Installers of energy saving technology
Electric Vehicle Charging Overview

Introduction

We have put this document together to explain the technology, design considerations and standards associated with Electric Vehicle (EV) charging stations.

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Electric Vehicle Charging Overview

1. About us

Incorporated in 2010, Phoenix Renewables Ltd trade as The Phoenix Works. Based in Leeds, West Yorkshire, we offer a range of energy saving technologies and specialise in electric vehicle charging stations and infrastructure.

1.1 The Phoenix Works

The Phoenix Works is a family business built on reputation, quality and customer service. We have our own highly-skilled workforce and have built excellent relationships with industry leading manufacturers. This enables us to offer our customers systems of the highest quality and specification, at a competitive price.

1.2 Service

Customer service is our priority and our customer satisfaction record is testament to this. We deliver all projects in-house with our core team, and in addition, we have established relationships with key partners. By combining resources The Phoenix Works can complete larger projects in a timely, efficient manner, whilst maintaining the high standards by which we are renowned.

1.3 Technology

The Phoenix Works have a comprehensive portfolio of specialist products and excellent working relationships with key manufacturers. Manufacturer trained, with extensive product knowledge, we search the market to provide our clients with products which are technically superior, backed by industry leading warranties. In conjunction with manufacturers, all our systems are designed in-house by our highly motivated team of engineers; we install the right technology first time.

1.4 Accreditations

The Phoenix Works are NICEIC Approved Contactors, NICEIC Domestic Installers (Part P accreditation) and Electro-technical Certification Scheme (ECS) members.

Our installation engineers are all trained to NVQ Level 3 standards on BS7671:2008 the 17th Edition of the Wiring Regulations. Our lead installation engineers are qualified to Level 3 in City & Guilds 2394 Initial Verification and are certified by the NICEIC for Electric Vehicle charging equipment installation.

We take our employee’s health and safety very seriously and are members of the Constructors Health and Safety Scheme (CHAS).
# Electric Vehicle Charging Overview

## 2. Charging Modes and Standards

### 2.1 Charging Modes

The table below provides a summary of the recognised options that are available for charging electric vehicles. They are referred to as “Charging Modes” 1, 2, 3 and 4.

<table>
<thead>
<tr>
<th>Charging Mode</th>
<th>Electric Vehicle Supply Equipment (EVSE)</th>
</tr>
</thead>
</table>
| **Mode 1** (Standard Charge) | - Connection by use of standard single-phase or three-phase socket outlets (e.g. BS 1363, BS EN 60309)  
- Supply to EV not exceeding 16A per phase and not exceeding 250V AC single-phase or 480V AC three-phase  
- No control pilot function provided by the equipment. This can affect the safety of the charge to the user and/or vehicle |
| **Mode 2** (Slow Charge) | - Connection by use of standard single-phase or three-phase socket outlets (e.g. BS 1363, BS EN 60309)  
- Supply to EV not exceeding 32A per phase and not exceeding 250V AC single-phase or 480V AC three-phase  
- Control pilot (communication) function provided by an in-cable control box (not via the standard socket-outlet)  
- RCD protection provided between the plug and EV or as part of the in-cable control box |
## Electric Vehicle Charging Overview

<table>
<thead>
<tr>
<th>Charging Mode</th>
<th>Electric Vehicle Supply Equipment (EVSE) (continued)</th>
</tr>
</thead>
</table>
| **Mode 3**    | - Connection by use of dedicated single-phase or three-phase socket outlets, or via a tethered cable  
               |  
               | - Supply to EV not exceeding 63A per phase and not exceeding 250V AC single-phase or  
                 |  
               | - 480V AC three-phase  
               |  
               | - Control pilot (communication) function provided by the equipment via the dedicated socket-outlet or tethered cable  
               |  
               | - RCD protection provided as part of the equipment or supply circuit |

**Mode 3**  
(Fast Charge)

![Image of Mode 3 EVSE]

| **Mode 4**    | - Connection by use of a tethered cable  
               |  
               | - Supply to the EV from the dedicated charging equipment is DC (typically 500V 125A)  
               |  
               | - Control pilot (communication) function provided by the equipment |

