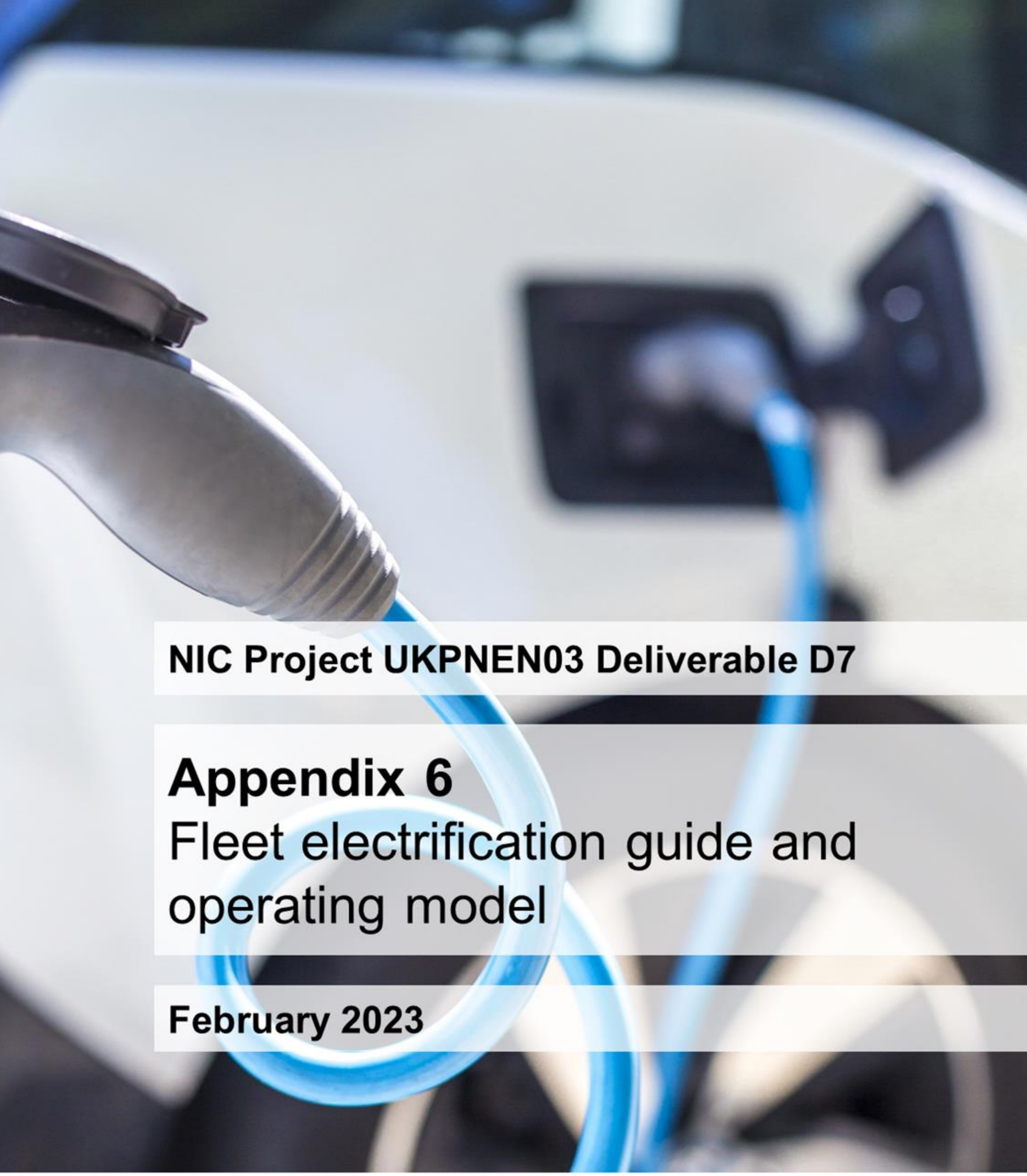


NIC Project UKPNEN03 Deliverable D7

Appendix 6
Fleet electrification guide and operating model

February 2023

Optimise Prime

HITACHI Inspire the Next · Uber · Scottish & Southern Electricity Networks · centrica · Royal Mail · UK Power Networks

Contents

Introduction

Optimise Prime is the world's largest trial of commercial electric vehicles (EVs). It is an industry led EV innovation and demonstration project that brings together partners from leading technology, energy, transport and financing organisations, including Hitachi Vantara, UK Power Networks, Centrica, Royal Mail, Uber, Scottish & Southern Electricity Networks, Hitachi Europe and Novuna Vehicle Solutions.

Since early 2022, data from the use of over 8,000 EVs driven for commercial purposes has been gathered and analysed. Optimise Prime has also implemented a range of technical and commercial solutions aimed at accelerating the transition to electric for commercial fleet operators while helping GB's distribution networks plan and prepare for the mass adoption of EVs. Through cross-industry collaboration and co-creation, the project aimed to ensure the security of energy supply while saving money for electricity customers, helping the UK meet its clean air and climate change objectives and transition to a net zero carbon economy.

This document is based on the fleet electrification experience of the Optimise Prime partners. It provides a step-by-step guide for fleet operators/managers who are considering the electrification of their fleets, developing businesses cases, and planning for rollout.

The guide also presents learnings on the operational capacity and capabilities required to operate a fully electric fleet. It focuses on aspects related to infrastructure readiness and the key considerations to account for when selecting, installing, and operating the required hardware and software solutions to optimise charging.

Optimisation refers to the creation of a charge schedule to:

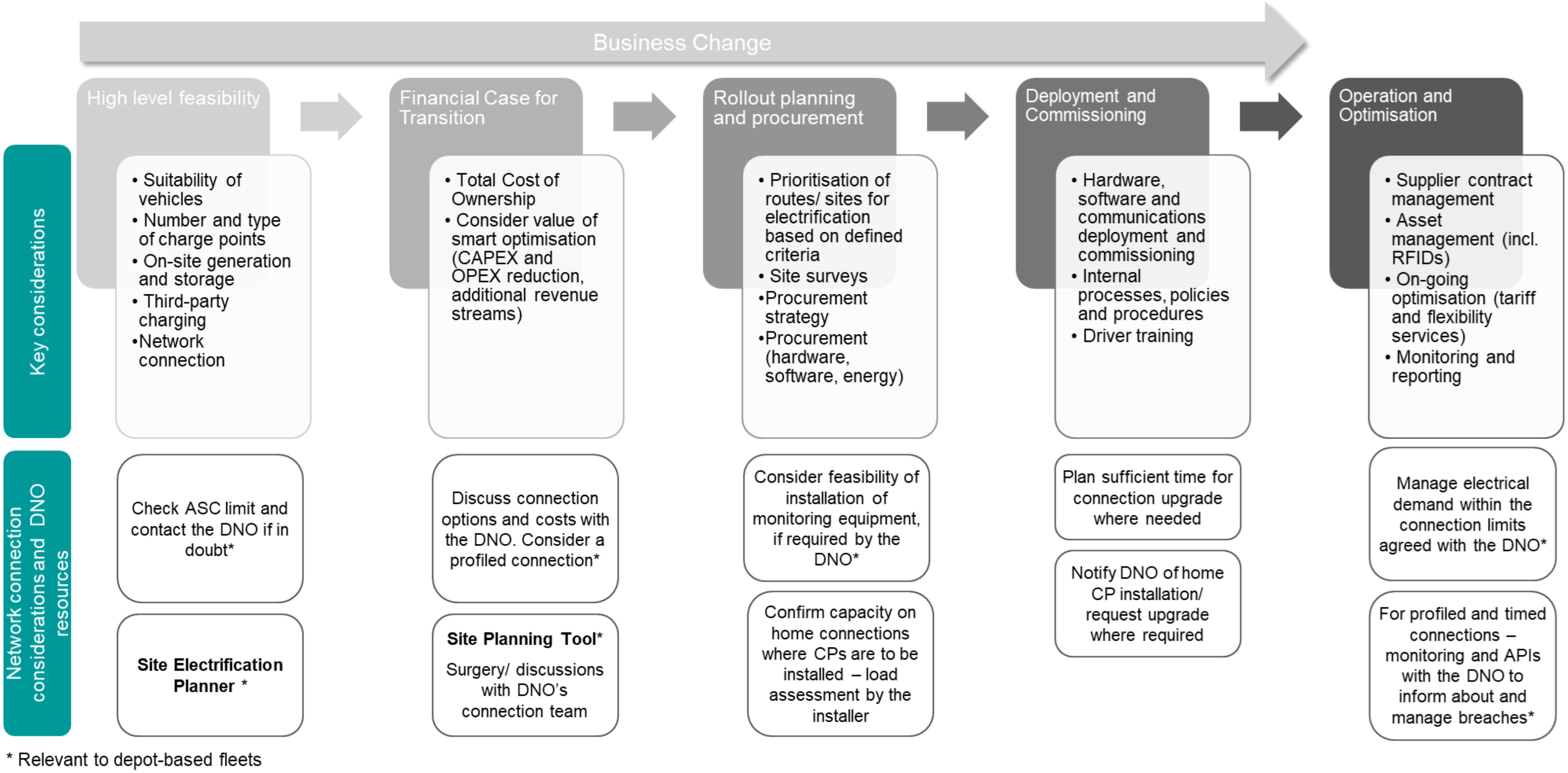
- Charge vehicles within the existing connection capacity (Available Supply Capacity – ASC), or enable adherence to a profile agreed under a profiled connection agreement, thus avoiding or reducing connection upgrade cost and waiting time for a connection upgrade; and/or
- Reduce the cost of charging, by charging when electricity is cheapest; and/or
- Allow load shifting to respond to flexibility markets to generate additional revenue.

Aspects related to vehicle selection and standard fleet operation are not discussed in detail; they are only considered as far as they may interact with the ability of the fleet to benefit from charging optimisation.

This document was originally published as part of Optimise Prime's fifth deliverable, D5, and builds on lessons learnt discussed in Deliverable D3. It aims to signpost activities that should be considered early in the electrification journey to enable effective operation and optimisation. However, the exact sequence of activities may differ depending on the capacities of each organisation and the characteristics of its fleet.

The process shown in Figure 1 is generic, and most steps apply to depot-based fleets, as well as mixed and home-based fleets, unless otherwise indicated. Details of this process are described in more detail in the following sections.

Figure 1 – Fleet electrification process overview



See page 10 for details of the Site Electrification Planner and Site Planning Tool.

1 High Level Feasibility

The objective of this phase is to understand the feasibility, costs, and the likely timescales of the transition and to ensure that key constraints are well understood.

1.1 Vehicles

The first step to initiate fleet electrification is usually a feasibility assessment based on vehicle usage patterns and other operational requirements, for example to establish whether there are suitable EV models on the market to meet needs. The analysis of telematics data can be helpful to ensure that appropriate vehicles (e.g. battery size sufficient for daily/weekly distances) are available to address any concerns related to range and inform the prioritisation of transition, which could be phased by site or other grouping.

Fleet electrification in the Optimise Prime trials has generated several learnings about EV procurement. For example, the initial EV models chosen by Royal Mail had a range of 80 miles and no Direct Current (DC) charging, which limited the rate of charging. While this would be suitable under normal circumstances it proved problematic at times of peak service demand at depots with alternate-day charging (i.e. two EVs for one charge point socket). Due to the inability to fast charge at public CPs, these vehicles may not be able to complete two consecutive shifts on the same charge. However, as new vehicle models come onto the market, with larger batteries, range will become less of an issue.

In the early stages of EV rollout, Royal Mail prioritised electrifying shorter routes and British Gas prioritised drivers with off-street parking and sufficient space to install a charge point (CP), subsequently offering EVs to those who would need to rely on public charging. Analysis of telematics data, from the internal combustion engine (ICE) vehicles, will allow the fleet manager to estimate the electrical demand once the whole fleet is electrified, and therefore the future electrical requirements, total site capacity and number of CPs required for a depot to meet future demand. Deliverable D4 Section 3.6 provides an example of how Royal Mail telematics data was used for this purpose.

1.2 CPs

The decision on the number and type of CPs will depend on the operational characteristics and requirements of the fleet, as well as the space availability and layout of the location. While the feasibility of the installation will need to be verified by site surveys, at a later stage, it is possible to estimate the number and type of CPs required based on operational requirements and telematics data. For example, for a depot-based fleet model, telematics analysis will uncover the appropriate times for charging that can meet the range requirements for the following shift (e.g. overnight, ready for the next day). This will help to determine the number and speed of the CPs required (see Table 1 for charge point speed overview). Futureproofing CPs should also be considered – technology will progress over the lifetime of these assets (~10 years) and more vehicles will be able to benefit from a higher rate of charge. Where electrification is gradual, futureproofing cabling and network connection capacity upfront will also reduce the incremental cost of any additional infrastructure which might be needed in later stages.

Table 1 – CP types and charging speeds

CP Type	Charge Speed	Time needed to charge from 20% to 90% SoC		
		40kWh battery capacity EV	60kWh battery capacity EV	80kWh battery capacity EV
AC 16A single phase	3.6kW	8 hours	12 hours	16 hours
AC 32A single phase	7.4kW	4 hours	6 hours	8 hours
AC 32A three phase	22kW	1 hour 20 minutes	2 hours	2 hours 40 minutes
Rapid DC CCS	50-100kW (example calculated at 50kw)	35 minutes	50 minutes	1 hour 10 minutes
Ultra-rapid DC CCS	100+kW (example calculated at 150kW)	12 minutes	18 minutes	24 minutes

Times given are approximate and may vary due to the vehicle's on-board charging system. Not all vehicles are capable of charging at all rates, especially 22kW AC and Ultra-rapid DC.

Royal Mail opted for 7.4 kW single phase CPs, deemed to be sufficient for overnight charging. Initially, a one-to-one ratio of vehicles to charge points was the guiding principle to enable overnight charging without the need to unplug vehicles during that time. However, at some depots this was not possible due to space constraints and operational workarounds had to be implemented, such as charging every other day (and having staff swap EVs later in the evening). Based on learnings from the initial trials, Royal Mail has introduced a strategic target to reduce the charge point to vehicle ratio to 1:2 across the fleet. This will require business processes to be put in place to manage alternate day charging. The process will be managed by the depot managers and is intended to be prescriptive, with charging schedules defining when and where each vehicle should be plugged in.

From the point of view of optimisation, having some flexibility in the times of charging is desirable, and a one-to-one charge point to vehicle ratio with predicable plug-in patterns is easiest to manage. Faster, three phase 22 kW CPs also allow quicker charging and therefore more flexibility in times at which vehicles can be charged, provided that the vehicles are capable of charging at this speed. These benefits need to be weighed against additional infrastructure costs. For example, a three-phase charge point may be approximately 20% more expensive than a single-phase charge point, and require larger cabling, but it provides a future proof solution as more EVs start to accept an increasingly higher Alternating Current (AC) charging rate.

