)

Camden

Trojan installation streets in Camden across two areas, Hampstead and Swiss Cottage



Map of trial area and hubs in Hampstead in Camden



Map of trial area and hub in Swiss Cottage in Camden

Note: All streets are within a Controlled Parking Zone (CPZ). Only participants with the correct CPZ permit are able to use these chargepoints.

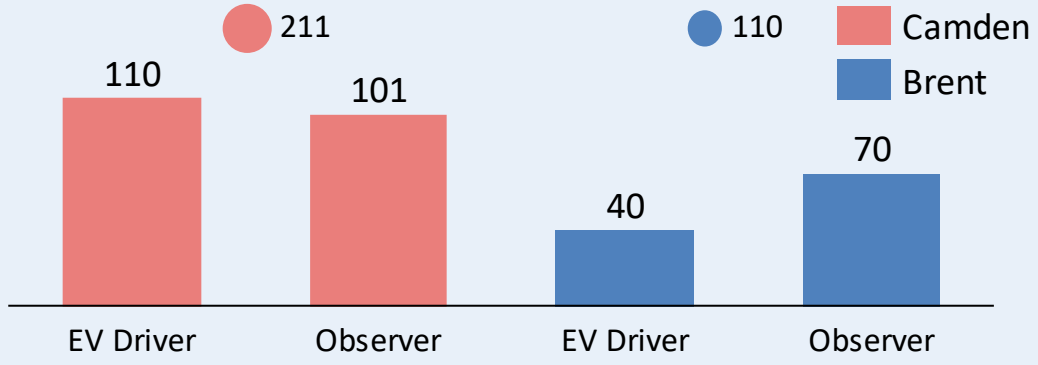
STEP trial recruitment significantly exceeded expectations

Heat maps – areas of darker red (Brent) or blue (Camden) show a higher concentration of EV Driver sign-ups

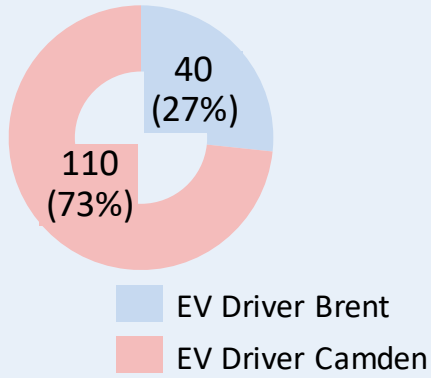
Recruitment aims have been well exceeded, with 150 EV Drivers signed up to participate (the maximum possible for the STEP trial)

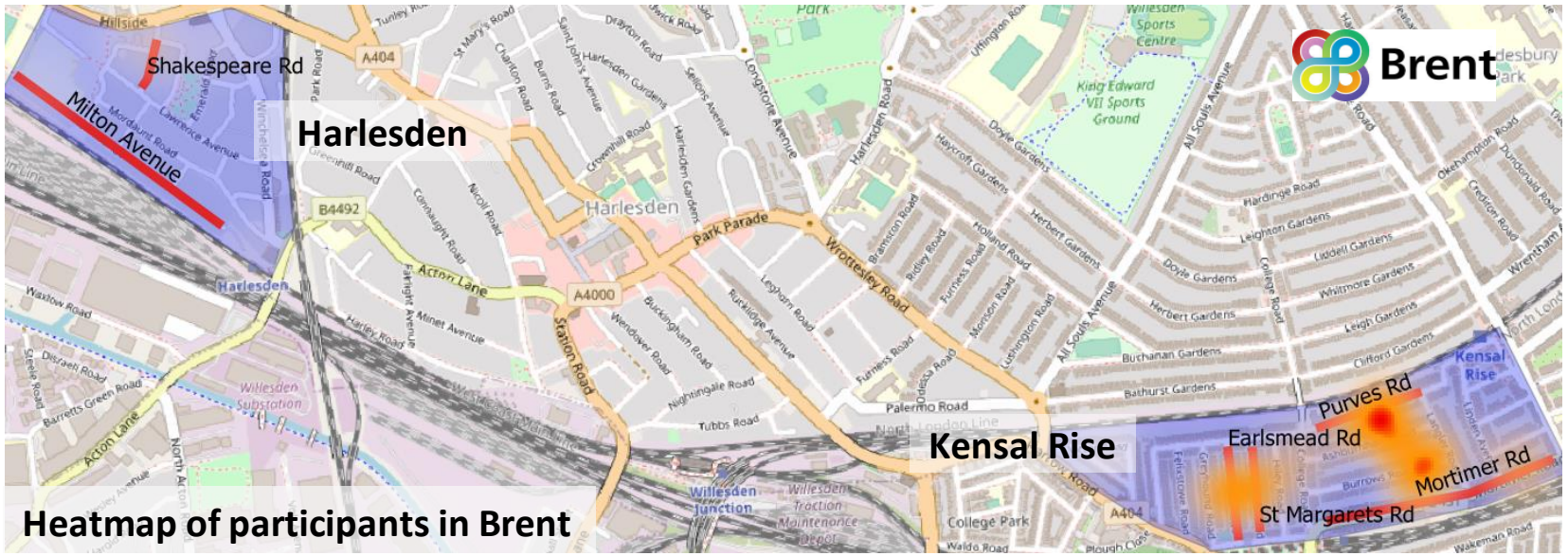
- Additional participants are now being added to a **waiting list**, which currently includes **over 25 EV Drivers**

