Report on the Current Situation and Future Direction of Electric Vehicle Charger Standardisation

July 2010

Contents

Appendices

1. Introduction

1.1 Purpose of the study

The purpose of this report is to identify the current situation, and possible future direction, regarding standardisation of the charging equipment, with specific emphasis on the charge connectors, used for conductive charging of both pure-electric vehicles and plug-in hybrid electric vehicles.

1.2 Scope

The scope of this report is as follows:

- The report covers the components used to connect the vehicle to an electrical supply for the recharging of its battery, ie the vehicle inlet, vehicle connector, outlet socket, plug and cable. A diagram illustrating these components is shown in Appendix 2.

- From a standards perspective, the report predominantly focuses on the standards issued by the International Electrotechnical Commission (IEC) and by the Society of Automotive Engineers (SAE), as these have become the most influential standards in this arena. However, information on standards from other standardisation bodies has been included where relevant.

- From a legal requirements perspective, the report focuses on the European (EC and ECE) and US legal requirements.

- The report covers the legal requirements applicable to all categories of motor vehicle, ie M1, M2, M3, N1, N2 and N3. (Note: Definitions of these vehicle categories are given in Appendix 1.)

- The report only considers pure-electric vehicles and plug-in hybrid electric vehicles.

2. Standards and Recommended Practices

This section gives details of the current status of the standardisation activities relating to electric vehicle charging connectors, including information on both currently published standards and those which are still under development.

2.1 SAE (Society of Automotive Engineers)

The SAE Recommended Practice on electric vehicle charge connectors is SAE J1772 – Electric Vehicle and Plug-in Hybrid Vehicle Charge Coupler, which was revised and re-issued in January 2010. It contains specifications for vehicle inlet and vehicle connector to be used for the conductive AC charging of electric vehicles and plug-in hybrid electric vehicles. Specifications for a conductive DC charge coupler are still under development by the relevant SAE Task Force.

The vehicle inlet and vehicle connector specification contained in SAE J1772 is designed to be compatible with two levels of conductive charging, which are defined within the Recommended Practice as:
AC Level 1 – Single phase, 120V AC, 12A/ 16A, and
AC Level 2 – Single phase, 208-240V AC, ≤ 80A.

The charge coupler design (vehicle inlet and vehicle connector) specified by SAE J1772 is a five pin/contact design with a latching mechanism and an optional locking mechanism. The functions of the five pins/contacts are specified as follows:
Contact 1 – AC Power L1.
Contact 2 – AC Power L2, N.
Contact 3 – Earth (ground).
Contact 4 – Control pilot (allowing communication between the vehicle and the electrical energy supply equipment).
Contact 5 – Proximity detection (allowing the vehicle to detect the presence of the vehicle charge connector and immobilise the vehicle).

SAE J1772 also includes requirements on the data communication, EMC performance, durability, impact resistance, electrical safety and environmental performance of the vehicle charge coupler and its accessories.

Note: SAE J1772 only covers vehicle inlets and the mating vehicle connectors. It does not cover electrical supply outlet sockets and mating plugs. The reasons for this are that:

- Charge cables for AC Level 1 charging are usually fitted with domestic plugs for use with domestic electrical outlet sockets.

- For AC Level 2 charging, it is common practice in the US for the charge cable to form part of the charging station/charge point.

An example of an SAE J1772 type vehicle inlet and vehicle connector is shown in Appendix 4 and a summary of the electrical ratings for this type of charge connector is shown in Appendix 5.

2.2 IEC (The International Electrotechnical Commission)

The IEC standard covering the overall electric vehicle conductive charging system is IEC 61851, which covers equipment for charging electric road vehicles at standard AC voltages up to 690V and at DC voltages up to 1000V. This standard is published in separate parts under the general title "Electric Vehicle Conductive Charging System". The main parts of this standard are:
Part 1: General requirements.
Part 21: Electric vehicle requirements for conductive connection to an AC/DC supply.
Part 22: AC electric vehicle charging station.
Part 23: DC electric vehicle charging station.

