Electric Vehicle Charging Infrastructure

A Design Guide

V1.3.3

EV ASSOCIATION SCOTLAND

OREF
ORKNEY RENEWABLE ENERGY FORUM

Electric vehicle charging infrastructure design guide.

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1. Introduction:

Charging points are not cheap. They are possibly the most expensive piece of infrastructure presently being installed in public car parks and it is important that they are installed in the best locations within the chosen sites.

This guide seeks to develop good practice for charging infrastructure in terms of safety, signage and general use. It specifically shows how to increase the value of this investment up to 4 fold at practically no cost through forethought.

This guide has been drafted in order to help designers of the public estate (few of whom have experience in driving EVs) make the best use of scarce resources. It draws on personal experience of electric vehicle drivers.

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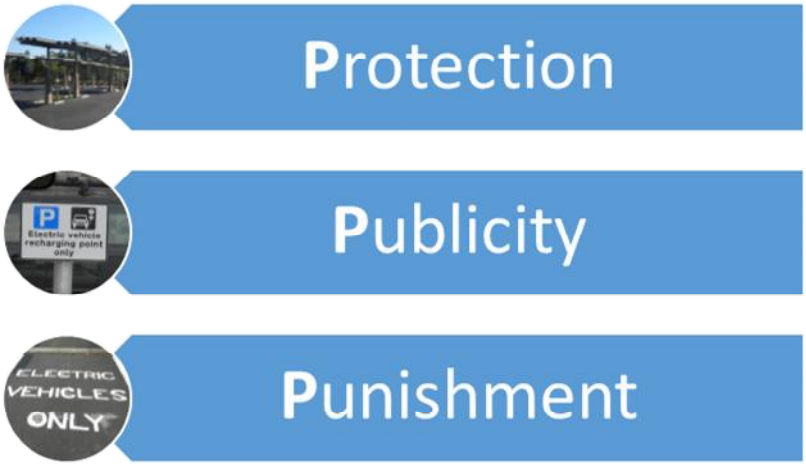
2. Underlying principles:

The Guide is drafted so as to seek to deliver the four fundamental requirements of a successful public charging network:

The infrastructure needs to be:

- **R**eadily Available - national coverage providing the correct units for each type demand at the appropriate locations (13A sockets, Posts, and rapids)
- **R**eliable - all units must work first time.....every time… for every user.
- **R**obust - If a unit fails, then there needs to be a back-up at hand; either another rapid or a fast charger post. This will mean building charging hubs.
- **R**apidly Commissioned – A fixed time scale from installation to fully operational within 1 month.

In addition to the requirements this guide also promotes 3 Ps



- **P**rotection - for users, service personnel, and the fragile equipment. This would include lighting and canopies where appropriate.
- **P**ublicity - way-finding, site signage, and accurate up-to-date maps
- **P**unishment - fines for mis-use of spaces to stop "bay-blocking"

3. About the authors

The Orkney Renewable Energy Forum (OREF) was set up in 2008 to seek to make the most of the opportunities presented by renewables in the county. Members of the forum meet to exchange ideas to promote energy efficiency and the preferential use of renewable energy over unsustainable sources. As a direct result Orkney has seen a significant uptake of EVs with an estimated 80 cars in use daily on the islands.

The Electric Vehicle Association of Scotland is a membership organisation seeking to maximise the use of EVs.

The main authors of this report are OREF & EVAS members: Neil Kermode is a Fellow of the Institution of Civil Engineers and keen EV driver, and Jonathan Porterfield a well-known EV advocate and alternative fuel vehicle dealer. Neither are aligned to any charge point supplier of vehicle manufacturer, but both are passionate about making the most of limited public funds to ensure the effective roll out of EVs. Input has been received from numerous other drivers and particularly from Doug Robertson of EVAS.

This information is offered without cost or warranty and the opinions expressed are those of the authors alone.