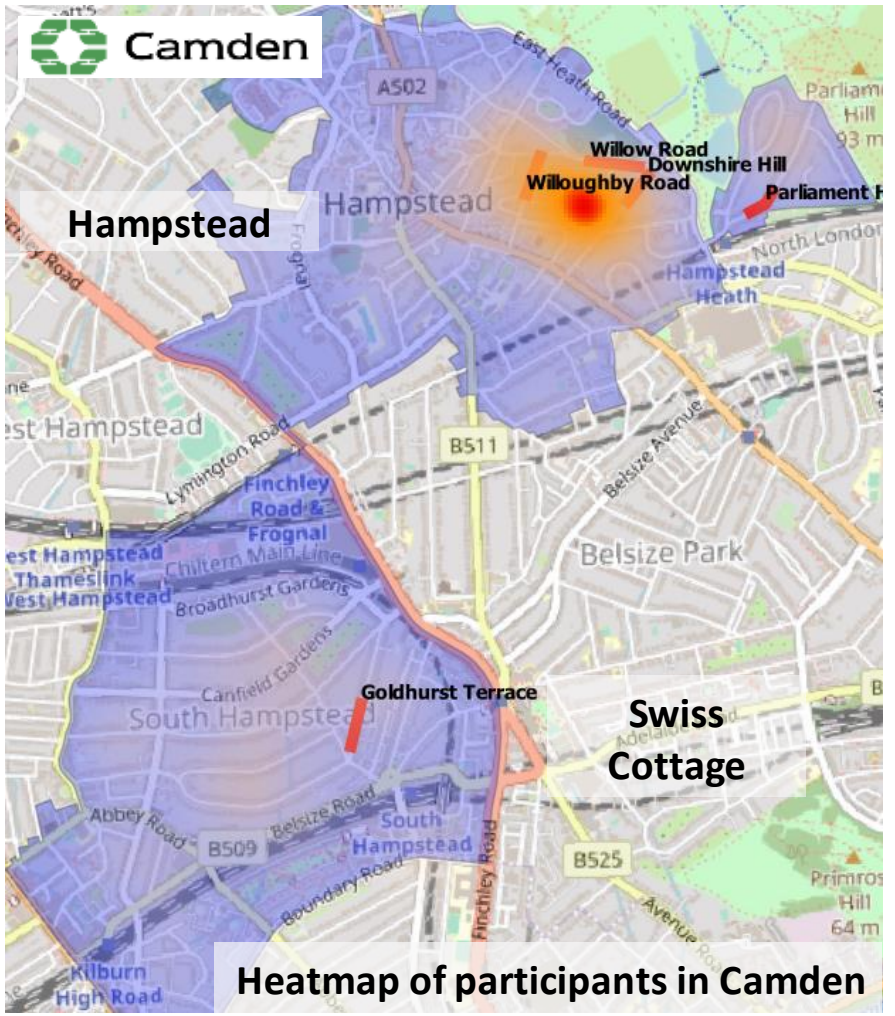
Sign-ups in Brent and Camden by category (borough totals in circles)



