# Document 4 – Site Assessment Methodology

To adopt electric vehicles, it is imperative to understand how and where they will be charged. For electric refuse collection vehicles (eRCVs) charging will be done at the operator's depot. Assessing whether the electricity network connection(s) at the depot is constrained and how vehicles will be charged must be done before making any investment decisions.

In this document the process to follow to assess a site for EV charging infrastructure deployment is described at a high level using a hypothetical case study. In a following document, this process will be applied to real data provided for a Welsh ULEV fleet depot.

Figure 1 shows the high-level process to be followed, each step of which will be expanded in the following sections of this guidance document:

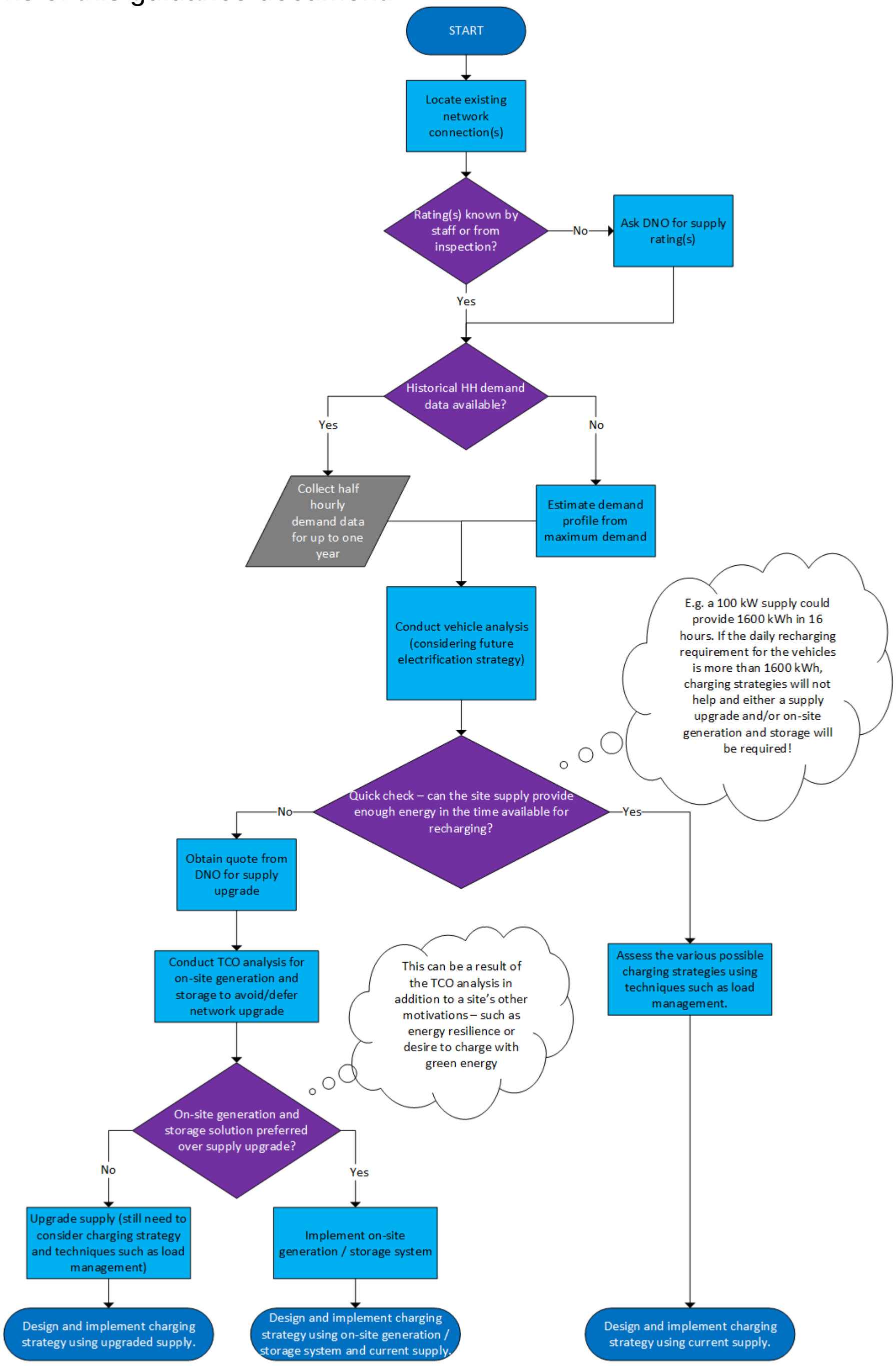


Figure 1: Overall Site Assessment Process

# 1 Existing network connection(s)

## 1.1 Introduction

The first step for a site assessment is to understand the electricity supply. For smaller sites there is likely only one connection to the Distribution Network Operator (DNO) but for larger sites there may be multiple connections. Very large sites may have their own dedicated distribution sub-station(s) and a private distribution system.

If a site has an energy or facilities manager, they should know the size (in kVA or even MVA) of all supplies. For smaller sites however who do not require these roles, it will be necessary to inspect the incoming supply to understand its rating and the number of phases present (i.e. whether it is a single or three-phase connection).

If a site only has a single-phase connection, it is likely that the connection will be constrained and an upgrade to a larger three-phase supply necessary. In addition, a three-phase supply is likely to also be required to deliver three-phase AC charging and/or DC charging (as DC chargepoints typically use a three-phase AC supply).

For rating, whilst some DNO cut-outs are labelled, a competent electrician or electrical engineer will be needed to assess the capacity of an incoming DNO supply as it could be limited by the rating of the DNO supply cable, the DNO cut-out (supply fuse), or the meter tails (on the DNO side of the meter). Your DNO will be able to assist with this inspection if required.

