MAYOR OF LONDON

Mayor of London / Gnewt Cargo - Electric Vehicle Trial

Charging Infrastructure and Network Analysis Report

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Executive Summary

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

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 covers the period between November 2017 and March 2018. It describes the charging requirements and the grid impact of the trial and details early findings from the data collected on the existing fleet, charge points and trial vehicles.

The energy requirements for charging were assessed in two scenarios; one where the smart charging was used and the other where non-smart chargers were used. It was found that the Gnewt Cargo site has a greater charge capability than is required for current activities. Results also demonstrated that a move to smart charging could allow for a large increase in the number of EVs that could be supported in terms of grid connection (not space or number of sockets).

Currently, Gnewt Cargo predominantly charges vehicles at their depot located in Bromley by Bow near Central London. The opportunities for using public charging infrastructure (in addition to the depot) were evaluated against the charging requirements of the existing and trial EV fleets.

Preliminary findings indicate the existing and trial EVs in the Gnewt Cargo fleet do not need to use public charge points to meet their current operational requirements. Using public charging infrastructure has additional costs and interrupts the delivery schedules of the drivers unnecessarily. Public charge points could assist fleets with different delivery profiles if their operations exceeded the range of their vehicles (124 miles for eNV200s)[1].

We would like to thank Thomas Newby of The Phoenix Works for his contributions to this report.

[1] Nissan, 2019, article discussing the attributes of the e-NV200 in this study (Available Online)

Introduction

Gnewt Cargo specialises in delivery of goods using EVs. At present, commercial EV fleets engaged in logistics activity within London tend to comprise purpose-built small cars and vans (max. capacity 4.2 m^3) with limited uptake of larger (min. capacity 8 m^3) electric vans.

A trial has been undertaken as part of the Mayor of London/Gnewt Cargo EV trial project to understand the charging requirements and the impact on the electrical network associated with the transition to larger EVs. Gnewt Cargo has begun to trial 15 Nissan Voltia eNV200s and 4 BD eDucatos to deliver goods in conjunction with their existing EV fleet of 4 Nissan eNV200s and 39 Renault Kangoo light goods vehicles (LGVs).

This report describes the charging infrastructure and the grid impact of the project trial and details early findings from the data collected on the existing fleet and trial vehicles. The approach described in the Data collection and transformation section in this report highlighted that the trial BD eDucato EVs were not being used at the time of analysis, so their data is omitted from this report, but will be included in an updated version at the end of the trial.

To understand and evaluate the trial’s smart charging infrastructure and allow for vehicle type comparison, the energy consumption, charging requirements and operation performance of the existing fleet and trial vehicles were established. The charging requirements were then assessed against the charging infrastructure performance to provide preliminary conclusions and insights including the potential to utilise public charging infrastructure.

Table 1 overleaf summarises the specifications of the different electrical vehicles that made up the Gnewt Cargo fleet in March 2018.

Table 1 Trial and current fleet EV comparison table.

Vehicle Information	Trial larger EV		Current smaller EV	
	BD eDucato	**Nissan - Voltia eNV200**	**Renault Kangoo**	**Nissan eNV200**
				
Make	BD	Nissan - Voltia	Renault	Nissan
Model	eDucato Cargo	eNV200 (Voltia Converted)	Kangoo Z.E.	eNV200
Overall dimensions – length / width / height (mm)	5998 / 2050 / 2522	5030 / 1760 / 2420	4282 / 2138 / 1844	4560 / 1755 / 1858
Gross weight (kg)	3500	2000	2146	2220
Payload volume (m^3)	13	8.0	3.4	4.2
Battery Size (kWh)	62	40	33	40
Number of EVs with data availability	4	15	33	5

The BD eDucatos began their trial period in March 2018, with 7 additional Nissan eNV200s (modified) expected to join the trial and upgrades being made to the charge point capabilities in 2019. Therefore, in October 2019 an update to this report's findings will be provided (to include the additional data collected between now and the end of the trial data collection period, September 2019).

Background

The Mayor of London / Gnewt Cargo Ltd project, which runs from July 2017 to December 2019, will examine the impact of larger EVs used for delivery and logistics purposes in London using a range of logistical, environmental and economic performance factors. Gnewt Cargo specialises in delivery of goods using electric vehicles.