4. What happens when charging?

Most public chargers will be accessed by means of an RFID swipe card. The card generally either unlocks some sockets or livens up sockets/plugs.

Electric vehicles (EVs) use most charge points by means of a cable carried in the vehicle. The cable is generally between 4 and 8m long and each car will have a charging socket in its bodywork often in the bonnet or where the 'filler cap' would be.

Note: there is presently no standard location on cars for the 'filler cap' which makes the designers' job challenging when faced with this diversity.

Fast charger at Old Academy, Stromness

Getting the right part of the car to within 5m or so of the charge point allows charging to take place.

Plugging the car in initiates electronic negotiation between the car and the charger and if all is well charge begins to flow. If some error or fault is detected the system shuts down.

Chargers often display coloured LEDs to indicate their status. Unfortunately there is no standardisation on these, so there can be some variation depending on manufacturer. An example of one set being:

- Steady Green – ready for use
- Flashing Blue – in the process of initiating connection/awaiting cable
- Steady Blue – supplying charge
- Steady Red – fault.

Often the cars also have some form of indicator showing that they are receiving charge. Regrettably that too is not standard.

Upon completing of charging it is ideal if the drivers unplug and move their car out of the way to allow others to use the charger. Unfortunately this does not always happen and bays can become blocked by now charged cars. See section 11 for enforcement suggestions.

5. Types of chargers and how they are used

There are three types of chargers

- Fast chargers
- Rapid chargers
- Home points

It is important to recognise that EVs are NOT charged in the same way as people refuel internal combustion engined cars. Fossil cars fuel weekly or monthly in a process that takes around 5 minutes. EVs refuel daily or more often in a process that can take between 0.5 and 6 hours depending on need and charger type.

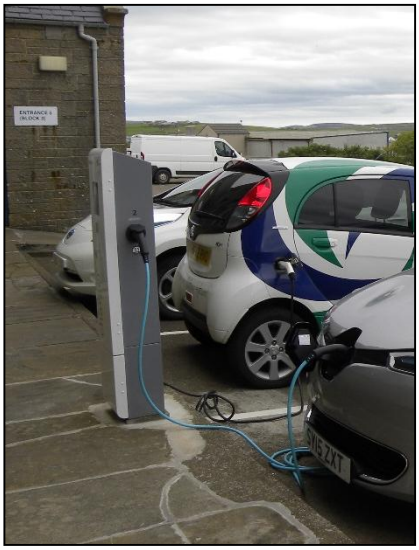
EV drivers are therefore adept at ‘sipping’ charge when the opportunity presents itself rather than only re-fuelling when they are out of charge. Most fossil cars are refuelled when they are less than 25% full. Most EVs will be kept topped up for most of their time.

EV drivers will therefore often not need to fully charge their vehicles at a charge point because they will not be empty. As a result they will not always need to take as long as stated for a full charge.

a. Fast Chargers

Most of the public chargers being installed are ‘fast chargers’ and most are effectively a wall mounted socket or a post with a pair of sockets

Charging can take several hours from ‘fast chargers’ such as the one shown, but many EV drivers often just need a ‘top-up’ charge and may plug in for an hour or so. The occupancy of these chargers is therefore of unpredictable duration and require a flexibility of use.



b. Rapid Chargers

Rapid chargers deliver charge at a higher current and therefore charge faster than ‘fast chargers’! They will deliver about 80% of the charge the car needs in the first 30-40 minutes.

Due to battery chemistry they cannot fully charge a car at this same rate so whilst it is possible to fully charge the car on a ‘rapid charger’ it will take over an hour. Such full charging is therefore an inefficient use of a ‘rapid charger’ and should be discouraged.

They are more expensive and require a higher capacity electrical connection. They will generally have the cable incorporated in the charger and are therefore more like conventional petrol pumps in appearance.

c. Home Charging

As the name suggests this is done at home, generally off road on driveways and home garages.

Charging generally takes place overnight using off-peak electricity. Some have captive cables, some are sockets and utilise the vehicle’s portable cable.

