FASTER: A SITE-SELECTION METHODOLOGY FOR JOURNEY EV CHARGERS

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ABSTRACT

Establishing sites for publicly accessible electric vehicle charging equipment is a challenge facing local authorities across Scotland. To date, this process has predominantly been an ad-hoc, funding dependent activity aimed at providing a nationwide network of chargers. The FASTER project seeks to deploy 73 journey chargers across Northern Ireland, the border region of the Republic of Ireland and the west coast of Scotland. This paper presents the methodology developed for siting 24 'rapid' DC journey chargers in Scotland.

INTRODUCTION

The FASTER project [1] is a €6.4 million EU INTERREG V funded project led by East Border Region Ltd in partnership with the University of Strathclyde's Power Network Demonstration Centre and HiTrans (Highlands and Islands Transport Partnership). The project aims to reduce the impact of fossil fuels and transport emissions through the delivery of 73 new publicly accessible 'journey' (≥50kW) charging points across Western Scotland, Northern Ireland and the Border Region of the Republic of Ireland to support car drivers as they make the switch to electric vehicles. The project is working with several rural local authorities across Western Scotland (Figure 1) to identify suitable locations for 24 rapid DC chargers to be installed throughout 2022.

Scotland already has an extensive publicly owned charging network covering the country with >488 journey chargers and >1,590 'destination' AC charging sites. With many existing charging locations, local authorities, tasked with the roll-out and operation of these chargers, face challenges with further infrastructure deployment, including:

- meeting existing user-demand (including seasonal peaks),
- anticipating areas where public charging may be required in the future,
- ensuring a suitable geographic spread of chargers to reduce range anxiety,
- minimising the costs associated with connecting to local distribution networks, and
- ensuring that their portfolio of sites is at least revenue neutral, in the long term.

Scotland hosted approximately 10 journey charging devices per 100,000 population in January 2021 [2] rising to 12.9 devices per 100,000 at the start of January 2022 [3] (where a journey charger is considered as a device that can charge at ≥25 kW – although most such chargers in Scotland are rated at c. 50 kW). With electric vehicles representing 21.4% of new car sales in December 2021 [4] combined with the pending implantation of low-emission zones in Scotland's biggest cities [5], Scotland is beginning to see a large-scale shift towards the use of low-carbon, battery-electric vehicles.

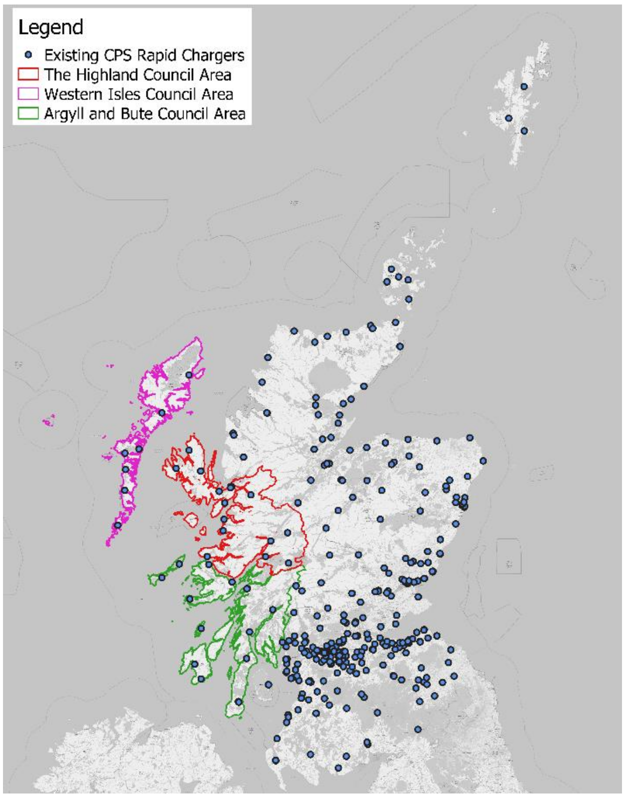

Figure 1. FASTER Local Authority Regions – Scotland.