At present EV fleets tend to comprise purpose built small cars and small vans (capacity maximum 4.2 m^3). There is a limited production and uptake of larger electric vans (minimum capacity 8 m^3). Put another way, there are currently few EV equivalents to the Mercedes Sprinter (capacity 8.5 m^3/ payload 1,035 kg). This is in part due to the low production/demand loop. A reaction to this shortfall is the customised build of EVs but these vehicles can be expensive to produce and purchase. This project examines the benefits/disbenefits of the introduction of larger EVs to London's road and power networks.

The impacts of the EVs are being measured in terms of technical viability and reliability and evaluation of charging infrastructure. The assessment includes considering the impact of larger EVs (min. capacity 8 m^3) and different charging approaches/technologies on the power network.

The new electric cargo vehicles, which are the subject of this trial, are the Nissan Voltia eNV200 (capacity 8 m^3) and the BD eDucato (capacity 13 m^3). To evaluate the performance of these new large vehicles, they will be compared to the current Gnewt Cargo electric fleet (composition listed in the introduction section above).

The trial of the larger electric vehicles began in November 2017 with 15 Nissan Voltia eNV200. In January 2018 4 BD eDucato were added. These trial vehicles are expected to be operated under trial conditions until the end of September 2019. All trial vehicles were fitted with the Fleetcarma fleet telematic system.

Alongside these trial vehicles, smart charging infrastructure by EO Charging was installed at Gnewt Cargo's depots in January 2018. This included eoHubs which allows the connection and management of 30 eoGenius chargers per eoHub. This set up will allow for cost effective installation while actively managing the load across the chargers once the automatic load management (ALM) system is operating before the end of the trial. The EO Charging smart charging features are still being developed to meet the requirements of the site. Therefore, some of the benefits stated are theoretical and will be tested in the latter stages of this trial.

Data collection and transformation methodology

Data Collection and Transformation Methodology

The data used for the evaluation was collected from three main sources for the trial period; the Gnewt Cargo telematics system operated by Fleetcarma.

The timescale assessed for this report is between November 2017 and March 2018 period, with only data received over this time included in the analysis. This matches the start of the operation of the trial vehicles EVs.

To make use of the data available, anomalies were removed, and the average performance of every vehicle was analysed over the time considered. The anomalies were those data points that were incorrect due to telematics inaccuracies. Refer to Appendix A for further information on the challenges faced during the data transformation process.

Charging Infrastructure

Emerging charger types

There is a large variety of EV charge points available on the market, each suited for a specific charging requirement and hence applicable for a certain purpose. For example, a 3 kW slow charger can be supplied from a regular domestic plug socket and take 10 hours to charge a Nissan eNV200 to 75% charge, whereas a 50 kW rapid charger would theoretically take ~36 minutes to charge the Nissan eNV200. However, this requires a costly power connection and is not possible for many EVs. Table 2 highlights the range of chargers available, their typical application and charging time.

Table 2 Emerging EV charging infrastructure[2]

<table>
<tr><th>Charger type and power output</th><th>Maximum Charging time (0 – 100%) [3]</th><th>Regular Applications of Charge Points</th><th>EV Range Applicable to</th></tr>
<tr><td>Slow: 2.4kw to 3kW</td><td>10 hours</td><td>Residential, overnight charging</td><td rowspan="2">All EVs</td></tr>
<tr><td>Fast: 3.7 kw to 7kW</td><td>6.5 hours</td><td>Residential, on-street charging</td></tr>
<tr><td>Fast: 11kW to 22kW</td><td>2 hours</td><td>Residential[4], on-street charging</td><td rowspan="4">Limited to EVs accepting this charge-rating

(None of the Gnewt Cargo distribution fleet is capable of this type of charging with their existing setup as at March 2018)</td></tr>
<tr><td>AC Rapid 43kW to 50 kW</td><td>35 minutes</td><td>Commercial[3], on-street charging</td></tr>
<tr><td>DC Rapid 20kw to 50kW</td><td>1 hour</td><td>Commercial[3], on-street charging</td></tr>
<tr><td>Tesla Supercharger, 130kW DC</td><td>11 minutes</td><td>Commercial[3], on-street charging</td></tr>
</table>