Details on these chargers is outside the scope of this guide, but some general siting principles apply.

Charging at work may be undertaken in a variety of ways although many businesses are installing home or fast chargers.

6. Where to site chargers

This is the main consideration for a designer. A well placed charger will be able to serve many users, a poorly sited one will be a complete waste of money and cause frustration for users and embarrassment for the provider.

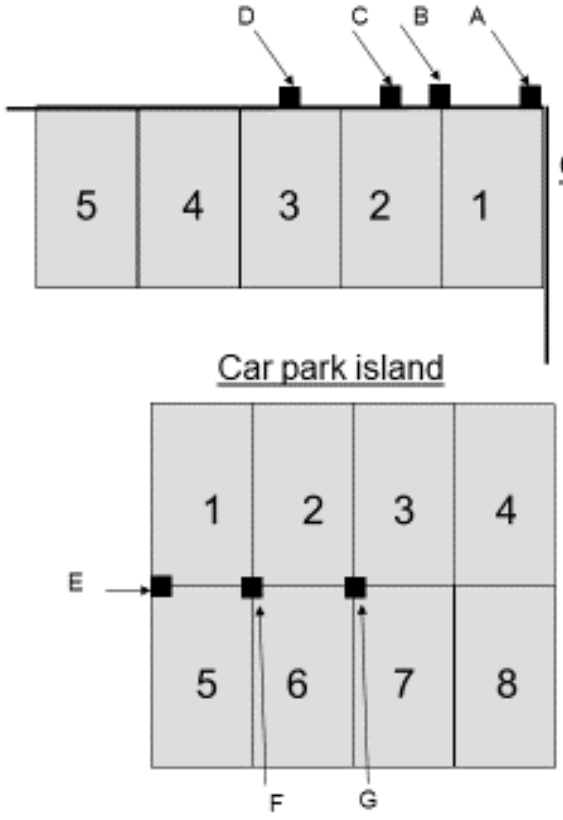
Careful consideration of location is key and the following may make the siting a success:

a. Think about the space

Most chargers can service EV spaces within 5m or so. They may only be able to service two at a time due to the number of sockets on them, but they can serve more than 2 spaces sequentially if properly placed.

(2 cars on charge, 1 waiting without having to be moved)

Maximising the numbers of spaces that can access a charge point is a critically important role for any designer. As shown below it is possible to have an enormous effect on the usability of the charger simply by placement within the car-park.



EV Charger Location Options

Position	Accessible by spaces
A	1
B	1,2,3
C	1,2,3,(4)
D	(1),2,3,4,(5)
E	1,2,5,6
F	1,2,(3),5,6,(7)
G	(1),2,3,(4),(5),6,7,(8)
() denotes 'just about'	

Conclusion: Careful thought can increase the number of spaces with access **4 fold**.

Some examples of bad and good charge location designs follow.

b. Keep out of the corners

Regrettably too many chargers are being put into corners of car parks which then make them less usable than need be the case. By placing chargers in a corner the range of the cable is limited to one side of the charger.

In some cases such as the one shown below, the combination of short charger lead, corner site and location of car 'filler' on the offside rear of some vehicles means it is necessary to park on the pavement to get a charge or park the cars cross ways as shown below.

Helmsdale - Badly sited rapid charger May 2015

Helmsdale. The only way to get 2 cars onto charger simultaneously without blocking the footpath.

The interaction of bay spaces and placement can also have a huge effect. In the photos below the point has been put on the ‘wrong wall’ of the car park.

Tain - Badly sited charger. Cannot put car fully in bay.

Tain - Alternate parking needed to use charger for even one car.

In the case below the location is both hard to park in and the bays will prevent certain vehicle configurations as the cables will not stretch far enough. Spaces in front of chargers works best.

Badly sited Irish point on a traffic island!

Sometimes 2 spaces can be served by a post in a corner, but with a little more thought this same charger could serve 4 or possibly 8 spaces.