1.3 Home-based Fleet Considerations

For home-based fleets, the ability to install a home CP is a major consideration. Availability of off-street parking and space for charge point installation is not the only barrier. Centrica's British Gas found that in many residential properties, particularly in locations with no gas connection where electric storage heaters are often used, the domestic electrical installation is already at capacity or nearly overloaded.

In terms of process, Centrica perform the initial domestic load assessment and depending on location, the Distribution Network Operator (DNO) may subsequently choose to perform a physical load assessment too. Centrica estimate that approximately 25% of potentially suitable locations are not able to proceed due to the result of the load assessment or due to services being looped. Looped services[1], are where two properties share a single electricity service cable, can also lead to delays and increase the costs of installation. Such supplies may need to be un-looped to enable charge point installation, with potentially intrusive works for the connecting customer and neighbouring properties.

Location of the parking space may also create issues for charge point installation. For example, if it is located at the far end of a garden, a lengthy electrical cable will likely need installing or replacing, causing additional cost and disruption that not all drivers welcome.

Where home charging is not available, alternative solutions can be considered. For example, as part of the Virtual Fuel Card offering, Centrica has negotiated arrangements with public charging networks that give drivers, who do not have access to a driveway, an ability to charge conveniently at reduced rates, billed directly to the company. As of June 2022, approximately 23% of British Gas's 800 EVs made some use of public charging (and this is forecasted to increase as more of the fleet converts). However, home charging is the default option, wherever possible, because of its convenience and the lower cost of charging on a domestic electricity tariff (when compared with a public charge point).

The applicability of Office for Zero Emission Vehicles (OZEV) grants should also be considered. Currently grants apply to individual installations, thus the driver must be the owner of the charge point installed at their home to be eligible. Without the OZEV grants, the CPs are likely to be fully funded by the employer and retention clauses can be considered for the drivers, obliging them to cover part of the cost should they leave the company before a specific period. However, due to lower charging costs on domestic tariffs as compared to public charging, Centrica's British Gas is taking steps to make charge point installation at home as accessible to as many drivers as possible.

1.4 Future charge point innovations: Vehicle to Grid (V2G)

V2G CPs can make other services available, such as selling energy back to the grid, or discharging the vehicles to cover other demand on the site during times of high electricity prices to reduce the overall energy cost. While V2G is not in the scope of Optimise Prime, it may become an option in future years for fleets to create additional value from flexibility. Other innovation projects are exploring the value of V2G in in different contexts, for example: project Sciurus estimated that a domestic V2G charge point could make the vehicle owner £410 per year compared to an unmanaged charge point[2], a modelling study concluded that V2G could deliver 20% to 60% more value than smart charging, depending on the value streams targeted[3]. As part of the V2G Hub initiative UK Power Networks have helped develop a guide to the potential benefits to customers of V2G technologies which can be found at https://www.v2g-hub.com/services/. UK Power Networks is also working as part of the Powerloop[4] consortium to trial a new tariff with payments for V2G exports.

The price of V2G CPs remains a major barrier. However, as technology advances the premium (cost difference between a V2G and a smart charge point) is expected to reduce from the

[1] UK Power Networks, Looped Services https://www.ukpowernetworks.co.uk/internet/en/help-and-advice/documents/looped_services.pdf [accessed on 16.02.2022]
[2] Commercial Viability of V2G: Project Sciurus White Paper, January 2021. Available at: https://www.cenex.co.uk/app/uploads/2021/01/V2G-Commercial-Viability-1.pdf [accessed on 27.09.2021]
[3] Cenex, Understanding the True Value of V2G. 07.05.2019. Available at: https://esc-non-prod.s3.eu-west-2.amazonaws.com/2019/06/Cenex-WP-2-True-Value-of-V2G-Report.pdf [accessed on 27.09.2021]
[4] Powerloop website https://octopusev.com/powerloop

current ~£4,000 to between £660 and £1,164 in 2030[5]. To date, the choice of V2G capable vehicles has also been limited, as V2G capability via DC charging currently relies on the CHAdeMO protocol, primarily limited to vehicles produced by the Nissan-Mitsubishi alliance. The Combined Charging System (CCS), the most common DC charging protocol on the market, does not currently enable V2G, although the body promoting CCS, CharIN, has a roadmap for implementing Vehicle to Home (V2H) and then V2G into the CCS standard by 2025[6]. Once the standard becomes available, it will likely take some time for compatible vehicles to come onto the market. Meanwhile, several vehicle manufacturers such as Hyundai and VW are investigating the potential for V2H and V2G via AC charging. While V2G potentially offers financial benefits, the use of this technology must be balanced against the requirements for operational use of the vehicle – for example, a vehicle providing an on call response service may not be a suitable candidate for V2G.

1.5 On-site generation and static battery storage

The option to install Low Carbon Technology (LCT) may be considered on suitable sites with sufficient space for on-site electricity generation such as solar PV and wind power. Analysis of site electricity demand should be conducted to establish how generation and/or energy storage could contribute to lowering energy costs and the achievement of carbon emission reduction targets. At this stage initial estimates can be sought from installers to understand the cost and generation potential.

Requirement for on-site generation and storage might have an impact (either positive or negative) on the network connection requirements and costs, so it is important to discuss these options with the DNO while considering the changes in the connection agreement. In cases of depots connected to a constrained part of the electricity network, on-site generation and energy storage may deliver significant benefits by allowing the accommodation of more CPs within a lower ASC and reducing the capital expenditure (CAPEX) on electrical infrastructure. The ASC is the maximum amount of power a site can import from the network at any given point in time. It is measured in kiloVolt-Amps (kVA). It may also be referred to as Maximum Import Capacity (MIC) or Maximum Power Requirement (MPR). The ASC is first agreed with the DNO at the time of connection and may be varied after that.

1.6 Third-party charging

To maximise the utilisation of the charging infrastructure, and improve the economics of the electric fleet, some fleet operators may wish to consider granting access to their charging infrastructure to third parties at times of low utilisation by their own fleet. In doing this, businesses need to be mindful of the potential safety and security issues resulting from allowing members of the public into busy operational depots.

Where sufficient electrical connection and space for additional charging infrastructure is available that can be separated from the main operations and dedicated purely to third-party charging, these can be monetised through an agreement with a third-party charging operator.

To make third-party charging economically viable, the benefits of improved utilisation/ additional revenue will need to outweigh the cost of managing site access and operations (including booking and billing) and the potential limitations on optimisation, as third-party charging is typically less predictable.

[5] Element Energy, V2GB - Vehicle to Grid Britain final project report. Available at: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/06/V2GB-Public-Report.pdf [accessed on 27.09.2021]
[6] https://electricnation.org.uk/2020/09/02/the-future-of-vehicle-to-grid-ev-charging/

1.7 Network connection – depot-based fleets

For depot-based fleets, it is important to check the depot's ASC early in the process. Some depots will have sufficient capacity, however if the ASC is insufficient to accommodate the envisaged number of CPs in addition to the baseload demand of the building, and the depot is in a constrained part of the electricity network then a network upgrade may be required. The costs of network reinforcements might have a material impact on the total cost of fleet electrification, however smart charging can significantly reduce this impact.

The current ASC of a site can be found in the connection agreement (this is an agreement between the site owner and the DNO). If this is not available, the capacity in kVA on the electricity bill paid by the site can serve as a guideline. Smaller sites without a specific ASC will be limited to 23kVA (single phase) or 69kVA (three phase).