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[2] Myles Barker, R. E., 2016. Making the right connections: General procurement guidance for electric vehicles, s.l.: UK Electric Vehicle Supply Equipment Association.(available online)
[3] Charging times based on a 24kWh battery that is fully discharged
[4] Required electricity connections that are greater than 32A, single phase

Chargers may also be segregated by their “smartness”. In the context of EV charging, smartness is defined as the ability of the charger to respond to several factors to optimise and control the charging process. These factors include, but are not limited to:

- **Peak electrical load of the site:** The smart feature can ensure that all the EVs are not charged simultaneously while also providing sufficient charge for all the EVs for the next day’s operations. This results in a reduction in peak power demand that results in more EVs being charged for a smaller connection or for the connection costs to be reduced.

  Although Gnewt Cargo procures their power in bulk, other tariffs have different peak and unit charges related to power consumption at different times of day. The EO charge point smart feature should enable this to be factored into the charge profiles shifting the demand to the cheapest time periods when possible. Refer to the Load Analysis chapter for further information.

- **Prioritisation of most depleted EVs:** Smart chargers can also optimise charging based on the state of charge of the EVs connected. Chargers would prioritise charging fully depleted vehicles over vehicles that are partially charged. This strategy ensures that all the EVs are able to perform their deliveries the next day.

- **Reduction of greenhouse gas emissions:** The national grid publishes the carbon intensity of the electricity from the grid on an hourly basis. This information can be theoretically fed into the smart charge point to minimise the carbon intensity of the fleet operations.

- **Accessing additional revenues:** Smart chargers can assist with the operation of the electrical network, exporting energy (vehicle-to-grid only, V2G) or reducing charge-rate to maintain the balance of supply and demand. This utilisation, though in its infancy, could provide additional revenue by providing flexibility services to the electricity network operators. Refer to the Load Analysis chapter for further information.

Historically, charge points do not have the ability to respond to the factors listed above have been termed “non-smart” chargers by the market. The charge points installed in January 2018 at Bromley by Bow and Greenwich include an EO Charging Hub, which, through the communications interface, provides the smart charging capabilities.

Ultimately, the vehicle on-board power electronics controls the charge-rate. Consequently, there are some limitations as to the range of acceptable power input.

Public on-street charging infrastructure

The Gnewt Cargo EVs are currently charged at the depots where the electricity is bought at commercial rates (low cost) and there is no requirement to disrupt the delivery schedule. Despite this, public charging infrastructure offers the potential for the EVs to top up their batteries when away from the depots. Government policy and the rise of EV sales has led to an increase in the deployment and use of public EV charging points. As of August 2019, there are an estimated 3,500 public EV charging points in Greater London[5].

To understand whether public charging infrastructure could be utilised for cargo EVs, the following items were taken into consideration:

- Charging speed and connectors available
- Providers and commercial models for the charging services
- Location and access

Charging speed and connectors

The available public charge points cover a variety of charger plugs and connections to provide rapid, fast and slow charging services. The type of charger plug facilitates the different charging speeds alongside the power rating of the charge stations and vehicle capability. The overview to the charger connections can be found under Emerging Charger Types. Figure 1 shows the range of EV plug designs.

Figure 1 Range of EV connectors (adapted from Zap Map[3])

The preliminary findings show the current depot charging facilities provide sufficient charging for all EVs in the fleet, including the trial EVs. This indicates that public charge points would not be required for the project.

Rapid or fast charging may provide an opportunity to top up while on a delivery round. The preliminary findings show the present delivery round of both the existing and trial vehicles only consumed 10kWh of energy which does not exceed the battery sizes of any EVs in the fleet (40kWh for the eNV200). Therefore, a recharge whilst on route is not necessary

5 Zap Map: https://www.zap-map.com/statistics/

assuming the vehicle left the depot with greater than 20 kWh of charge. This may change if Gnewt Cargo expands its area of coverage or stem mileage.

While it may be unnecessary to recharge to extend the delivery service on a round, EV battery life may be extended by taking the opportunity to recharge outside of the depot. This would avoid driving with a low state of charge which is detrimental to the long-term performance of the battery[6]. This is, however a minor factor for Gnewt Cargo as the additional labour cost is most likely going to outweigh the benefit. For other distribution companies that travel greater distances this will be important as the majority more than 10kWh (~35 km per day).

