MAYOR OF LONDON

Mayor of London / Gnewt Cargo – Update on the Electric Vehicle Trial

Charging Infrastructure and Grid Analysis Report Update

December 2019

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CONTENTS

Executive Summary

The project is divided up into the following reports:

- Baseline Report
- Operational Costs and Environmental Benefits
- Key Barriers Report
- Charging Infrastructure Grid Report
- Q1 Environmental Update Report
- Q2 Environmental Update Report
- Q3 Environmental Update Report
- Q4 Environmental Update Report
- Q5 Environmental Update Report
- Q6 Environmental Update Report
- Q7 Environmental Update Report
- Operational Costs and Environmental Benefits refresh
- **Charging Infrastructure Grid Report refresh**
- Final Data Analysis Report
- Final Report

This report presents the grid and network implications of electric vehicle (EV) uptake by a London delivery fleet, updating a previous report on this topic. As part of this, nearly two years of operational data of London's largest fully electric delivery fleet, Gnewt Cargo, was collected and analysed. This included data from their 66[1] delivery vehicles, their Bromley-by-Bow depot grid connection and 40 charge points during the trial period. The smart hardware installed in the equipment onsite allowed for a high resolution of data.

This analysis investigated the effectiveness of electric vehicle smart charging at minimising the electrical demand at periods of peak use.

Since the original Charging Infrastructure Grid Report there has been an increase in the number of Gnewt Cargo EVs without a grid capacity upgrade resulting in a greater dependency on smart charging. The increased utilisation of smart charging has allowed more insights into how it operates, and its effectiveness compared to the previous study.

[1] The total number of vehicles in the Gnewt fleet in operation has varied throughout the trial. For the purposes of this report, data on 66 vehicles (including all of the trial vehicles) is analysed.

The primary conclusions of this study were:

1. **Smart charging has reduced the grid connection size needed to accommodate the larger Gnewt Cargo fleet by over 100%**. The adjusted peak electrical demand has been kept below 120 kVA despite the total charging capacity theoretically exceeding 278 kVA when all charge points are being used by the EVs with highest charge rates[2]. Non-smart charging would have required a grid connection upgrade costing thousands of pounds to have the same number of vehicles and charge points.

2. **The use of smart charging reduces the grid charges and operation charges associated with the larger EV fleet**. Reducing the peak of the additional vehicles avoids serious grid upgrades (130% increase in capacity), including the installation of a transformer in the area. This upgrade would be prohibitively expensive for Gnewt Cargo. Therefore, day to day management of the site does not require any changes or compromise for the core business and ultimately allows lower cost deployment of additional EVs.

3. **The smart charging manages the load at a very high time resolution.** The smart charging algorithm manages functions on a second by second basis ensuring that the capacity is never breached and that there is large flexibility within the system. This is critical for ensuring that devices on the system are protected and the supply is not tripped.

4. **Smart charging has potential to be utilised to a greater extent to bring more benefits to the local grid.** Currently, smart charging is only being utilised to ensure the peak load does not breach the site capacity. If Gnewt Cargo was on a 'time of use' electricity tariff, the smart charging could alter charging demand profiles to a greater extent, assisting with wider local grid network operations. Policy and market mechanisms to incentivise greater uptake and utilisation of smart charging will have large benefits for the deployment of EVs and grid operations.

[2] Assuming a power factor of 0.95 – 430 kW charging capacity.

Introduction

Background

The Mayor of London / Gnewt Cargo project (running from July 2017 to December 2019) examined the performance of a set of innovative electric vehicles (EVs) used for delivery and logistics purposes in London. The project tested the trial vehicles against a range of logistical, environmental and economic performance factors.

The key objectives of this report were to evaluate how the use of smart charging affects the impact of Gnewt Cargo's EV fleet on the grid. Smart charging can be defined as the optimisation of the time of charging in order to achieve the following aims:

1. Minimise electricity and connection charges; and
2. Stay within contracted supply capacity for the site (also considering the building load).

This report updates the previous evaluation of the grid implications of the Gnewt Cargo operations which analysed data collected between November 2017 and March 2018. That previous report focused on two areas which are challenged in this study:

1. **Public charge points –** Evaluated the different public charge points available in the Gnewt Cargo operating areas and how they could be utilised. The report concluded there is no benefit to Gnewt Cargo using public charging points with current fleet delivery profiles.

2. **Smart charging –** Explored how smart charging could allow additional EVs to operate from the site. With the grid connection large enough to cater for the existing fleet, there was no benefit to using smart charging to change the Gnewt Cargo charging profile and the data reflected this.