IEC 61851 Parts 1, 21 and 22 have been published and are available, but Part 23 is still under development. IEC 61851 Part 1 includes definitions of the "modes" of charging and charge connection "cases". These definitions are reproduced in Appendix 3 for information and reference.

The specific requirements on the plugs, outlet sockets, vehicle connectors and vehicle inlets for the conductive charging of electric vehicles referred to in IEC 61851 are contained in a separate IEC standard; IEC 62196. This standard is published in separate parts under the general title "Plugs, Socket Outlets, Vehicle Couplers and Vehicle Inlets - Conductive Charging of Electric Vehicles". The main parts of this standard are:
Part 1: General requirements.
Part 2: Dimensional interchangeability requirements for AC pin and contact tube accessories.
Part 3: Dimensional interchangeability requirements for DC pin and contact tube accessories.

The First Edition of IEC 62196 Part 1 has been published and is available. A Second Edition version is currently at the Committee Draft Voting stage and is expected to be published in February 2011. IEC 62196 Part 2 is also at the Committee Draft Voting stage and is expected to be published in February 2011. IEC 62196 Part 3 is still under development.

The scope of IEC 62196 Part 1 covers plugs, outlet sockets, vehicle connectors, vehicle inlets and cable assemblies for conductive charging systems with a rated operating not exceeding either 690V AC, at a rated current not exceeding 250A, or 1500V DC, at a rated current not exceeding 400A. It contains requirements on the construction, electrical performance, electrical safety, EMC

performance, durability, impact resistance and environmental performance of charger plugs, outlets, connectors, inlets and cable assemblies.

Note: IEC 62196 covers vehicle inlets and mating vehicle connectors, but also covers electrical supply outlet sockets and mating plugs. This is necessary because, in Europe, charging stations/charge points with permanently attached cables and vehicle connectors (Case C) are not common. Usually, the charging station/charge point only provides an electrical supply outlet socket, suitable for Case A or Case B charging connection.

IEC 62196 Part 2 contains specifications, including dimensional requirements, for three types of connector interface: Type 1, Type 2 and Type 3.

The Type 1 interface, which is equivalent to SAE J1772 and is for use in vehicle inlets and vehicle connectors, is a five pin/contact design, for use with single phase AC, 250V, 32A. However, a note in the standard permits Type 1 vehicle couplers with a rated current up to 80A for the US. The functions of the five pins/contacts are specified as follows:

Contact 1 – Mains 1 (L1).
Contact 2 – Mains 2 (L2), Neutral (N).
Contact 3 – Earth (ground).
Contact 4 – Control pilot (allowing communication between the vehicle and the electrical energy supply equipment).
Contact 5 – Connection switch (allowing the vehicle to detect the presence of the vehicle charge connector and immobilise the vehicle).

The Type 2 interface, which is for use in vehicle inlets, vehicle connectors, outlet sockets and plugs, is a seven pin/contact design, for use with single phase AC, 250V, 20A or 32A, or 63A or 70A, or three phase AC, 380-480V, 20A or 32A, or 63A. The functions of the seven pins/contacts are specified as follows:

Contact 1 – Mains 1 (L1).
Contact 2 – Mains 2 (L2).
Contact 3 – Mains 3 (L3).
Contact 4 – Neutral (N).
Contact 5 – Earth (ground).
Contact 6 – Control pilot (allowing communication between the vehicle and the electrical energy supply equipment).
Contact 7 – Connection switch (allowing the vehicle to detect the presence of the vehicle charge connector and immobilise the vehicle).

The Type 3 interface, which is for use in vehicle inlets, vehicle connectors, outlet sockets and plugs, is a four, five or seven pin/contact design with a shutter to prevent contact with live parts.