Providers and commercial models

EV charging infrastructure in the UK is divided into national and regional networks which are often funded by a range of providers including car manufacturers, electricity suppliers, charging network operators and local authorities. These providers offer various ways to access their infrastructure:

- **Pre-paid / Pay-As-You-Go:** Fixed fee between £10-£20 per year and a connection fee range of £0.30-£1.80 with a usage fee range of 9p/kWh-30p/kWh[7].
- **Subscription service:** Subscription fee between £4/month to £8/month with potential additional usage fee of 3p/min-4p/min[8].
- **Free to use:** The free cost chargers are provided by either public bodies that have a wider social benefit agenda or private companies, such as Tesla, which recover their investment through sales of supplementary products such as household electricity or automobiles. In the long term, there is uncertainty over the funding of these charge points when EVs become more prevalent.

[6] Uddin et al., "On the possibility of extending the lifetime of lithium-ion batteries through optimal V2G facilitated by an integrated vehicle and smart-grid system," *Energy,* vol. 133, pp. 710-722, 2017 (available online)

[7] Zap map, 2018, charging infrastructure utilization costs (available online)

[8] Zap map, 2018, charging infrastructure utilization costs (available online)

Location and access

Public charging facilities are provided in car parking structures, on-street parking bays, service stations, or as part of the destination facilities. The current spread of the public charging infrastructure within London is not evenly distributed with a gap towards the east. Figure 2 shows the spread of charging infrastructure against the current main depot and delivery areas for Gnewt Cargo.