This report considered the implications of smart charging in reducing the grid impacts of EVs. It evaluated additional datasets that cover a longer time period with additional EVs operating on the site. This report focuses on the latter stages of the trial when the smart charging was fully operational.

- Unlike the time period covered in the previous study, the deployment of seven additional vehicles shown in Table 1 and corresponding charge points in

Table 2 has required the use of smart charging to ensure that the peak capacity of the grid connection at the depot is not exceeded.

Although this occurred infrequently it is fundamental to avoid high capital costs and additional operational concerns. The use of smart has effectively enabled the deployment of more EVs without requiring additional grid capacity.

Table 1 – A summary of the new Gnewt Cargo electric vehicles*

Row Labels	No. of vehicles	Approx. years operation	Average of Average Daily Distance (km)	Average of energy use (kWh/km)	Charge rates (kW)
Renault Kangoo Z.E 2014	35	3.5	29	0.24	3.6 kW
Nissan eNV200 2014	5	3.5	39	0.20	7 kW
BD Otto eDucato EV 2017	4	2	35	0.33	7-11 kW
Nissan eNV200 (including Voltia, Vic-Young)	22	0-2	37	0.22	7 kW

*uses Fleetcarma telematic historic data downloaded on 27/10/2019 for all vehicles

Table 2 – An overview of the different Gnewt Cargo charge points

	No. of charge points	No. of charge points (currently being installed)	Manufacturer	Installer
7 kW medium charger	30	40	EO Charging	The Phoenix Works
22 kW fast charger	10	10	EO Charging	The Phoenix Works
Vehicle to grid 10 kW charger	0	10	Nuvve	The Phoenix Works
Total capacity (kW)	430kW	600 kW		

Acknowledgments

We would like to thank Miles Freeman of EO Charging and Thomas Newby of The Phoenix Works for their input and support in producing this report.

EO Charging are the **suppliers** of Gnewt Cargo's charging infrastructure.

Founded in 2015, EO Charging designs and manufactures EV charging stations and smart software for homes, fleets and destinations.

The Phoenix Works have delivered the smart charging **consultation, design and installation** of Gnewt Cargo's charging infrastructure.

Established in 2010 The Phoenix Works helps homes, workplaces, businesses, and the public sector to embrace renewable technology. They specialise in designing solar, battery storage, and electric vehicle charging solutions.

Data collection and transformation methodology

Data Collection and Transformation Methodology

Throughout the trial, data has been collected from the vehicles, charge points and grid connection. This section details the process involved and the analysis required. The main data sources used to inform this study are summarised in Table 3, with their resolution, time period and relevance.

Table 3 outlines the main data sources used for this study

Data Source	Provider	Time resolution	Time period	Description & relevance	Data transformation
Grid connection	Electricity provider	30 mins	~2 years	Half hourly electrical demand for the entire site (including office and other onsite operations).	Segmented by different months to identify how smart charging is applied in different months.
Specific charge points	EO charging and operators	Second by second for each phase	~2 days	High resolution operational data for each charge point, including the activation of active load management	Filtered for the occasions when smart charging opted to reduce the load by processing the active load management commands
Vehicle charge data	Fleetcarma	Exact second of the start and end of charge cycles	~2 days	High resolution charge data according to the vehicles	Plotting of specific vehicle data
Vehicle operation data	Fleetcarma	Hourly	4 years	Data on the delivery profiles of the vehicles and their efficiencies	Analysis of the distances and energy requirements of the different vehicles
Installation details	The Phoenix Works	N/A	N/A	Details of the installation works and infrastructure considerations	Calculating the non-smart charger peak load

The EO Charging's data is collected using the EO Hub (a smart charging device that connects up to 32 EO Genius chargers) which records why certain charging decisions are made during the charging process.

There are two EO Hubs for the site that control the smart charge points. They send signals to communicate the data to the EO Cloud which stores and processes charge data.

Figure 1 The EO Hub (left) and the EO Genius charge point (right)

Fleetcarma is the telematics provider used on this project that tracks all the vehicles and their performance. The dashboard shown in Figure 2 enables the different data sets to be downloaded in csv format.