All EV Drivers by borough



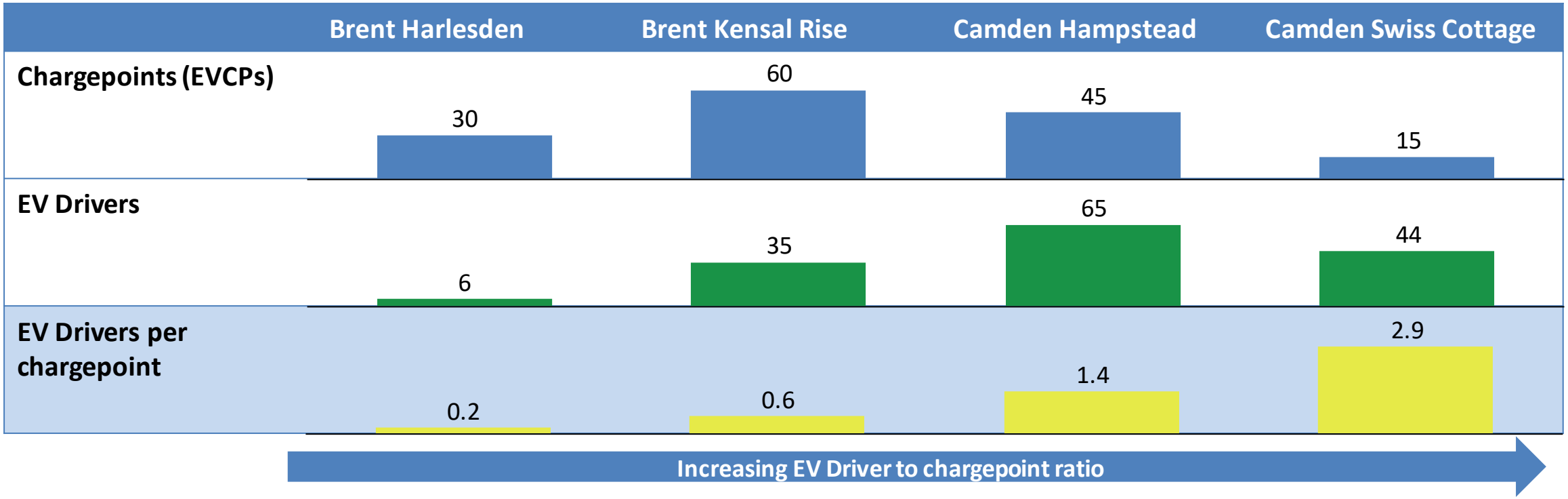




Observer count includes EV Driver participants beyond the 150 limit, currently on the waiting list

The distribution of EV Driver sign-ups and chargepoints across the two boroughs results in 4 trial areas with varied EV Driver to chargepoint ratios

The Swiss Cottage area in Camden has 15 times more EV Drivers per chargepoint than the Harlesden area in Brent



This difference in these ratios will be used to assess key research questions in the trial, for example:

1. What is the availability of the chargepoints? Can EV Drivers always use chargepoints on their preferred street?
2. Do Trojan Energy chargepoints negatively affect parking on the streets they are installed on? Does this vary by street?

>> Results from these key research questions will feed into Trojan Energy's future strategy

EV – Electric Vehicle

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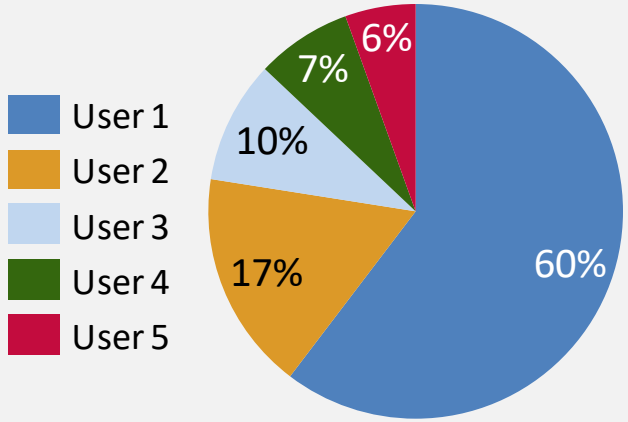
During trial recruitment and installation, an early trial of 5 EV Drivers took place on Mortimer Road in Brent and provided invaluable feedback to the full trial

Data
Jul 21 – Mar 22

Early trial on Mortimer Road in Brent

- From July 2021 – March 2022, 5 users on Mortimer Road in Brent were given a prototype lance to charge on one of 5 installed prototype chargepoints
- These users provided invaluable feedback which has fed into the full trial of 150 chargepoints
- In total, these 5 users completed over **250 charging sessions** within this period, charging over **4,800 kWh (approximately 14,500 miles)**

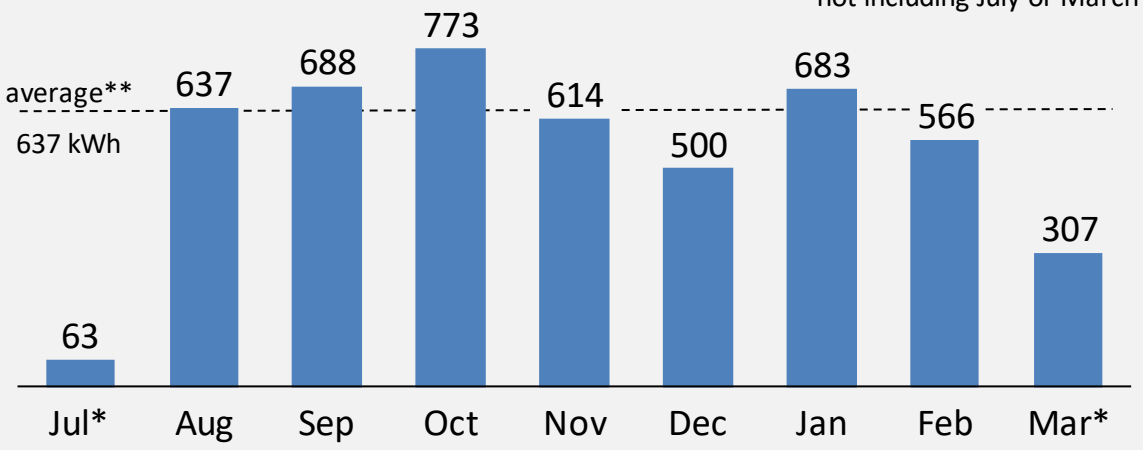
Charge by user (% of total kWh)