While local authorities have good local knowledge of their operational area, they have limited visibility of EV growth projections and the associated impact on the power distribution network in their region. A major limitation is the lack of visibility of the power distribution network topology and the available capacity – particularly at low voltage levels, where most costs and upgrades apply. To assist local authorities in the deployment of new charging infrastructure, the team at the Power Networks Demonstration Centre (PNDC) has implemented a layered modelling approach to help identify candidate sites for rapid charger deployment. This methodology considers charging demand forecasts, geospatial coverage, existing usage rates and site-specific metrics including land ownership and user convenience. The model produces a

ranked-order list and an interactive GIS (geographic information system) mapping file to help local authorities and transport partnerships understand priority locations for EV infrastructure. The top identified sites were assessed from a power-capacity perspective to anticipate where potentially costly grid connections are likely and mitigate against them prior to formal connection applications by considering nearby alternatives. The data-underpinning the entire process is from publicly available sources helping to create an open and transparent process for local authorities and third-parties to re-use.
This paper summarises the methodology developed for the FASTER project and provides examples demonstrating the benefits of the approach. In one such case study, savings of c. £35k were achieved through minor relocation (<1 km) of a potential site (noting that the total average site budget, including the purchase of the rapid EV charger itself, was c. £45k). The paper also highlights the data sources required to repeat this study for other areas and outline learnings discovered through this process. Finally, the paper summarises several ways the outlined methodology could be developed further.

METHODOLOGY

The methodology developed for the FASTER project is a multi-staged process summarised in the subsequent sub-sections. The site identification process is outlined first, followed by an overview of the power capacity assessments designed to determine the likely grid connection implications at each site. Figure 2 summarised the high-level structure of these processes.

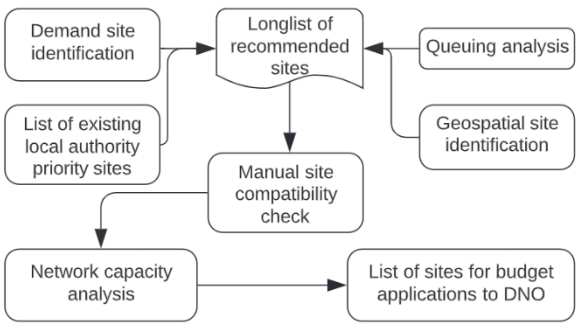

Figure 2. FASTER methodology overview.

<u>Site Identification</u>

The site identification process aimed to create several 'long-lists' of candidate sites for EV charging based on:

a) areas where improved coverage from a journey time perspective are required,
b) communities where forecast demand at journey chargers is likely to be high,
c) inferring where queuing at existing charging infrastructure can be expected, and,
d) existing local authority priority/preference sites.

Distribution network availability was not considered at this stage as user convenience of charge points was deemed to be a more important initial consideration. The process for creating these long-lists will be briefly outlined.

Geospatial Coverage Analysis

The geospatial coverage process (Figure 3) considers the existing journey charging infrastructure within the FASTER region with a short boundary into the adjacent regions. Using the ORS tools [6] QGIS plugin, it was possible to calculate driving time isochrones from the existing journey charge points and determine areas deemed not to be covered, i.e. the network gaps.

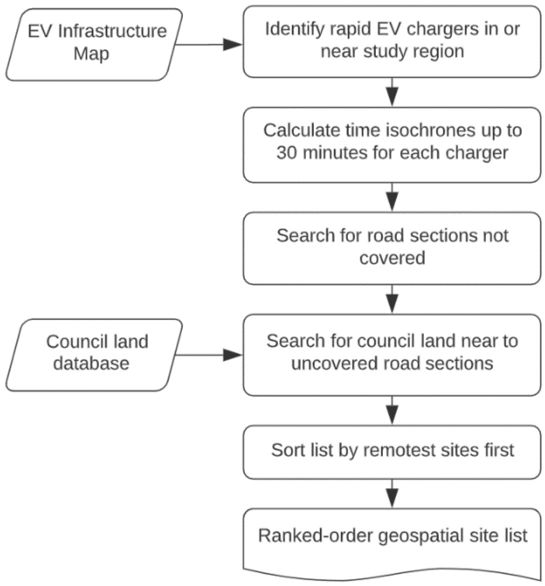

Figure 3. Geospatial coverage process to identify gaps in existing journey charging network.