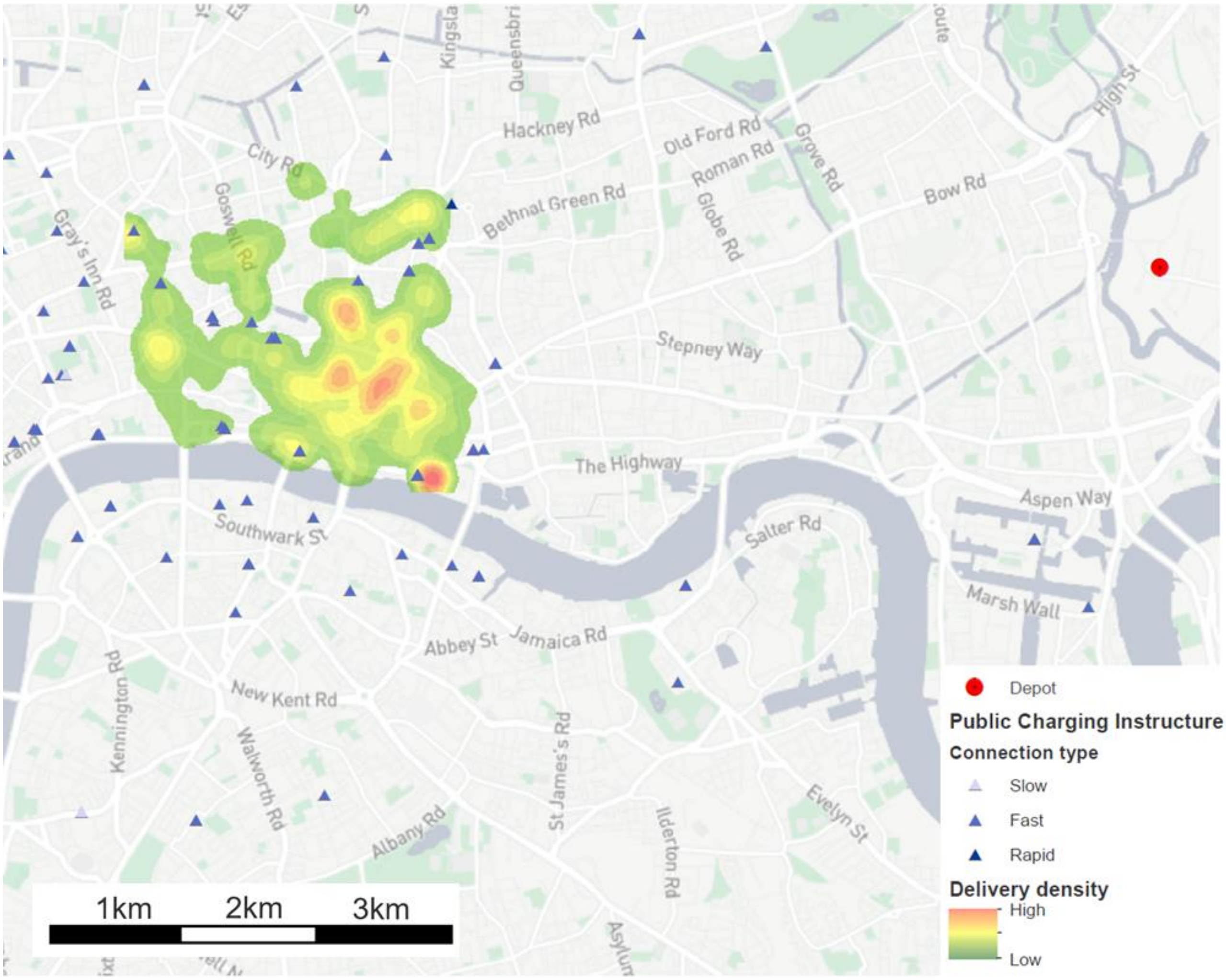

Figure 2 Public charging infrastructure available around depots and delivery area.

The public charging infrastructure shown here is provided by the National Charge Point Registry published in May 2014 as the current data is publicly available and may be missing updated information. Delivery information shown here is from a three-day sample in April 2018.

The opportunities of utilising the public charging infrastructure will depend on the destination, origin of the EV and what the corresponding detour (if any) required. Preliminary findings indicate the existing and trial EVs do not need to rely on public charge points to meet their operational requirements. Public charge points may be used to take advantage of reserved free parking spots or to extend battery life. However, there are limited charging points which may be within a suitable walking distance (approximately 400m) from the vehicle to the existing delivery destination profile. This is particularly the case around Bank and Liverpool Street.

Opportunities for Gnewt Cargo

The majority of operational EVs in the fleet will either be fully charged or out conducting deliveries during the day, resulting in the Gnewt Cargo depot charge points being free for other users. The availability of the charge points in the depot offers the opportunity to lease them out to the public, other commercial fleets or other users to supplement revenues.

Load Analysis

Charging routine

The typical charging routine for the EVs was analysed using Fleetcarma's interface. Generally, Gnewt Cargo's EVs plug into a charge point between 4pm-8pm; this practice results in a 57kW peak in power drawn at the end of the workday, despite most of the charging sessions being complete by 10pm.

This peak is not optimal for the grid operation because it coincides with the broader network evening peak across the UK when people arrive home and turn on their appliances. For Gnewt Cargo this also is not optimal as it creates an unnecessary peak electrical demand for their site, which with expansion, could result in the need for a larger and more expensive grid connection. See Figure 3 below which shows an example operation profile for one of the existing Gnewt Cargo fleet EVs for two and a half weeks taken from Fleetcarma, where green indicates travel and blue indicates connection to a charge point.

As discussed previously, one charge per day at the depot is sufficient for the EVs to meet the requirements of the current operation.

Figure 3: Typical EV charging routine where green is times when the vehicle is driven and blue when it is being charged

The data was analysed from EO's portal between (February to March 2018) to investigate the actual peak demand of each charging station. This data is shown in Figure 4.

At Bromley by Bow, the grid connection is capable of 270 kW peak. The peak power demand of 57 kW during a typical operational day in the sample period can be seen in Figure 4. The highest peak demand throughout the sample period evaluated is 68.4kW. This confirms the current connection has sufficient capacity to meet Gnewt Cargo's current operational requirements.