User 1 is a taxi driver and therefore has very high mileage and charged on a Trojan Energy chargepoint almost daily

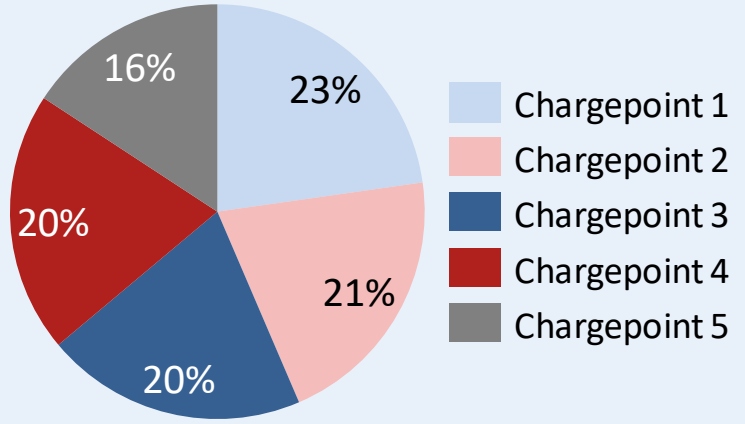
Charge by month (kWh)

*not a full month of charging
**not including July or March



Charge by chargepoint (% of total kWh)

Each chargepoint was used for a similar proportion of charging during the trial



Assuming 3 mile/kWh average

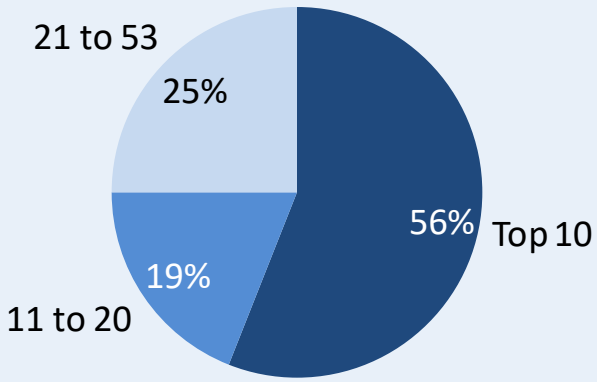
The full trial of 150 chargepoints launched in April 2022 and has so far received positive feedback from EV Drivers and Observers

Data
April – June 22

Full trial in Brent and Camden

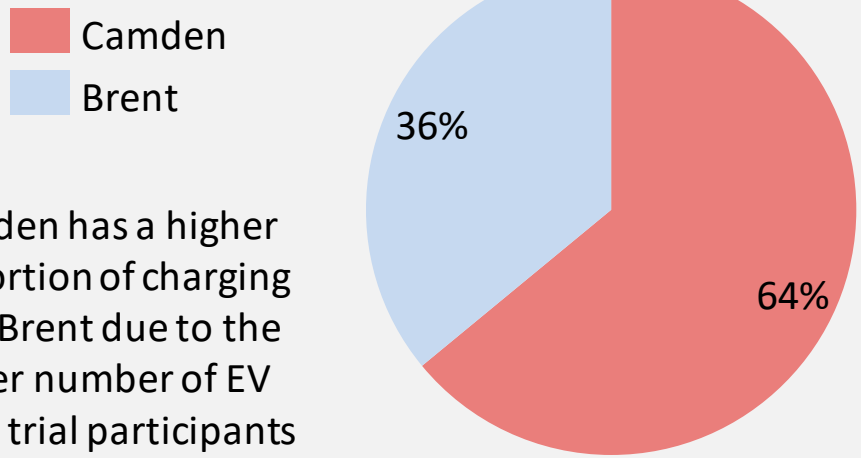
- From April 2022, the full trial of 150 chargepoints is live
- The trial is capped at 150 EV Driver participants (1 per chargepoint). In future work, Trojan Energy expect a higher number of users per chargepoint, and therefore higher utilisation
- By June 2022, 53 users had charged over **283 charging sessions**, charging nearly **5,000 kWh (approximately 15,000 miles)**

Charge by users (kWh)



The top 10 users account for just 19% of users who have charged so far, but have 56% of charging consumption to date

