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EV Charging Infrastructure

Croeso i Gyngor Castell-nedd Port Talbot
Neath Port Talbot Council

April 2021

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Version:	Comment:	Issued:
V1	Client Draft	April 2021

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Glossary of Terms

Abbreviation	Meaning
AC	Alternating Current
ACN	Adaptive Charging Network
BEV	Battery-electric Vehicle
CCC	UK Committee on Climate Change
CCS	Combined Charging System
DBEIS/BEIS	(Department for) Business, Energy, and Industrial Strategy
DC	Direct Current
EV	Electric Vehicle - usually battery-powered (BEV)
EVCI	Electric Vehicle Charging Infrastructure
GHG	Greenhouse Gas, CO2e, in transport usually CO2, CH4 and N2O
GVW	Gross Vehicle Weight
GWP	Global Warming Potential
HCV	Heavy Commercial Vehicle – also known as HGV – over 3.5t MAM
HGV	Heavy Goods Vehicle – also known as HCV – over 3.5t MAM
ICE	Internal Combustion Engine – Petrol/Diesel/Gas
LCV	Light Commercial Vehicle – Van – up to 3.5t MAM
MIC	Maximum Import Capacity – Measured in kVA
OCA	Open Charge Alliance
OCPP	Open Charge Point Protocol (currently v2.0.1)
OEM	Original Equipment Manufacturer, e.g. Ford, Nissan, Toyota etc.
OLEV	Office of Low Emission Vehicles
OSCP	Open Smart Charging Protocol (currently v1.0)
RCV	Refuse Collection Vehicle (eRCV - electric RCV)
REEV	Range Extended Electric Vehicle
REGO	Renewable Energy Guarantees of Origin
RRV	Resource Recycling Vehicle (eRRV - electric RRV)
SECR	Streamlined Energy and Carbon Reporting
SoC	State of Charge – how much charge is left in the battery.
ULEV	Ultra-Low Emission Vehicle
ULEZ	Ultra-Low Emission Zone (London only)
V2G	Vehicle to Grid – Technical Guidance (UK Power Networks)
V2O	Vehicle to Office: simpler than V2G, also V2H – Home

1 Executive summary

This report provides Neath Port Talbot Council (NPTC) with an analysis of the electric vehicle charging infrastructure (EVCI) that will be required by a zero emission battery electric fleet and the capacity available at key depot locations. The analysis was undertaken by the Welsh Government Energy Service (WGES) and funded by the Welsh Government Decarbonisation and Energy Division.

If the whole NPTC fleet could be transitioned to battery electric vehicles (BEVs), we would expect the energy use to fall by up to 75% from 9,990 MWh (excludes plant) to 2,500 MWh and for annual energy costs to fall from an estimated £1.028 million to £303,000 saving £725,000 each year. This annual energy cost saving can help fund the vehicles and the charging infrastructure.

The fleet review has not identified any class of vehicle that, on the basis of average daily energy consumption, could not be replaced with a battery electric model by 2030, if not well before, some categories – for example 4x4 pickups – are not yet available but they are in prototype. There are already over 140 battery electric cars on the UK market, and we expect the full range of battery electric LCVs and rigid HCVs to be available to order from OEMs by the end of 2023.

Transition to an all battery-electric fleet will require a planned programme to roll out an EVCI infrastructure at key depots, at secondary sites where vehicles are (or will be) based such as council offices, as well as at schools and community centres. This will require the maximum import capacity (MIC – measured in kVA) at some sites to be upgraded and that may involve the upgrade of the physical supply grid infrastructure.

The speed of transition to a zero emission fleet will be restricted by the funding available and, in the case of the battery electric vehicles, the ability to charge the vehicles overnight at their normal base location. Most of the NPTC fleet (200 vehicles) is based at SRC Quays, a further 49 at Tregelles Court, 35 in schools around the borough, eight at “SRC Depot” and then small numbers at seven other sites. It is understood that the waste fleet based at SRC Quays may relocated to a refurbished waste transfer station (MREC) at Crymlyn Burrows which has a good grid connection as there was an Energy from Waste plant on the site.

Within the borough NPTC does have significant renewable generation capacity. The area has the largest installed renewable capacity of any local authority in Wales. Unfortunately, we have not been able to identify any renewables site that could be economically connected to the main depot by a private wire. Our survey has not been exhaustive, but it would appear the vehicles will need to be charged from the grid. We understand that there are proposals for PV at several of the sites, but this will be of limited value for charging vehicles as it is not available overnight, is subject to big seasonal variation and is usually small scale compared to the charging requirement of BEVs.

Fleet electrification is a major 10-year project; a dual 7.4 kW charge point with card reader and telemetry can cost from £1,700 to £2,700, dual 22 kW charge points can cost up to £4,000 each and some HCVs will require two. DC chargers cost from £12,000 to £25,000 or more depending on the kW capacity which can range from 50kW to over 300kW. The following table estimates the minimum cost of the hardware required to charge the entire fleet wherever they are located (including home based).

Vehicle Class	Fleet	Charger Type	Cost per Point	Minimum	Notes
HCVs/RCVs/RRVs	81	22/44kW AC, 50kW DC	£1.8K - £25K	£324,000	HCVs can use twin 22/44kW AC
HCV - Minibuses	36	22kW AC	£900 - £4K	£64,800	
LCVs & Cars	195	7.4kW AC	£750 - £1.5K	£146,250	
Total	**312**			**£535,050**	Excludes VAT & installation

There will be additional costs associated with the charger management system, annual maintenance, protective bollards or kerbs, groundworks and with the upgrade of site maximum import capacity (kVA). It is important to develop a detailed plan for each site to avoid unnecessary additional groundworks in the future. The EVCI project can be integrated into the capital investment in new sites, as well as the refurbishment of existing depots and offices and spread over 10 years (2021-2030). There is also the opportunity to integrate on-site and off-site private wire generation as well as battery storage which can help avoid grid upgrades, reduce energy costs, and add to long term cost and GHG savings.

A large battery electric fleet could play a future role in local grid services using vehicle to grid (V2G) systems to provide power back to the grid or to provide other grid balancing services regulating the quality of the local electricity supply. Much of the fleet is parked up at the weekend and its stored energy could be a source of revenue but at the moment this is not supported by all vehicle charging systems and may not be a feature of the European Combined Charging System (CCS) system for 8-10 years.

The estimates of site capacity in this report are based on the current energy consumption of the ICE fleet adjusted for the significantly better energy efficiency of an electric vehicle (they use between 25% and 30% of the energy used by ICE vehicles). The estimates are therefore dependent on the accuracy of the fuel and mileage data of the fleet. The data should be refined for specific fleets by a detailed study of tracking data over a representative period – for example, several cycles of refuse and recycling collection.

For the NPTC road transport fleet to be successfully decarbonised by transition to battery electric vehicles a team needs to co-ordinate all aspects of the project including the roll out of EVCI over the next ten years. If the entire fleet is still charged from the UK grid in 2030 its emissions will fall by about 90% to 228 tonnes (this depends on how rapidly the grid decarbonises and how efficient the BEVs are). To achieve carbon neutral will require private wire renewables equivalent to at least 2,280 MWh per annum. This is equivalent to the estimated annual output from a 1.1 MW wind turbine or a 2.4 MW solar photovoltaic array with battery storage.

The Quays site has a 250 kVA supply but we understand the local transformer has spare capacity of 650 kVA (100 kVA is allocated to the SRC Depot site). That additional capacity can only be accessed by upgrading the supply cable to The Quays but that should be an affordable option. We have therefore modelled the energy use at The Quays using both the 250 kVA limit and the 900 kVA limit. At 250 kVA the site can support the equivalent of twelve 7.4 kW charge points overnight with no spare capacity during the day (it appears to regularly exceed the site capacity). At 900 kVA it can support the equivalent of 70, 7.4 kW chargepoint all day and 25 overnight because the daytime exceedances would be within the site capacity.

The MREC site also has the capacity (839 kW) to support a large number of chargepoints, the equivalent of 113, 7.4 kW points during the day or 38, 22 kW AC units as required by some HCVs/RCVs. A further 210 kW of capacity is added at night which is equivalent to 28, 7.4 kW units or ten 22 kW units. To access this overnight capacity will require smart, dynamic chargepoints.

With the RCV/RRV fleet coming back to the depot during the early afternoon there is a long charging window before it need to be fully recharged so it is quite possible that more than this number of chargepoints could be accommodated on both The Quays and the MREC Crymlyn Burrows sites.

The implementation of EVCI is a critical enabling step in the transition of the fleet to BEVs but NPTC has the advantage of good power supplies at its principal depots and a lot of renewable generation within the borough. It is very important that NPTC establishes a team to determine where to install the charging infrastructure the fleet will need and also investigates how it can be charged with 100% renewable, private wire, electricity.

2 Summary of recommendations

Item	Recommendation	Difficulty	Risk	Estimated Cost	Notes
1	Establish a team with the objective of rolling out Electric Vehicle Charging Infrastructure based on the best available data regarding the predicted energy consumption of the electric vehicles and their base locations.	Moderate	Moderate	£0.5m to £1.0m over 10 years.	EVCI is a critical enabling step in the transition to zero emission vehicles. A lot of the investment will have a longer operational life than the vehicles. 10-20 years or more.
2	Use tracking data and detailed daily rounds (refuse/recycling) and route (gritters/sweepers) data to model the variation in energy demand more accurately across the high-energy specialist HCV fleets.	Moderate	Low		This will refine the information about the site capacity required and avoid procurement of unnecessary grid capacity.
3	Accurately monitor the energy consumption and charging profile of the electric vehicle fleet as it grows.	Moderate	Low		Understanding how to minimise the cost of charging a growing BEV fleet will inform future plans.
4	Determine the cost of the capacity increase at The Quays site and confirm the available capacity at the MREC Crumlin Burrows site.	Moderate	Low		It seems very likely that it will be cost effective to upgrade The Quays site and make full use of the capacity at the MREC.
5	Engage with the local DNO and determine the maximum available capacity at the Tregelles Court site. Could some or all of the fleet be relocated to sites with greater capacity.	Low	Low		At sites like Tregelles Court there will be a balance between the cost of a capacity upgrade, the use of smart, dynamic charging systems and the addition of private wire generation.
6	As part of the EVCI project investigate the opportunity to invest in photovoltaic generation (on buildings and on overhead canopies). Consider the use of on-site battery storage at the depots to store daytime output from PV and wind.	Low	Low		The cost of both PV and battery storage is falling rapidly. Without private wire renewables the fleet will still have a residual GHG footprint in 2030 if charged from the UK grid.