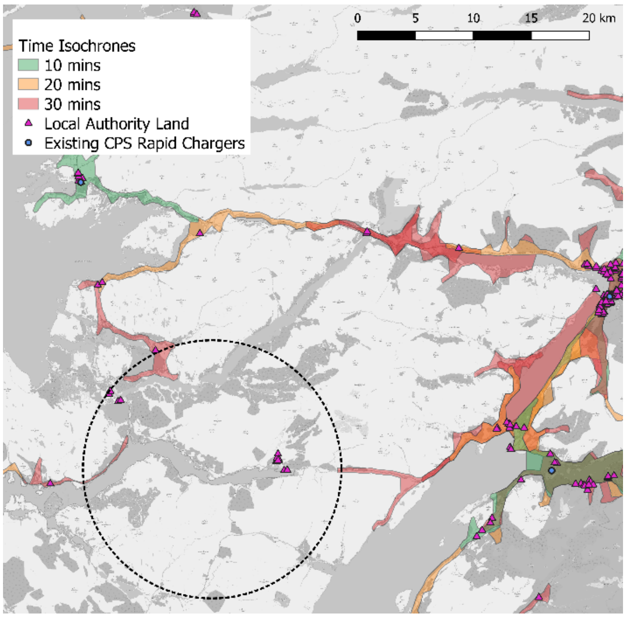

Figure 4. Time isochrones for the existing network with an area of poor coverage outlined via the dashed circle.

To visualise the process set out in Figure 3, Figure 4 presents the time isochrones up to 30 minutes for a subset of the study region. From this visualisation, we see that there are several council assets (pink triangles) not covered by the isochrones suggesting that the area is poorly covered by journey charging infrastructure and that land opportunities exist for development. Deploying a rapid charger at one of the council assets and recalculating the journey time isochrones yields Figure 5. The introduction of this single charging device significantly improves the time coverage in the area.

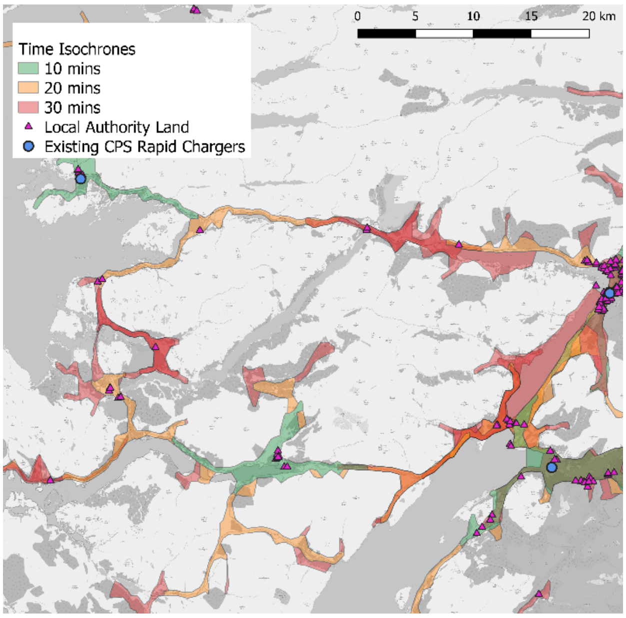

Figure 5. Recalculated time isochrones based on the introduction of a single journey charge point on local authority land.

Demand Analysis

This analysis identifies communities where the demand for publicly accessible rapid EV charging will be required to meet short-term demand growth in EV usage. Several datasets underpin this analysis as outlined in Figure 6.

The output of this analysis was a ranked-ordered list in terms of an average daily energy density per square kilometre (kWh/km^2). The density element of this analysis is important to capture those living in housing where charging at home is less likely and a greater reliance on public infrastructure is required. Once the daily energy density for each census zone was calculated, the energy served by existing charging infrastructure was subtracted from the calculated value to determine how much additional infrastructure is required to meet demand.

Figure 7 presents the demand analysis results in the form of a heat map for the three local authorities studied with Figure 8 representing the energy densities calculated for the urban area outlined in the dashed area in Figure 7.