It is designed for use with single phase AC, 250V, 16A or 32A, or three phase AC, 380-480V, 32A. The functions of the pins/contacts are specified as follows:

Contact 1 – Mains 1 (L1).

Contact 2 – Mains 2 (L2) - optional.

Contact 3 – Mains 3 (L3) - optional.

Contact 4 – Neutral (N).

Contact 5 – Earth (ground).

Contact 6 – Control pilot (allowing communication between the vehicle and the electrical energy supply equipment).

Contact 7 – Connection switch (allowing the vehicle to detect the presence of the vehicle charge connector and immobilise the vehicle) - optional.

Examples of IEC 62196-2 Type 1, 2 and 3 vehicle inlets and vehicle connectors are shown in Appendix 4 and a summary of the electrical ratings for these types of charge connector are shown in Appendix 5.

As stated previously, the Type 1 charge connector is basically equivalent to SAE J1772.

The Type 2 charge connector was developed by a consortium of predominantly German companies, including vehicle manufacturers such as Daimler, energy companies such as RWE and Mennekes, a leading manufacturer of electrical plugs and connectors. The Type 2 connector has been widely adopted for the electric vehicle demonstration projects in Germany (eg Berlin, Aachen, etc) and many of the major European vehicle manufacturers have begun to adopt this connector for the vehicle inlet and vehicle connector. However, the main obstacle to its adoption as the standard charge connector for both the vehicle side and the electrical supply side for the whole of Europe is that some European countries have national building codes/regulations on electrical installation which require electrical contacts to be "shuttered" and the Type 2 connector does not have "shutters". The IEC are currently attempting to establish how many European countries have requirements for electrical contacts to be "shuttered" in their national building codes/regulations to understand the scale of this problem.

The Type 3 charge connector was specifically developed to address the "shutter" issue and the vehicle inlet, vehicle connector, outlet socket and plug specifications include "shutters". The Type 3 connector is being supported and promoted by the "EV Plug Alliance", which was originally an alliance formed between Schneider Electric, Legrand and SCAME. However, since its inception in March 2010, Gewiss, Marechal Electric, Radiall, Vimar, Weidmuller France and Yazaki Europe have also joined the EV Plug Alliance.

2.3 Japan

Whilst both the SAE and the IEC are still developing standards for DC charging, in Japan a standardised DC charging system has already been developed and adopted which allows DC charging at up to 500V DC at up to 125A. The vehicle inlet and vehicle connector for this DC charging system is covered by Japan Electric Vehicle Standard (JEVS) G 105-1993 – Eco-system connector for electric vehicle charging station, which has been published by the Japanese Automotive Research Institute (JARI). This Japanese DC charging system was developed by a number of Japanese automotive manufacturers in association with the Tokyo Electric Power Company (TEPCO) and the connector is often referred to as the TEPCO connector.

This DC charging system is known as CHAdeMO and in March 2010, Toyota, Nissan, Mitsubishi, Fuji Heavy Industries and the Tokyo Electric Power Company formally established a "CHAdeMO Association" to "increase quick charger installations worldwide" and "standardise how to charge vehicles". Already, some DC charging equipment manufacturers in both Europe and North America have signed up to the CHAdeMO Association and are developing chargers using the CHAdeMO protocol.

3. Legal Requirements

This section gives details of the current legal requirements relating to electric vehicle charge connectors and on the expected development of legal requirements in this area.

3.1 Europe

Currently, there are no European legal requirements which specify the type or design of connector to be used for the conductive charging of electric vehicles. However, United Nations Economic Commission for Europe (ECE) Regulation No 100 on the construction, functional safety and hydrogen emissions of pure-electric vehicles does contain the following requirements on the charging systems of electric vehicles:

- "In no case shall the vehicle be capable to move by its own means when it is galvanically connected to an energy supply network or to an off-board charger."
- "The components used when charging the battery from an external source shall allow the charging current to be cut in case of disconnection without physical damage."
- "The coupling system parts likely to be live shall be protected against any direct contact in all operating conditions."
- "All exposed conductive parts shall be electrically linked through a conducting wire plugged to earth when charging."