The location(s) of the supply and existing distribution equipment is important to prioritise locations for the charging infrastructure. If there is only one suitable location for vehicles to be parked then there is no flexibility however if there is multiple options then the availability of power may influence the decision of where to locate the infrastructure; parking electric vehicles near to the source of power will minimise charging infrastructure installation costs. For larger deployments of infrastructure it may be worth considering splitting the installation between multiple supplies to share the load.

## 1.2 Example

For the hypothetical case study, we will assume a site has a single three-phase DNO 100 kVA supply and the EV charging infrastructure can be located close to the supply.

# 2 Existing Loads

## 2.1 Introduction

To understand the capacity of a site's connection(s) to recharge EVs, it is first important to understand the existing loads from all other electrical equipment on site, including any existing EVs. The more detailed the data, the better. In order of preference, a site assessment would use:

- One year's worth of half-hourly metering data for each supply.
- Half-hourly metering data for a week from both the highest demand month, typically January, and the lowest demand (and highest generation month, if applicable), typically July.
- The maximum demand for a peak demand winter and summery day. Typically weekdays. This can be combined with the site metering profile type/class[1] to generate an estimate of the site's load profile using one of ELEXON's profile classes[2].

## 2.2 Example

Historic half-hourly metering data is not available however the peak summer and winter demand is known and the Metering Point Administration Number (MPAN) profile class is 5[3].

- Peak summer demand = 25 kW
- Peak winter demand = 30 kW

This would yield the predicted load profile shown in Figure 2. Using the hypothetical site supply of 100 kVA and assuming an overall power factor[4] of 0.95 and subsequent safety factor of 0.95 (which can be changed according to the level of uncertainty of site non-EV loads and risk appetite of the particular site), we achieve a reduced maximum load of 90 kW.

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[1] This guide shows how to find the profile class from the meter MPAN.

[2] Profiling - Elexon BSC

[3] Non-domestic maximum demand customer with a peak load factor of < 20%. This means that the metering system gives the maximum demand for a given period and the total energy supplied is less than 20% of the maximum energy that could be delivered if the site were to run at maximum capacity continuously.

[4] Power factor represents inefficiency in a system. At a site level, it is the ratio of real power used to do useful work (e.g. to charge EVs) to apparent power (expressed in kVA) demanded by the site. The apparent power is what is important for the DNO and therefore it is important to include power factor in supply calculations. Your site's power factor may be included on your energy bill.

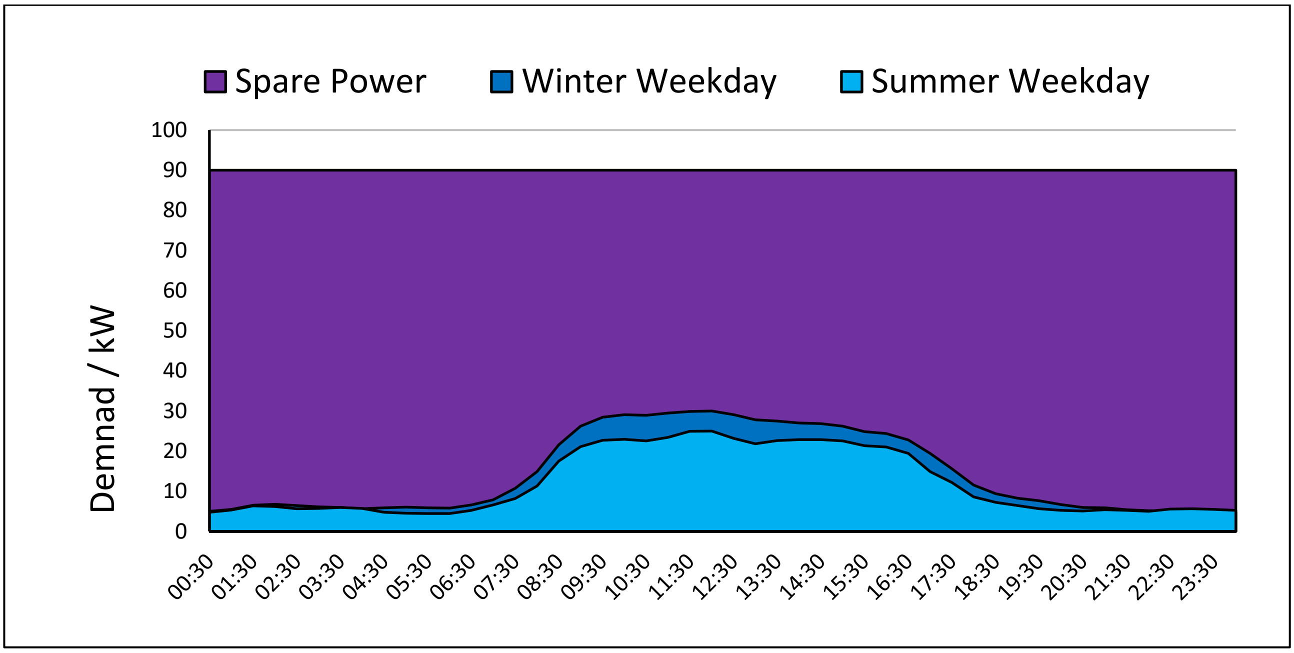


Figure 2: Example load profile

The design point will be the winter weekday. This is because the highest non-EV loads will coincide with the highest charging requirement for the EVs as a result of low winter driving efficiency and regular use of energy intensive cabin heating.

The resulting load factor is approximately 16%. Meaning, of the 2160 kWh that could be consumed on a 90 kW supply if running at maximum load continuously for the whole 24 hours, 346 kWh are consumed leaving 1814 kWh available for EV charging.

The predicted load profile shows how important it is to use real metered data if possible; if there were significant night-time loads these would not be predicted by the ELEXON profiles.