The demand analysis helps identify areas where high levels of charging events on public infrastructure are to be expected – in reality, the use of EV hubs in these areas may prove the most cost-effective solution going forward.

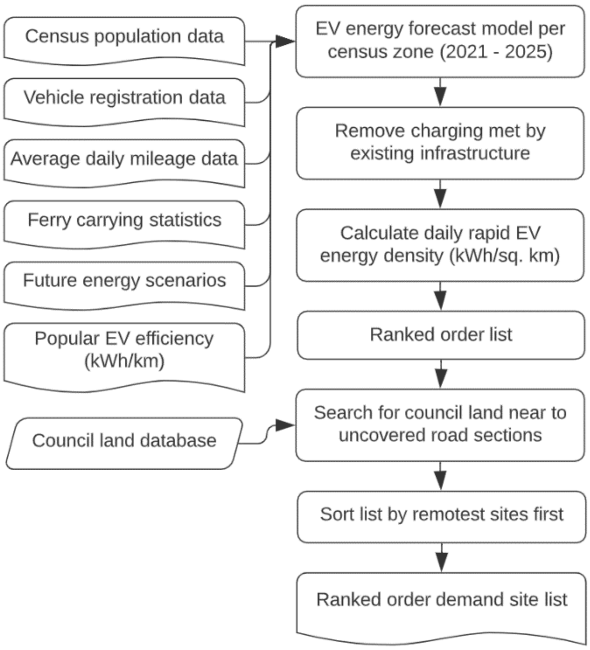

Figure 6. Demand analysis process.

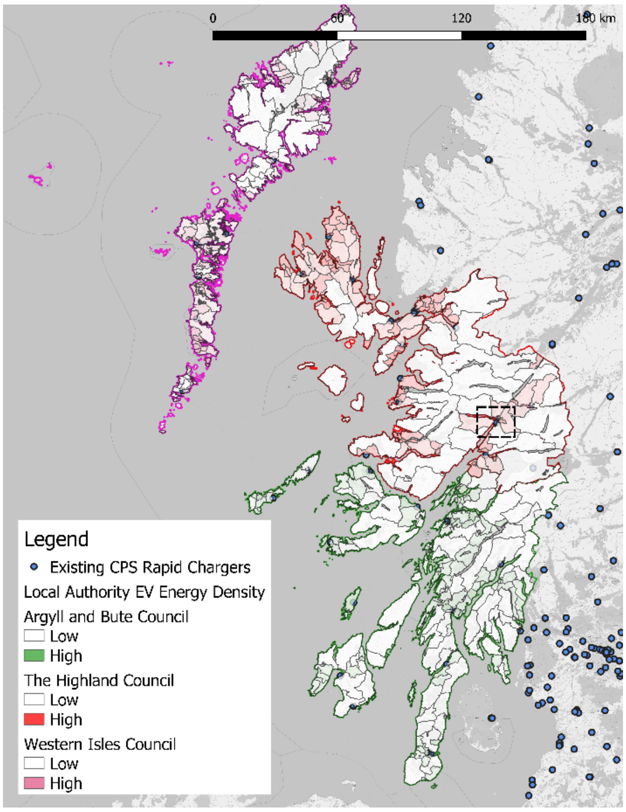

Figure 7. Overview of EV demand density for study region with an area of high density outlined by the dashed area – see Figure 8.