The 01 series of amendments to ECE Regulation No 100, referred to as ECE 100.01, have recently been adopted and extend the scope of the Regulation to include hybrid electric vehicles. Although the 01 series of amendments contain a number of significant revisions to the technical requirements of ECE 100, the requirements specifically relating to the charging system have remained predominantly unchanged.

Over the past few months, the European Commission has developed a draft mandate addressed to CEN, CENELEC and ETSI requesting them rapidly to develop and review standards relating to the charging of electric vehicles. The final version of this mandate was officially handed over to CEN, CENELEC and ETSI on 1 July 2010. However, the Commission has not indicated that it will introduce legislation to mandate compliance with any of the resulting standards.

If the type of charge connector were to be mandated in European legislation, this would most likely happen via an amendment to ECE 100. However, no such proposals have yet been suggested or discussed within the relevant ECE working group.

Note: Compliance with ECE 100 is mandatory for European Whole Vehicle Type Approval (ECWVTA).

3.2 US

The only US legal requirement which specifies the type of connector to be used for the conductive charging of electric vehicles is the California Code of Regulations (CCR), Title 13, Division 3. Section 1962.2 of these Regulations states that:

"Beginning with the 2006 model year, all vehicles [apart from those which are only capable of being charged from a standard household electrical socket] must be equipped with a conductive charger inlet port which meets all the specifications contained in Society of Automotive Engineers (SAE) Surface Vehicle Recommended Practice SAE J1772 REV NOV 2001, SAE Electric Vehicle Conductive Charger Coupler, which is incorporated herein by reference. All such vehicles must be equipped with an on-board charger with a minimum output of 3.3 kilovolt amps."

In 2008, the California Air Resources Board (CARB) published a draft amendment to section 1962.2 of the California Code of Regulations (CCR), Title 13, Division 3, to refer to the latest level of the SAE Recommended Practice. The proposed new wording for section 1962.2 contained in the draft amendment is as follows:

"Beginning with the 2010 model year, all vehicles [electric and plug-in hybrid] must be equipped with a conductive charger inlet port which meets all the specifications contained in Society of Automotive Engineers (SAE) Surface Vehicle Recommended Practice SAE J1772 REV JAN 2010, SAE Electric Vehicle Conductive Charger Coupler, which is incorporated herein by reference. All such vehicles must be equipped with an on-board charger with a minimum output of 3.3 kilovolt amps or an on-board charger with sufficient power capability to restore 95% of ARB certification UDDS range or Equivalent All Electric Range in four hours or less."

Adoption of this draft amendment was postponed in 2008, pending final publication of the amended SAE Recommended Practice. However, this amendment is expected to be adopted as part of a package of revisions to the Californian ZEV Regulations later this year.

4. ACEA Recommendations

On 24 June 2010, The European Automobile Manufacturers Association (ACEA) issued a press release stating that "European automobile manufacturers have defined joint specifications to connect electrically chargeable vehicles to the electricity grid in a safe and user-friendly way". The recommendations adopted by ACEA are intended to "enable the relevant EU standardisation bodies to make rapid progress with defining a common interface between the electricity infrastructure and vehicles throughout Europe" and "provide decisive guidance to public authorities that are planning investments in public charging spots".

The recommendations adopted by ACEA, which include a large number of caveats, only cover AC conductive charging of passenger cars and light commercial vehicles. Recommendations covering DC charging and the AC conductive charging of heavy duty vehicles are still under development.

ACEA has divided the timeframe of its recommendations into two distinct phases. The Phase 1 recommendations are applicable now until a point in time where the relevant standards have been finalised and published, and sufficient lead time has been permitted for their implementation (a date of 2017 is suggested in the recommendations). The Phase 2 recommendations become applicable once the relevant standards have been finalised and published, and sufficient lead time has been permitted for their implementation.