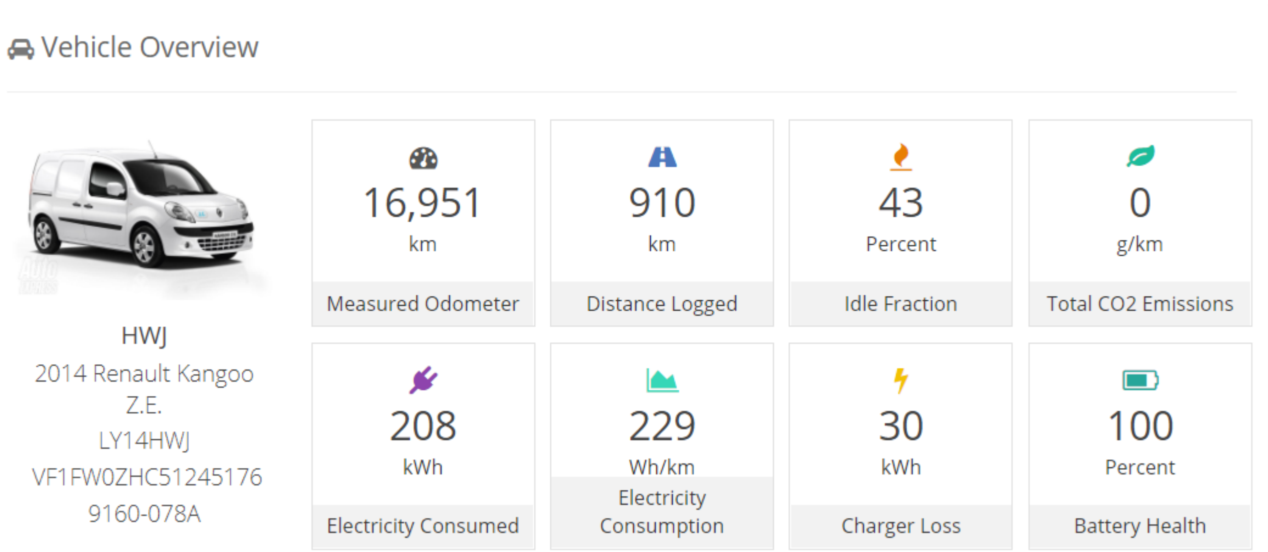

Figure 2 Fleetcarma interface that allows dissection of telematics data for each van

Operations Update

Section Focus

Since the last study, seven additional Nissan eNV200 vehicles were added to the fleet with two additional fast chargers from EO to cater for these additional vehicles and Gnewt Cargo operations. The increased number of vehicles and more regular deliveries from Gnewt Cargo led to a larger fleet distance travelled and the vehicles returning with a lower state of charge. The consequential growth in the amount of electricity used at the facility is shown in the graph in Figure 3.

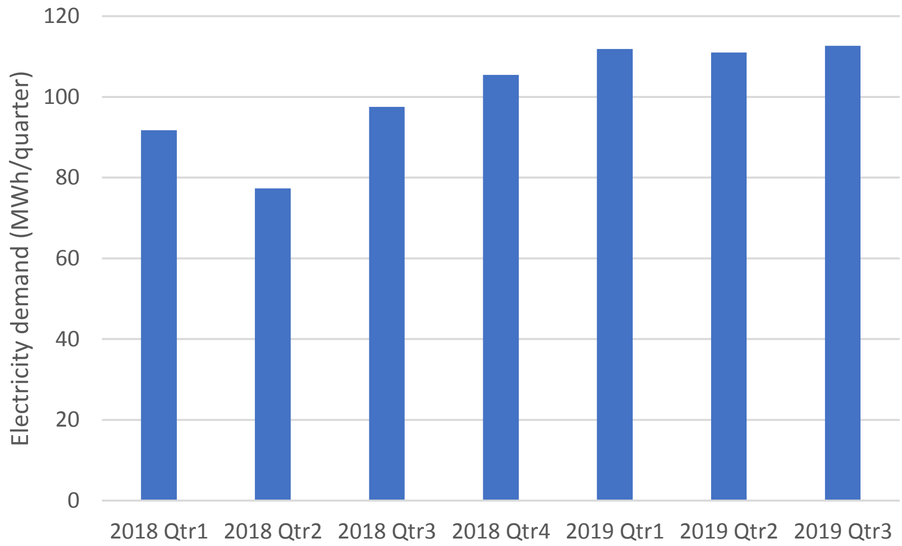

Figure 3 Quarterly electricity used (MWh) at the Gnewt Cargo depot, Bromley-by-Bow

To put the scale of the site's operations into perspective, the average annual electricity use of a domestic property in the UK is 3.1MWh/year[3], so the Gnewt Cargo delivery EVs and all onsite operations equate to the same electrical demand as approximately 140 UK homes.

In the period between the original report and this update, total monthly distance travelled has more than doubled from 25,000 km to 60,000 km. However, the energy demand of the total site has only increased by 25%. This small increase in total energy use compared to distance travelled can be attributed to: demand by other onsite operations remaining

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[3] Ofgem typical domestic consumption values for a medium sized household https://www.ofgem.gov.uk/gas/retail-market/monitoring-data-and-statistics/typical-domestic-consumption-values

constant; EV auxiliary loads, such as cabin heating, not increasing linearly with distance travelled; newer EVs having higher energy economy (driving further with less electricity); and different usage profiles.