3 Assessing site EV charging capacity

3.1 Fleet EV Charging Infrastructure (EVCI)

Appendix A provides an in-depth introduction to the subject of EVCI and to the issues discussed in this report and is aimed at readers unfamiliar with EVCI. Definitions of common EVCI terminology are in Appendix F.

The Energy Saving Trust Guide to chargepoint infrastructure (2017) provides comprehensive information on EVCI. Other useful reports include the older Beama Guide To Electric Vehicle Infrastructure (2015) as well as Beama Best Practice for Future Proofing Electric Vehicle Infrastructure (2020) and Making the right connections, UK EVSE, (2019). All these reports help the reader understand the technology behind EVCI but this is rapidly evolving sector and some of the advice in these documents may have been superseded.

3.2 Analysis of half hour data sets

The charts in Appendix B are based on the half hourly (HH) electrical energy consumption data at fleet depots and principal offices provided by Neath Port Talbot County Council (NPTC). Each chart shows the following consumption data for 2019/20 displayed as a single week:

- the maximum energy used on-site in any half-hour period (blue),
- the average daily consumption in any half hour period (black line),
- the baseload or minimum daily consumption in any half hour period (red),
- the “static” charging capacity (dark green),
- the “dynamic” charging capacity (pale green).

The “static” charge capacity is the difference between the maximum recorded site use and the site maximum import capacity (MIC) adjusted by the site power factor. The “dynamic” capacity is a measure of the energy available between the recorded peaks of maximum usage; most of this capacity is usually available during the evening and at weekends.

The “static” capacity is so called because it can be used to charge vehicles without any sophisticated demand management controls. Provided the total kW demand of the installed charging points cannot exceed the static capacity, the system is self-limiting.

For example, if the static capacity is 25 kW, then three 7.4 kW (22.2 kW) charge points could be installed and used at the same time without exceeding site capacity and with no further management. The static capacity is also available 24 hours a day, and all year around, so the only constraint on its use is a desire to avoid higher daytime tariffs and periods of peak demand on the UK Grid.

The “dynamic” capacity represents unused capacity that falls between the peaks of daily “domestic” usage by the rest of the site. This capacity could be accessed by using charge points on timers but that would require careful management to ensure a significant margin of error between the demand from the charging points and other site loads.

The static capacity can be combined with a control system to regulate the current to the charge points such that it never exceeds the site’s static capacity and to that could be added, at timed intervals, the site’s dynamic capacity. So, in our example of 25 kW capacity, we could have six 7.4 kW charge points but if all six are in use the power to each would be limited to 3.7 kW. As vehicles become fully charged, so they stop charging and their share of the site’s 25 kW capacity is reallocated over the remaining vehicles.

This is an efficient strategy and should ensure that all the vehicles are fully charged with the lowest maximum import capacity. It is cost effectively implemented using one primary controller which can support 10 to 20 drone charge points (the exact number depends on the manufacturer of the chargepoint system).

The final enhancement is to add a system to continuously monitor the total site load and adjust the power made available to the vehicle charge points accordingly. A “load balancing” system allows all the capacity above the site’s baseload to be utilised.

This type of control system must be very responsive and work 100% of the time, as a failure to adjust charging capacity in response to an increase in demand elsewhere on the site could result in a site blackout or penalty charges for exceeding the site maximum import capacity. A demand responsive EVCI may also require a significant upgrade to the building’s energy management system and much tighter management of the electrical systems in use within the building. It may cost less to buy capacity from the DNO than install smart or dynamic charging.

At each site we have considered the capacity available all year around, but capacity will vary from summer to winter. In the summer, capacity can be constrained by daytime air conditioning demand but may be supplemented by an extended period of photovoltaic generation (if installed).

In the winter, heating demand during the day and, in the worst case, night-time storage heaters, will impact on charging capacity as will extra demand from lighting due to the shorter day length. If installed, photovoltaic generation at this time of the year will be severely limited by the shorter day length and reduced solar intensity.

3.3 Summary of sites with HH data

The sites' maximum import capacity (MIC - kVA), capacity (kW) and existing EVCI are summarised in Table 3-1.

Table 3-1 Site summary showing maximum import capacity, power factor and available capacity

Location with HH Data	Fleet	Maximum Import Capacity (kVA)	Power Factor	Available Capacity (kW)	Installed EVCI
The Quays (current configuration)	200	250	0.95	238	4
The Quays (900 kVA feed)	200	900	0.95	855	
MREC Crymlyn Burrows	1*	2,500	0.95	2,375	0
Tregelles Court	49	120	0.95	114	5
Port Talbot Civic Centre	5	400	0.95	380	2
Croeserw CEC	0	140	0.98	137	
Neath Multi-Story Car Park	0	100	0.95	95	
Port Talbot Multi-Story Car Park	0	70	1	70	

There are also single 7.4kW chargepoints at the Library HQ site and Tawe Terrace.

3.4 Summary of available site capacity

We have analysed each site based on the HH consumption data provided. The detail of each site analysis is provided in Appendix B. The results of the analysis are summarised in Table 3-2.

Table 3-2: Summary of estimated available capacity and supported charge point capacity.

Site	Static Headroom kW	Dynamic Headroom kW	7.4 kW Static	7.4 kW Dynamic	Weeknight[1] Capacity (kWh)	Notes
The Quays 250	0	90	0	12	5,830	
The Quays 900	524	190	70	25	42,850	
MREC Crymlyn Burrows	839	210	113	28	63,431	Limited dynamic
Tregelles Court	58	20	7	2	5,142	
Port Talbot Civic Centre	177	120	23	16	18,000	
Croeserw CEC	83	30	11	4	7,273	
Neath MCP	64	10	8	1	4,518	
Port Talbot MCP	37	10	5	1	2,853	
Total	**1,258**	**490**	**167**	**90**	**107,048**	**The Quays @ 250**

[1] This is the total MWh available 7pm, to 7am, Monday to Friday

We estimate that the average overnight fleet requirement is about 10,484 kWh (**Error! Reference source not found.**). According to the data available these have an average total overnight capacity (Mon-Fri, 7-7) of 107,048 kWh or 21,410 kWh per weeknight. If just The Quays, MREC and Tregelles Court are considered then the overnight capacity off-peak is 74,403 kWh and the average weeknight capacity is 14,880 kWh.

There is more than enough capacity to charge most of the fleet if the full capacity of both The Quays and the MREC are used. At worst, a new cable will be required at SRC Quays but the departure of all the heavy duty RCVs and RRVs to MREC may mean that the SRC Quays site will be able to recharge the residual fleet with the existing capacity.

The site of concern is Tregelles Court where 49 vehicles are based but there is currently limited capacity. If these vehicles cannot be relocated to a site with more capacity, then a site upgrade will be required.

4 Meeting the demand for EV charging

4.1 Estimating the maximum import capacity required

Estimating the annual energy requirement of an electric vehicle fleet if you already know the energy (kWh) used by the conventionally powered ICE fleet is straight forward but is very dependent on data quality.

The BEVs will require between 25% and 30% of the ICE energy. But just as the energy efficiency (mpg) of the diesel or petrol vehicles varies through the year, so the efficiency of the electric vehicle fleet varies with ambient temperature and there will also be daily variation in the mileage driven and energy used for ancillary equipment. That makes determining the maximum import capacity (MIC) needed to charge the vehicles on the most energy intensive day of the year harder to estimate accurately without comprehensive telemetry data.

Table 4-1: Estimated energy requirement of an all-electric fleet (30% ICE energy use, 240 working days)

Fleet	Typical Charger Type	Fleet Size	BEV Total kWh/day[1]	kWh/Vehicle /Day
HCV – Refuse and Recycling Vehicles	22-44 kW AC – 50+ kW DC	42	4,841	115.3
HCV – Rigids – Tippers, Gritters etc.	22-44 kW AC – 50+ kW DC	39	1,791	45.9
HCV – Minibuses (9-17 seat)	22-44 kW AC (7.4 kW AC)	36	507	14.1
LCV – vans up to 3.5 tonnes	7.4 kW (22 KW AC)	163	2,999	18.4
Fleet cars – SUV, MPV, Estate etc.	7.4 kW AC	32	303	9.5
Total		**312**	**10,484**	

[1] This total excludes the electric vehicles already in use.

Based on the 2019/20 composition of the fleet up to 117, 22-44 kW AC or 50-100 kW DC chargers will be needed for all the heavy vehicles (depending on battery size some of the large minibuses could be charged with 7.4 kW units) and 195, 7.4 kW AC chargers will be needed for the van and car fleets (Table 4-1).

The expected average daily energy requirement of the HCVs suggests they could all be easily charged in much less than 12 hours with 22 kW AC units, but their large batteries mean that a fully depleted vehicle will need access to a 22 kW unit to fully recharge overnight. The total maximum capacity needed for 117, 22 kW units, if used simultaneously, would be 2,574 kW which is significant. The 195, 7.4 kW units for the vans and cars would add another 1,443 kW to that maximum capacity. But many vehicles will be fully charged in as little as three hours, so most of that capacity - which comes at a cost - would be unused for much of the charging period.

The average daily energy requirement of the HCV fleet (including RCVs) is estimated to be 6,631 kWh and if this is spread over a 12 hour charging window the maximum capacity required is a much more achievable and affordable 552 kW. The average daily requirement of the LCV and car fleet is estimated to be 3,302 kWh and over a 12-hour charging window this is 275 kW. So, if the charging can be spread over the 12-hour charging window the capacity required is closer to 827 kW or about 870 kVA (assuming a 0.95 power factor). This is not all required on one site, it almost is all needed at the SRC Quays depot but the energy intensive RRV/RCV fleet may be relocated to the MREC site in the future which could mean a major upgrade at The Quays is not needed.