## 2.3 A Note on Phase Balancing

Three-phase sites will have a mixture of single and three-phase loads connected which can create an imbalance in phase loads. When deploying single phase AC charging it is possible to be strategic about which supply phases are used in order to find the optimum balance of loads. However, for eRCV charging infrastructure that is either three-phase AC or DC (which requires a three-phase AC input) the load on each supply phase is equal. Therefore, when completing the analysis required to design a charging strategy as per section 5 of this document, it is important to consider the impact of the additional EV charging load on all three supply phases.

The EV charging installer will consider phase balancing as part of their installation design.

# 3 Vehicle Analysis

Before assessing site power requirements, it is important to understand the charging capabilities and daily energy requirements of each individual electric vehicle under typical fleet operating conditions.

The following information is the minimum required to estimate electric vehicle charging requirements:

- Useable battery capacity (kWh) – also known as net battery capacity. To extend battery life a safety margin is built in to prevent the battery from fully charging or discharging. Useable battery capacity is typically 90% of the nominal or gross battery capacity. If there is any uncertainty, useable battery capacity should be confirmed with the vehicle manufacturer.
- Maximum charging power (kW, AC and DC) – some vehicles can be specified with higher power on-board chargers at an additional cost, for example an 11 kW AC charger rather than a 7 kW AC charger.
- Shift start and end times (available time for charging).
- Daily energy consumption – electric vehicle energy consumption varies significantly by drive and duty cycle. This is particularly the case for RCVs which have large additional power requirements meaning that energy consumption is a factor of vehicle speed, bin lifts, compaction cycles, payload, and external factors such as driving style or ambient temperature. As such, for larger fleets it can be difficult to accurately assess the daily energy consumption for each vehicle. The following options are available in order of amount of resource required:
    - Assume that all vehicles use a near full charge of the battery each day (e.g. 80% - most vehicles issue warnings then limited performance at lower states of charge). This will likely result in a significant overestimation of energy consumption and, as a result, an over specified charging system. This is low risk operationally but can significantly increase project costs.
    - Gather data from other fleet operators that have deployed similar vehicles.
    - Calculate average daily energy consumption for diesel vehicles (from daily fuel use, 1 litre of diesel = 9.98 kWh of energy) and apply an energy factor to estimate electric vehicle energy consumption. Battery electric RCVs typically use at least 66% less energy than an equivalent diesel vehicle.
    - Undertake a managed vehicle trial and measure energy consumption across a wide range of conditions and vehicle operations.
    - Develop fleet specific drive cycles and commission independent vehicle testing to be undertaken under controlled conditions.

Understanding daily vehicle energy consumption is critical for implementing a cost-effective charging strategy with adequate power to meet the fleets operational requirements.

Based on initial data analysis, 200 kWh a day energy requirement with an available charging time of 16 hours is typical of eRCV usage from experience by Cardiff and Newport.

# 4 Site Supply Evaluation

## 4.1 Introduction

Once the daily recharging requirement for the vehicles is known, it is possible to evaluate whether the current network connection(s) is capable of delivering the energy required in the available charging time, or whether mitigation action (including potentially upgrading the supply) is necessary. This step is best explained by continuing the previous example.

## 4.2 Example

From steps Error! Reference source not found.1 and 2, we achieved a load profile graph of existing loads indicating the spare power available at a site with a 90 kW connection and reasonably modest site non-EV loads. If we then exclude the power that is redundant given the available charging times for the vehicles (i.e. the times during which they are operational and away from site), we can produce Figure 3:

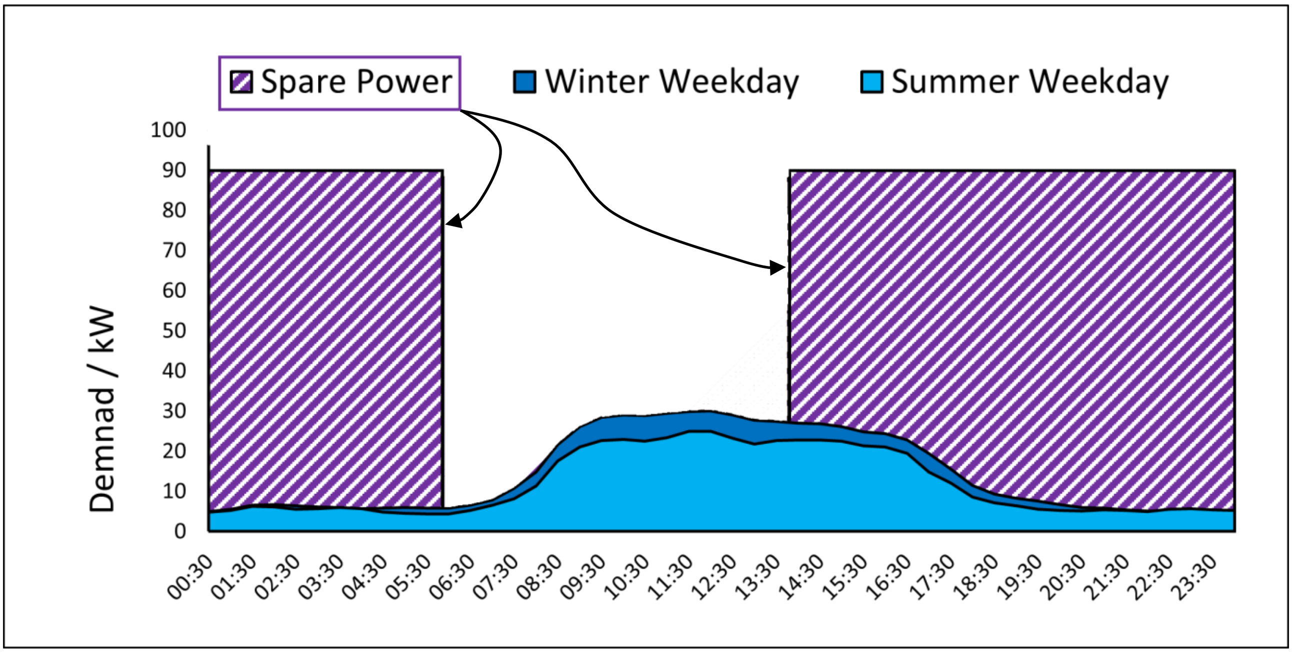


Figure 3: Spare Power Accounting for Vehicle Availability

Accounting for the 8-hours operational window from 06:00 to 14:00, the total energy that can be used for charging from the "spare power" above the requirement of the winter weekday is approximately 1271 kWh. Following on from step 3, if each vehicle needs to be recharged 200 kWh daily, then we can quickly determine that if the deployment involves 6 or less vehicles then this can be achieved using the existing network connection without upgrade. How this is done is explained in step 5. If, however, more than 6 eRCVs with a 200 kWh daily recharge requirement are to be deployed (either immediately or in the future) then, as explained in step 0, either the supply must be upgraded or alternatives such as generation and storage need to be considered.

After understanding the existing site loads, connection and vehicle recharging requirements, a quick evaluation of whether the existing network connection is sufficient can be done. It is important at this stage to consider future strategy – whilst it may be achievable to connect some vehicles a more comprehensive electrification of fleet vehicles in the longer term may require further action.

# 5 Design Charging Strategy

## 5.1 Introduction

If the site has sufficient capacity to recharge the vehicles in the available time, then the next decision to make is how the recharging is to be done. The number of options will vary depending on the recharging requirements. There are two possible scenarios:

1. There is no limitation in terms of power or energy. The vehicles to be deployed can be charged at maximum power without management without risking overloading the supply. This is an example of an unmanaged charging strategy (Strategy 1).
2. The energy required for recharging can be delivered, but it must be done in a managed way in order to avoiding overloading the supply due to the presence of non-EV loads active during the recharging time of the EVs. To overcome this, there are three further strategies:
    a. Use any timed charging functionality within the charger or the vehicle(s) to stagger the charging of vehicles so that they do not all charge at once and overload the supply (Strategy 2).
    b. Deploy Level 2 static load management (Strategy 3).
    c. Deploy Level 3+ dynamic load management (Strategy 4).

In this section the impact of the actual power variation during a charging session, which can increase the required charging time, (see document 1 – Introduction to EV Charging) and the impact of charging efficiency (see section 5.5), which can increase the site load and/or required charging time, is not included for simplicity. However, it is important to consider both effects when designing the charging strategy, to ensure enough time is available for charging and to avoid overloading the site supply.

Also, for simplicity, only the impact of EV charging on the total site load is shown. If there is any imbalance in loads across the phases of a three-phase site, then the risk of overloading a particular supply phase will also need to be evaluated.

## 5.2 Examples

Returning to the same case study, we can show examples of the potential outcomes by considering strategies in which we deploy different number of eRCVs, each again with the same recharging requirement of 200 kWh daily, with a maximum charging system power (i.e. the least of the maximum charging power of the charging infrastructure and vehicle charging system) of 40 kW.

### 5.2.1 Strategy 1 – Unmanaged charging

If just one eRCV with 40 kW charging capability is to be recharged, then this can be done without limitation and no charge scheduling or load management techniques are necessary. However as soon as two eRCVs are deployed, the site capacity is exceeded, as shown by Figure 4:

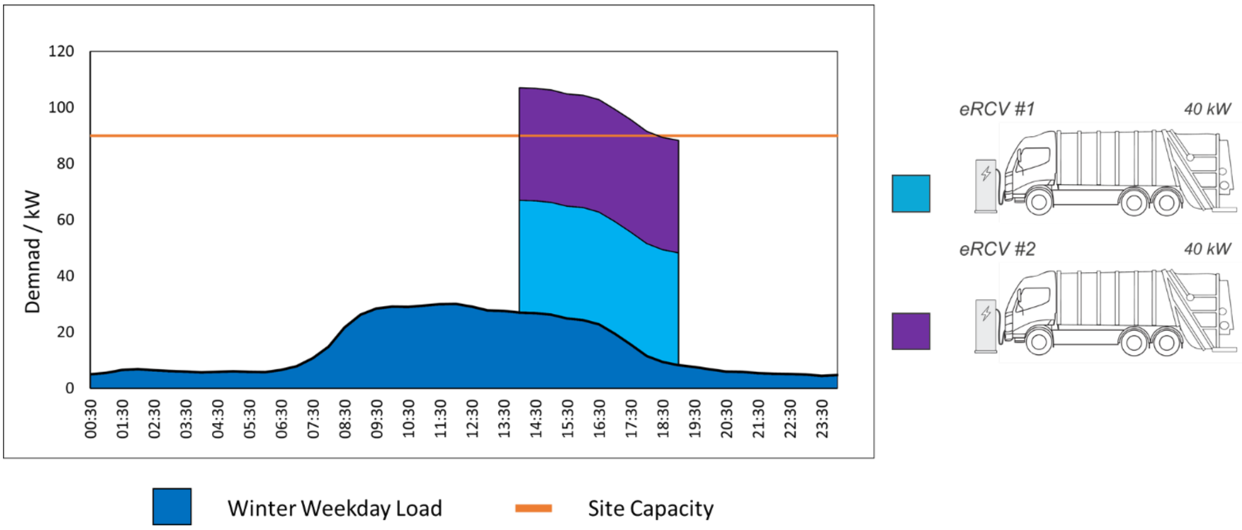


Figure 4: Strategy 1: Unmanaged Charging

Although very simple to implement, unmanaged charging is likely only possible for low numbers of vehicles, as indicated by this example. In addition, the system has no intelligence and therefore could risk overloading the supply if any unpredicted short-term large loads are present at the same time as the EV charging. Finally, this behaviour - leaving the vehicle fully charged and always charging at maximum power[5] - will be detrimental to battery health. The large batteries used in eRCVs will be the vehicle's most valuable asset and therefore it is important to preserve battery health.