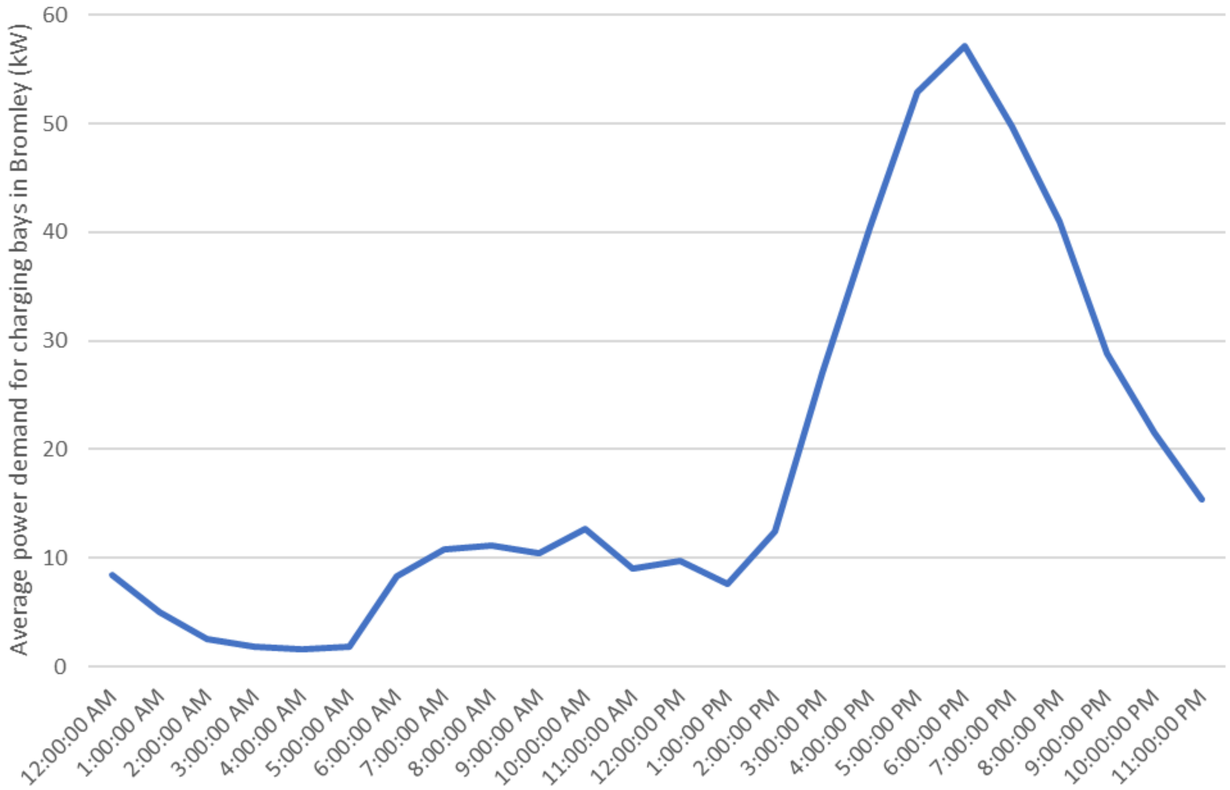

Figure 4: Average daily peak power demand at Bromley by Bow charging station for a typical day in the sample period

Application of smart charge points

As can be seen in Figure 4, the smart charging capability does not appear to be having a noteworthy impact. This is thought to be due to the drivers shift end times as they correlate with the peak demand between 2pm and 10pm. Another clear indicator that the smart charging is not being utilised is due almost no charging occurring between 1am and 5am which from a grid operation and minimising the overall peak is preferable.

This lack of utilisation of the smart feature is predominately due to there being no benefit for the operator. The peak demand is 68.4kW, yet the grid connection for the site can cater for 270kW (3.9 times the current one) and Gnewt Cargo buys their electricity in bulk with no variation in the time of use peak or unit rates.

Ultimately as Gnewt Cargo expand their operations and potentially the distance the drivers go is expanded the dependency on smart features increases. This will be investigated in the final report.

The smart feature once operation will benefit the local grid operation. The EV loads will likely be shifted to periods of low grid demand. This would save infrastructure costs for the grid which is value that Gnewt Cargo could capture by changing its electricity procurement to have a temporal element which would save electricity costs[9].