This analysis assumes that every day of the year, the vehicles return needing the same charge and that we can put as much charge as we want into a vehicle with a low State of Charge (SoC). Unfortunately, neither of these assumptions are true. The SoC of returning vehicles will vary from day to day and throughout the year. It is possible that on some days, several vehicles return with a low SoC due to extended routes, diversions, heavier loads, greater use of ancillaries such as compactors and adverse weather conditions. The speed at which they can be recharged is limited by the capacity of the charging infrastructure they are connected to and the vehicles' internal charging systems.

One way of improving the accuracy of the predicted energy requirement is to take tracking data from all the ICE vehicles for a period of several weeks or several cycles of operation, use it to determine the worst case SoC on return to the depot and then model recharging the fleet by incrementing the Maximum Import Capacity until all vehicles are fully charged at least one hour before they are required (this allows time for the use of pre-conditioning). This process will also identify occasions when vehicles cannot complete the working day with the proposed battery capacity and will need a top-up charge at some time during the day. Its weakness as a method is that it uses historic data to predict the future and assumes reconfiguration of rounds and routes could not eliminate some of the high-energy requirements.

In the absence of tracking data there are at least three strategies for estimating the site capacity required:

The first is to calculate the capacity needed for all the required chargers to operate simultaneously at full power – this is the simplest option, but many vehicles will be fully charged in less than four hours leaving very expensive capacity unused throughout the rest of the overnight charging period. However, where there is a small number of vehicles on a site with only 7.4 kW or 22 kW charge points this strategy may be adequate, especially if combined with in-vehicle timer management and may be lower-cost than expensive charger management systems.

The second method is based on the calculated average energy requirement with an uplift of 25% (Table 4-2). This may not be sufficient to cover all the seasonal and daily variation in the fleet's energy demands and should be subject to continual review, as more of the fleet is transitioned to battery electric vehicles. Experience to date suggests that the greater the variation in energy demand across a fleet at a site the greater the percentage uplift needed, so a fleet that combines both heavy vehicles and light vans with some returning at 20% SoC and others at 80% SoC may require an uplift of 50% to cover the worst-case requirement.

Table 4-2: Site capacity requirement - simple average working day model (sites with more than one vehicle)

Fleet Locations	Fleet	Annual kWh	WD EV kWh	kW 12 hour Window	kW 12 Hour 25% Uplift[1]	+Site Capacity Required (kVA)
SRC Quays	200	2,080,659	8,967	747	935	+890
Tregelles Court	49	184,907	770	64	85	+10
At School	35	49,940	208	17	25	-
SRC Depot	8	43,998	183	15	20	+30
Tawe Terrace	7	38,257	175	15	20	-
MREC	1	14,928	62	5	10	+0
Port Talbot Civic	5	11,569	48	4	10	+0
Unknown	4	8,064	34	3	5	-
Cimla hillside	2	3,907	16	1	5	-
Neath Civic	1	2,790	12	1	5	+0
Margam Park	1	1,953	8	1	5	-
Total	**313**	**2,440,973**	**10,484**	**874**	**1,125**	**+930**

[1] This uplift is explained in full in the text – it provides headroom for days when demand is high, rounded up to nearest 5kW.

The third and final strategy assumes the average capacity will be sufficient throughout the year and that even if vehicles are not fully charged on departure the following day, they will have sufficient capacity to complete their duties because most vehicles return with significant residual charge and they can all be fully recharged at the weekend. This might be regarded as a higher risk but low cost strategy.

To some extent, the strategy chosen will also depend on the available capacity in the local grid:

- If the local grid has significant unused capacity and there are no other users on the sub-station, then the MIC can be increased incrementally as demand requires, with no risk of another local user taking the capacity for their own fleet or processes.
- If the local grid is severely constrained there may be no available capacity and then the focus of attention is on the most cost effective way of providing that capacity which may not be a grid upgrade and could be installation of PV and battery storage. It will also depend on the site's operational life.
- Between these two extremes the depot may be in competition with other local fleet operators for capacity, and it may be necessary to buy as much capacity as possible now in order to future-proof the site from expensive grid upgrade (reinforcement) in the future.

NPTC will need to upgrade the capacity at its main fleet depot to support its fleet and the next step is to engage with the DNO (SP Energy Networks) to determine the available capacity at each site. This request can be made through existing channels or on the SP Energy Website using the Quote+ service. The site allows three capacity options to be considered at each site and the offer of capacity is valid for three months.

Appendix A: Introduction to EVCI

A.1 Charging an electric vehicle fleet

With the exception of some emergency service vehicles and 24/7 delivery vehicles or passenger services, most fleets of electric vehicles can be fully recharged overnight, or during other periods of inactivity. If the electric vehicle has been matched to the service being delivered, it should, if fully charged, be able to complete its normal working day without top-up charging. There are high mileage services which do offer frequent top-up charging opportunities – for example, an inter-site delivery or minibus service – but these are a special case. It is also possible to consider a split shift service where a rapid-charger top-up to 80% battery capacity during the day would enable a second shift to operate. These are special cases and the business case for each needs to be considered separately.

A.2 AC or DC charging and Smart Management

There are two basic types of charging infrastructure: AC (Alternating Current) and DC (Direct Current). An AC charger relies on the vehicle's "on-board" charge management system to convert the AC to DC and ensure that the battery is not damaged during charging. This is the simplest type of charger. The output of AC charging systems ranges from 3.7kW (240 Volt, 16 Amp, single phase) up to 44 kW (400 Volt, 60 Amp, three phase) but are usually 7.4 kW (240 Volt, 32 Amp, single phase) or 22 kW (400 Volt, 32 Amp, three phase).

Limited information is exchanged between the vehicle and the AC charger, as the "on-board" hardware and software is managing the charging process. As a result, the AC charger does not know the State of Charge (SoC) of the battery or the battery capacity. That will change when the Open Smart Charging Protocol is widely adopted by both vehicle manufacturers and charge point suppliers but until then, AC systems cannot use information about the vehicle's State of Charge (SoC) and battery size (kWh) to develop an optimal strategy.

DC charging systems deliver the power directly to the batteries and bypass the vehicle's AC/DC on-board charge management system. To do this safely and without damaging the expensive batteries, the DC charge point must communicate with the vehicle's battery management system and understand the size of the battery as well as its SoC. DC chargers are, therefore, a lot "smarter" and management of DC charging can be more sophisticated as the charge management software knows the SoC and battery size of connected vehicles.

ABB has announced a 350 kW "Terra" rapid charger which, in theory, could provide a compatible electric car with about 100 miles of range in five minutes and it is unlikely that DC charging technology will stop at 350 kW. Tesla are known to have ambitions for much higher charging rates, their fastest V3 "Superchargers" are 250 kW and are connected to a 1MW power cabinet, they reduce Tesla charge times by 50% - so fast that some Tesla owners have complained they do not get a long enough break after three or four hours driving. A Tesla V4 Supercharger is under development and the company is understood to be considering 1MW or even 4MW for their Tesla Semi truck.

One way of making both the AC and DC system 'smarter' is to require the driver to enter all the information needed by the charging system, either through a smart phone app or on the charger itself. The EV charging infrastructure at CalTech, California, is an experimental system that requires the driver to enter the vehicle's details (this includes battery size) the current SoC of the battery and the time when the vehicle is required to be 100% charged. This information is then processed through an optimisation algorithm to minimise the electricity demand and carbon impact, while still meeting the user's requirements – the system is known as an Adaptive Charging Network (ACN). It is not commercially available yet and the optimisation algorithms are still subject to refinement but have been published as open source code.

In the short term, the closest we can get to the perfect charging system may require the integration of on-board vehicle telematics with a vehicle identification system in the charge point. The telematics can report the SoC and battery capacity to the charge management system and the charging post can report which vehicle is plugged in, either by using a contactless RFID Card or automatic number plate recognition (ANPR) camera.

A charging strategy must also consider the non-linear nature of the process. If a vehicle returns to a 7.4kW charger wanting 74 kWh of energy to replenish its battery, it will take longer than 10 hours to fully recharge it. When a battery is fully depleted there is little internal resistance to the flow of current (Amps) and so energy can be quickly transferred to the battery but as it reaches 80%-90% SoC, the internal resistance increases, and the charging system has to increase the voltage to maintain the current. However, there is a maximum voltage above which damage to the battery will occur. When that voltage is reached, the flow of energy to the battery (Amps) falls and the battery charge rate diminishes. Because of this, the vehicle that returns to a 7.4kW charger requiring 74 kWh of energy may take 12 hours to fully recharge.

A.3 Number of charge points

Our expectation is that every vehicle requiring overnight charging will have its own parking bay and charge point as this allows the charging load to be spread throughout the evening making maximum use of the site import capacity. The alternative is to have some sort of charging rota for drivers or to have someone on site, overnight, whose job it is to move the vehicles from parking bays to charge point bays. Rota systems are prone to user error and a failure to plug in on the allotted evening would mean the vehicle may not be available for use the following day.

To have someone moving the vehicles to charging bays throughout the evening would require the charging system to know the SoC of the fleet and calculate the order in which vehicles should be presented for charging. There would also need to be spare capacity to cope with vehicles returning with a lower SoC than expected.

There is the option of using rapid DC chargers like a conventional fuel pump, but this could result in queuing and long delays without careful time management as a full charge could still take over 20 minutes. In the future it may be possible to charge new battery technologies more quickly and fully recharge a vehicle in 5-10 minutes from a powerful DC charger; that technology is not available on the current generation of vehicles but will have a role if a rapid top-up is required during the working day.