The next step involves comparing the maximum demand, i.e. the most the site could draw from the distribution network to the site's ASC. This is the sum of the peak site demand and the maximum demand (i.e. total power from all proposed CPs) from the planned charging infrastructure[7].

- If the maximum demand is within the ASC and total charge point demand is less than 30% of the total site demand, then the DNO only needs to be notified within 30 days of installation.
- If EV charging takes the maximum demand above the ASC or total charge point demand is more than 30% of the total site demand then an application needs to be made to your DNO and approved before installation of the charge points can proceed.

The effect of maximum demand on the network can be reduced by applying smart charging and the cost of increasing the ASC can be clarified with the DNO on this basis. To ensure network integrity, the DNO may also require an import/export limiting device, which would be approved by the DNO as an automatic way to curtail excessive load. Such arrangements are novel and their application to low voltage connections were developed as part of Optimise Prime. Section 5 of D5 describes how such an arrangement could be implemented.

There are a range of possible connections, including:

- **Firm connections** – traditionally, a DNO would offer a firm connection, meaning the same ASC level is applicable throughout the day, which cannot be exceeded.
- **Flexible connections** – alternative connection type currently used mainly for renewable generators. A curtailment assessment report gives an estimate of how often the renewable generator's connection may be curtailed over the course of one year. This estimate depends on factors such as historical network power flows, typical load, and generation profiles. Curtailment is managed by the DNO based on available network capacity. Flexible connections allow generators to connect to the network faster and at a lower cost. This connection type is less well suited to demand customers, such as EV fleets, where operational reliability is important.
- **Timed connections** – alternative connection type currently applied in UK Power Networks' areas to a small number of customers connected at high voltage level, such as bus depots. Such connections specify different ASC levels at different times of the day, with up to four different time bands. To maintain network integrity, as a last resort measure, the DNO may disconnect a sacrificial load at the site if the agreed ASC is exceeded, following a series of warnings issued to the operator. This connection type became available in 2020 and five bus garages have so far benefited from a timed connection, each saving between £100,000 and £900,000 on connection costs when compared to a firm connection. The monitoring solution has shown that compliance with

[7] Engineering Standard EDS08-5050 includes some diversity factors that may be helpful here: EDS 08-5050 Electric Vehicle Connections (ukpowernetworks.co.uk)

the profile at each site has been successful thanks to reliable load management systems used by bus garages, and it has not been necessary to revisit the connection agreements.

- **Profiled connections** – a new connection trialled by Optimise Prime. The concept is similar to the timed connection, but profiled connections are extended to customers connected to the low voltage (LV) network and can be more granular (e.g. allowing up to 48 different half-hourly ASC limits throughout the day). The design of profiled connections is intended to offer the customer a connection profile best matched to their needs while ensuring a high level of utilisation of network assets and reducing the overall cost to customers.

With smart charging, a LV-connected depot operator might be able to reliably reduce their peak demand and apply for a lower firm connection or, in the future, for a profiled connection.

Figure 2 shows an example of a depot electrification journey, with focus on the interaction with the DNO and references to the tools available to support the depot operator and the appointed installer in this process. The exact sequence of these steps may differ, depending on the amount of data available, types of analysis conducted at earlier stages of feasibility, and the specifics of the procurement process.

Optimise Prime developed two self-service tools to support this process:

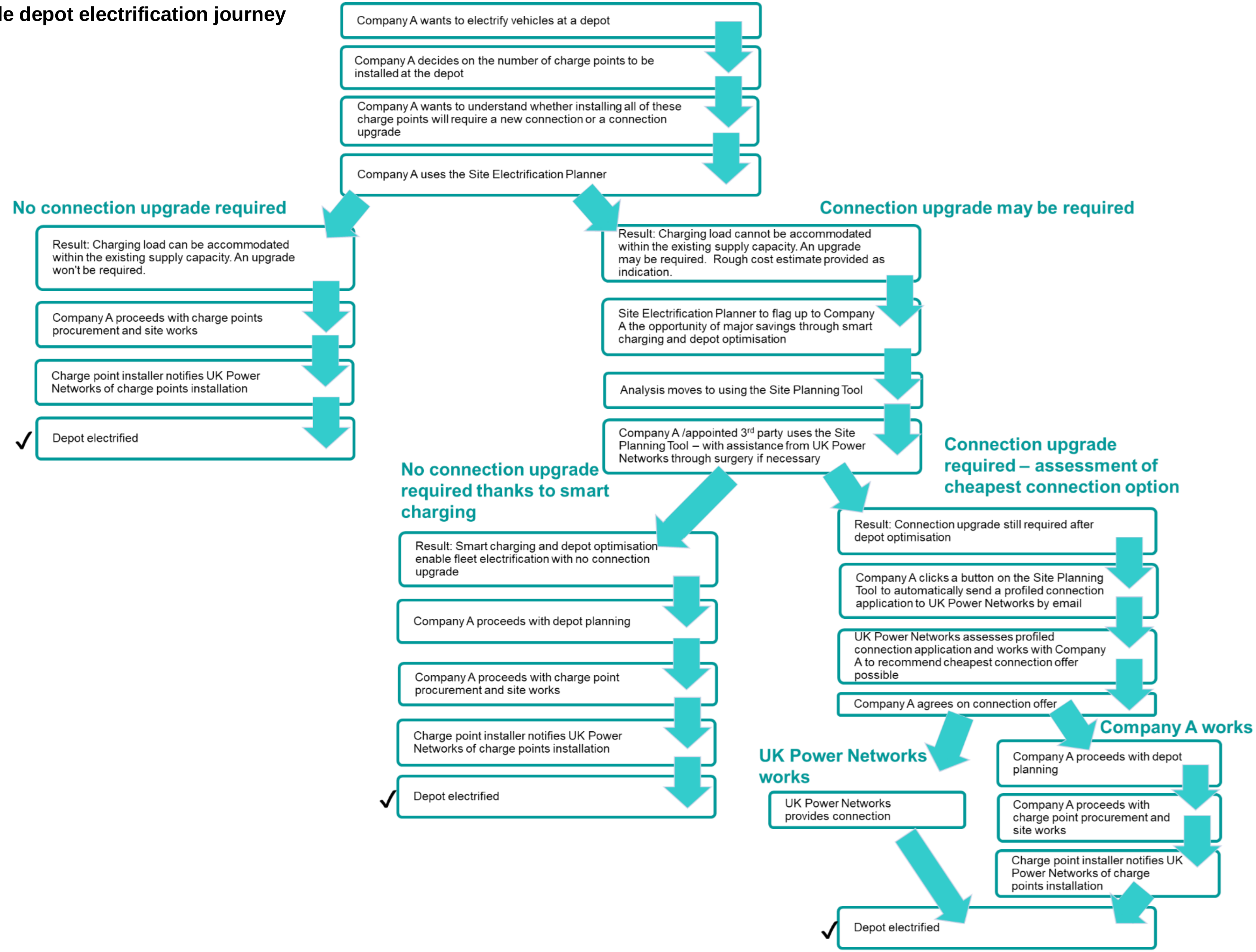
- **Site Electrification Planner:** https://www.ukpowernetworks.co.uk/optimise-prime/site-electrification-planner designed to give a quick estimate of the cost to connect EV CPs at existing sites based on four inputs (number of CPs planned, power rating of the CPs, the ASC and current peak demand).
- **Site Planning Tool:** https://www.ukpowernetworks.co.uk/optimise-prime/site-planning-tool-introduction which requires more granular inputs and calculates the ASC required under different optimisation scenarios including a base case, unmanaged charging, and smart charging. The results from the tool will provide a good basis for discussion with the DNO.