Charge by borough (% of total kWh)



Camden has a higher proportion of charging than Brent due to the larger number of EV Driver trial participants in the area

- In Camden, the most popular hubs so far are Willow Road and Willoughby Road
- In Brent, the most popular hub so far is Mortimer Road
- The top users tend to use the same chargepoint(s) when they charge
  - The top 5 chargepoints have been used for over 25% of all charging so far

Assuming 3 mile/kWh average

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STEP project key achievements and lessons learned by task (1/2)

	Key achievements	Key lessons learned
Design and Manufacture 	• **Design, manufacture and certification of Trojan Energy's novel chargepoint system – lance, connector and cabinet** • A **prototype technology** was produced for key learnings before mass manufacturing • 150 chargepoints/lances and 15 cabinets manufactured	• **Trialling five prototype versions** of the system in a real-world situation **provided invaluable learnings** and improvements to the final technology design
Recruitment and Engagement 	• STEP **customer offer developed,** and **engagement material created** • **Recruitment completed** with **150 EV Driver** participants – reached the **maximum limit for the trial** • **Ongoing engagement** with trial participants – including **training** before first use	• **Engaging with the community ahead of works** is important – particularly with residents whose property is close to the chargepoints • Important to **keep participants aware of any updates to the trial** so that the community remains engaged
Site Preparation and Installation 	• **Detailed site assessment for each street** – confirming lack of other infrastructure below the surface, suitability for grid connection and, in the case of Camden, not impacting heritage areas • **Civils and electrical work** of all cabinets across Brent and Camden complete	There are **many nuances involved in site selection** which will affect chargepoint installation and usage, including: • **Availability of parking on streets** • Congestion with other **street furniture** on the pavement and **other utilities** underground • Suitability for additional **grid connection** • **Heritage sites** require extra work to ensure that the technology blends in with the streetscape

STEP project key achievements and lessons learned by task (2/2)

	Key achievements	Key lessons learned
Commissioning and Operation	• **Safety testing** of all cabinets on-street completed • **Billing mechanisms** successfully tested • Developed **portal** for customers to select their charging preferences and see their billing	• Users have noted the **importance of online portal**, particularly for checking billing, and have **provided feedback** on what else they would like on the portal
Monitoring	• Collection, monitoring and live analysis of **chargepoint utilisation data** • **Monitoring log** for issues and maintenance completed	• By collecting and **reporting utilisation data** to the funding bodies, Innovate UK and OZEV, Trojan Energy can **contribute to wider learnings and knowledge sharing** across the EV sector
Consumer Research and Dissemination	• Developed **pre- and post-trial surveys** for all participants • Trojan Energy and the STEP project have received **wide press coverage** in the UK and international media	• Spending time to **carefully construct surveys** is key to monitoring trial success and adds value to future projects • Ensuring **high customer response rate** for surveys via offering incentives and sending reminders is key

STEP key achievements by partner

Trojan Energy Ltd

- Technology has been **designed and optimised**, with **input from real world users**, **generating IP** in the process
- **Two additional projects** developed from STEP, 1 funded by OZEV (DoorSTEP) and 1 funded by BEIS (SmartSTEP)
- **Showcased the charging technology** to industry stakeholders both through events and on-street demonstrations
- **Developed commercial opportunities with several local authorities, fleet operators and businesses**
- Featured in a wide range of **media publications** including the Financial Times and Reuters

Element Energy (an ERM Group company)

- **Successfully managed** the project from the funding application stage to delivery
- Facilitated **two follow-on projects** to further develop Trojan Energy's technology – the SmartSTEP and DoorSTEP projects
- Ensured **strong engagement from participants** via effective communications and with **wider stakeholders** via press releases and launch events

Brent

- Improved **technical skills/knowledge** of chargepoints
- Additional collaboration with different partners through **participation in other government-funded projects** – DoorSTEP and SmartSTEP

Camden

- Encouraged **strategic thinking about electric vehicle chargepoint** infrastructure in the borough going forwards
- Improvements in project management for future projects

UK Power Networks (Delivering your electricity)

- Developed skills on how to manage complex grid connections for electric vehicle chargepoints
- Aided understanding of the customer experience when connecting charging infrastructure to the grid. This has allowed UKPN to improve processes, and collaboration with project partners has also helped to develop potential commercial products, such as flexible connections
- **Participation in other government-funded projects** – SmartSTEP, smart charging is a key research area for UK Power Networks

University of Leeds

- **Leading novel academic research** – such detailed research into on-street charging behaviour has not been completed before
- Academic papers will be published and the **findings will lead into future research**

Octopus Energy

- Allowed the exploration of the idea to merge a customer's home energy bill with an on-street chargepoint bill
- Enabled **participation in other government-funded projects** – SmartSTEP, smart charging is a key research area for Octopus Energy