A further benefit of have one charger per vehicle is the ability to use “pre-conditioning”. This is the term given to either heating/defrosting (winter) or cooling (summer) the vehicle while it is still attached to the power supply and just prior to it entering service. Typically, pre-conditioning can be configured to turn on 30 minutes before the vehicle is normally required and it can also be initiated from a phone application. Using this feature means the vehicle starts the day at the right temperature and with a 100% SoC and battery capacity is not used defrosting the windows or cooling down the driver’s compartment.

Charging cars and commercials up to 3.5 tonnes

For vehicles with battery sizes up to 75 kWh, a 12 hour charging window usually provides enough time in which to recharge the battery from a fully depleted SoC (only 10% residual charge in the battery) using a basic 7.4 kW charger. Almost all the vans up to 3.1 tonnes Gross Vehicle Weight (GVW) have battery options under 75 kWh, as do cars with a single charge range of less than 240 miles. Only cars and vans specified with a greater range or load carrying capability and therefore larger 100 kWh batteries, may need longer than 12 hours to fully recharge at 7.4 kW from 10% SoC.

On many sites, 7.4 kW charging can use the site’s unused capacity to charge a small fleet of cars and vans, without the need for complex charger management. As long as the combined demand of all the chargers operating simultaneously does not exceed the available capacity, there is no requirement for smart charger management.

A simple domestic 7.4 kW AC charger can be purchased from hardware stores for under £400 and installed by a competent electrician. The most sophisticated 7.4 kW charge points with card scanner, GPRS network connection, management software and full barrier protection cost about £1,700 for a two-port pillar. A further £1,000 for specialist installation, management software, billing systems, commissioning, and on-site support should be added to this, with about £250 of that cost being an annual expense. These costs can escalate if a lot of groundwork is required, or if the system requires local grid infrastructure to be upgraded.

Charging heavy commercial vehicles (from over 3.5 tonnes to over 30 tonnes)

Heavy commercial vehicles, with very large 200 kWh to 300 kWh batteries (or potentially even bigger in the future) need a more powerful charging infrastructure if they are to recharge in time for work the following day. This can be 22/44 kW three-phase AC (400V, 32/60A) units which can be doubled up (two per vehicle), or more sophisticated 50-150 kW DC chargers. Some large buses with 385 kWh battery packs use 2 x 44kW AC chargers. These high-power AC and DC systems require a much greater investment in the electricity supply infrastructure and the technology of DC rapid charging is advancing quickly, so DC chargers are much more likely to become obsolete or require upgrading in the future.

The cost of DC infrastructure starts at about £12,000 per unit and increases with DC capacity – some systems cost over £30,000 each. To that can be added significant cabling costs and sometimes grid infrastructure upgrades, if the site does not already have a very good electricity supply.

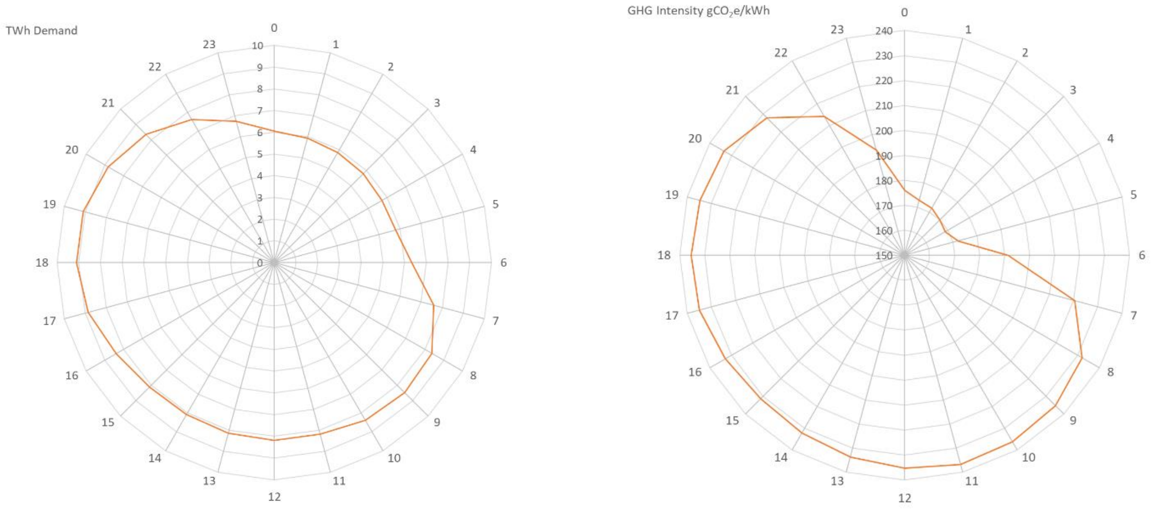
It is very likely that large parts of the charging infrastructure, and in particular the expensive cabling and groundworks, will outlive the first generation of electric vehicles. It is also very unusual to include the cost of the onsite bulk diesel tanks, fuel dispensing system, fuel monitoring software, and the annual maintenance of the fuel system in the whole life cost model of a diesel vehicle.

A.4 Getting the timing right

Ideally, vehicles should be charged overnight, to avoid the demand from large scale EV charging having a negative impact on the grid. During the working week, from 06:00 to 23:00 hrs, demand on the UK Grid is at its maximum and grid GHG emission intensity ($kgCO_2e/kWh$) may be high due to the use of fossil-fuel based generation to meet demand.

However, avoiding the peak entirely leaves a very narrow window of seven hours in which to charge vehicles. The reduction in GHG emissions from avoiding the higher “daytime” intensity is only 10%-15% over the entire charging period and in terms of tonnes of GHG rather than percentage this will diminish in importance as the grid decarbonises.

Figure A-1: Variation in energy demand (TW) and GHG intensity (gCO_2e/kWh) during the working day (2019).



Note the above chart of GHG intensity has an axis from 150 to 240 gCO_2e/kWh

During the summer months, on-site PV generation can be used during the late afternoon and early evening to charge vehicles at a time when the “domestic” site load is falling. Using the PV to displace grid import will have a significant cost saving and GHG emission reduction.

Some organisations have addressed the problem of site capacity by installing battery storage that can store any unused capacity during the day and then charge the vehicles at night (see Section 3.6).

A.5 Getting the tariff right

When implementing an electric vehicle fleet, it is important to negotiate low off-peak tariffs for electricity at all sites where the electric vehicles are based. This may mean a new tariff structure as the highest demand may have shifted from daytime to off-peak use.

There is an increasing range of innovative tariffs in the domestic sector aimed at owners of electric cars as well as households with “power walls” and at least one of these – Agile Octopus – includes negative tariffs. During the first nine months of 2020 there were 80 hours of negative electricity pricing in the UK. The domestic Octopus Go tariff charges £0.05/kWh from 00:30 to 04:30 hours because it makes use of surplus generation. With many more large battery electric vehicle fleets on the grid the need for “curtailment” of wind generation could be significantly reduced or eliminated.

It is anticipated that innovative tariffs will become available in the commercial sector as the BEV charging market grows. The National Grid Electricity System Operator (ESO), working with partners, has already developed and published an open system called the “Carbon Intensity API” which makes available the predicted carbon intensity of the grid up to two days in advance in half hour periods.

In the future this forecast could be used to adjust the price paid for electricity by lowering the cost (£/kWh) when renewable generation is high (carbon intensity low) or curtailment of wind generation may occur and increasing the cost when fossil fuel generation is high (carbon intensity high). This has the aim of modifying customer behaviour as well as being used to directly manage the activity of “smart” appliances which could include electric vehicle charging systems. The objective would be to eliminate curtailment of wind generation and match demand to supply throughout the day.

A.6 Overcoming capacity issues

An issue at some depots is the lack of local grid capacity and, as indicated earlier, the upgrade of the local grid to provide the significant additional capacity required can be very expensive. On sites with inadequate capacity there may be another local substation with spare capacity that can be accessed. In the first instant the local Distribution Network Operator (DNO) should be contacted but they may not be able to offer an affordable solution.

Alternatives to DNO capacity upgrades include the use of on-site renewable generation coupled with battery storage or just the use of battery storage to absorb any spare capacity during the day and then feed it back into the vehicles overnight combining stored energy with site capacity. This is the solution that has been implemented at the bus company Stagecoach’s Guildford Depot by Zenobe Energy.

Figure A-2: Tesla Powerpack (78 units) installed at Stagecoach's Guildford Dept

The Tesla Powerpacks charge during the day when the depot is empty and then discharge at night into the bus fleet. According to Zenobe, owner and supplier of the pack as well as the charging infrastructure, the system was installed more quickly than the grid upgrade required at the site and at a lower cost. It also has the advantage that it can be moved to another site if Stagecoach no longer have access to the depot.

There are Independent DNOs (IDNOs) in the market such as Vattenfall and Octopus/Eclipse Power and these may also offer innovative and affordable grid reinforcement or upgrade options including integration of PV canopies and battery storage with the grid upgrade and charging systems.

Some of the heavy goods vehicle manufacturers (for example Volvo) are entering into partnership with energy providers to offer a “turn-key” solution which includes installing the charging infrastructure, refurbishing, or recycling of the vehicles at their end of life and refurbishing, repurposing, or recycling of the batteries.

A.7 Being paid for Grid Services

A large fleet of electric vehicles, including heavy good vehicles with 300 kWh or larger batteries, is also a large "sink" for surplus renewable generation and could play an important part in balancing the UK's electricity system, providing grid frequency response, and balancing services including absorbing excess capacity from renewable generation and returning it to the grid at times of peak demand (Vehicle to Grid – V2G). All these functions have a commercial value in the electricity supply market and can reduce energy costs.

BYD UK, a Chinese EV bus manufacturer, Alexander Dennis their UK manufacturing partner, the bus operator Go-Ahead London, SSE Enterprise, UK Power Networks and Leeds University are working on a project to link 28 BYD/ADL Enviro 400EV double decker buses in a Bus2Grid project which will go live at the UKs largest electric bus garage in Northumberland Park, London in summer 2021.

The stored energy in the buses will be used to help balance London's power grid and optimise energy management. The garage will eventually support charging 120 Buses. According to SSE Enterprise the energy stored in the 28 buses could return up to 1MW of power to the grid.