UK Power Networks also have a number of resources available on their website to help with EV CPs connections, including guides. They have also created a short overview of the process available here: https://www.ukpowernetworks.co.uk/electricity/electric-vehicle-charging-point/installing-larger-or-multiple-chargers

Most DNOs hold connection surgeries with their connections team free of charge (e.g. UK Power Networks & SSEN), where the different options can be discussed before a connection application is made.

A fleet operator can find their local DNO at the following link:
https://www.energynetworks.org/operating-the-networks/whos-my-network-operator.

Figure 2 – Example depot electrification journey



1.8 Network connection – home based fleets

Installation of a home charge point on domestic connection at an employee's home will not usually lead to additional connection costs. However, as mentioned above, in some cases the connection may already be overloaded and an upgrade to a three phase connection may be required to accommodate a charge point. UK Power Networks' innovative Smart Connect tool can automatically assess requests for connection of EV CPs and other LCTs, offering instant approval when within existing capacity or automatically referring to the relevant team if additional works are needed.

Further detail on the upgrade which may be required is available here https://www.ukpowernetworks.co.uk/electricity/upgrade-reduce-electricity. The cost of upgrading to a three phase solution in UK Power Networks' area ranges from £1,700 to £6,000 in the majority of cases.

The installer of a charge point must notify the DNO within 30 days about the installation. DNOs offer self-service tools to enable this, for example: UK Power Networks' Smart Connect https://www.ukpowernetworks.co.uk/smart-connect and SSEN's Online Applications portal https://www.ssen.co.uk/Forms/Onlineapplications/.

2 Financial business case for transition

Once the connection costs and their potential implications on the configuration of assets are understood, the financial business case for transition can be revisited. Most organisations consider the Total Cost of Ownership (TCO) of an electric fleet compared to an ICE fleet over a specific period.

The value that smart charging can add to the business case should be considered at this stage, as this will inform the capabilities (and cost) of infrastructure and control systems that will be required. Smart charging can add value through:

- **Reducing the CAPEX of the new connection or connection upgrade, where a lower firm or a profiled connection is enabled.** Currently, non-domestic customers connecting to distribution networks face an upfront charge made up of the cost of new assets needed to connect to the existing network, and a contribution towards the reinforcement of existing shared network assets, where this is required. From April 2023, the connecting customer will no longer be required to make a contribution towards shared network assets, but will still need to pay for sole use extension assets, such as cables or transformers that only serve their site. Regardless of the cost allocation, profiled connections will still be beneficial, because they will allow the accommodation of more demand on the network without reinforcements, thus reducing the socialised cost paid by all the network users. In constrained locations, there could be benefits in terms of speed of connection for fleets willing to accept a profiled connection.
- **Reducing the cost of charging** by ensuring the vehicles are charged efficiently at times when electricity is cheapest (i.e. utilising time-of-use or a dynamic tariff linked to wholesale energy market prices)
- **Enabling additional revenue from flexibility services** by varying the time and/or rate of charging based on turn down signals from the electricity networks and receiving a payment for this service.

The potential contribution of these value streams is further discussed in the TCO analysis in Appendix 4 of Deliverable D7.

2.1 Business change

An electrification project crosses functional boundaries within an organisation and involves functions such as fleet management, energy management, facilities, operations, procurement, finance, and HR. It is useful to ensure organisational buy-in and build a broad coalition of internal stakeholders early on in this process to ensure smooth implementation and operation.

Operational departments, in particular, should be involved at the high-level feasibility stage. In some cases it may prove more economic to change operational practices to reduce costs of electrification.

Operational staff at sites play an important role in ensuring the effective management of charging and optimisation. For example, at the Royal Mail delivery offices, it is necessary for the delivery office managers to ensure that the Radio-Frequency Identification (RFID) tags are correctly allocated and kept with each EV to ensure that the correct vehicle is identified when plugged into a charge point. Delivery office managers are not responsible for the profit and loss account of their depot, as energy bills and connection costs are handled centrally, so they are not usually incentivised to modify their depot operations to save energy costs as is the case with smart charging. To overcome this, Royal Mail has invested time in educating delivery office managers in the benefits of a cleaner fleet to drivers, customers, and the business – this has helped build understanding in the importance of managing the EV charging process effectively.

The Optimise Prime project experience suggests that involving drivers early in the process is beneficial in building their confidence and awareness. For example, Royal Mail engaged extensively with the unions and depots, and provided driver familiarisation training. The training is provided by an external agency and its cost is similar to ICE driver training. The time commitment for new drivers is approximately three hours, a change-over training for ICE drivers transitioning to EV takes one and a half to two hours. The benefits of this approach came through in the Optimise Prime driver questionnaires, with 94% of Royal Mail EV drivers stating in the first questionnaire that sufficient support was provided and generally high level of support for the transition. Through early engagement with their engineers, British Gas also built up a significant level of support and interest in EVs, with the number of those interested in transitioning to an EV exceeding the number of available vehicles (see Behavioural analysis, Appendix 5 of Deliverable D7).

3 EV Rollout plan

During the feasibility stage, an initial rollout plan and electrification timeline should be developed. This could include piloting the solution in selected locations prior to rolling out across all sites or electrifying the most suitable routes first across the whole estate. In their wider rollout plan beyond Optimise Prime, Royal Mail identified suitable sites and prioritised them based on several business-specific operational criteria with the view to maximise EV miles driven and the number of EVs across the estate. Benchmark cost per parking bay was used to exclude sites where electrification was not economically viable, primarily due to high network connection costs following initial engagement with the DNOs. The initial rollout will include cabling and electricity distribution network connections needed for full electrification, while CPs are going to be rolled out gradually in line with vehicle replacements.

The prioritisation could also be informed by the availability of data, with well understood locations electrified first, in parallel with monitoring and data collection activities across sites where insufficient information is available.

3.1 Detailed planning and procurement

Key activities in this stage include site surveys and procurement of the different components of the solution. A detailed site survey may uncover considerations that will lead to changes of the rollout plan. For example, the cost of renewing the electrical installation may limit the number of CPs that are economically feasible on a site.

3.1.1 Site surveys

Royal Mail's experience has shown that the importance of detailed site surveys, particularly on older sites with a history of change, should not be underestimated, as outlined in Deliverable D3, section 3 (3.2.3.1).

Comprehensive site surveys should consider the location of CPs and the ability to route cables to the connection point, as well as options for communications infrastructure. Depending on site design, certain operations may need to be moved to alternate areas to allow for easier cable routing. Table 2 provides an overview of the key items a site survey should consider.

The survey is usually conducted by the supplier selected to install the infrastructure. However, some organisations may choose to have the survey conducted by their general electrical contractor, prior to procurement. In the case of Royal Mail, the surveys were conducted by two different contractors due to the volume of work, each of the contractors covered different sites. The surveys took place after charge point procurement and one of the contractors was also the supplier of CPs across all sites.