Birmingham City Council

- Developed **technical knowledge** of on-street charging as well as the key next steps required for future on-street chargepoint deployment

LA – local authority, DNO – Distribution Network Operator, OZEV – Office for Zero Emission Vehicles, BEIS – Department for Business, Energy and Industrial Strategy

Trojan Energy have grown significantly during the STEP project and are continuing to expand

Trojan Energy team

Trojan Energy's team is growing:

- At the start of the STEP project, Trojan Energy had 4 full-time employees
- Now, Trojan Energy has over 25 employees and is aiming for 40 by end of 2022

Additional projects

Several projects have followed on from STEP (*New partner*)

1. DoorSTEP/Aon
   - working with EE, Brent Council and *Oxfordshire County Council*
2. SmartSTEP
   - working with *Landis+Gyr*, EE, Brent Council, Octopus Energy, UKPN and University of Leeds
3. De-ICEr
   - Trojan Energy funded, *Cleverciti* parking technology company are subcontractors

Commercial opportunities

Commercial opportunities have significantly increased:

- Discussions ongoing with many Local Authorities and businesses across the UK
- Expanding market position in the UK with sights on the first international project
- Over 200 requests for a Trojan Energy chargepoint installation internationally
- Post-trial contract to be agreed with Brent and Camden after trial has been assessed

Intellectual property

Intellectual Property (IP) generated:

- Internationalised flat and flush patent
- Broken out some backend software from the patent – now a separate patent
- Applied for IP on De-ICER and Aon (STEP led to these)

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Trojan Energy developed additional technology, De-ICEr, to allow customers in Camden to see the availability of chargepoints in real-time via the Trojan Energy portal

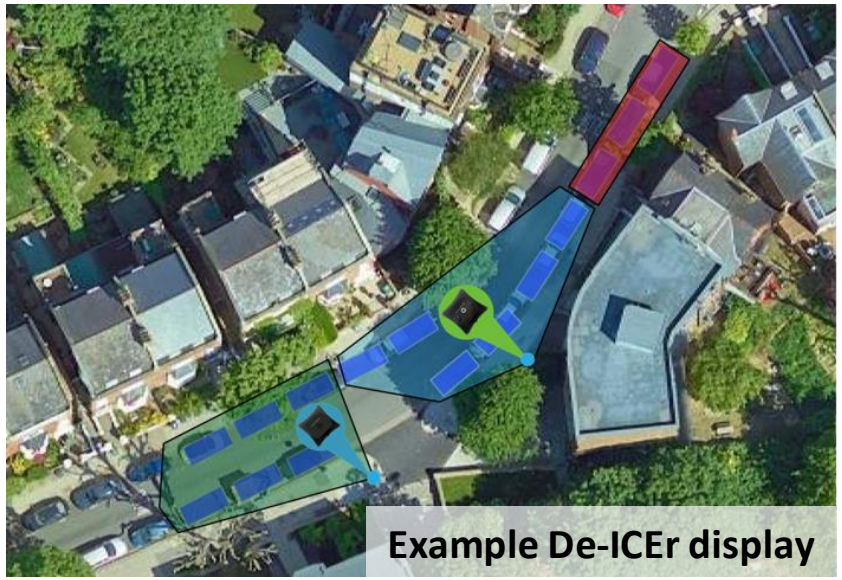
De-ICEr software

- As an additional offering, Trojan Energy developed De-ICEr as part of the STEP trial
- De-ICEr technology uses on-street sensors, provided by Cleverciti, to detect availability of parking spaces
- Users can check availability of chargepoints via the Trojan Energy portal, and can request to be notified once one becomes available

Benefits of De-ICEr

- **Increases utilisation of the chargepoints**
- **Saves time for users** by letting them know when chargepoints are available
- **Removes need for EV-only parking bays**