To understand the potential impact of smart charging, it was estimated on average:

- The large EVs (8m^3 capacity – Nissan Voltia eNV200) require approximately 10 kWh per day (charge time of ~3.3 hours).
- Smaller EVs (max. 4.2m^3 capacity –Renault Kangoo & Nissan eNV200) require approximately 9 kWh per day (charge time of ~3 hours). The lower overall efficiency of the small EVs is due to them being older than the trial EVs (despite the Nissan Voltia eNV200 being bigger, the data indicates that their overall efficiency is higher, likely due to the technology being newer and therefore having improved operation).
- The EVs are plugged in for approximately 12 hours each night

Utilising these assumptions, it has been calculated that the smart charging if utilised to minimise the peak would reduce it by as much as 80%. If there was an incentive for the peak to be reduced (limited capacity for the site or time of use charges) then the smart charging could have a big impact at reducing the peak.

[9] Octopus, 2018, agile time of use tariff that varies depending on time of day (Available Online)
A.Bruce & L.Ruff, 2018, Carbon Intensity – UK hourly carbon intensity of the grid (Available Online)

This distribution can be done through both Static Load Management (SLM) where scheduling is used or through Active Load Management (ALM) which actively responds to other factors, such as electricity pricing and carbon intensities[10].

The EO smart charging capability is required the reduction in peak demand can be analysed. The calculations of the theoretical impact of smart charging can be verified once smart charging data is available and ALM is operational which is due to happen in the 2019.

Overall, these results indicate Gnewt Cargo has a substantially spare capacity than is necessary for its current operations. If Gnewt Cargo was to implement the ALM system, then it could recharge a significantly larger fleet without needing to increase the grid connection capacity. Theoretically, the existing grid connection with an effective ALM could be used to charge a fleet of 220 vehicles with similar delivery profiles (that is, using less than half of the battery capacity and needing only one charge per day). Alternatively, it could reduce the size of its connection and reduce the annual associated connection cost (standing charge on the electrical connection).

For the London wide grid, which already is constrained in areas, smart charging will be beneficial. In London, one in five substations has only 7% spare capacity during peak demands. Although Gnewt Cargo already has the capacity if they would like to move to other sites or other distribution companies become fully electric then this would represent large challenges for the city. Therefore, techniques such as smart charging could assist in mitigating this or making sites with smaller connections viable[11].

Potential for reverse grid charging

In addition to minimising adverse effects on the grid, EVs have the potential to assist with grid regulation and access additional revenues through vehicle to grid exports (V2G) if connected to smart chargers with the ability to export electricity to the grid. V2G revenues may be generated through:

- **Arbitrage:** by charging the EV with when the electricity is relatively cheaper and discharging it when electricity prices are high.

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[10] EO Charging Hub, 2018, product description (Available Online)

[11] Greater London Authority, 2015, London Infrastructure plan 2050, (Available online)

- **Ancillary services:** through the provision of ancillary services to National grid including frequency response, load balancing, and voltage support[12].

Although the concept of V2G has been tested in several pilot projects, a number of technical, commercial and regulatory challenges need to be overcome to make it a viable proposition to fleet EV owners. Challenges include, but are not limited to:

- **Electric Vehicle Capability:** manufacturers on the most part do not offer this feature in their vehicles.
- **Battery degradation:** studies have shown that unintelligent V2G, where the vehicle is charged and discharged fully each day, is detrimental to the lifetime of an EV battery.[13] However, a recent study suggests intelligent V2G which maintains the EV battery at an optimum state of charge (between 62% and 79%) can minimise degradation.[14]
- **Market access:** provision of ancillary services, such a frequency response, requires a minimum of 1 MW to be tendered in the market. Large fleet owners may overcome this through the use of energy aggregators with appropriate technology solutions. Open Energi, an energy aggregator in the market, is trialling this proposition in the UK[15].
- **Policy implementation:** policy makers need to provide clarity on aspects such as disbursement of payments to V2G providers, double taxation, dynamic pricing and regulations on the potential role of aggregators.

Given the current challenges and potential benefits, a variety of industry stakeholders are working together to develop a viable proposition.

Recently, the Department for Business and Industrial Strategy (BEIS), in collaboration with the Office for Low Emission Vehicles (OLEV) and Innovate UK, announced £30 million of funding to develop the business proposition and core technology around V2G.[16]

The projects will comprise eight feasibility studies, five collaborative R&D projects and eight demonstration projects, bringing together vehicle manufacturers, aggregators, infrastructure operators, energy suppliers and academia from across the UK.