Table 2 – Site survey considerations

Site survey item	Considerations
Preferred location of the CPs	• Determine the location of the CPs with respect to the electrical intake, parking spaces and access, both during construction and for maintenance • Consider the distance between distribution boards and CPs, the cost of cabling and any obstacles that may prevent connection • Is the road surface in a good condition? What is the ground surface? • Obtain site services drawings for locations of underground services
Electrical Connection points	• Assess location of electrical connection point • Assess cable route • The cost of installing CPs remote from buildings (e.g. on pillars in car parks, which require ground works; cable trenches) can be significantly more than wall mounted devices and cables in existing cable trays • Assess if there is any ducting that can be re-used • Assess location of the metering cabinets • Is a new substation required on site? Where would that be located? • Check existing earthing.
Electrical survey	• Ensure that the load of the CPs is within the limits of the circuits and DNO supply capacity • Where there are not sufficient spare breakers additional distribution boards may need to be installed • Assess supply capacity by the size of main incoming cable

Site survey item	Considerations
	• Assess maximum demand through electricity metering • Assess main distribution board and sub distribution boards for rating and spare ways • Assess the space in the switch room for the new EV distribution board • Obtain site electrical schematic • Assess earthing arrangements
Reverse parking impact on parking space size	Many depots require vehicles to reverse park. The additional space required for this (approximately 20%) needs to be considered, together with the appropriate placement of the charge point to connect safely to the vehicle's charging post
Signage	May be required to prevent use of EV bays by ICE drivers, or to remind drivers of charging procedures
Bollards/bump strips/charge point protection barriers	To ensure that vehicles line up to the CPs correctly and do not accidentally damage the CPs
Connection to Building Management System (BMS)	Connection to the BMS should be considered to enable optimisation. Site load data from the BMS will be required to understand the capacity available for EV charging on the depot's electrical connection. If BMS is not available, the survey should consider the feasibility of installation of building load monitoring equipment
Construction access/ materials storage	A plan will be needed for the installation of the CPs without interrupting day-to-day operations
Data networking	• Assess GSM coverage & under/over ground parking • Assess data networking requirements and connection for the communication between the CPs and the back office • For some locations ethernet connection may be more suitable (with additional costs for installation) or signal boosters may be required.
Data usage on SIMs	Optimisation may require more frequent communication with CPs, resulting in additional costs if using mobile data

Futureproofing the electricity distribution network connection and cabling installation should also be considered at this stage. Even if the rollout of CPs is conducted in stages, the total future electrical demand and cabling needs should be considered early on to avoid the need for retrofit/increasing connection capacity at a later stage at a higher cost.

Based on the site surveys, formal connection applications can be submitted to the DNOs, where required, to obtain final quotations for any upgrade. While early discussions with the DNO to obtain budgetary estimates for the connection, a binding quotation will only be provided based on an application formally submitted. Depending on the nature of the upgrade, this will typically involve contestable and non-contestable work. The former can be delivered by the DNO or an accredited Independent Connections Provider (ICP), while the latter must be conducted by the DNO.

Another consideration that should be made during the surveys is around the ability to install point of connection monitoring. If a profiled connection or lower firm connection is agreed with the DNO and requires smart optimisation to stay within the ASC, the DNO is likely to require a monitoring device to be installed at the depot operator's expense, as highlighted in Section

1.7. It is important to assess the feasibility of this as part of the surveys and deployment planning.

3.1.2 Procurement

An increasing number of suppliers on the market provide comprehensive fleet electrification solutions including installation, commissioning, operation, and maintenance. Alternatively, the different components of the solution can be procured separately, and project managed by an in-house team. Agreeing an approach early on is key to designing an effective procurement strategy.

A mixture of these approaches were applied by Royal Mail and British Gas. For example, in terms of communications infrastructure, the preferred installation route for Royal Mail was to place a turnkey contract for the installation, commissioning, operation and maintenance of the on-site communications infrastructure (Deliverable D3: 3.2.3.2).

Alternatively, an approach of dividing the work according to area of responsibility and assigning one party as the lead responsible party for coordinating the sub-activities can be applied. In this case, contract coordination effort and impact on future support arrangements should be considered (Deliverable D3: 3.2.3.2).

3.1.2.1 Hardware and software procurement

This section provides guidance on the aspects that should be considered while procuring the key components of the solution, with focus on what is required to make the most of smart optimisation, building on lessons learned described in Deliverable D3. Procurement of vehicles and financing options for vehicles and infrastructure are not discussed in this document, as they are broadly similar to those for existing ICE vehicles.

Table 3 – Considerations for electrification solution enabling efficient smart charging

Solution element	Considerations
CPs and CPC (Charge Point Controller)	• Centrica carried out an evaluation of charge point models. Key procurement criteria were interoperability, Measuring Instrument Directive (MID) compliant metering, for recording fleet energy usage, including use of RFID, supplier track record and price (Deliverable D3: 2.2) • The CPs should be designed/procured together with the control system, to simplify the process of integration, as retrofitting can create significant complexity (Deliverable D3: 3.2.3.1) • Vehicle identification method should be considered. Ideally this should be done directly with the vehicle e.g. via the Plug and Charge standard, part of ISO 15118. However, as the rollout of this standard is at an early stage, use of RFIDs may need to be considered and processes put in place to manage the RFID tags.

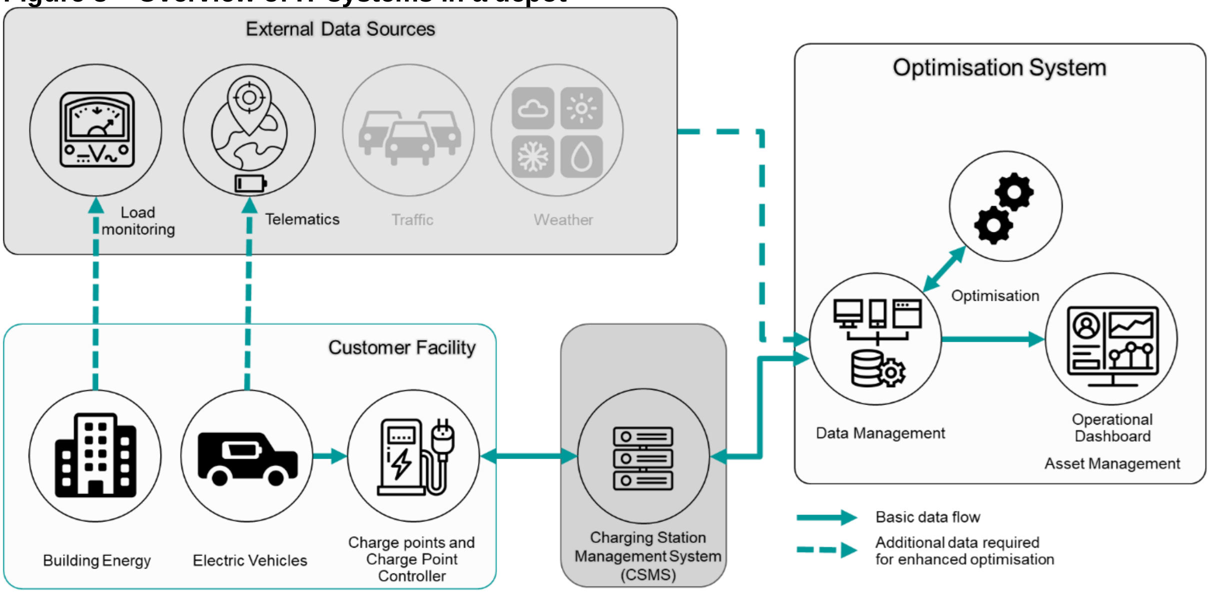
Solution element	Considerations
CSMS (Charging Station Management System) or Backoffice system (terms used interchangeably)	• Ability to communicate over Open Charge Point Protocol (OCPP) between the charge point and the vehicle, to support operations and maintenance functionality and remote firmware updates • The CSMS can be tied to a charge point vendor or be provided by an independent vendor for future flexibility. The latter is likely to make future integration of CPs from other vendors easier • CSMS may include basic load balancing to ensure a specific load is not exceeded
Optimisation system	• This covers optimisation over and above the capabilities offered by a CSMS and may include minimising energy costs by taking account of a Time-of-Use (ToU) tariff, integration with telematics to take account of the vehicle State of Charge (SoC), using the fleet schedule to prioritise charge to the vehicles that need it most urgently • Ability to integrate with telematics to enable prioritisation of charging individual vehicles or groups of vehicles – see Deliverable D3: 3.3.3.1 for considerations regarding telematics integration • Ability to receive and respond to flexibility requests by changing the planned charging times, within operational boundaries. This will be needed to enable demand response and generate additional revenues from providing flexibility to the DNO and/or National Grid. • Ability to optimise against a ToU electricity tariff and/or carbon intensity. More advanced systems may be able to optimise against a dynamic tariff, such as Octopus Agile, or pricing signals provided by an Aggregator. In the latter case, the Aggregator would typically have their own CSMS and would be acting as a CPO.
Site monitoring	• Required to optimise site load and charging load within the connection limit • Real time monitoring is of value especially on sites with unpredictable/ irregular baseload • May require multiple metering points, depending on complexity/age of the site • Ability to measure voltage and power factor will enable a higher level of accuracy, however monitoring current is usually sufficient
Communications infrastructure	• Communications – although coming with a higher up-front cost a common Local Area Network (LAN) connection was found by Optimise Prime to be a more reliable solution for depots than mobile cellular communications. Also, this can reduce ongoing comms costs for larger installations • Centrica opted for mobile cellular communications for the driver's homes, because using the drivers' broadband via a Wi-Fi connection was not deemed sufficiently reliable (because it might be turned off) • If the CPs are managed by a CPO, they may specify how the CPs connect to the CSMS