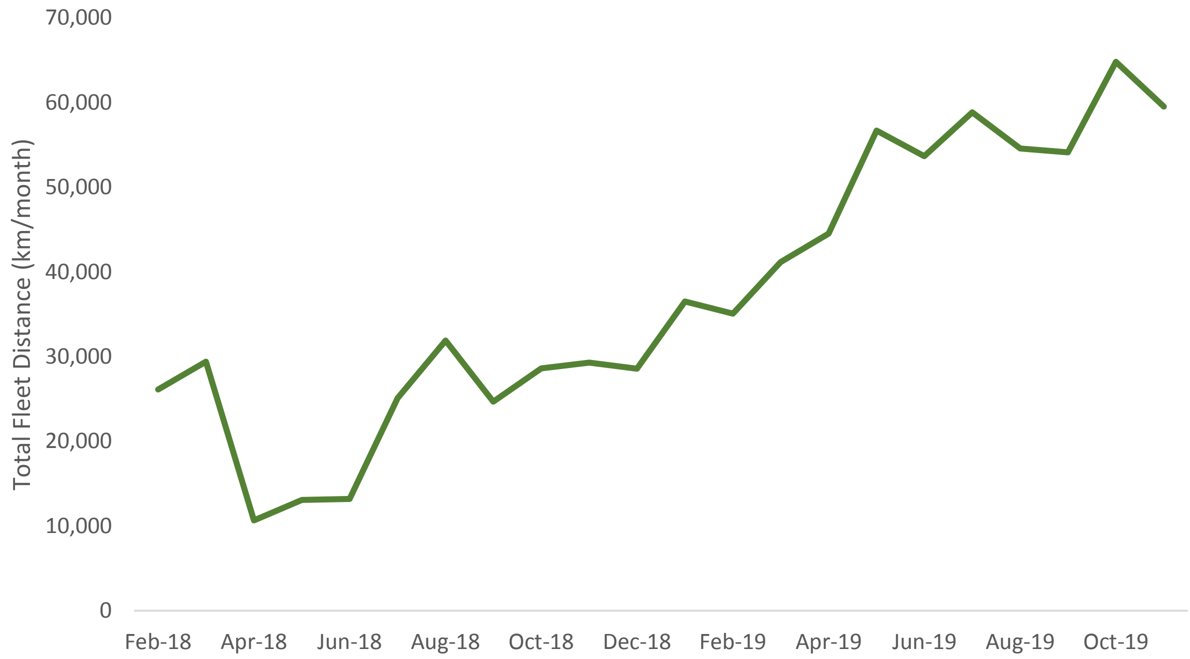

Figure 4 Fleetcarma reported daily fleet distance (km)

In addition to the smart charging being relied upon, additional vehicle telematics and high time resolution data have been received from the charge points. More detailed charge point data enabled a better understanding of how the algorithm functions.

Load Analysis Update

The additional charge points have a higher power capacity to allow faster charging which resulted in a total potential site peak demand of 265 kW (278 kVA) accounting for the current charge limitations of the vehicles. This total peak electrical demand is higher than the site's 120 kVA connection. As can be seen in Figure 5, this resulted in the peak electrical demand being exceeded for brief occasions in Q4[4].