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[12] National Grid, 2018, Balancing services, details related to the different ancillary services that are required to operate the grid (Available online)

[13] Dubarry et al., "Durability and reliability of electric vehicle batteries under electric utility grid operations: Bidirectional charging impact analysis," *Journal of Power Sources,* vol. 358, pp. 39-49, 2017

[14] Uddin et al., "On the possibility of extending the lifetime of lithium-ion batteries through optimal V2G facilitated by an integrated vehicle and smart-grid system," *Energy,* vol. 133, pp. 710-722, 2017 (available online)

[15] Open Energi, 2018, "New power: consortium to roll out vehicle to grid trials this year" (available online)

[16] Upside Energy: https://upsideenergy.co.uk/2018/01/28/upside-energy-wins-three-vehicle-to-grid-projects/.

Preliminary Conclusion

Summary of findings

The Mayor of London / Gnewt Cargo project provides an insight to the impact of larger electrical vehicles (EVs) used for delivery and logistics purposes in London and the associated charging requirements and load impact.

With the current operational requirements, the evaluation of the charging infrastructure indicates that Gnewt Cargo has a substantially larger supply connection capacity than is necessary. This could be reduced now, though the benefits of utilising smart charging and associated load management will support further reductions if desired.

If Gnewt Cargo were to activate their smart charging system's Active Load Management feature, they could increase the fleet size substantially without needing to increase the supply connection capacity. The availability of the charge points in the depots offers the opportunity to lease them out to other users to supplement revenues.

The utilisation of public charging infrastructure to support the charging requirements of the existing fleet and trial vehicles only provides limited advantages as the current charging requirements are met at the depots. The Gnewt Cargo EVs receive sufficient charge from overnight charging at the depot that is cheaper (as much as 50%) than public charging and also more convenient. This may not be the case for other distribution companies that cover larger areas.

These preliminary findings are based on early trial data available between November 2017 and March 2018. With seven additional trial EVs expected to join in April 2019 and upgrades being made to the charge point capabilities, an update to this report's findings will be provided to include the additional data collected between now and the end of the trial period of data collection running until the end of September 2019.

Next Steps

There are several options that can be evaluated further as the project progresses. These are as follows:

- Further analysis of the data at the end of the trial to better understand operational performance of EV and their associated costs. This will include the assessment of the BD eDucato and comparison of a new Nissan eNV200 (modified) to the existing Nissan Voltia eNV200 as an effective baseline.
- Further analysis for the technical optimisation of smart charging infrastructure to meet Gnewt Cargo’s delivery requirements. Investigations can quantify the optimal network connection size, suitable times for charging and optimal state of charge for EVs.
- Quantification of the financial benefits of smart charging infrastructure.
- Assessment and quantification of additional revenue streams for Gnewt Cargo, including participation in ancillary services and energy arbitrage.
- Evaluation of the potential for embedded generation and batteries at EO’s charging station to save costs and reduce the burden on the local network.
- Assess the financial benefits and implications for allowing access to EO’s charging stations to other users.

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Appendix A

Data transformation challenges

A number of challenges that were identified during the data collection process. Therefore, we under took a data transformation process to produce a comparable and tangible data source for our analysis. These challenges have been highlighted in the table below.

Data Challenge	Arup Solution
Instances where Fleetcarma data was missing, incomplete or had large anomalies	The weighted harmonic averages[17] were utilised to remove the data points that were incorrect. The reasons for the missing data were investigated by Gnewt Cargo with Fleetcarma. In addition, detailed analysis of specific vehicles of different typologies were conducted. This was used to validate the conclusions made from using the averages and justify the removal of anomalies (predominately due to the data collection software not functioning correctly).
Lack of data points for the BD eDucato EV 2017	Omitted from the conclusions at this stage in the study. There were only a couple of weeks of operational data and it was clear that the majority of the time they were not being utilised.
Lack of smart charge point operation data	The theoretical smart charging capabilities were calculated for the EO Charging stations. This was done by applying the anticipated smart charging functions mathematically (distributing the charge over the entire stationary time of the fleet). Once this feature is activated, these numbers will be updated with actual ones.

[17] The harmonic mean is a type of numerical average, calculated by dividing the number of data points by the reciprocal of each number in the series. This is a weighted mean