Figure A-3: Northumberland Park electric bus depot

SEE Enterprise also point out, "If the entire London bus fleet of around 9,000 vehicles were to be converted with the technology being used in the Bus2Grid project, it could theoretically provide enough energy to supply more than 150,000 homes."

UK Power Networks forecasts there will be more than 3.6m electric vehicles connected to its network by 2030, an increase of more than 3.5m on the 95,000 vehicles currently in its region. This will create significant additional demands on the energy system and the options are either to build new infrastructure to meet this demand or to introduce smart charging systems.

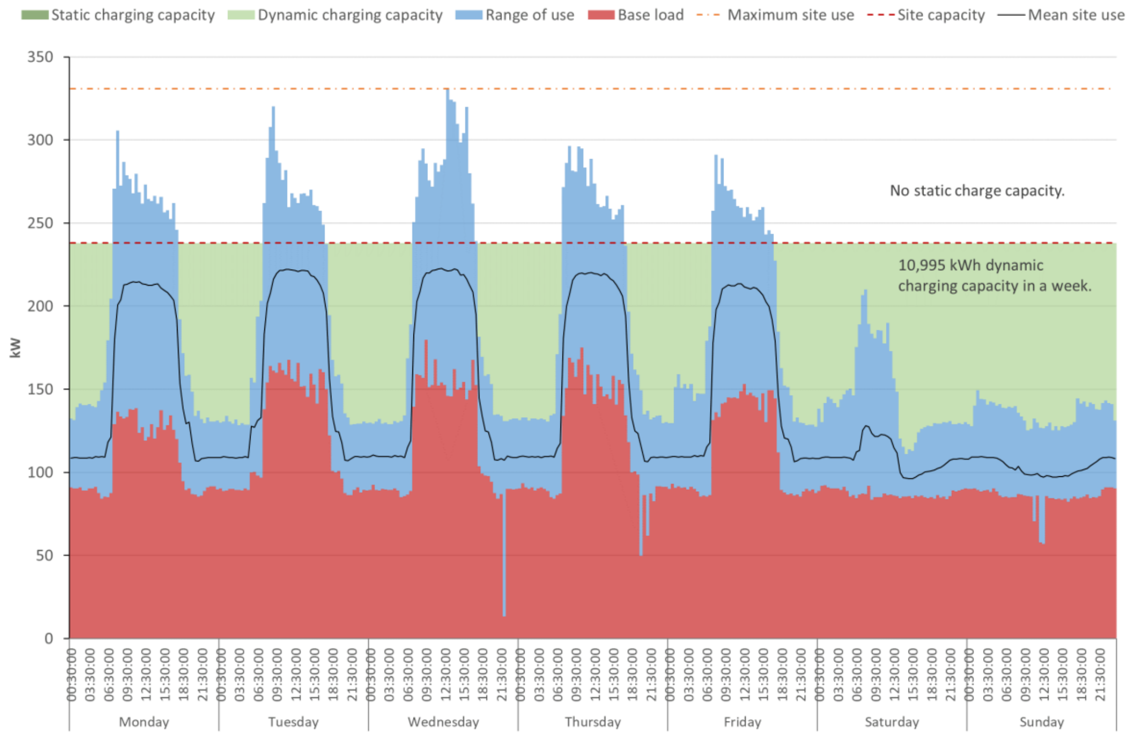
Appendix B: Half Hour data analysis

B.1 SRC Quays (250 kVA)

Table B-1: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
SRC Quays	250	0.95	238	

Figure B-1: Energy Consumption Profile – Full Year



The data suggests that this site regularly exceeds its maximum import capacity (MIC). We did not have complete 2019/20 data as the supplier has ceased trading and the HH data has not been available since July 2019. To compensate for this we used all the available data from 1st January 2017 but even that record was incomplete with several months missing (July 2018 to September 2018). Annual consumption data supplied by the Energy Manager (Table B-2) suggests this approach will produce representative data and, if anything, is likely to slightly underestimate capacity as consumption has been falling year-on-year.

Table B-2: Annual energy consumption The Quays site (kWh)

Month	2017 - 18	2018 - 19	2019 - 20	2020 - 21
Feb	111,749	116,515	90,456	96,335
Mar	119,137	105,248	99,025	88,890
Apr	109,393	101,125	93,434	87,146
May	105,360	100,461	92,975	74,852
Jun	106,976	99,512	94,313	71,559
Jul	100,323	109,634	100,659	74,577
Aug	115,539	103,774	97,307	76,528
Sep	92,566	105,488	92,237	74,755
Oct	98,835	106,524	101,531	87,769
Nov	103,669	100,436	102,474	84,327
Dec	113,104	101,220	96,553	81,611
Jan	111,249	108,084	101,638	87,307
Total	**1,287,900**	**1,258,022**	**1,162,601**	**985,658**

Table B-3: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	0	0	0	0	4	
Dynamic capacity	10,995	5,830	90	12		
Total	**10,995**	**5,830**	**90**	**12**	**4**	

During an average week at The Quays, with the current supply and demand, there would be no static capacity and 11 MWh of overnight dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the dynamic capacity is 6 MWh.

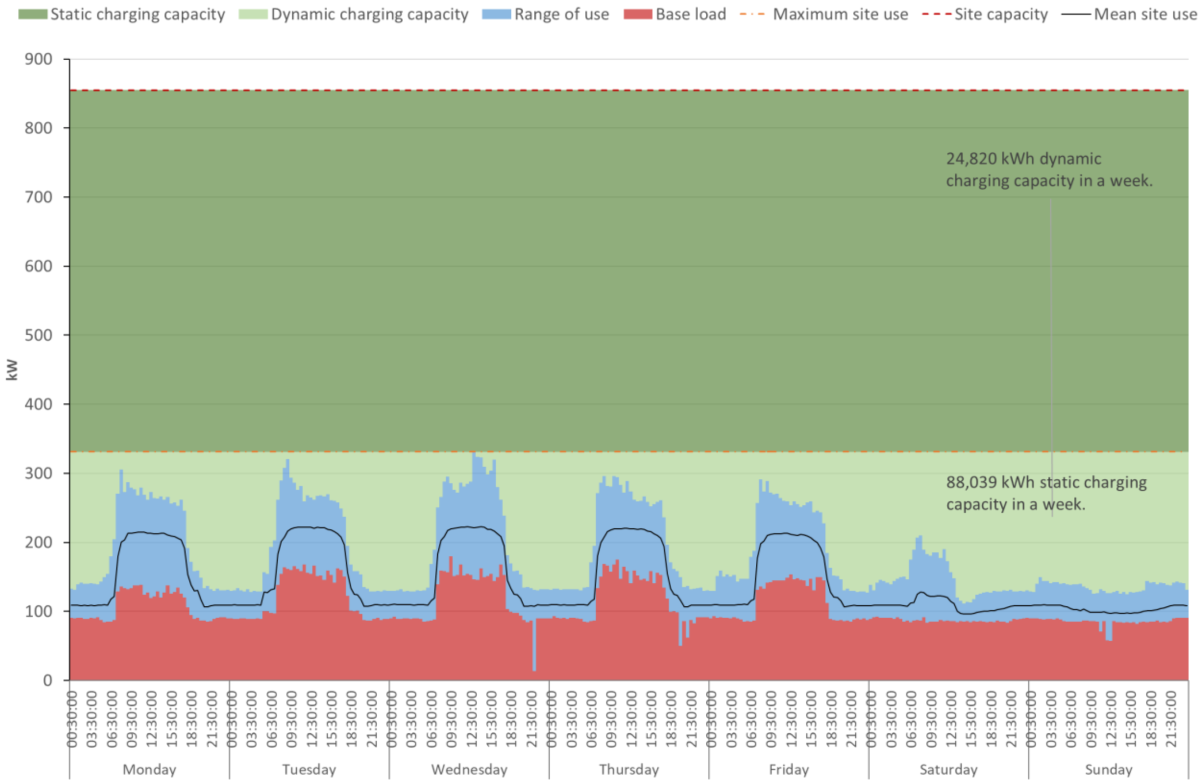
The 90 kW of dynamic capacity that is available overnight which would support twelve 7.4 kW chargepoints, but this will need timer control or dynamic demand responsive management.

B.2 SRC Quays (900 kVA Upgrade)

Table B-4: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
SRC Quays	900	0.95	855	

Figure B-2: Energy Consumption Profile – Full Year



24,820 kWh dynamic charging capacity in a week.

88,039 kWh static charging capacity in a week.

Table B-5: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	88,039	31,442	524	70	4	
Dynamic capacity	24,820	11,407	190	25		
Total	**112,859**	**42,850**	**714**	**95**	**4**	

Following an upgrade of the site supply we estimate that during an average week there would be 88 MWh of static capacity and 25 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 31 MWh, and the dynamic capacity is 11 MWh.

The static headroom is 524 kW which is enough for seventy 7.4 kW charge points to operate concurrently and to their full capacity all day. Another 190 kW is available overnight which would support a further twenty five 7.4 kW chargepoints, but this will need timer control or dynamic demand responsive management.

With timers or dynamic charger management the site could support at least ninety five 7.4 kW chargers, more if vehicles do not require a full 12 hour charge and smart charging is used.