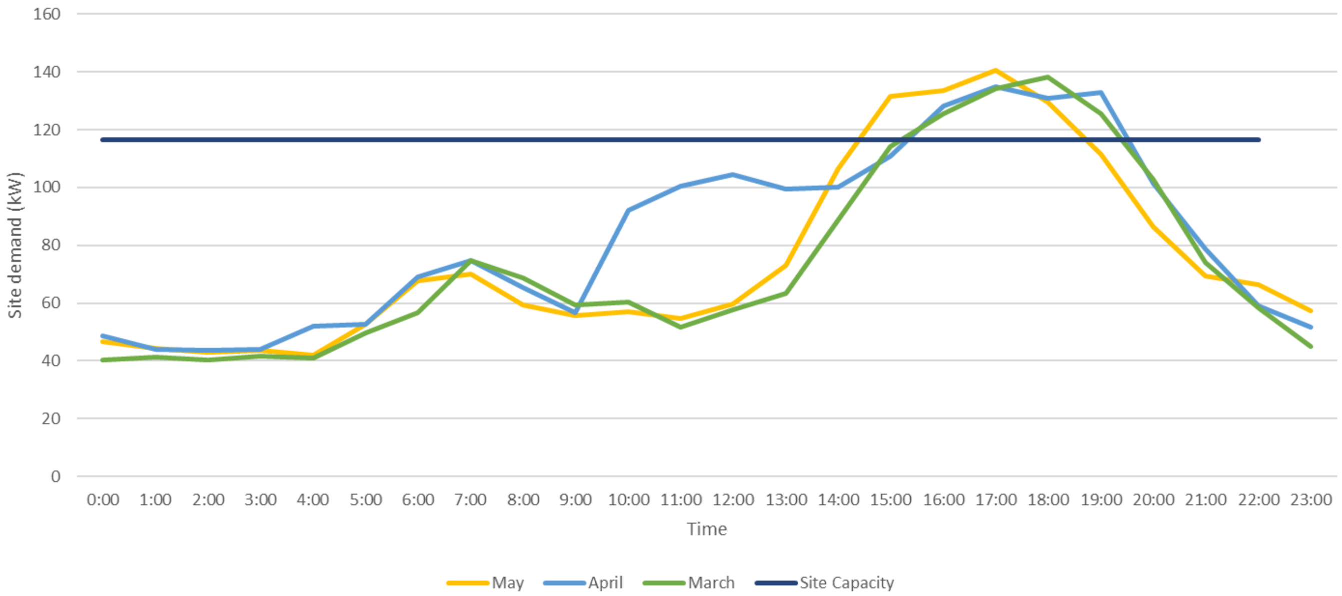

Figure 5 Power demand (kW) profile for the site three months before smart charging was being used to manage the demand

The exceeding of the 120 kVA limit was found by Phoenix Works (the charge points installers) to be due to the drivers using extension cables and not due to the smart charging malfunctioning. The extension cables were not factored into the smart charging operations, resulting in their additional demands not being accounted for and the 120 kVA threshold being exceeded.

Removing the extension cables from the facility, doing formal charge point training for the drivers and improvements to the charge-station management allowed the smart charging to bring the load below the 120 kVA (116 kW) connection capacity. This can be seen in Figure 6 where the peak grid capacity is not exceeded across the day.

Figures 5 and 6 shows the EO Hub controlling demand by delaying EV charging by two to three hours to a time when the grid connection capacity will not be exceeded. The

[4] This was possible because the Gnewt Cargo connection has an infrastructure capacity of 200 kVA even though it previously contracted a 120 kVA connection minimize costs.

changes have not compromised operations as the rest of the night remains to charge the vehicles.