### 5.2.2 Strategy 2 – Time scheduled charging

With at least two vehicles to be deployed, some form of management required. Time scheduled charging stops short of using load management techniques, instead relying on chare timing functions in the vehicle, charging infrastructure or chargepoint management system to control when each vehicle is charged. With the same site and vehicle charging requirements as before, three vehicles can be charged in the sixteen hours available with simple charge scheduling, with each vehicle programmed to be recharged one after the other:

[5] Simplified, battery degradation is caused by two factors; calendar ageing (i.e. age) and cyclic ageing. Calendar ageing is accelerated by storing the battery at very low or very high states of charge and cyclic ageing is accelerated by high or low discharge rates.

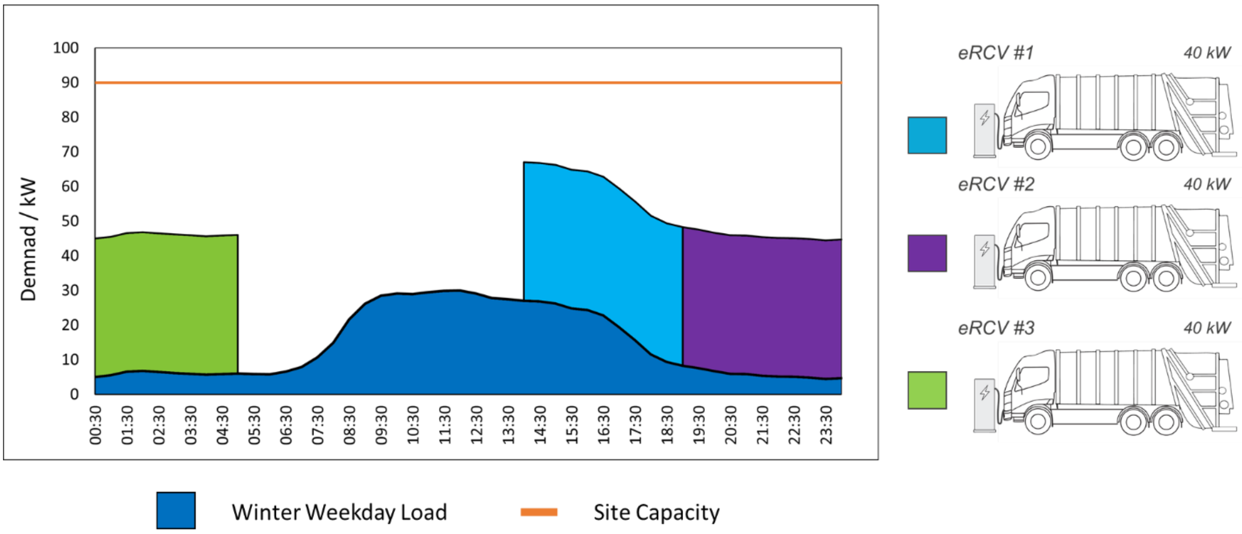


Figure 5: Strategy 2: Time Scheduled Charging

This is not strictly load management as it requires human intervention. This is even possible by sharing charging infrastructure and physically switching which vehicle is connected once each vehicle is charged sufficiently.

> Time scheduling is a basic feature that is commonly provided as standard in EVs, EV chargepoints or by chargepoint management systems. Therefore this can be a good way to quickly deploy a greater number of vehicles on a connection without the need for load management. However, there is a limitation to how many vehicles that are deployable as the available power is not effectively utilised and, as with unmanaged charging, the risk of overloading the supply is not mitigated.
>
> These techniques are not recommended due to the amount of human intervention they require and the fact that they are not robust to any change in personnel or vehicle operation.

### 5.2.3 Strategy 3 – Static load management

As explained in Document 2 – Introduction to load management, static load management is where, in order to avoid exceeding the site capacity, the available power is divided between the number of chargepoints to reduce the maximum power of each. Returning to the example, the peak weekday winter site non-EV load is 30 kW, 60 kW lower than the site capacity (with power factor and a safety factor included). Table 1 shows how by downrating the power of each chargepoint using static load management, a greater number of eRCVs could be charged compared to the first two strategies.

| Number of Chargepoints | Derated Charging Power with Static Load Management (kW) | Time Required for 200 kWH eRCV Charge Requirement[6] |
|---|---|---|
| 2 | 30 | 6 hours 40 minutes |
| 3 | 20 | 10 hours |
| 4 | 15 | 13 hours 20 minutes |
| 5 | 12.5 | 16 hours |
| 6 | 10 | 20 hours |

Table 1: Static Load Management Charging Times

Four chargepoints charging four eRCVs could be reliably charged with static load management. Deploying 5 eRCVs is arguably too high risk a charging strategy given that the time required for charging is exactly equal to the time available. The load profile for the four chargepoint deployment scenario is depicted in Figure 6:

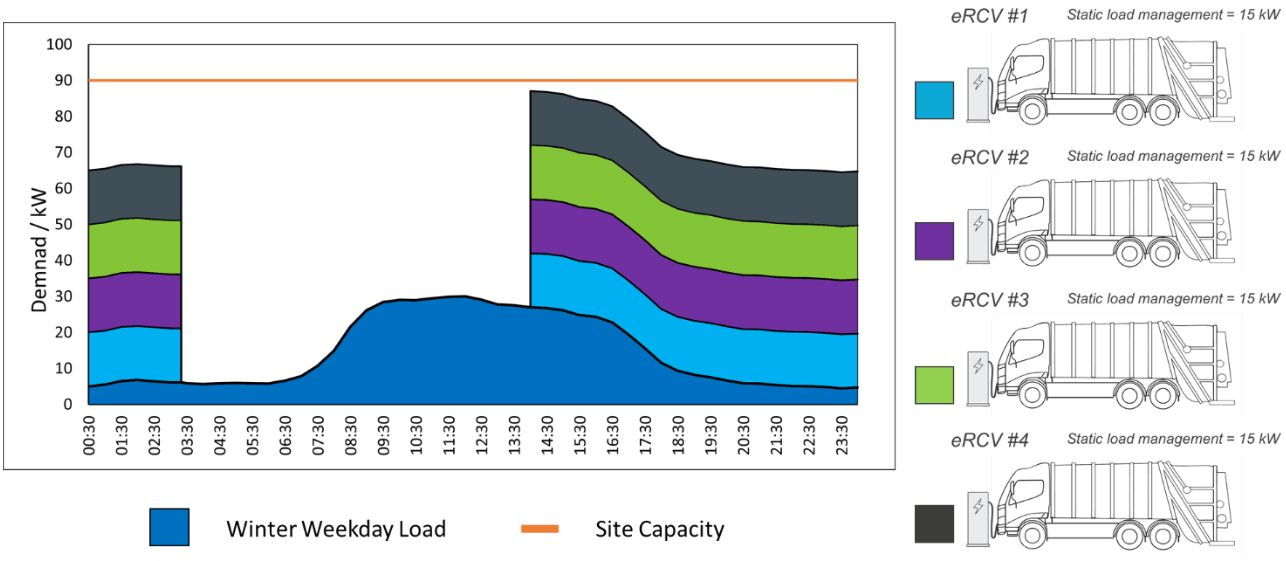


Figure 6: Strategy 3: Static Load Management

Static load management improves on the previous two scenarios in terms of the amount of available energy used for recharging. However, it is dependent on an accurate and stable prediction or measurement of the non-EV loads. If these change, then static load management cannot respond dynamically and hence can risk overloading the supply. For the same reason, sites with very peaky loads are not suitable for static load management. Therefore, static load management is most useful for sites with very consistent (day-to-day) and predictable non-EV loads.

[6] Note that these times do not account for any reduction in average charging power due to ramp up and ramp down of power in charging profile. This may increase the time for charging, although the additional time will be lesser for greater derating of the maximum charging power with load management.

### 5.2.4 Strategy 4 – Dynamic load management

With dynamic load management, the available power is calculated and distributed in real-time by monitoring the non-EV loads. Returning to the example, with the 1271 kWh available from the vehicles' return time of 14:00 to 06:00 the next morning, a dynamic load management system can be used to safely recharge 200 kWh for six vehicles. This is shown by FIGURE:

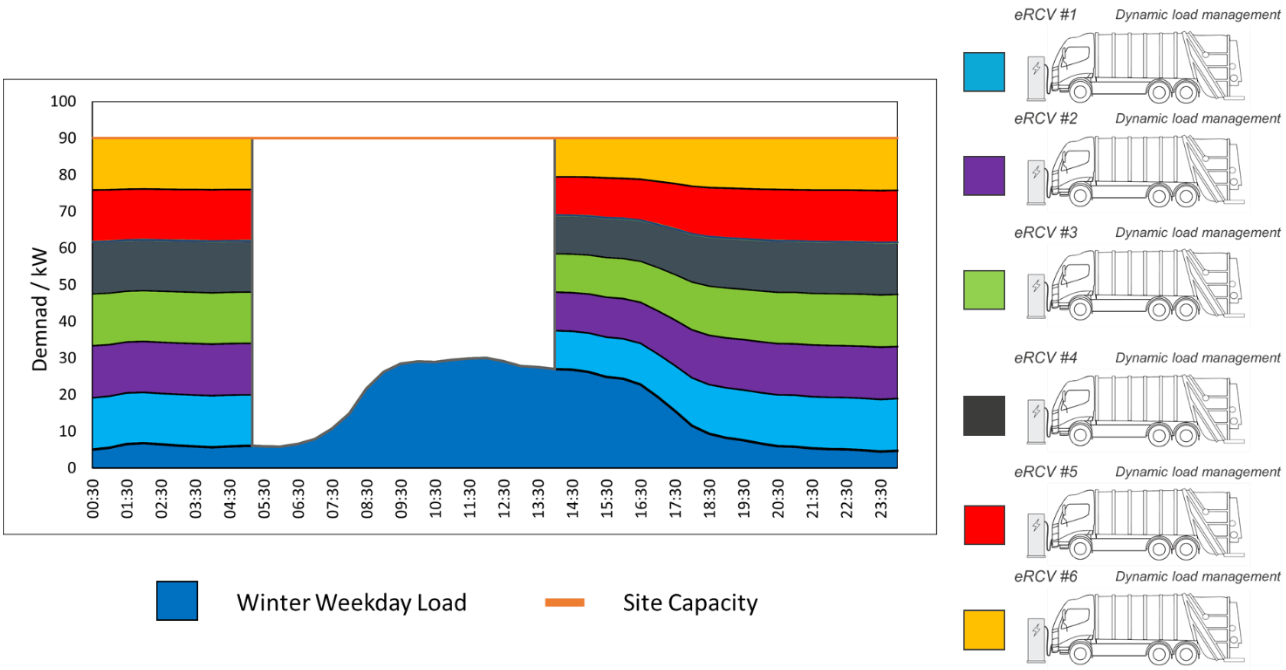


Figure 7: Strategy 4: Dynamic Load Management

In this example, the charging for each vehicle would take approximately 15 hours and 10 minutes finishing at 05:10, 50 minutes prior to the start of the next day's shift.

Dynamic load management makes the most effective use of the available power to allow the most vehicles to be deployed whilst mitigating the risk of overloading the site's network connection.