B.3 MREC - Crymlyn Burrows

Table B-6: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
MREC	2,500	0.95	2,375	

Figure B-3: Energy Consumption Profile – Full Year

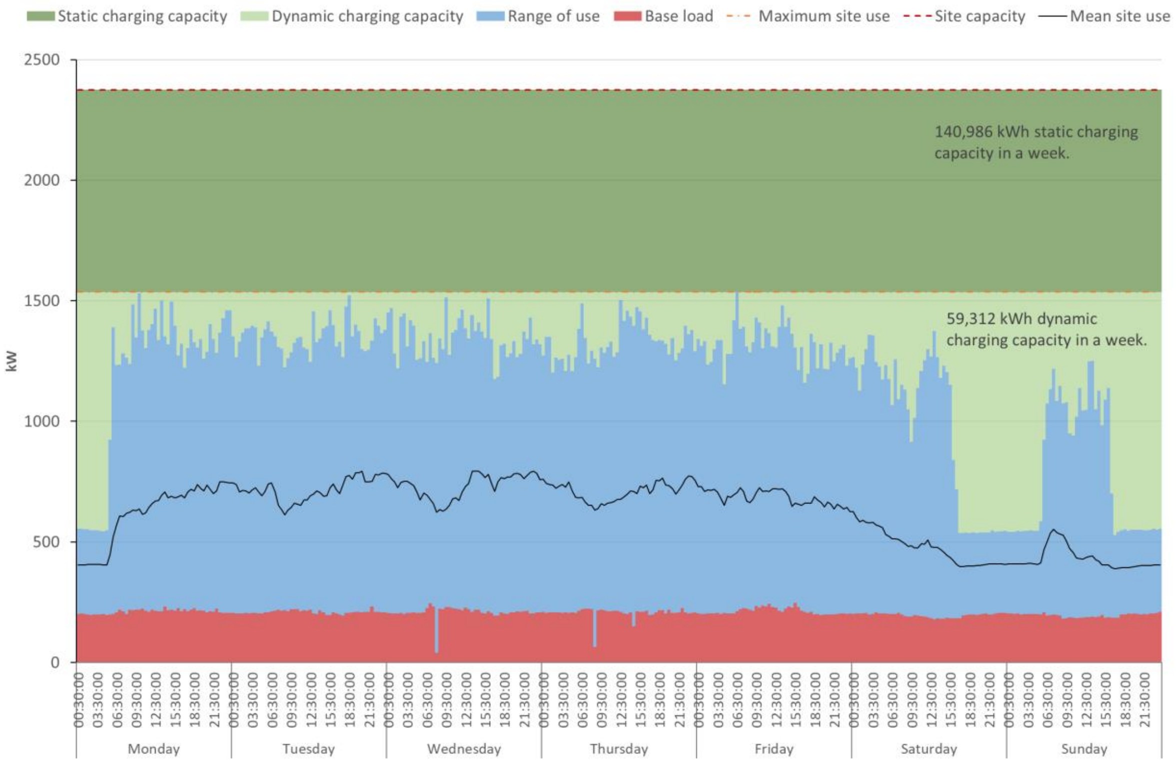


Table B-7: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	140,986	50,352	839	113		
Dynamic capacity	59,312	13,080	210	28		
Total	**200,297**	**63,431**	**1,049**	**141**		

During an average week there is 141 MWh of static capacity and 59 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 50 MWh, and the dynamic capacity is 13 MWh.

The static headroom is 839 kW which is enough for 113, 7.4 kW charge points to operate concurrently and to their full capacity all day, this is equivalent to 37 of the 22 kW AC points required RRVs and 16 of the 50 kW DC points used by some RCVs. Another 210 kW is available overnight which would support a further 28, 7.4 kW chargepoints, but this will need timer control or dynamic demand responsive management.

With timers or dynamic charger management the site could support over 140, 7.4 kW chargers, more if vehicles do not require a full 12 hour charge.

B.4 Tregelles Court

Table B-8: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
Tregelles Court	120	0.95	114	

Figure B-4: Energy Consumption Profile – Full Year

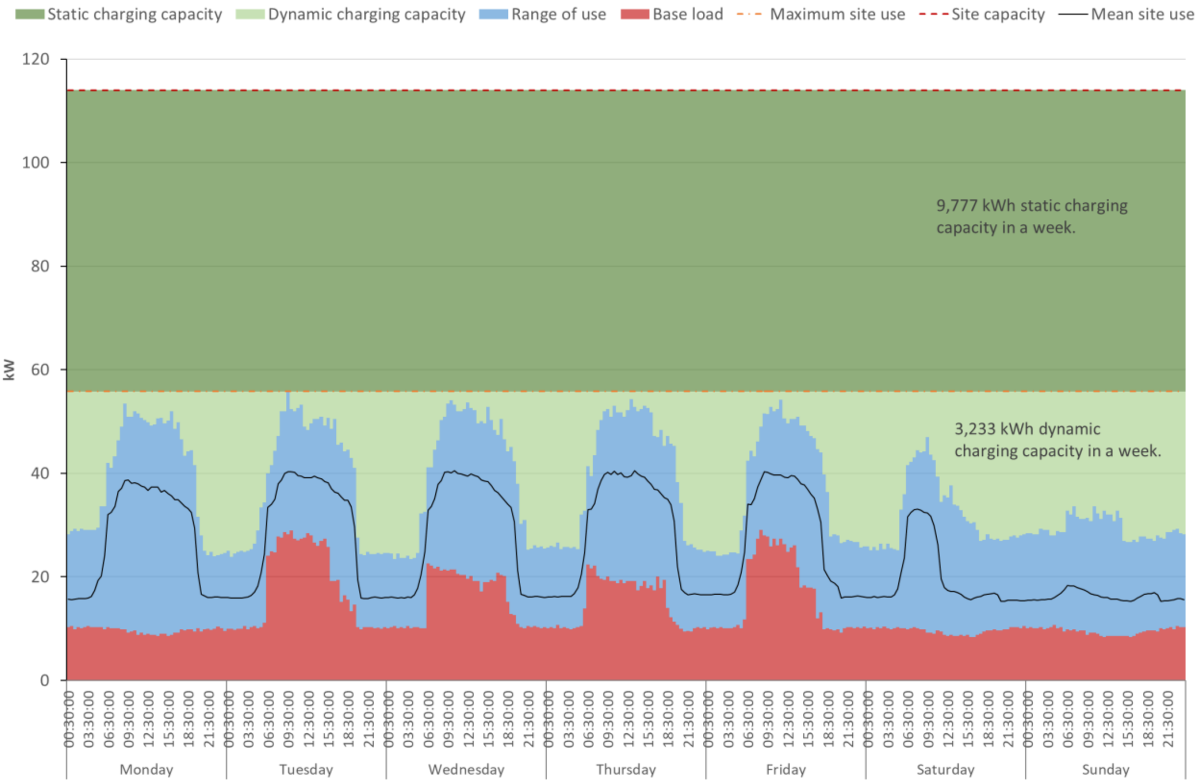


Table B-9: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	9,777	3,492	58	7	5	
Dynamic capacity	3,233	1,650	20	2		
Total	**13,010**	**5,142**	**78**	**9**	**5**	

During an average week there is 10 MWh of static capacity and 3 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 3.5 MWh, and the dynamic capacity is 1.7 MWh.

The static headroom is 58 kW which is enough for seven 7.4 kW charge points to operate concurrently and to their full capacity all day. Another 20 kW is available overnight which would support a further two 7.4 kW chargepoints, but this will need timer control or dynamic demand responsive management.

With timers or dynamic charger management the site could support over nine 7.4 kW chargers, more if vehicles do not require a full 12 hour charge. The site already has five chargepoints.

B.5 Port Talbot Civic Centre

Table B-10: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
Port Talbot Civic Centre	400	0.95	380	

Figure B-5: Energy Consumption Profile

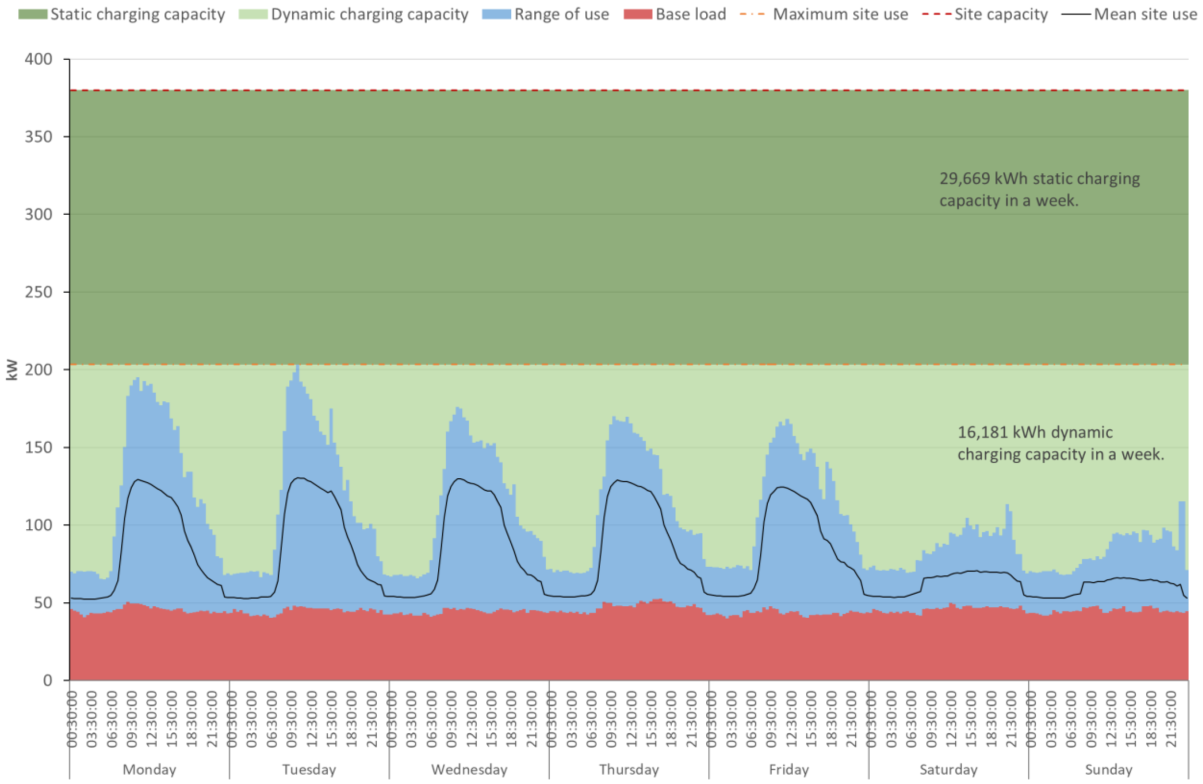


Table B-11: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	29,669	10,596	177	23	2	
Dynamic capacity	16,181	7,404	120	16		
Total	**45,850**	**18,000**	**297**	**39**	**2**	

During an average week there is 30 MWh of static capacity and 16 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 11 MWh, and the dynamic capacity is 7.4 MWh.