The Phase 1 recommendations can be summarised as follows:

- There should be no restrictions on the type of vehicle inlet and vehicle connector. However, vehicle manufacturers must provide at least one charging cable with the vehicle that is fitted with either a Type 2 plug for Mode 3 charging or a domestic plug for Mode 2 charging.
- Public charging points should be provided with a Type 2 outlet socket for Mode 3 charging. Where the charging cable forms part of the public charging point, a separate Type 2 outlet socket outlet should also be provided. Industrial (IEC 60309) outlet sockets are permissible during this transitional period.
- For home charging, standard domestic outlet sockets may be used for Mode 2 charging. Alternatively, Type 2 outlet sockets for Mode 3 charging or Industrial (IEC 60309) outlet sockets for Mode 2 charging may be provided.

The Phase 2 recommendations basically specify that Mode 3 charging should become the standard charging mode, using the outlet sockets, plugs, vehicle inlets and vehicle connectors defined in conjunction with the ongoing CEN/CENELEC/ETSI activities. However, in their recommendations, ACEA do express strong support for the Type 2 connector.

5. Survey of Vehicle Manufacturers

In March 2010, the SMMT Electric Vehicle Group circulated a questionnaire to its members requesting information on the charging equipment and connectors that they were specifying for their vehicles. Responses were received from 13 companies, covering 20 vehicle models. The responses covered 12 passenger car models, six light goods vehicle models and two heavy goods vehicle models, and included information on vehicles which are currently available and on vehicles which are due to be introduced over the next couple of years.

An analysis of the responses to the questionnaire has highlighted the following points:

- All of the vehicles are supplied with a charging cable.
- The majority of the vehicles (55%) are designed to be charged by a single phase, 230V, 13A/16A supply.
- 35% of the vehicles are designed to be charged by a three phase supply.
- 40% of the vehicles are designed to be charged at 32A and above.
- Only three of the vehicles are designed to accept DC charging. However, some other manufacturers stated that they are considering DC charging for the future.
- 45% of the vehicles currently utilise IEC 62196-2 Type 1/SAE J1772 connectors for the vehicle inlet and the vehicle connector. However, two of these vehicles will switch to IEC 62196-2 Type 2 connectors in the next two years.
- Only 10% of the vehicles currently utilise IEC 62196-2 Type 2 connectors for the vehicle inlet and the vehicle connector.
- 45% of the vehicles utilise the IEC 62196-2 Type 2 connector for the plug.

A summary of the responses to the main points covered by the questionnaire, in chart form, is given in Appendix 6. A full summary of the responses to the questionnaire is given in Appendix 7.

6. Charge Connector Suppliers

Currently, the main supplier of SAE J1772 type charge connectors is Yazaki and the main supplier for IEC 62196-2 Type 2 connectors is Mennekes. However, as the market for electric vehicles and plug-in hybrid vehicles grows, the number of suppliers offering such products is gradually increasing. Also, SCAME is planning to start production of IEC 62196-2 Type 3 connectors in the near future.

A list of the currently identified electric vehicle charge connector suppliers is given in Appendix 8.

7. Charging Infrastructure

7.1 UK

Currently, publicly available electric vehicle charging points are available at around 100 locations in the UK, with some locations offering multiple charging points. London has the greatest number of charging points, with over 250 publicly available charging points at around 70 different locations. Almost all of the currently available charging points provide an outlet socket and require the use of a detachable charging cable, with the vast majority providing a 240V/13A electrical supply via a domestic three pin outlet socket. A small number provide a 240V/16A electrical supply via an IEC 60309 industrial outlet socket, known as a "blue commando". An example of a typical current UK charging point is shown in Appendix 9.

Thanks to the "Plugged-in Places" scheme, the number of electric vehicle charging points is due significantly to increase over the next few years. The first three regions to receive "Plugged-in Places" grants are London, Milton Keynes and the North East. Between them, they plan to have 2,500 additional charging points available in their first year and over 11,000 in the next three years.