Solution element	Considerations
Telematics	• Telematics provides operational benefits, such as notification of vehicle faults, and being able to infer driver behaviour for the purposes of driver training/feedback • For the purposes of charging management, the management/ optimisation system needs to be kept up to date with all EVs and CPs in operation– the more accurate the vehicle schedules, the higher the benefits of optimisation • Most telematics providers provide solutions for both ICE and EV vehicles. EV telematics should additionally provide details of EV specific metrics such as battery SoC and plug in/out events. • For AC CPs, SoC is not visible via a charge point; for DC CPs SoC may be obtained directly via the charge point. Therefore, to infer the state of charge of vehicles, the optimisation system might have to rely on telematics data
Current limiting device	• This might be required by the DNO to ensure the integrity of the electricity network. The G100 device limits the power draw by automatically disconnecting some of the site load when the ASC is exceeded. This will need to be agreed with the DNO on case-by-case basis and would typically be procured by the installer
Low carbon technologies (LCTs) – solar PV and batteries	• Integration with the optimisation system for the purposes of whole-site optimisation should be considered – using multiple vendors will make integration more complex
Fuel card/charging cost reimbursement system	• A system to monitor and enable the reimbursement of the cost of charging at drivers' homes and at public charge – see section 2.3 of Deliverable D3 for details • The system should be capable of seamless integration with the expenses/accounting system of the fleet operator, reducing the cost of the process

The solutions elements above can be combined into an overall IT system for managing the fleet and infrastructure on site, as illustrated in Figure 3.

The above requirements are based on the experience from the Optimise Prime project, which did not test V2G or provision of flexibility services to National Grid (e.g. frequency services). Also, the project did not include traffic or weather data as external data sources, to manage depot charging, however they could be used to further improve optimisation. These may create additional requirements, going beyond the capabilities of the systems tested on the project.

Figure 3 – Overview of IT systems in a depot



3.1.3 Energy procurement

Additional electrical demand from depot-based EV charging may significantly increase electricity demand and cost across the estate. This may be a good opportunity to review energy procurement practices and look for a supply arrangement better aligned with organisational goals, be it cost reduction, risk management or achievement of emission reduction targets.

A business electricity bill is comprised of two major components: the commodity cost (cost of electricity) and non-commodity costs, also referred to as pass-through charges, including government levies and charges for the use of electricity transmission and distribution networks. These pass-through charges are driven by regulation and therefore mostly independent of the choice of energy supplier. However, some of these costs are calculated retrospectively on an annual/periodic basis and are not known to the supplier ahead of time. This may lead suppliers to include a risk premium in the energy price to account for this uncertainty. The commodity cost can be highly variable in the wholesale markets. The extent of exposure to this variability and hedging strategies will depend on the type of commercial arrangement with the electricity supplier.

While energy procurement was outside of the scope of Optimise Prime, generally the following options are available to larger users:

- **A fully fixed price contract:** a contract from a supplier which is fixed for an agreed term and all commodity and pass-through costs are included in the price. This provides a cost certainty for the contract duration but is likely to include the supplier's risk premium as they do not know how pass-through charges or Renewable Energy Guarantees of Origin (REGO) prices will change during the contract term. REGOs are issued whenever renewable energy is generated but are traded separately to electricity. Suppliers can provide REGO-backed electricity tariffs, i.e. tariffs offered as renewable tariffs, whereby the supplier purchases the appropriate amount of REGOs.
- **A flexible contract:** a contract from a supplier that offers a framework to buy energy when the market price is right for the customer. Managing such a contract requires expertise, either in-house or from a specialist intermediary, but may result in savings by lowering the commodity cost and the risk premium related to non-commodity price components. The customer takes on the risk of pass-through charges variability, but pays only for the charges applied, without the additional risk premium.

- **A Power Purchase Agreement** (PPA)/**Corporate Power Purchase Agreement** (CPPA): a contract between a power producer, such as wind or solar farm, and a corporate off-taker. The PPA defines the conditions of the agreement, such as the amount of electricity to be supplied, price, term, structure, and penalties for non-compliance. Since it is a bilateral agreement, a PPA can take many forms and is tailored to meet both parties' requirements. Over recent years, corporate PPAs have become the primary route to market for new renewable energy assets and play an important role in the transition to net zero carbon. A PPA is usually approximately 10 years in duration and allows the buyer to lock in competitive prices over that term, providing certainly over the commodity component. While a green tariff can be achieved through REGOs, a PPA is a more direct way of enabling the building of new renewable assets.

End user approaches to hedging will reflect the size, resources, and risk appetite of the organisation. Typical approaches by customer type as defined by their metering arrangement and annual demand are summarised in Table 4. Customer types are based on the customer's connection type and metering arrangements, for instance non half hourly (NHH) metering is used for smaller sites (SME and domestic) as they require less electricity. Customer types can be broadly classified under Small and Medium Enterprises (SMEs), Mid-market customers, and Industrial & Commercial customers, based on their size.

Royal Mail fall into the largest user category with a total demand over 30 GWh per year across multiple sites. With strategic priorities of ensuing cost certainty and converting to renewable energy, Royal Mail are reviewing the procurement strategy considering the impact of EVs.

The contract provisions will define the price of electricity paid by the site at different times of the day, ranging from a flat tariff (a fixed price per kWh of electricity, regardless of when it is used) to a ToU tariff with two or more fixed time bands throughout the day, to more variable arrangements. Most business tariffs fall into the ToU category.

The different time bands of the ToU tariff can be utilised by an EV smart charging system to minimise the cost of charging.