School Place, Kirkwall – Option B chosen.

This location allows 2 vehicles to be easily charged, possibly 3 by stretching to the parking space to the left, but introduces a trip hazard by the charge point having been placed at the back of the footpath rather than at the kerb.

Kinross - Option C chosen for fast chargers and Option D for the rapid charger.

Note the bay in use by the car and the one to the left can both be used for the rapid charge. If the car had found the rapid charger full it could still access the middle charger without moving.

Also note the absence of a footpath means there is no trip hazard from trailing cables and the chargers have been placed closer to the kerb than the preceding ‘School Place’ example.

Keele Services - Option F chosen allowing maximum benefit to be gained from chargers

7. Other Considerations

Trip hazards. Avoid wall-mounting units where there is a pathway.

Warness Park Kirkwall >

Impact protection is more necessary for pedestal units than wall mounted.

< St Margaret's Hope.

Lynnfield Hotel, Kirkwall >

8. Signage

This is the approved Department of Transport symbol for an EV charge point. However there is a plethora of other signs and symbols in use.

It may be necessary to provide waypoint signs within car-parks to direct drivers to the facility if it is not clear.

At the charge bay it is preferable that any sign used should be so placed as to be in the eye-line of the driver parking in the space. This will help reduce the opportunity of the defence of ignorance from any inappropriate use.

Sign visible to driver at rapid in Ferry Road, Stromness >

<Clear signage in Shetland

9. Painting of spaces

As yet there is little public awareness of the importance of EV spaces to EV drivers. As a result the spaces need to be clearly marked. There is no readily understandable logo (as there now is with disabled spaces) and so it is necessary to be unmistakably clear as to the role of the space.

One photo above shows the clear words 'Electric Vehicle Only'. On a conventional asphalt surface this is sufficient.

Some places have used coloured surfacing (usually green) and this has the advantage of being unmistakably different even when a car is parked on it.

However there is some evidence that the subsequent application of thermoplastic marking may be difficult and prone to failure. (but the point has been reasonably well placed to serve 2 spaces)

Tickety-boo, Kirkwall >

10. Finding a charge point

Drivers may often be very low on charge when they get to a charge point and it is essential that the points are easily findable. Marking on conventional road-signs (as happens for parking or other services) would be an advantage as shown above.

Most EVs have navigation systems and will have charge point information loaded in. It is therefore critical that the accurate location is used when registering a newly installed point with such systems.

As yet there is no single public register of charge points and a myriad of online resources have grown up. Regrettably each have their shortcomings, but it is inevitable that the best will dominate the space in due course. Present leaders include:

- ZapMap
- Openchargemap.com
- PlugShare
- National Charge Point Registry

The charge point supplier may have their preferred site, however the designer should seek to keep up to date with this fast moving area.

11. Enforcement

Regrettably some Internal Combustion Engined (ICE) vehicle drivers ignore markings in their desire to park.

ICE drivers can park anywhere as can EV drivers if they don't need a charge. However consideration needs to be shown to EV drivers whilst charging infrastructure is comparatively rare. In order to ensure that this courtesy is shown it may be necessary to compel 'non-charging' drivers to keep spaces vacant. This applies equally to a charged EV as it does to ICE vehicles.

Fines running along similar lines to those imposed on drivers who use disabled spaced should be considered.

There is therefore an advantage in ensuring that the 'Electric Vehicle Only' marking is visible in the space even when parked in. (painted in dotted green box below). This may help use peer pressure to prevent inconsiderate use of the space as shown below. (This blocking of EVs by ICE vehicles is known as ICEing by the EV community)

Ferry Road, Stromness 22/5/2015 – 2 illegally parked cars.

There is an as yet unresolved issue of EV drivers using charge point spaces when not strictly necessary. Any EV that is not plugged in should be treated the same way as an ICE vehicle.

It would therefore be more useful to paint '***Charging Electric Vehicles Only***' on spaces to make it clear to EV users that this is not an EV parking space, but an EV charge point.