**Mode 4**  
(Rapid Charge)

![Image of Mode 4 EVSE]
## 2.2 Charging Durations

<table>
<thead>
<tr>
<th>Charging Mode</th>
<th>Variant</th>
<th>Power Output*</th>
<th>Example</th>
<th>Estimated Charge Time**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode 1</strong> (Standard Charge)</td>
<td>13A BS 1363 Socket Single Phase</td>
<td>3.0kW</td>
<td><img src="image" alt="13A BS 1363 Socket Single Phase" /></td>
<td>10-12 hours</td>
</tr>
<tr>
<td><strong>Mode 2</strong> (Slow Charge)</td>
<td>16A BS EN 60309 &quot;Commando Socket&quot; Single Phase</td>
<td>3.7kW</td>
<td><img src="image" alt="16A BS EN 60309 &quot;Commando Socket&quot; Single Phase" /></td>
<td>6-8 hours</td>
</tr>
<tr>
<td><strong>Mode 3</strong> (Fast Charge)</td>
<td>16A Tethered Charging Station Single Phase</td>
<td>3.7kW</td>
<td><img src="image" alt="16A Tethered Charging Station Single Phase" /></td>
<td>6-8 hours</td>
</tr>
<tr>
<td><strong>Mode 3</strong> (Fast Charge)</td>
<td>32A Charging Station Single Phase</td>
<td>7.4kW</td>
<td><img src="image" alt="32A Charging Station Single Phase" /></td>
<td>3-4 hours</td>
</tr>
<tr>
<td><strong>Mode 3</strong> (Fast Charge)</td>
<td>32A Charging Station Three Phase</td>
<td>22kW</td>
<td><img src="image" alt="32A Charging Station Three Phase" /></td>
<td>1-2 hours</td>
</tr>
<tr>
<td><strong>Mode 3</strong> (Fast Charge)</td>
<td>63A Charging Station Three Phase</td>
<td>43kW</td>
<td><img src="image" alt="63A Charging Station Three Phase" /></td>
<td>30 minutes</td>
</tr>
<tr>
<td><strong>Mode 4</strong> (Rapid Charge)</td>
<td>500V DC 120A Rapid Charger</td>
<td>50kW</td>
<td><img src="image" alt="500V DC 120A Rapid Charger" /></td>
<td>30 minutes***</td>
</tr>
</tbody>
</table>

*Can vary depending on vehicle and grid voltage. **Based on a 24kW battery pack, times can vary due to vehicle charge regulators. ***charge to 80% capacity.
2.3 Charging Standards

**Type 1 – J1772**

The adopted standard in Japan and the US, Type 1 - J1772 connectors allow single phase charging only, up to 32A (7.4kW). This charging standard incorporates control pilot (communications) functions.

**Type 2 – IEC 62196**

Generally adopted by European manufacturers, Type 2 IEC 62196 connectors allow both single phase and three phase charging up to 63A (43kW) per phase. This charging standard incorporates control pilot (communications) functions.

**JEVS (CHAdEMO)**

Generally adopted by Japanese and US manufacturers, CHAdeMO is a connector used on DC Rapid Chargers only and is able to deliver up to 62.5kW of high voltage DC.

**CCS Combo**

The DC Combo charging standard combines both AC and DC charging in a single connector. Type 1 and Type 2 variants are available which can deliver up to 90kW.

---

<table>
<thead>
<tr>
<th>Standard</th>
<th>Plug</th>
<th>Socket</th>
<th>Compatible Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 – J1772</td>
<td><img src="image1.png" alt="Type 1 Plug" /></td>
<td><img src="image2.png" alt="Type 1 Socket" /></td>
<td>Chevrolet Volt&lt;br&gt;Citroen C-Zero&lt;br&gt;Fisker Karma&lt;br&gt;Ford C-Max Energi&lt;br&gt;Ford Focus Electric Mia&lt;br&gt;Mia Electric Van&lt;br&gt;Mitsubishi I-Miev&lt;br&gt;Mitsubishi Outlander PHEV&lt;br&gt;Nissan NV200 SE Van&lt;br&gt;Nissan Leaf&lt;br&gt;Peugeot Ion&lt;br&gt;Renault Fluence&lt;br&gt;Renault Kangoo&lt;br&gt;Smiths Edison Van&lt;br&gt;Smiths Newton&lt;br&gt;Tata Indica Vista EV&lt;br&gt;Toyota Prius&lt;br&gt;Vauxhall Ampera</td>
</tr>
</tbody>
</table>
## Electric Vehicle Charging Overview

| Type 2 – IEC 62196 | Audi A3 e-Tron  
|                   | BMW i3  
|                   | BMW i8  
|                   | Chevrolet Spark  
|                   | Mercedes B Class E-cell  
|                   | Mercedes SLS EV  
|                   | Mercedes E-Cell Van  
|                   | Porsche Panamera S  
|                   | PHEV  
|                   | Renault Zoe  
|                   | Smart  
|                   | Smart 2  
|                   | Smart 3  
|                   | Tesla  
|                   | Volkswagen e-Up  
|                   | Volkswagen e-Golf  
|                   | Volvo V60 PHEV  
| JEVS (CHAdeMO) | Citroen C-Zero  
|               | Mitsubishi i-Miev  
|                | Mitsubishi Outlander PHEV  
|                   | Nissan Leaf  
|                   | Peugeot Ion  
| CCS Combo | BMW i3  
|          | BMW i8  


2.4 Communications Protocol

Mode 3 and 4 Electric Vehicle charging standards require communication between the Electric Vehicle and charging station. The communication is needed for battery power monitoring/management, charge rate management and safety.