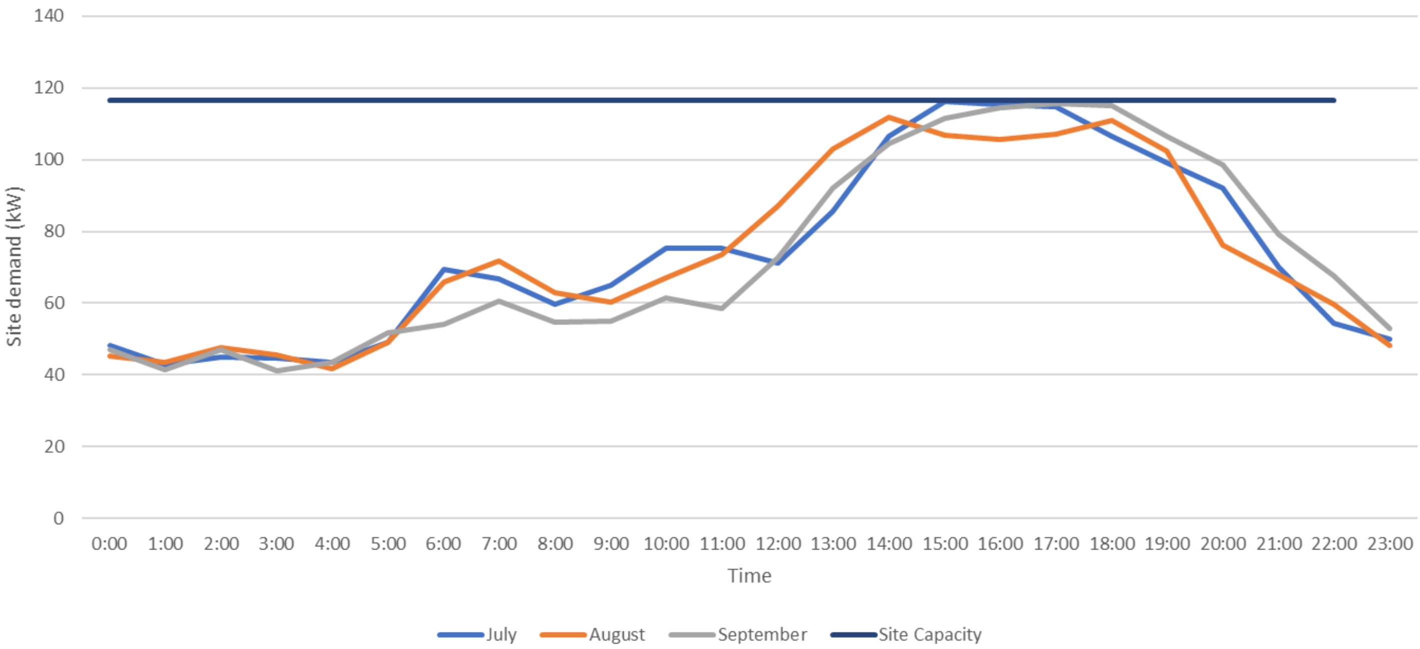

Figure 6 Hourly power demand (kW) for three months when smart charging is being used to manage the demand

Earlier in the trial, there was no incentive for smart charging because the site had enough grid connection capacity to meet EV charging demand and the tariff structure did not incentivise demand shifting since the electricity was procured at a bulk rate.

Gnewt Cargo Smart Charging Routine

The smart charging commands were analysed at second by second resolution over two days. The commands are informing each EO charge station to change the current (and power) of the electricity being provided. The hourly average change was taken of the commands sent throughout the 2 days and plotted in Figure 7. It was found that for the majority of the time the smart charging is being used to increase the load at times that are usually low power on the site (ref to Figure 5). By charging at time periods of low site demand less charging is needed in future when the overall site might have a high demand. Without this capability larger fleets would not be fully charged with the available dwell time.

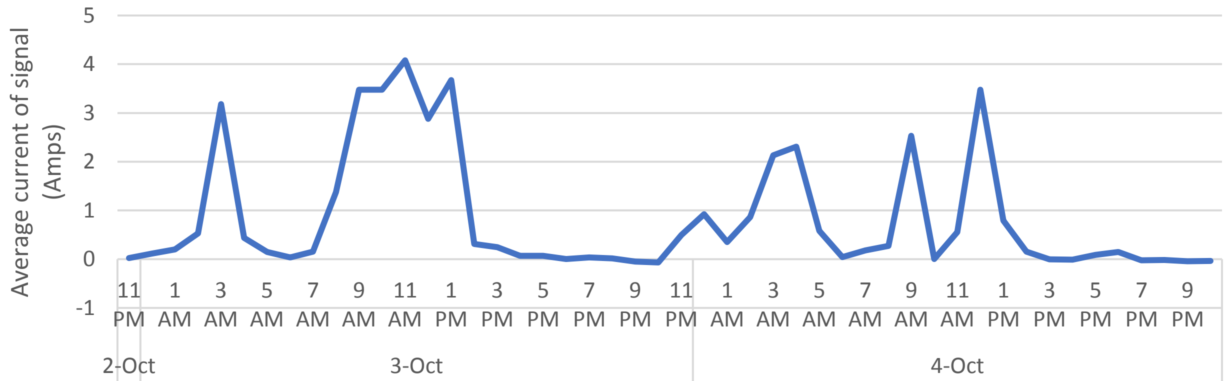

Figure 7 shows the hourly average of the signalled smart charging signals

The other way that the smart charging minimises the peak load is by directly reducing the charge rate at peak times. These occurrences are far less frequently as they only arise when the capacity could be exceeded. To observe these occurrences, the smart charging commands were filtered to show only power reducing signals (negative), which were subsequently summed. The results are shown in Figure 8.

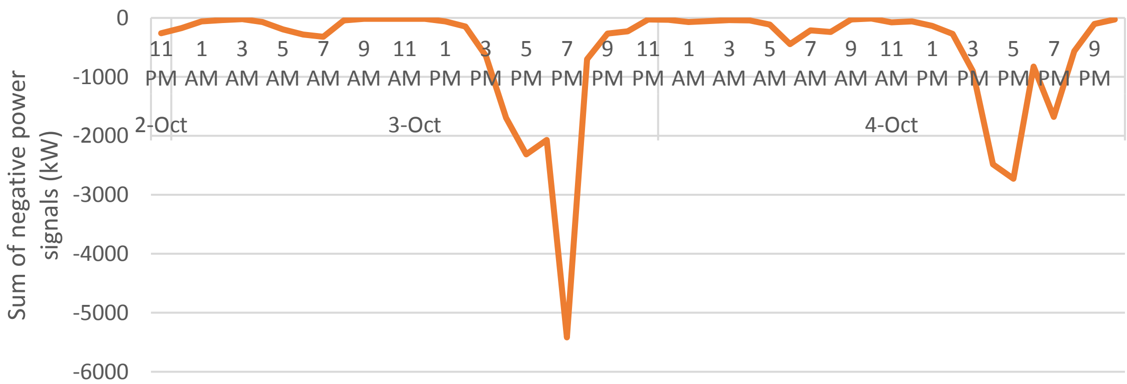

Figure 8 Occasions when the smart charging reduces the total power demand of the charging vehicles