Note that in this example if a seventh vehicle was being deployed then not even dynamic load management would suffice as there is simply not enough deliverable energy with the current network connection and the available charging time. In this instance, the alternatives discussed in section 0 would need to be considered.

## 5.3 Charging Strategies Summary

Table 2 gives a summary of the four charging strategies results from the example site.

| | Strategy 1 – Unmanaged charging | Strategy 2 – Time-scheduled charging | Strategy 3 – Static load management | Strategy 4 – Dynamic load management |
|---|---|---|---|---|
| Number of vehicles rechargeable | 1 | 3 | 4 | 6 |
| Load factor (for 16 hour period where vehicles available to charge) | 0.27 | 0.53 | 0.66 | 0.95 |
| Total peak site load / kW | 67 | 67 | 87 | 90 |
| Vehicles recharged by[7] | 19:00 (same day) | 05:00 (next day) | 03:20 (next day) | 05:10 (next day) |
| Mitigation of the risk of overloading the site supply? | No | No | No | Yes |
| Suitability | Only suitable for small deployments of chargers/vehicles or sites with plentiful spare power and low / no risk of overloading the supply | Can allow more vehicles to be deployed than with unmanaged charging but does not mitigate overloading the supply. | Can be useful for sites with predictable site loads where applying static load management does not de-rate charging power significantly. Does not mitigate overloading the supply | Intelligent system that will adjust real-time EV charging load in response to site loads. Necessary for sites with uncertain other non-EV loads. Risk of overloading the supply mitigated. |

Table 2: Charging Strategies Summary

## 5.4 Future Proofing

Whichever charging strategy is selected, it is imperative that any site considers the needs of the future as well as just the present. Whilst a simpler strategy may be suitable for the current electrification, will it still be when more electric vehicles are included in the fleet in the future? It may be the case that even though the current network connection is sufficient for a small deployment of vehicles and charging infrastructure, in the near future upgrading the supply or employing alternative strategies (as discussed in section 0) should be considered up front.

> When choosing a strategy for EV charging infrastructure, it is very important that the impact of any future deployments of EVs on the site are also understood.

[7] This does not account for reduced average power due to the ramp up and ramp down in power of the charge profile.

### 5.5 Charging Efficiency

Unfortunately, no EV charging process is 100% efficient. This means the energy used will be greater than the energy that is transferred to the EV battery. The overall efficiency from input to the charging infrastructure to the EV battery is typically in the region of 85-90%. What this means for your charging strategy consideration, as the main source of inefficiency happens in the rectification of AC to DC power, depends on whether you are using AC or DC charging:

- In AC charging, the rectification process happens on the vehicle using the on-board charger (OBC). Therefore, for example, the 22 kW supplied to the vehicle will result in 19.8 kW battery charging power for a 90% efficient OBC.
- In DC charging, the rectification process happens off-board. Therefore, for example, a 50 kW output DC charger will require 55.6 kW input power for a 90% efficient rectifier.

In both systems there will be other sources of inefficiency, such as parasitic energy usage by the Battery Management System (BMS) when charging at high power. It is important to understand whether sources of inefficiency are upstream or downstream of the point in the system at which the charging power is rated. This point is typically the charging infrastructure output or vehicle inlet. Inefficiency upstream will have the effect of increasing the required system input power, and hence increasing the site load. Inefficiency downstream will lower the battery charge rate and hence increase the time required to charge the vehicle.

For AC charging, the effect of charging efficiency will mainly be to increase the required charging time whilst for DC charging the effect will be to increase the required site load to supply the charging system. By talking to suppliers to understand both the inefficiency of the charging infrastructure and the EV charging system the impact on charging times and site loads can be calculated.

# 6 Upgrade Connection and/or Deploy Generation and Storage

There will be situations where even with dynamic load management there is not enough capacity to deliver the required recharging energy during the available charging time. This can be due to the site having a small, low capacity, network connection; wanting to deploy a significant number of EVs; or a combination of both.

In these cases, either the DNO connection must be upgraded, or we need to consider deploying energy storage and/or on-site generation. Which option is preferable will likely depend on whether the Total Cost of Ownership (TCO) of on-site generation and storage technology is lower than the (often significant) cost of upgrading the DNO connection.

## 6.1 Making a DNO Connection

Even for deployments with no upgrade required it is necessary to at very least notify the DNO once the installation has been completed. For some installations, this notification must be done prior to installation. The starting points for connecting EV chargepoints to a DNO supply are given in this section.

For any EV charging project, it is recommended that the relevant DNO is engaged as soon as possible.

### 6.1.1 Connection to an Existing Supply

The process to connect EV chargepoints to an existing supply depends on a number of factors, including whether:

- The site's maximum demand is expected to be increased as a result of the EV charging deployment.
- The maximum demand will exceed the maximum import capacity (i.e. whether an upgrade is being requested).
- AC or DC charging is being deployed.
- The maximum current of the site prior to and after the EV charging is deployed.

The best place to start is with the flowchart provided by the Energy Networks Association[8] which will guide you to the relevant documents.

### 6.1.2 Applying for a New Connection

Requests for an entirely new connection must be submitted to the local Distribution Network operator (DNO). For Wales, this is either Western Power Distribution (WPD) in the south or ScottishPower Energy Networks (SPEN) in the north. Guidance on how to complete an application is provided at the following locations:

- Western Power Distribution - Application for a New / Augmented Connection
- ScottishPower Energy Networks: Getting Connected

### 6.1.3 Timescales and Costs

The timescales and the costs for DNO connections are summarised in Table 3. Note that these are costs for general new and upgraded connections; charges for connecting EV charging may vary:

[8] low-carbon-technologies-combined-installation-process-flow-chart.pdf (energynetworks.org)

Table 3: WPD and SPEN Connection Costs and Timescales

| | | Quotation | Works | |
|---|---|---|---|---|
| | | Timescale | Cost | Timescale |
| Western Power Distribution | Single small business connections 70 kVA or above<br>Multiple small business connections | ≤ 25 days | £9,000 + VAT | 6 weeks |
| | Typical large business connection (HV) | ≤ 35 days | £29,000 + VAT | 14 weeks |
| | Extra high voltage connection | ≤ 65 days | Price on request | 2 years |
| ScottishPower Energy Networks | Small connections | Not specified | £300 - £3,000 | 8 weeks |
| | Medium connections (up to 1 MVA) | Not specified | £5,000 - £100,000 | 3 – 6 months |
| | Large connections (greater than 1 MVA) | Not specified | £100,000+ | 18-24 months |

Further estimates are provided by online tools on DNO websites; however, costs vary by location. Again, early engagement of the DNO is imperative to understand costs and timescales.