On connecting an Electric Vehicle to a Mode 3 or 4 charging station, communication takes place between both devices. Charge rate is defined, safety checks are carried out and then a managed charging session is delivered. The communications protocol will end the charging session when required (whether safety or battery derived) and make the charging station safe.

3. Payment Systems

Many publicly accessible charging stations require payment before a charging session is allowed. Payment systems may also be introduced in commercial premises as a method of managing benefit-in-kind tax. There are several methods of taking payment available including a very basic coin/token payment system or an NFC reader. However, the most common method of taking payment from an EV driver at present is through the use of a network membership scheme.

Network membership schemes provide EV drivers with an RFID access card which allows them to access any charging stations which are registered on the network. There is often a cost associated with joining such a scheme and charging sessions are then billed to the EV driver, usually by Direct Debit or deducted from pre-purchased credits.

At present there are several network operators hosting membership schemes, some of which are detailed below:

- Charge-Your-Car [www.chargeyourcar.org.uk](http://www.chargeyourcar.org.uk)
- Chargemaster [www.chargemasterplc.com/polar_online](http://www.chargemasterplc.com/polar_online)
- ChargePoint Genie [www.chargepointgenie.com](http://www.chargepointgenie.com)
- Ecotricity [www.ecotricity.co.uk/for-the-road](http://www.ecotricity.co.uk/for-the-road)
- PodPoint [www.pod-point.com/](http://www.pod-point.com/)
- Franklin Energy [www.franklinenergy.co.uk/](http://www.franklinenergy.co.uk/)
- Source East [www.sourceeast.net/](http://www.sourceeast.net/)
- Source London [www.sourcelondon.net/](http://www.sourcelondon.net/)

When planning a journey in an electric vehicle it is worth planning your trip in advance and considering whether membership to a network will be required.
4. Design Considerations

4.1 Cable and Switchgear Selection

For design purposes Electric Vehicle charging stations are to be considered “full load” devices with no diversity factor applied. This means that all cabling and switchgear must be selected and erected on the assumption that the charging station will be drawing a full and constant load.

4.2 Residual Current Protection

Every charging station installation must be protected by an RCD as stated in BS7671:2008 the 17th Edition of the Wiring Regulations:

“Every charging point shall be individually protected by an RCD. The RCD shall disconnect all live conductors, including the Neutral.

The RCD protecting the charging point shall be at least a Type A RCCB (pulse DC detecting). If it is known the DC component of the residual current exceeds 6mA then a Type B RCD (DC detecting) shall be installed.”

Most charging stations are supplied with built-in RCD protection. When installing a charging station with built-in RCD protection, installers need to be aware of existing RCD’s in consumer units/distribution boards and ensure discrimination is considered.

4.3 Earthing and Bonding

If any alteration or addition is being made to an electrical installation, the electrician is required to first check, amongst other things, that the existing earthing and bonding arrangements are adequate. This is because the safety of any new work, however minor, will depend on those earthing and bonding arrangements (as does the safety of your existing installation). Bonding is installed on all incoming services to a building such as water supplies, gas supplies, oil supplies and structural steelwork. No work can be carried out until the adequacy of the earthing and bonding has been confirmed.

4.4 Earthing Electrodes

Depending on the type of earthing system provided to a property and the location of the charging point, an earthing electrode may be required (typically a ‘rod’).

TN-C-S (PME) earthing systems use a combined protective (earth) and neutral conductor in order to return current flow to the star point of a supplier’s transformer. As the neutral and earth conductors are joined, it is possible for current to flow through any metallic objects which are part of the electrical installation, for example; bonded water pipes or gas pipes. As everything in the property is connected, no differences in potential exist which means electric shock is not possible, this is called an equipotential zone. Careful consideration is required when siting an EV charger to avoid exporting an equipotential zone to an area where a difference in potential may be experienced, for example, at the end of a driveway. In this situation, the charging station should be isolated from the suppliers PME earthing system and earthed to an electrode. This ensures no differences in potential are present and reduces the risk of electric shock.
4.5 Maximum Demand Assessment

When considering the installation of EVSE on an existing supply, the IET Code of Practice highlights the installer’s responsibility to “Assess the adequacy of the supply capacity for the new electric vehicle load plus any existing load, before installing the charging equipment”.