It is also interesting to note just how many signals the smart charging uses to control the load. The resolution of the smart controls is second by second which is far higher than that showed in Figure 8. For example, Figure 9 shows a count of the smart charging signals for each hour, where over 12 thousand changes in power are sent in one hour. Hence, the summed kW of the negative signals exceeds the 120 kVA capacity of the grid connection.

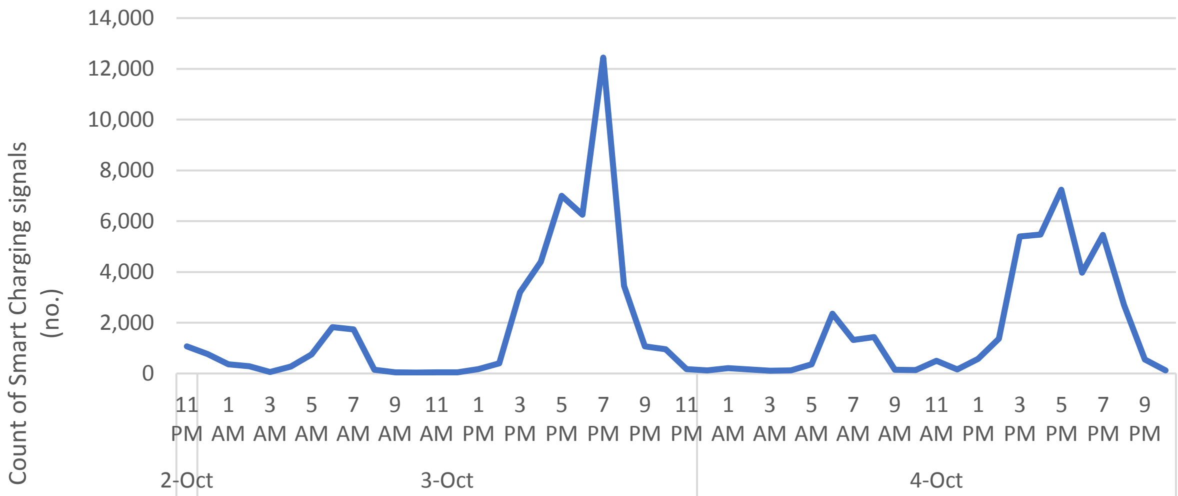

Figure 9 indicating the total number of signals sent over each hour by the smart charging system

Gnewt Cargo smart charging grid implications

The site has a grid connection of 120 kVA. Upgrading the grid connection to 200 kVA would increase the standing charge by £103 per month[5]. Beyond 200 kVA would require a new substation and other changes to the local network. This additional cost would be prohibitive and make the scheme uneconomical, demonstrating the importance of smart charging.

The local Distribution Network Operator (DNO) is responsible for ensuring there is adequate capacity in the area. For London and the Gnewt Cargo area, UK Power

[5] Using the British Gas business deemed standing charge for London low voltage connection at 4.17 p/kVA, 2019.

Networks (UKPN) is the DNO, whose responsibility it is to proactively plan for an increase in EVs being charged on the local network.

Figure 9 shows a UKPN typical demand profile for London, which approximately matches that of the Gnewt Cargo site. This correlation of demand results in more stresses on the grid infrastructure because the peak for the local infrastructure is increased.

The likelihood of demand exceeding supply would be mitigated if smart charging could shift the majority of the load from the evening peak (5-8pm) to midnight-3am. One risk to shifting the EV charging load later in the evening is vehicles may not be charged fully by the beginning of the next business day. Although this risk can be managed through smart charging, the financial incentives to EV fleet operators are insufficient to encourage a change in behaviour.