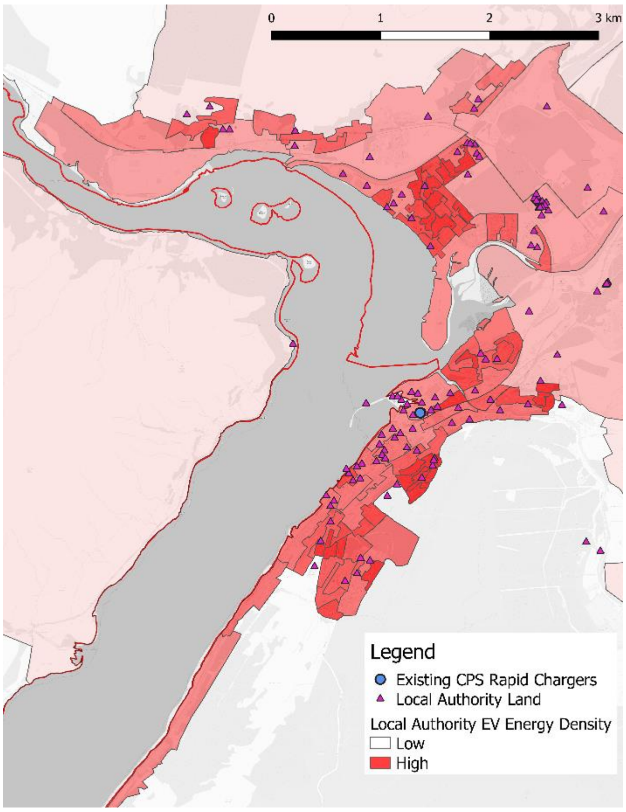

Figure 8. Detailed view of the highlighted area in Figure 7 displaying EV demand density in an urban population centre.

Queuing Analysis

The final element of the site identification analysis examined the utilisation of existing journey chargers in the FASTER region. Several metrics were calculated based on charge place utilisation data to determine;

- average annual daily demand for each charge-point,
- annual peak daily demand, and
- the likelihood of subsequent charging events being within 5 minutes of one another.

These statistics were used to help indicate areas where ‘doubling up’ of existing chargers would be required to meet short-term demand growth. Again, these were presented in a prioritised list to local authorities for consideration.

Power Capacity Assessments

The site identification activities outlined in the previous sub-sections all produce a ranked-order ‘long-list’ for each assessment criteria. These long-lists were supplied to local authority partners to allow them to select a suitable mix of candidate sites based on the analysis outlined in the previous section and allow them to add any priority sites. Power capacity assessments were then conducted for this short-list of sites. The capacity assessment process is summarised in Figure 9 with an example GIS extract showing a sub-section of the network studied in Figure 10.

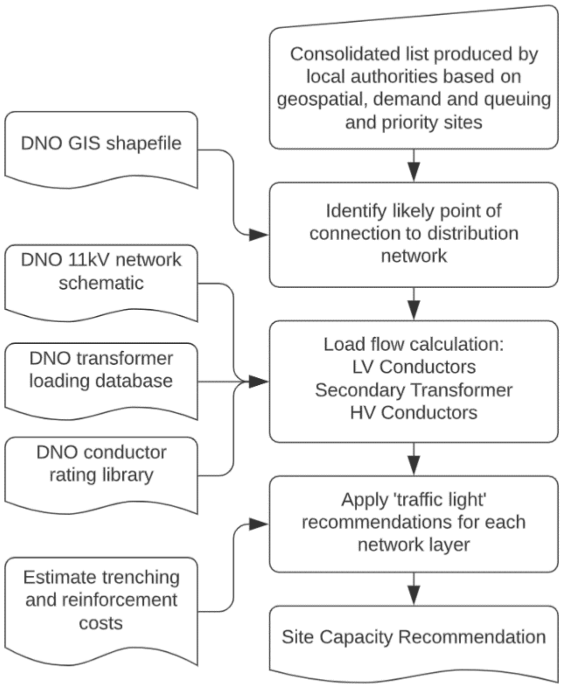

Figure 9. Power capacity assessment process.