An ‘adequacy of the supply’ assessment, highlighted in the IET Code of Practice, is required prior to any EVSE installation. This requires a load survey to calculate the maximum demand including the new electric vehicle charging equipment at the property.

The Phoenix Works offer clients the option of carrying out the maximum demand survey remotely by use of a monitoring device. The information provided by the monitoring device allows us to assess the maximum demand of the property and ascertain whether the installation of EVSE is feasible within the existing supply limits.

Where an electricity supply is found to be unsuitable for EVSE installation it is possible to contact the local Distribution Network Operator (DNO) and request an increase in capacity.

The implications of installing EVSE on an electricity supply with high demand could result in overloading and the potential for fire.
5. Referees

With over 2500 Electric Vehicle charging stations installed to date, The Phoenix Works have extensive experience with a wide variety of manufacturers and models of Electric Vehicle charging station. Please find some project specific referees below:

5.1 City of York Council

The Phoenix Works have successfully managed, designed and installed several Electric Vehicle charging projects for City of York Council. The projects have many challenges including significant civil works, DNO applications and management of grid infrastructure upgrades. In 2015, The Phoenix Works were appointed to manage, design and install an Electric Vehicle rapid charging project in York City Centre. The project was partially funded by the Office of Low Emission Vehicles (OLEV) who set a strict completion date. The project had many challenges including significant civil works, site management and electrical design. In order to complete this project in the timescale dictated, The Phoenix Works installed seven 50kW rapid charging stations in 6-days; this included civil and electrical works.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Nature of Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of York Council</td>
<td>Hazel Court Eco Depot James Street York YO10 3DS</td>
<td>Multiple electric vehicle charging station installations</td>
</tr>
</tbody>
</table>
5.2 Zero Carbon World

The Phoenix Works are approved contractors for the Zero Carbon World charity and have worked closely together to install over 100 Electric Vehicle charging stations for a wide variety of commercial customers including Best Western Hotels, Marriott Hotels, Hilton Hotels, many guest houses, large independent hoteliers, churches and restaurants across the UK.

<table>
<thead>
<tr>
<th>Company Name Address</th>
<th>Nature of Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Carbon World Ltd 30 Gay Street Bath BA1 2PA</td>
<td>Multiple electric vehicle charging station installations</td>
</tr>
</tbody>
</table>
5.3 Leeds City Council

In 2014 The Phoenix Works successfully tendered for the installation of 8 Electric Vehicle charging outlets at a new Park and Ride in Leeds, West Yorkshire. The project had to be completed to a strict deadline and to the highest standards. Design, installation and management were all carried out in-house by The Phoenix Works.

Referee Details

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Leeds City Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Highways and Transportation Ring Road Middleton Leeds LS10 4AX</td>
</tr>
<tr>
<td>Nature of Contract</td>
<td>Multiple electric vehicle charging station installations</td>
</tr>
</tbody>
</table>
5.4 Charge Point Services – Domestic Installations

Working in an on-going partnership with Charge Point Services and utilising the OLEV grant scheme, The Phoenix Works install domestic electric vehicle charging stations on a nationwide basis.

| Referee Details |
|------------------|-----------------|-------------------|
| **Company Name** | Charge Point Services | **Address**       |
|                  |                  | 3 Bunhill Row     |
|                  |                  | London EC1Y 8YX   |
|                  |                  | **Nature of Contract** |
|                  |                  | Multiple electric vehicle charging station installations |
5.5 Cumbria County Council

In 2016 The Phoenix Works partnered with APT Controls for the installation of 14 Electric Vehicle charging outlets at multiple locations throughout Cumbria. The project had to be completed to a strict deadline and to the highest standards. Design, installation and management were all carried out in-house by The Phoenix Works. Every site required a new electricity supply installing; The Phoenix Works managed the liaison and logistics of these works.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>APT Controls Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>The Power House</td>
</tr>
<tr>
<td></td>
<td>Headstone Ln</td>
</tr>
<tr>
<td></td>
<td>Harrow</td>
</tr>
<tr>
<td></td>
<td>HA3 6NY</td>
</tr>
<tr>
<td>Nature of Contract</td>
<td>Multiple electric vehicle charging station installations</td>
</tr>
</tbody>
</table>
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Email: info@thePhoenixWorks.com
Web: www.thePhoenixWorks.com
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