Table 4 – Typical electricity contracting approaches by customer type

Customer Type	High-level classification (SME, Mid-Market, I&C)	Typical contract type	Hedging by
NHH 1-2	SME (PC1 and PC2 also include domestic)	Fixed price proposition; typically fully inclusive tariff; limited potential for passthrough of third party charges (TPC); renewable energy as an option	Supplier under fixed tariff proposition
NHH 3-4			
HH <1GWh	SME to Mid-Market	Fixed price, but with the application of flexible at aggregated level; growing potential for TPC passthrough; renewable increasingly as standard	Supplier, third party intermediary of aggregator
HH 1-10GWh		Emergence of flexible contracts; renewable as standard; TPC passthrough	
HH 10-30GWh	I&C	Flexible contracts as standard (trading desk access); renewable as standard; TPC passthrough	Supplier (under delegated authority), third party intermediary or

Customer Type	High-level classification (SME, Mid-Market, I&C)	Typical contract type	Hedging by
HH 30GWh+		Flexible contracts as standard (trading desk access); renewable as standard; TPC passthrough	aggregator. Larger energy intensive users may have dedicated in-house resource

Source: Cornwall Insight, October 2020

For example, the tariffs at Royal Mail depots during the project had five different time bands during the weekdays, with the cheapest rates between midnight and 06:30, allowing the vehicles to recharge overnight at low cost. The most expensive time bands were 11:00 to 14:00 and 16:00 to 19:00, reflecting the high DUoS (Distribution use of System charges, a component of the non-commodity cost) during these times of peak network use in UK Power Networks' area. The TCO analysis in Deliverable D5 illustrates the savings resulting from tariff-based optimisation.

For home-based fleets, the charge point installed at an employee's home will be on the same supply point/meter as the rest of the demand in the home. It is therefore difficult to advise the employees to change their domestic tariff to optimise the cost of EV charging, as this will impact on the rest of their electricity bill. There is currently no industry solution enabling two different electricity tariffs on one metering point, however changes are being discussed[8] that might enable this in the future.

Centrica have decided not to advise their drivers to switch their domestic tariffs, but a process was put in place to verify the tariffs and keep them up to date for reimbursement and optimisation purposes.

4 Deployment and Commissioning

This phase covers the installation, testing and commissioning of hardware and software. In addition, it should include staff training and any relevant changes to internal processes, policies and procedures. This may include instructions for drivers on when and where to plug in to improve predictability of charging patterns.

For fleets that require public charging, arrangements with public charging networks may need to be made. Initially, this was not required in the case of Royal Mail's return-to-depot model, as depot charging fully meets the requirements, although using public charging providers at some locations is being considered as electrification progresses.

In Centrica's case, public charging is required for drivers with larger patches, where the range of the vehicles may be insufficient for a whole day's work, as well as for those who do not have access to off-street parking where a charge point can be installed. To address these issues, Centrica have developed the virtual fuel card, which is now a commercial offering.

The following lessons learned from the project relate to this phase and are described in more detail in Deliverable D3 (section numbers in brackets):

- There can be a complex range of actors involved in the provision of depot charging, such as CSMS providers, facilities, depot operator, property, energy, procurement, drivers, and

[8] P375 'Settlement of Secondary BM Units using metering behind the site Boundary Point' https://www.elexon.co.uk/mod-proposal/p375/

IT systems maintainers, and it is essential to clearly define responsibilities during both the installation and operational phases (3.2.3.3).

- Where there are multiple Meter Point Administration Numbers (MPANs) at a site, the CPs should be recorded against which MPAN they are connected to at the time of installation (3.2.3.1). This will be relevant for the design of profiled connection and optimisation within a profile on a given meter point.
- Power infrastructure at larger and older sites can be complex and require additional time and resources to implement successfully (3.2.3.4).
- If a profiled connection or lower firm connection is agreed with the DNO, requiring smart optimisation to stay within the ASC, the DNO is likely to require a monitoring device to be installed at the depot operator's expense, on the DNO side of the meter. Experience from the Royal Mail trials shows that it is not always possible to install point of connection monitoring within distribution network infrastructure and installing on customer premises can be complex (3.4.1). This should be considered during surveys and deployment planning.
- Vehicle identification/RFIDs – the use of RFID tags to identify which vehicle is using which charge point within a depot is not always reliable, as tags could be swapped, get lost and replaced or drivers may not authenticate the charging session properly. Tighter vehicle and charge point integration (where the vehicle itself identifies to the charge point) would make optimisation of charging more reliable, simpler to implement and operate (3.2.3.1). If possible, vehicles and infrastructure compliant with the Plug and Charge standard should be selected. If not available, effective operational procedures to manage RFIDs should be put in place
- There may be a lack of consistent routines/policies for charging vehicles at the end of shift, and these will need to be put in place to get the most out of smart charging (3.2.3.5)
- Early involvement of operational staff and third parties is key to ensuring that commissioning proceeds with minimal disruption (3.2.3.3).

5 Operation and Optimisation

An Operations and Maintenance (O&M) contract will be advisable to set out preventative and corrective maintenance Service Level Agreements (SLAs), the process for 1st, 2nd and 3rd line support for the CPs, once installed. This will ensure effective monitoring and resolution of charge point faults.

In addition to the standard fleet management activities, the resources/capabilities required for following need to be considered:

- Contract management and coordination between suppliers – especially if the different elements of the solution are procured separately.
- Processes to ensure that details of all assets are up to date (Deliverable D3 3.3.3.1) – EVs, CPs and RFIDs (if used). This will enable effective optimisation.
- Operation of smart systems and participation in flexibility services – for organisations choosing to implement more sophisticated optimisation systems and participate in flexibility services, the effort of bidding for and managing flex contracts can be significant and require specialist expertise. This could be achieved either by building an in-house capability or contracting with a specialist aggregator. Which option is more suitable, will depend on the size of the organisation and the likely value that could be generated from flexibility provision. In the case of Royal Mail, it is estimated that once the flexibility process is up and running, approximately 0.1 fulltime equivalent (FTE) would be required to manage it across the nine participating depots, comprised of time contributed by staff at different levels (analyst, senior management, and depot managers). The potential costs and benefits of the provision of flexibility services to the DNO are discussed in more detail in the TCO analysis in Deliverable D5. Participation in other flexibility markets was out of

scope. However, a specialist aggregator would likely stack revenue from different flexibility value streams (DNO, National Grid, as well as wholesale electricity markets), thus potentially enabling a higher value. Even in the case of outsourcing the flexibility management to an external party, a level of internal expertise will be required in-house to procure and manage a flexibility operator and on depot level to troubleshoot any issues and ensure that the flexibility provision does not interfere with operational requirements. In the mid-term such services will be fully automated, requiring only minimal oversight from the fleet operator.

Royal Mail estimate that overall, the resources required to operate an EV fleet are roughly the same as those required to run an ICE fleet (excluding flexibility management). Based on experience to date, it is expected that maintenance will require less effort as EVs break down less frequently and on-going maintenance is less time consuming. Royal Mail maintain their vehicles in-house – all the technicians underwent an on-line Level 3 training course in EV maintenance and workshops are being fitted with EV CPs.

For home-based and mixed fleets, the process of reimbursement for charging costs will need to be managed. While Centrica have largely automated the process with their virtual fuel card solution integrated with payroll, some manual effort is required to keep domestic tariffs up to date for reimbursements and optimisation. For further details on solutions enabling the separation of commercial load on domestic connections, see Deliverable D5.