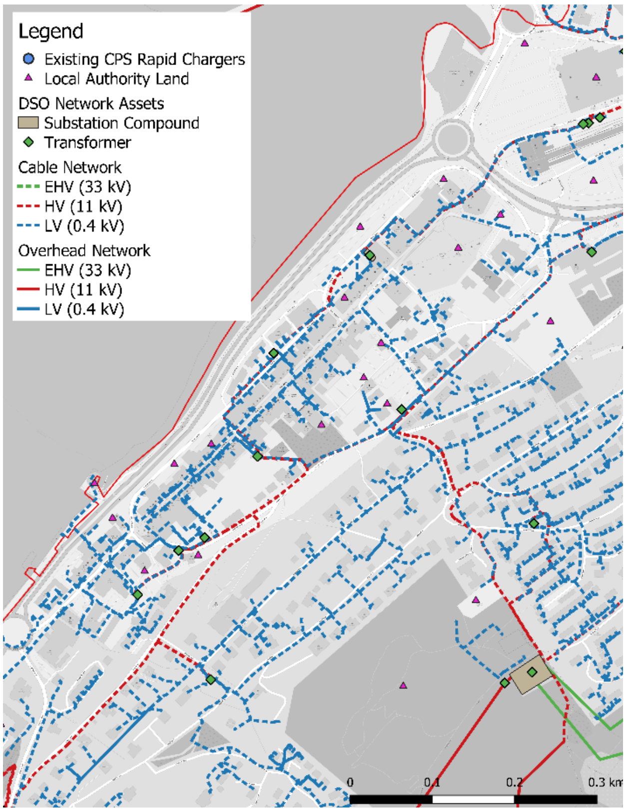

Figure 10. Example extract from DSO GIS network map.

CASE STUDY

Communicating power network opportunities and constraints to non-technical stakeholders is important to help them understand why grid connections between locations can be highly variable. To help address this, GIS extracts were provided alongside 'traffic-light' power capacity assessments for different network elements to help demonstrate where reinforcements may be required. Figure 11 provides an example where the local authority was considering hosting a charging point at 'Site A'. Network analysis indicated that significant upgrades were required to the LV network, secondary transformer, and the overhead 11 kV network to support this connection. 'Site B' was proposed by the team at the PNDC as an alternative as less extensive network upgrades were anticipated. Note that 'Site B' is in close driving range (<2 minutes) to 'Site A'. Budget quotations received from the distribution network operator indicated that this recommendation would save c. £35k – noting that the total average site budget, including the purchase of the rapid EV charger (c. £ 25k), was c. £45k.

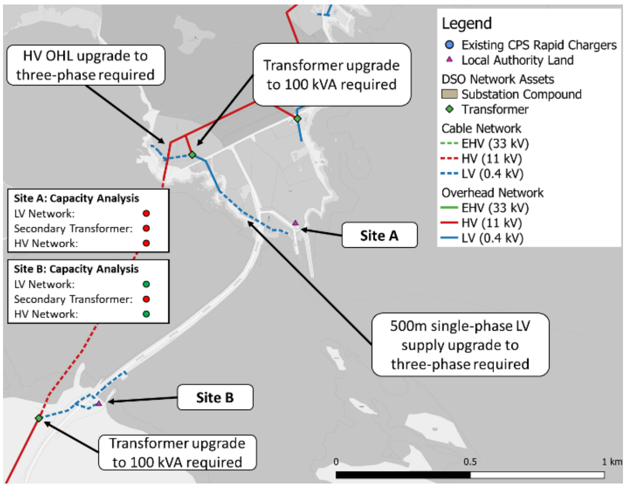

Figure 11. Example power capacity recommendation provided to local authority using 'traffic-light' notation to show challenges for potential charger locations.

DISCUSSION & FUTURE WORKS

A major challenge with deploying rapid electric vehicle charging in a rural environment is associated with the design of the existing electrical network. Rural sites often require transformer upgrades to support the new load with a lack of three-phase power areas also posing a significant barrier to many communities in Scotland. While the case study example demonstrated the potential savings possible via site relocation, analysis needs to be carried out to determine how much flexibility there is in site relocation before the value and convenience of the site decreases. With the cost of charging infrastructure, site accessories, bay marking and back-end costs relatively static between sites in different locations, the biggest variable between sites is the grid connection and the associated civil works required to get a supply to a site. In many cases, these enabling works can be greater than the asset value of the EV charger installed, and it is therefore important the investments in infrastructure have a long-term user-base that will justify the high upfront investment. To support future EV charging infrastructure deployment, it is anticipated that open-data sharing between stakeholders will be required to justify 'ahead-of-need' grid investment decisions.

CONCLUSION

This paper has provided a high-level summary of the approach developed for the FASTER project in Scotland. The methodology has identified candidate sites for the deployment of 24 EV journey chargers which are due to be installed throughout 2022 and early-2023. In addition to these chargers, PNDC identified several sites where sufficient network capacity existed, combined with a complimentary use case, to add supplementary dual-outlet 22 kW AC destination chargers within the allocated budget.

Acknowledgements

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