It is also likely that payment will need to be made to use chargers in future; probably through communications in the charge post or by smart phone. As yet it is not clear if a charge will be levied for charging AND parking or whether the cost of one will be wrapped into the other. However discouraging drivers from hogging precious charge bays by parking is not being tackled uniformly. Devising a suitable means of paying for use of the post, but not encouraging overstaying remains a challenge.

12. How many points are needed?

In the growing market it is impossible to provide a guide as to how many charge points are needed for a given number of cars. Charging habits will vary depending on the demographic of users (commute/shopping/school run), the type of vehicle (EV/Plug in hybrid), distance travelled within catchment and many other parameters including battery range. However it is reasonable to assume that home charging will grow with increasing penetration of domestic micro-renewables (solar PV and wind) and that new charging systems will evolve.

Placing infrastructure to service multiple vehicles is of prime importance and the provision of ‘duty & standby’ points to allow charging to cascade across vehicles during a day should be anticipated.

There is a growing view that clusters of charge points are probably more use than a limited number evenly spread out. This is because some points may fail and go unserviceable and EV drivers may not have the charge left to go and search for the next one. A cluster of EV points reduces this issue.

Also note that a cluster of points may well be cheaper to install due to a reduction in the costs of cabling at a single location as opposed to multiple tapings into the electrical grid at dispersed locations.

Also beware that plug in hybrid cars have a shorter electric range due to smaller batteries. If being driven just on electricity they will charge more often than ordinary EVs, but also take longer to charge per mile travelled. If you have a lot of plug-ins, you will need more points.

13. Future proofing

Bearing in mind the point that clusters of chargers may well be best; it is worth considering the costs of the improvements to the electrical supply that might be needed. If a transformer needs to be upgraded it may well be better to oversize it at the specification stage as the costs are not linear i.e. a double sized transformer may not be twice the price.

It is recommended that quotes be obtained for several sizes of electrical supply as you may save in the long run.

14. Canopies or no canopies?

San Diego Zoo – canopies and charge points.

There is school of thought that recommends canopies for charge points. For rapid chargers there may well be merit in considering them akin to petrol pumps. In the early days of motoring petrol pumps were situated outside shops. Now most pumps are under canopies to protect the motorist whilst refuelling. On the continent rapid charger networks are being built with canopies and also offer wi-fi whilst waiting the 30 minutes or so for a charge.

Some sites have been built with solar panels, however the energy delivered by the panels will rarely be sufficient to charge the car unless parked all day with a suitable allocation of panels per space. These would be better for fast chargers than rapids as the cost of the panels may not justify the expense. This may well work in locations sunnier than most in the UK.

In addition there may be concerns by local authorities about taking on the maintenance responsibilities for additional structures in the public domain.

On balance they may not represent the best use of limited budgets, although putting chargers in 24 hour multistorey car-parks might give the best to both worlds.

15. Contact details

Petrol stations are generally attended, so it is clear who to speak to in the event of a problem or fault being discovered with a pump, however most EV charge points will be unsupervised. There will occasionally be problems with chargers, so a coherent policy is needed as to whom to report such faults. This requires forethought and communication.

There appear to be two options:

1. If run by the local authority then the customer contact centre in the relevant authority need to know who to contact about faults.
2. If part of a national network then a central number will be available. Stickers are provided by one national provider, however they need to be put onto the points immediately after commissioning.

Irrespective of which solution is chosen it is imperative that the charge point bears information to allow it to be identified on a database and also bears the contact details for help. Unfortunately this is often overlooked and the chargers tend to be devoid of details on who to call. Anecdotally some manufacturers dislike stickers on their cabinets and make no provision for such information.

Placing the details on the associated adjacent signage might provide a suitable location if cabinet manufacturers fail to provide usable space.