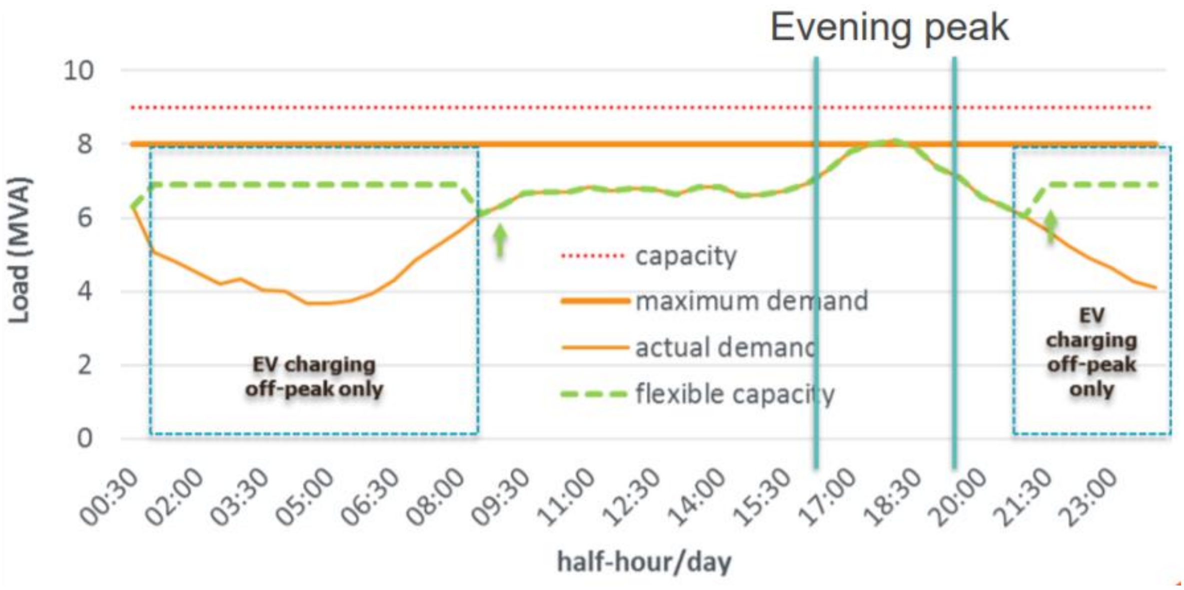

Figure 9 UKPN profile derived from material on EV integration available (here)

Vehicle to grid charging opportunities

The installation of Vehicle to Grid (V2G) charge points at the Gnewt Cargo depot was completed in October 2019, after the end of the trial data collection period. Analysis of their operation is out of scope for this trial. The V2G capability should enable Gnewt Cargo to eliminate their demand on the UKPN grid during peak hours. The initial analysis shows that once fully optimised this will be possible within the site capacity constraints. The V2G capability realisation work is being led by DREEV (Nuvve/EDF consortium).

Conclusions

This report has explored the effectiveness of smart charging at the Gnewt Cargo site in London. This is important because smart charging addresses the availability of grid connections and their respective high costs which are key barriers to EV deployment amongst fleets. The connection sizes and respective costs can be reduced by opting for smart charging systems, such as those offered by EO charging and The Phoenix Works, over dumb charging which is the norm.

The primary Gnewt Cargo site specific conclusions from this work are as follows:

1. **Smart charging has reduced the required grid connection size by over 100% for Gnewt Cargo**. The adjusted peak electrical demand has been kept below 120 kVA despite the total charging capacity theoretically exceeding 278 kVA when all charge points are being used by the EVs with highest charge rates[6]. Non-smart charging would have required a costly grid connection upgrade to have the same number of vehicles and charge points.

2. **The use of smart charging reduces the grid charges and resultant EV fleet operating costs**. Reducing the peak avoids serious grid upgrades, including the installation of a transformer in the area. Therefore, day to day management of the site does not require any changes or compromise for the core business and ultimately allows lower cost deployment of additional electric vehicles.

3. **The smart charging manages the load at a very high time resolution.** The smart charging algorithm manages functions on a second by second basis ensuring that the capacity is never breached and that there is large flexibility within the system. This resolution is critical for ensuring continuity of service, ensuring that devices on the system are protected and the supply is not tripped.

4. **Smart charging has potential to be utilised to a greater extent to bring more benefits to the local grid.** Currently, smart charging is only being utilised to ensure the peak load does not breach the site capacity. There are multiple policies that enhance the benefits of smart charging. These include ensuring a time-of-use electricity tariff and greater demand-led charging, which would incentivise smart charging to alter charging demand profiles not only to assist onsite operations but also that of the wider local grid network operations. This would benefit all parties, with lower infrastructure costs for the system despite larger demand and ultimately

[6] Assuming a power factor of 0.95 – 430 kW charging capacity

reduce Gnewt operation costs. Policy mechanisms to incentivise greater uptake and utilisation of smart charging will have large benefits for the deployment of EVs and grid operations.

Given these benefits it is recommended that awareness campaigns are initiated, and policies created that assist delivery drivers with their understanding of the benefits associated with smart charging and the value of paying for this additional capability.

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