De-ICEr functionality



Example De-ICEr display

De-ICEr sensor

DEICER - Giving EV drivers the parking advantage - Trojan Energy

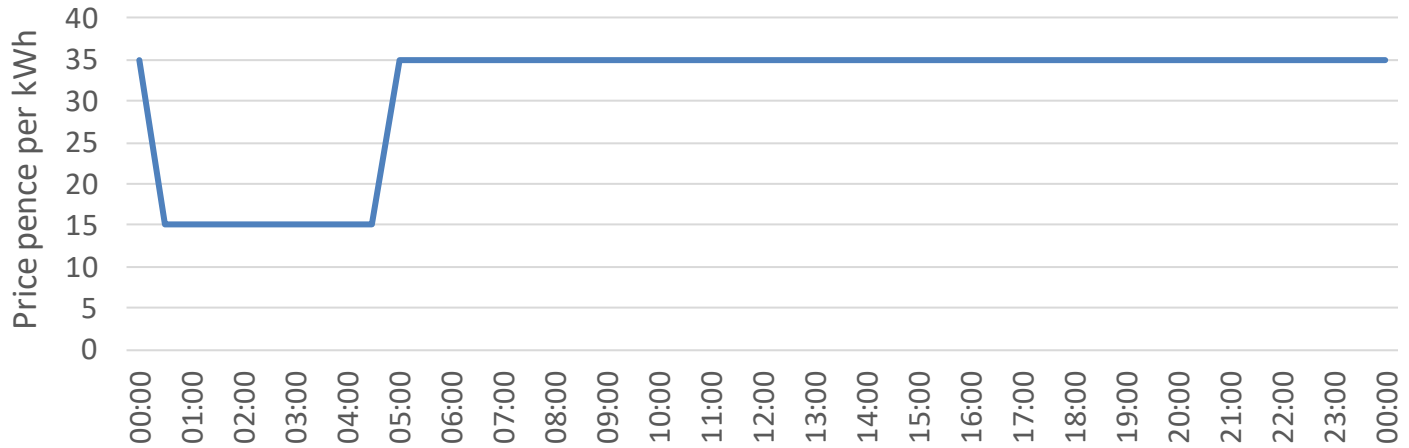
During STEP, some of the project partners won funding from BEIS to upgrade chargepoints in Brent to a new smart-meter enabled charging system - SmartSTEP

Department for Business, Energy & Industrial Strategy

SmartSTEP summary

- BEIS are interested in **testing charging using smart meters in an on-street context**
- Chargepoints in Brent have been set up to allow smart charging
- SmartSTEP offers the chance to capture **lower prices for smart charging** as well as trial using **charge control events*** through the smart meter to limit demand at peak times
- **Cheaper charging costs incentivises overnight charging**

Charging will cost **35p/kWh during the day outside of off-peak periods**, and will be reduced to **15p/kWh during off-peak periods** for four hours overnight 00:30-04:30



SmartSTEP customers are able to choose from three different charging options:

1. **Plug and play** – charge straight away as soon as you plug your lance in
2. **Delayed charging** – schedule your charging to start at 00.30 to make the most of the low-price electricity. You can also select an option to charge for only the hours where the price is 15p/kWh
3. **Smartcharge** – your Trojan portal will optimise your charging to reduce your costs and support the grid where possible

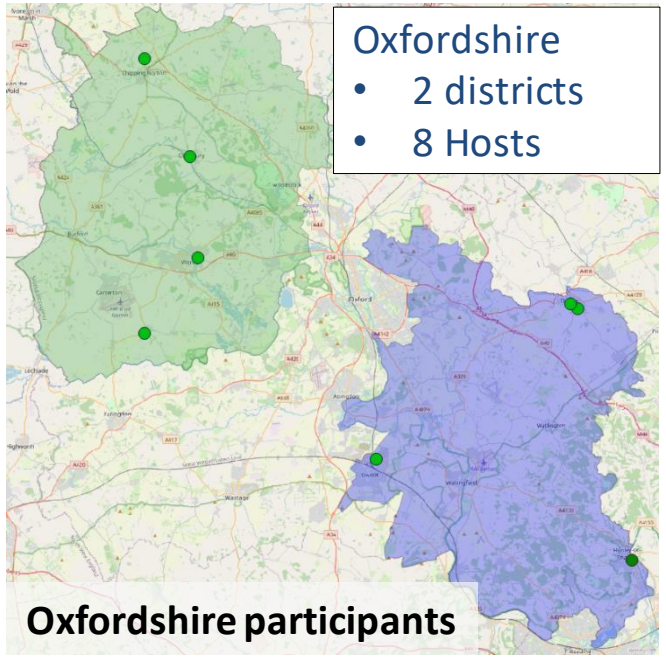
>> Each of these charging options can be selected in the Trojan portal. Default preference can be changed any time