The static headroom is 177 kW which is enough for 23, 7.4 kW charge points to operate and to their full capacity all day. Another 120 kW is available overnight which would support a further 16, 7.4 kW chargepoints, but this will need timer controls or dynamic demand responsive management.

With timers or dynamic charger management the site could support 39, 7.4 kW chargers, more if vehicles do not require a full 12 hour charge.

B.6 Croeserw Community Enterprise Centre

Table B-12: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
Croeserw CEC	140	0.98	137	

Figure B-6: Energy Consumption Profile – Full Year

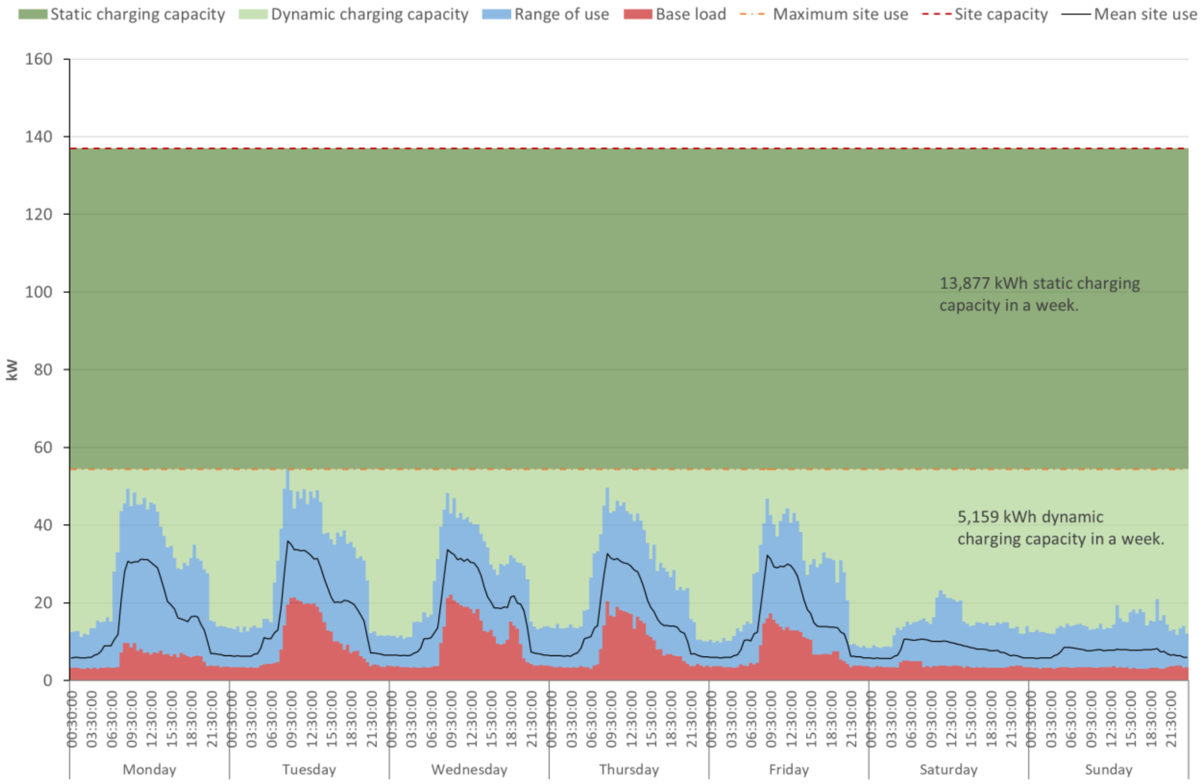


Table B-13: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	13,877	4,956	83	11		
Dynamic capacity	5,159	2,317	30	4		
Total	**19,035**	**7,273**	**113**	**15**		

During an average week there is 14 MWh of static capacity and 5 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 5 MWh, and the dynamic capacity is 2.3 MWh.

The static headroom is 83 kW which is enough for 11, 7.4 kW charge points to operate and to their full capacity all day. Another 30 kW is available overnight which would support a further four 7.4 kW chargepoints, but this will need timer controls or dynamic demand responsive management.

With timers or dynamic charger management the site could support 15, 7.4 kW chargers, more if vehicles do not require a full 12 hour charge.

B.7 Neath Multi-Story Car park

Table B-14: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
Neath MSCP	100	0.95	95	

Figure B-7: Energy Consumption Profile – Full Year

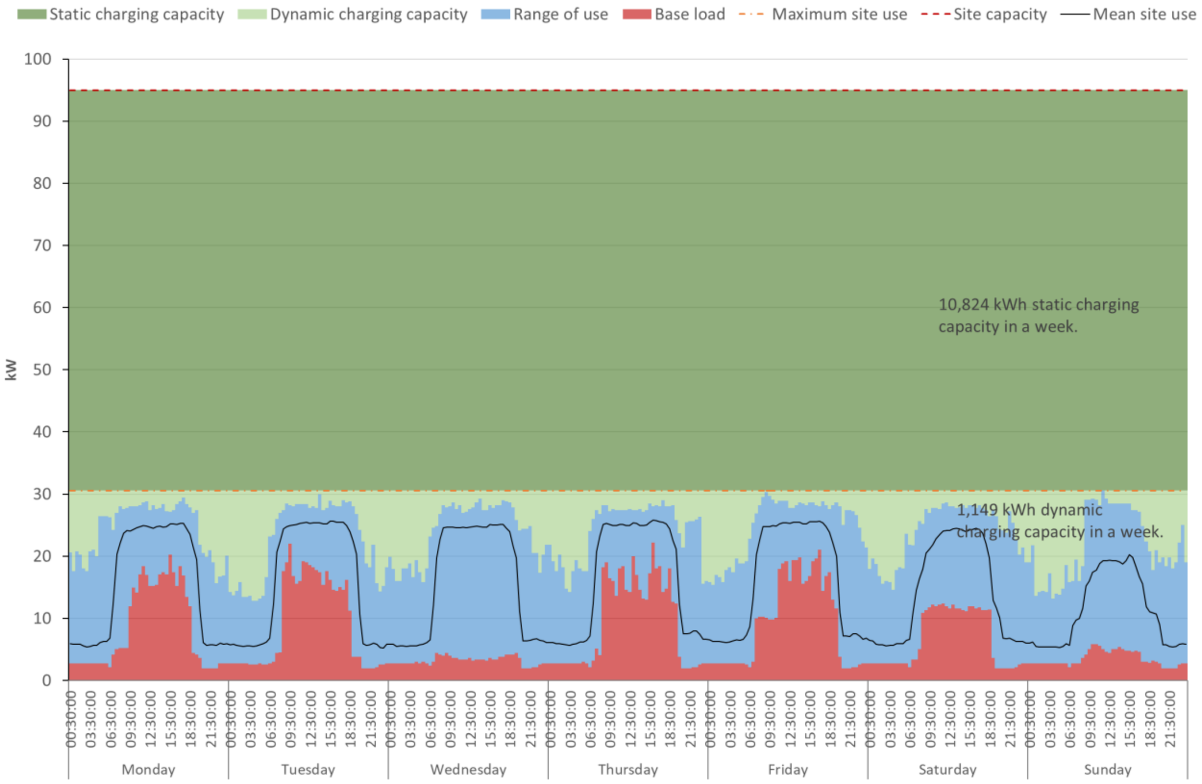


Table B-15: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	10,824	3,866	64	8		
Dynamic capacity	1,149	653	10	1		
Total	**11,973**	**4,518**	**74**	**9**		

During an average week there is 11 MWh of static capacity and 1 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 3.9 MWh, and the dynamic capacity is 0.6 MWh.

The static headroom is 64 kW which is enough for eight 7.4 kW charge points to operate and to their full capacity all day. Another 10 kW is available overnight which would support one additional 7.4 kW chargepoints, but this will need timer controls or dynamic demand responsive management.

With timers or dynamic charger management the site could support nine 7.4 kW chargers.

B.8 Port Talbot Multi Story Car Park

Table B-16: Site capacity, power factor, and available capacity

Site	Maximum Import Capacity (kVA)	Power Factor	Available (kW)	Notes
Port Talbot MSCP	70	1	70	