Note: If a charger is installed by a council, the switchboard's default seems to be to report it to the technical teams responsible for original installation. This is not logical as their job is normally to build infrastructure, not necessarily maintain it. On occasions these staff may well have set up maintenance arrangements with other bodies (such as option 2.), but the contact centre staff may not know that a step could be saved by referring direct to the maintainer…… unless someone tells them. A means of 'handover' should be planned within any installing organisation.

16. Out of order?

Charge points often display coloured LEDs to indicate their status. Green for ready to use, blue when delivering charge and red if there is a fault. However some chargers will only display a message on screen.

If a charge point is out of order it is often possible to get it re-set over the phone. A call to the maintainer is sufficient. However it is important to ensure that in the event of a bigger problem, or a period of extended unavailability, that an appropriate sign is put onto the charge point.

Leaving points without a sign builds frustration and damages confidence in the infrastructure.

17. Joint disabled/EV spaces

It was suggested at one time that disabled spaces could be provided with charge points. This was proposed as both sorts of spaces were felt to be 'under-used' by users and combining them would avoid 'wasting' valuable parking space. Such approaches are based on assumptions that both groups of users are not main-stream drivers and this represents an unfortunate form of discrimination.

Combining such spaces was also found to be a bad idea. The needs of each group are different and often incompatible.

- EV drivers have no need to be near the entrance to the building
- EV drivers do not need wider bays
- The number of EVs is increasing and will begin to obstruct essential disabled space provision.

Combined EV and disabled spaces should be avoided when planning provision of infrastructure.

It is possible that in due course there will be sufficient numbers of disabled EV drivers to justify disabled spaces with charge points exclusively for this group. However at present joint spaces are not recommended.

18. Planning

The number of electric vehicles is increasing and the need for public charging provision will inevitably rise.
Forethought in the provision of ducts and layouts for control cabinets and charge posts will save money in the long run.

In private housing developments the consideration of off street charge points would be helpful at the earliest stage.

Possible wider use of innovative approaches such as joint charge points and lamp columns should be considered. (Note: the example here is poor in that it either requires parking illegally on a red-route as shown, or would result in a trip hazard of trailing cables if parking on the left of the picture.)

Park Plaza Hotel, York Road, Westminster

19. Prime Spaces

There is no need to place EV charge points in preferential locations near entrances to facilities. Such spaces will generally be of more value for disabled spaces. Indeed using them for EV charging is likely to generate resentment and so should be avoided.

20. Manufacturers' guidelines

Manufacturers' instructions have concentrated on how to install their charge points products rather than where. These instructions are normally silent on the matters shown above and normally concentrate on duct layouts, holding down bolts and power requirements.

There is presently little experience in the construction industry of building charge points and few designers or installers have personal experience of using an EV. As a result there is a dearth of information at the point that siting decisions are taken by these groups. This has probably led to the poor siting shown above.

In due course it would be hoped that manufacturers would both support this (or similar) guides or incorporate the information in their own guides.

21. Communications

Many chargers communicate by mobile signal to a central server. If they fail to communicate some models protect themselves and trip out. It is therefore essential to be sure that there is a mobile signal of sufficient quality at the proposed charge point site. Failure to do so may result in the point being unreliable, particularly an issue in remote or rural locations.

22. Advice

The authors are not resourced to guarantee to provide advice on the siting of charge-points, but would be willing to provide comment as best they can. However the growing numbers of EVs on the road mean that there are increasing communities of such people about.

Designers are strongly advised to seek the views of experienced EV users before hardening up plans.

23. Summary

Nobody knew the issues that would arise when the de-carbonisation of personal transport started, but issues are being discovered along with workable solutions.

Some forethought in the installation of these new pieces of public realm infrastructure will allow much greater use to be made of these expensive investments.

Thank you for taking an interest and please do provide feedback on this guide. With care your work may feature in forthcoming editions of the guide. We'd prefer it if they features as good examples!

Orkney Renewable Energy Forum & Electric Vehicle Association of Scotland
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For comments on this guide (and help if we can manage it) then please contact:

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