SmartSTEP Trial - Smart EV charging in a public setting - Trojan Energy

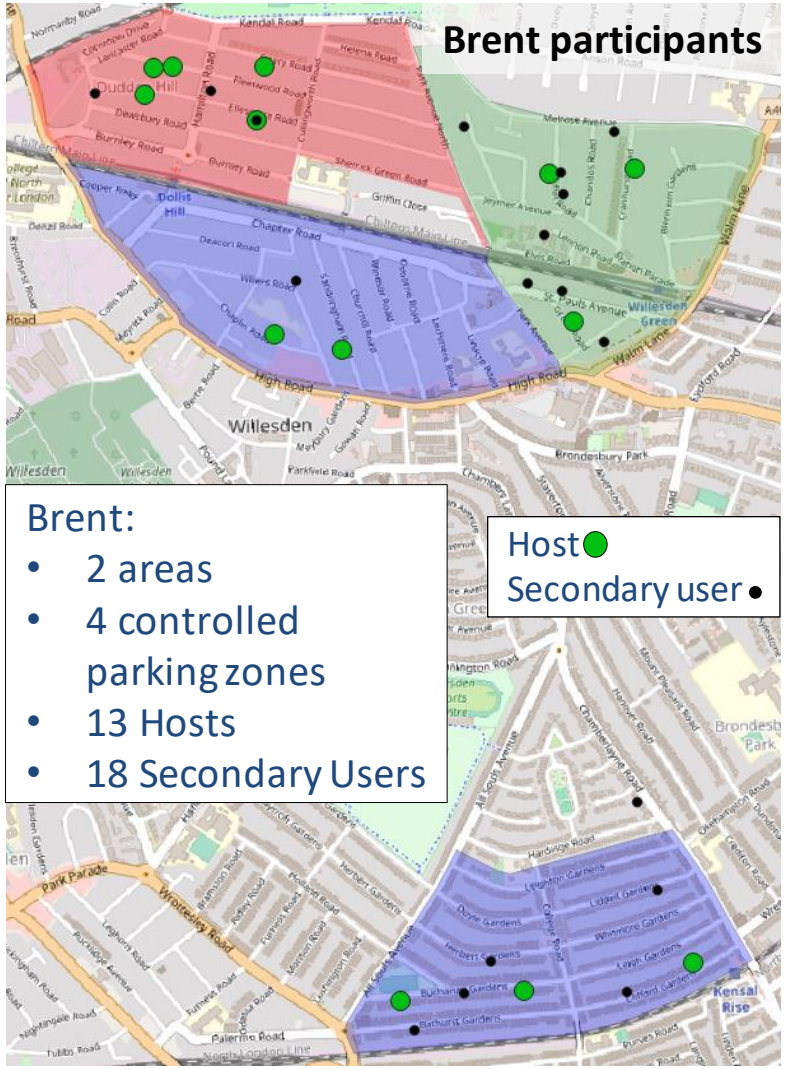
*in charge control events, charging speed is reduced. This can be overridden by users if they need charge immediately

DoorSTEP is another Trojan Energy project in parallel, involving the installation of a single chargepoint connected to a home energy supply

Aon charger technology



Oxfordshire participants



Progress to date

- **Designed, developed and manufactured the first Aon chargepoint units**
- **21 users across Brent and Oxfordshire** have signed up to have an **Aon chargepoint installed outside their property**
- **18 Secondary Users** in Brent have signed up to **use chargepoints installed outside other primary user's properties**

Thank you to the Office for Zero Emission Vehicles (OZEV) and Innovate UK (IUK)

Next steps

- All project partners have expressed an interest in working together again and many are doing so already across other projects
- The STEP trial in Brent and Camden is continuing to allow all project partners and trial participants to fully assess the Trojan Energy chargepoints and their impact
- At the end of the trial, Brent and Camden councils will decide post-trial arrangements for the chargepoints
- Later in 2022, trial participants will be asked to complete post-trial surveys on their experience with the Trojan Energy chargepoints in their area
  - Results of this post-trial survey will be key in determining the success of the trial

More information

- For further information on Trojan Energy and the STEP project, see:
  - Trojan Energy's Website: www.trojanenergyltd.com

Thank You

Many thanks to OZEV and Innovate UK for funding this project and providing guidance where needed

The STEP project is part of the Innovate UK On-Street and Wireless Charging cohort

Special thanks also to our Monitoring Officer, Martin Tillin, who has been instrumental to the successful operation of the project

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Site Selection & Recruitment

Utilisation – to date

Key Achievements

Resulting Innovations and Projects

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STEP Project Picture Gallery

Acronyms

Demonstrating the flat & flush chargepoint

Flat and flush chargepoints on Parliament Hill, Camden

Flat and flush chargepoint on Mortimer Road, Brent

Flat and Flush chargepoint on Parliament Hill, Camden

Flat and flush chargepoints on Parliament Hill, Camden

Launch Day in Brent

Project partners at the Launch Day in Brent

Lance charging on Mortimer Road, Camden

Launch day in Camden

Lance charging with live portal display

Josey Wardle, Innovate UK, with a lance

Project partners at the Launch Day in Camden

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Acronyms

Acronyms

List of acronyms used in this report

BEIS	Department for Business, Energy and Industrial Strategy
CPO	Chargepoint Operator
CPZ	Controlled Parking Zone
DNO	Distribution Network Operator
EE	Element Energy
EV	Electric Vehicle
EVCP	Electric Vehicle Chargepoint
ICE	Internal Combustion Engine
IP	Intellectual Property
IUK	Innovate UK
kWh	Kilowatt hour
LA	Local Authority
OZEV	Office for Zero Emission Vehicles
STEP	Subsurface Technology for Electric Pathways
UKPN	UK Power Networks