Figure B-8: Energy Consumption Profile – Full Year

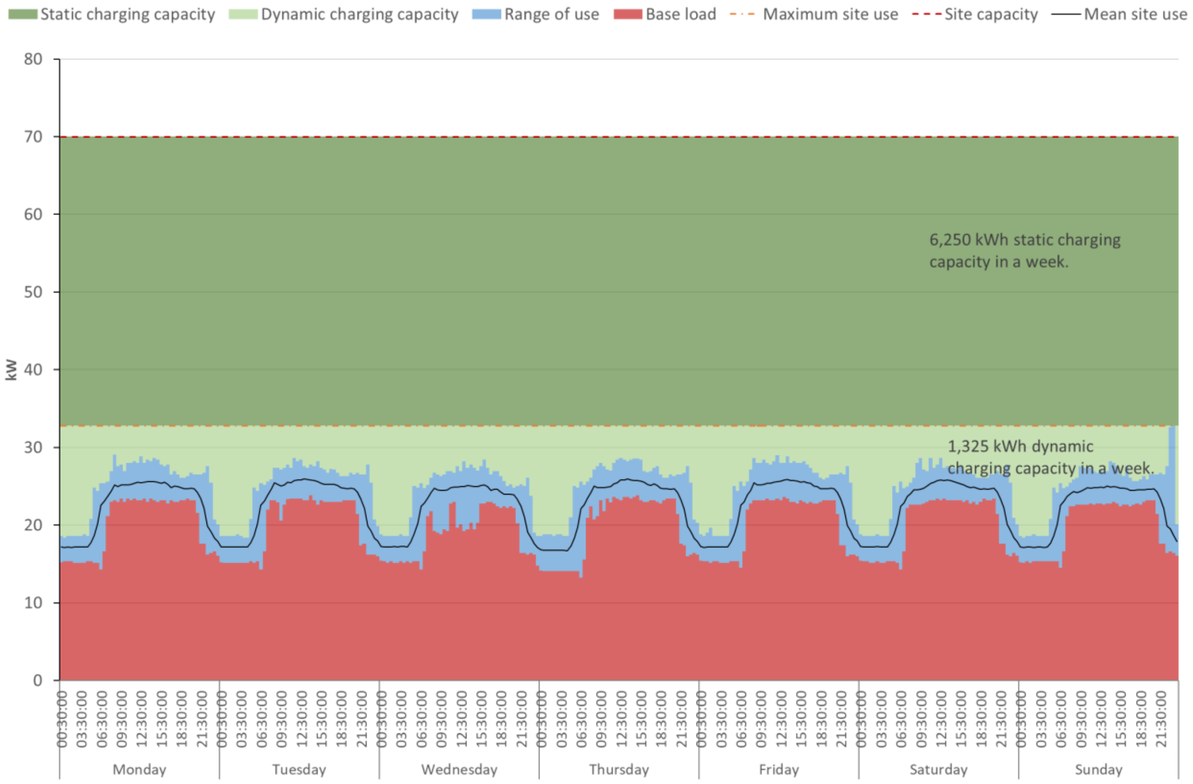


Table B-17: Available capacity and equivalent number of 7.4 kW chargers

Category	kWh 24/7	kWh Off peak	kW Headroom	7.4kW EVCI	Installed EVCI	Notes
Static capacity	6,250	2,232	37	5		
Dynamic capacity	1,325	621	10	1		
Total	**7,574**	**2,853**	**47**	**6**		

During an average week there is 6 MWh of static capacity and 1.3 MWh of dynamic capacity. During the off-peak period (7 pm to 7 am, Monday to Friday) the static capacity is 2.2 MWh, and the dynamic capacity is 0.6 MWh.

The static headroom is 37 kW which is enough for five 7.4 kW charge points to operate and to their full capacity all day. Another 10 kW is available overnight which would one additional 7.4 kW chargepoint, but this will need timer controls or dynamic demand responsive management.

With timers or dynamic charger management the site could support six 7.4 kW chargers.

Appendix C: Site Capacity Requirements

	Fleet Location	Fleet	Annual EV kWh	WD EV kWh	kW/12hr	kW +25%
1	The Quays	200	2,080,659	8,967	747	935
2	At School	35	49,940	208	17	25
3	Tregelles Court	49	184,907	770	64	85
4	Tawe Terrace	7	38,257	175	15	20
5	Port Talbot Civic	5	11,569	48	4	10
6	Cimla Hillside	2	3,907	16	1	5
7	Margam Park	1	1,953	8	1	5
8	SRC Depot	8	43,998	183	15	20
9	Neath Civic	1	2,790	12	1	5
10	MREC	1	14,928	62	5	10
11	Unknown	4	8,064	34	3	5

Appendix D: Grid-sourced renewable electricity

D.1 Concept of “Additionality”

A key factor that comes into play when determining if a low-carbon fuel purchase can be “included” in an organisation’s reporting is the concept of “additionality”. Has the purchase of that fuel resulted in more low-carbon fuel being produced than would otherwise have been the case or has your purchase increased demand and resulted in new build?

In 2021 purchasing electricity on a renewable electricity tariff does not result in additionality. Renewables are now the lowest cost form of electricity generation (£/kWh) and significant additional capacity is already under construction or planned. The building of fossil power stations has almost stopped, new-builds of combined cycle gas turbine (CCGT) generation would not be considered without first obtaining a “Capacity Market Agreement” to underpin the investment.

D.2 REGO certificates

Many organisations have opted to have their grid electricity supplied from renewable sources backed by Renewable Energy Guarantees of Origin (REGO) certificates. The GHG emissions of the electricity or gas can be reported in line with the “market-based” (consumer) value calculated by the supplier (for example zero gCO_2e/kWh if 100% renewable electricity) but it should be reported alongside the “location-based” (national) figure which is the actual GHG impact of the energy used.

This is because the zero-carbon benefit of the electricity has already been accounted for in the national UK grid figure. The benefit cannot be taken twice as the grid carbon factor for other consumers would need to be adjusted upwards to compensate.

The requirement to do this is fully documented in:

HM Government: Environmental Reporting Guidelines (ERG): Including streamlined energy and carbon reporting guidance. March 2019, pages 48-49

"Where organisations have entered into contractual arrangements for renewable electricity, for example through Power Purchase Agreements or the separate purchase of Renewable Energy Guarantees of Origin (REGOs), or consumed renewable heat or transport certified through a Government Scheme and wish to reflect a reduced emission figure based on its purchase, this can be presented in the relevant report using a “market-based” reporting approach. ***It is recommended that this is presented alongside the “location-based” grid-average figures*** *and in doing so, you should also look to specify whether the renewable energy is additional, subsidised, and supplied directly, including on-site generation, or through a third party. A similar “dual reporting” approach should be taken for biogas and biomethane (including “green gas”)."*

GHG Protocol, Scope 2 Guidance, Corporate Standard, Section 1.5.1, page 8

“Companies with any operations in markets providing product or supplier-specific data in the form of contractual instruments ***shall report Scope 2 emissions in two ways and label each result according to the method: one based on the location-based method, and one based on the market-based method.*** *This is also termed “dual reporting.”*

D.3 Use of “Private Wire” renewables

Where a company generates its own renewables on-site or locally, by using photovoltaic and/or wind with “private wire” or an on-site anaerobic digester and does not supply the power via the UK Grid it can be accounted for as a zero or low carbon supply, but the carbon intensity needs to be robustly audited, an AD plant will have fugitive emissions of methane and these need to be accounted for.

D.4 Time Specific Emission Factors

Also permitted are time-specific emission factors. The HM Government ERG states:

“Where available, time specific (for example hour-by hour) grid average emission factors should be used in order to accurately reflect the timing of consumption and the carbon-intensity of the grid.”

The carbon intensity of the grid varies throughout the day and the year. The grid data is publicly available in half hourly intervals, but organisations may have difficulty calculating this as it requires half hour consumption data.

Appendix E: Budget energy monitors

Products Available

Figure E-1: Typical three phase system

The image (Figure E-1) shows a typical setup. These devices are widely available and can also monitor single phase supplies.

An example of a supplier is SmartGreenShop, there are other suppliers in the market.

The equipment is low-cost (from about £90 to £150) and so there is no reason not to deploy one at each site where monitoring is required. They do not require any intervention and can be easily setup by anyone with a reasonable competence in IT.

We would strongly recommend the use of these on all sites with independent metering (not shared with other users) and no HH data as they give a clear picture of energy use and the opportunities for intervention, the likely impact of PV and the capacity for EV charging.

Guidance on installation

1. Make sure the current clamps are big enough to get around the cables coming into the main distribution boards – some buildings might need the “XL” clamps: if you plan to move the equipment around get the biggest version to cover most situations.
2. These clamps usually go to a small battery powered device that sends a Wi-Fi signal to the base station, so they need to be in range. We would recommend downloading an installation manual first to get an idea on the detail before you actually buy anything.
3. The base station must be linked to the internet by an Ethernet cable, so it needs to be close to the site router or to a network port. Be aware that you may need an IT Admin to give permission to let the data through some firewalls.
4. You can add multiple units to a single base station to monitor individual loads or distribution boards inside a large building.
5. Set up an online account to access the data.
6. Add the unique ID of your base station to the online account. You can add multiple base stations to a single on-line account.

There are also some versions of the kit that can monitor the output of Solar PV systems at the same time as the loads in the building.

Appendix F: EVCI Terminology

Table F-1: Definitions of common terminology

Terminology	Definition
AC	Alternating Current – the UK Grid is an AC system.
Phase	Single or Three Phase – AC Electricity is generated in three Phases.
DC	Direct Current – What batteries produce and need to charge.
kVA	kiloVoltAmp – a measure of apparent power.
kW	kiloWatt – 1,000 Watts – a measure of the actual power available.
PF	Power factor – the difference between kVA and kW.
kWh	kilowatt hour – measure of energy stored or used.
Volt	unit of electrical potential – mains 240 Volt, battery 400-800 Volt.
Amp	unit of electrical current.
Watt	unit of energy – Volts x Amps = Watts (DC and Single Phase AC).

How charge points are described

Actual Power, Current Type, Supply voltage, Supply current, Phase (Single or Three)

7.4 kW, AC, 230V, 32 Amp, Single Phase. 230 x 32 = 7,360 Watts ✓

22 kW, AC, 400V, 32 Amp, Three Phase. 400 x 32 = 12,800 Watts?

Three Phase so need to account for each phase, so we multiply by $\sqrt{3} = 1.732$

12,800 x 1.732 = 22,169 Watts ✓

44 kW, AC, 400V, 64 Amp, Three Phase. 400 x 64 x 1.732 = 44,339 ✓

50 kW, DC, 150-500 V_{DC}, 125 A_{DC}.

DC chargers range from 50 kW to 350 kW with 600 kW catenary available for buses.

Expect DC to keep increasing – 1MW and 2MW at service stations for HCVs and Coaches

Basic (Dumb), Smart and Dynamic

These terms are defined differently by different organisations. We use:

- A basic charge point is just a supply point. It has no built-in systems to talk to any other device. Plug in a vehicle and it delivers whatever kW is asked for up to its supply limit.
- A networked charge point can talk to back-end systems. It tells the system it has a car needing charge, it may have a contactless payment/ID system to identify the car or driver. Some can operate as “drones”.
- Smart Charging: A network of drone charge points with a controller to ensure total demand does not exceed a pre-set kW capacity. The system is self-contained. It is not connected to the site energy management system so has no information about site usage. It could include control by timers.
- Dynamic Charging: This is “Smart Charging” but the kW capacity varies dynamically depending on consumption by the rest of the site or by time of day. It may be integrated with the site energy management system.

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