## 6.2 On-site Generation and Storage

### 6.2.1 Introduction

Funding prohibitively expensive DNO connection costs was seen as the second most significant barrier to the growth of UK EV charging infrastructure in a recent report by Cenex for Transport & Environment[9]. This has been acknowledged by Ofgem, who are currently reviewing the current mechanism which makes the customer liable for upgrade costs as part of its Access and Forward-looking Charges Significant Code Review[10]. This could mean that in the future connection costs for demand are removed completely.

However, at present, the customer pays the bill for new connections or existing supply upgrades. Therefore, it can be cheaper on a TCO basis to deploy on-site renewable generation and storage. The customer may also value this approach as an investment in a green technology that provides additional resilience to loss of power to their operations in case of power cuts.

At a high level, the concepts are as follows:

- Energy storage – An energy storage system, typically a battery energy storage system (BESS) located on-site, is charged when demand is low and/or supply is high and then discharged when demand is high and/or supply is low.

[9] Electric Vehicle Infrastructure Barriers - Cenex

[10] Access and Forward-looking Charges Significant Code Review - Consultation on Minded to Positions | Ofgem

- On-site generation – Green energy generation by small-scale wind or solar photovoltaics (PV) located on-site, connected as part of the site's energy system behind the meter.

These technologies can be used either on their own or together, with varying benefit:

- Storage only – The battery is charged when demand is low – likely to be when the eRCVs are in operation – and discharged to provide additional supply in parallel with the network connection when the vehicles are charged, and demand is high.
- On-site generation only – Generating power on-site reduces the import required from the network connection. Whether this reduces the maximum demand of the site depends on when vehicles are available to be recharged and the generation profile of the renewable generation technology. For solar PV, peak generation will be around midday when eRCVs are in use and not available for charging.

  The overall imported energy consumption will be reduced and in some contexts the generation may exceed the demand (particularly if non-EV loads are low and the eRCVs are in operation) at some times and therefore power would be exported to the Grid.
- On-site generation and storage – When on-site generation and storage are paired then flexibility is gained over when the additional energy generated is used. Typically, the strategy would be to store energy by charging the BESS during times of peak generation when the eRCVs are operational and discharge when generation is low and demand for charging high.

  It can be possible to completely "off-Grid" a site if the sizing of the generation and storage systems is done such that all on-site loads can be met. However, this is unlikely to be a cost-effective solution given that the system must be sized to account for periods of low or no on-site generation – typically a period of consecutive short cloudy days in winter with no wind.

### 6.2.2 Cost Analysis

As mentioned, when considering deploying an on-site generation and/or storage system it will be necessary to compare the TCO of the system versus the cost of upgrading the network connection. The TCO of the system should include:

| | On-site Generation and Storage | DNO Connection Upgrade |
|---|---|---|
| Implementation | System design costs | New supply or upgrade fee to DNO |
| | Capital costs of hardware[11] | |
| | Installation costs | |
| Operation | Maintenance costs | |
| | Reduced energy costs due to less energy imported | Costs of energy imported |
| | Any operational revenue generated for export of surplus energy that cannot be stored for use on-site | |
| | Useable life | |
| End-of-life | End of life disposal / recycling costs and/or revenue[12] | |

[11] The capital costs of solar PV equipment has fallen between 64% to 82% since 2010. Likewise, the increased scale of the market has reduced costs considerably for lithium-ion batteries, which is the most popular battery chemistry for modern BESS.

[12] The market for lithium-ion batteries is still growing with increased demand for electric vehicles and battery storage. The recycling industry for this technology is still immature, however it is possible. It is expected that in the future exhausted batteries (i.e. batteries which have degraded to a point that they are no longer useable) will still hold residual value for recyclers.

Note, that the method to specify an on-site generation and storage system that provides the necessary functionality is a complex process which is not covered here.

### 6.2.3 Case Study

Connected Kerb provided on-site generation and storage integrated into an EV charging hub for Dundee City Council. The hub, the first of its kind in the UK, uses solar PV carports and a storage battery making use of second-life lithium-ion packs. This system allows the use of the energy generated on site to be optimised whilst managing the size of the required grid connection. For more information see the Connected Kerb website.

# 7 Conclusions

Designing a cost-optimised EV charging system for a depot is not a straight forward task. Achieving a minimum cost solution depends on obtaining accurate data for vehicle operations and existing site non-EV loads. Additionally, understanding how the vehicles' charging profiles and the charging efficiency can affect the required time to charge can be important.

There is a balance between intelligently making the most of use of available power through technologies such as load management and the risk of not being able to meet a fleet's recharging requirements if sufficient margin is not included in the system design. Some operators will prefer to spend the time evaluating and optimising their system whilst others will be happy to accept the cost of upgrading the DNO supply in return for a least-effort approach.

Whatever a site's preference, it is imperative that the future electrification strategy is considered to ensure the approach is future proof.

This document has provided a framework for conducting a site assessment to help fleet and energy managers through this process. Consultancies including Cenex can offer advice and assistance with depot EV charging designs if required.