Due to the current uncertainty regarding standardised charging connectors, most of these charging points will initially provide a 240V/13A electrical supply via a domestic 3 pin outlet socket. However, all three regions have stated their intention to provide these new charging points with an electrical supply to allow their upgrade to higher voltages and currents once the charge connector standardisation issues are resolved. Also, these three regions plan to install a small number of CHAdeMO type DC charging points.

7.2 Mainland Europe

Currently, in mainland Europe, publicly available electric vehicle charging points are only available in those cities that are running electric vehicle demonstration projects, such as Berlin, Paris, etc. Whilst it is common for these charging points to provide an outlet socket and require the use of a detachable charging cable, other aspects of the charging points tend to vary from city to city. However, the RWE charging point, featuring an IEC 62196-2 Type 2 outlet socket, is the type being used in all of the German cities running electric vehicle demonstration projects (eg Berlin, Aachen, etc) and is being used in some other European cities, such as Amsterdam. An example of a typical current German charging point is shown in Appendix 9.

7.3 US

In the US, it is common practice for the charge cable to be permanently attached to the charging point. The majority of the publicly available electric vehicle charging points are located in California, where there are well over 1,000 publicly available charging points at more than 600 different locations. Approximately half of these charging points provide inductive charging via paddles and, of the conductive charging points, a high proportion of them are fitted with Avcon vehicle connectors. However, this still leaves a significant number of conductive charging points fitted with an SAE J1772 vehicle connector. An example of a typical current US charging point is shown in Appendix 9.

Virtually all of the new charging points being installed in the US will be fitted with SAE J1772 vehicle connector and many of the existing charging points are being upgraded to SAE J1772

8. Conclusions

The main conclusions of this report may be summarised as follows:

- The SAE J1772 vehicle inlet and vehicle connector are rapidly becoming the accepted charging connector for the US and are likely to become mandated by Californian legislation in the near future.

- SAE J1772 compliant vehicle inlets and vehicle connectors are already available from at least one supplier, with other suppliers due to begin production by the end of 2010.

- Whilst the SAE J1772 vehicle inlet and vehicle connector provide an excellent solution for the US market, where three phase electrical supply is not commonly available and where it is common practice for the charge cable to form part of the charging point, they do not provide an ideal solution for Europe.

- The IEC 62196-2 Type 2 vehicle inlet, vehicle connector, outlet socket and plug appears to offer a better solution for the European market, permitting single or three phase charging at up to 70A.

- IEC 62196-2 Type 2 vehicle inlets, vehicle connectors, outlet sockets and plugs are already available from at least one supplier, with other suppliers due to begin production by the end of 2010.

- The European Automobile Manufacturers Association (ACEA) favour the IEC 62196-2 Type 2 connector.

- The main obstacle to the adoption of the IEC 62196-2 Type 2 connector as the standard European charge connector is that some European countries have national building codes/regulations on electrical installation which require electrical contacts to be "shuttered" and the IEC 62196-2 Type 2 connector specification does not include "shutters".

- The IEC 62196-2 Type 3 vehicle inlet, vehicle connector, outlet socket and plug may provide a solution as they have the necessary "shutters" and permit single or three phase charging at up to 32A.

- Currently, no suppliers have IEC 62196-2 Type 3 vehicle inlets, vehicle connectors, outlet sockets and plugs in production, although one supplier is planning to have them available by the end of 2010.

- As neither the SAE nor the IEC have yet finalised their standards on DC charging equipment and connectors, there is still an opportunity for a global harmonised standard for DC charging equipment and connectors.

The Japanese CHAdeMO DC charging system and JEVS G 105 (TEPCO) connector are already gaining worldwide acceptance as the standards for DC charging.

Appendix 1

European Vehicle Category Definitions

M1 – Vehicles designed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.

M2 – Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5000 kg.

M3 – Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5000 kg.

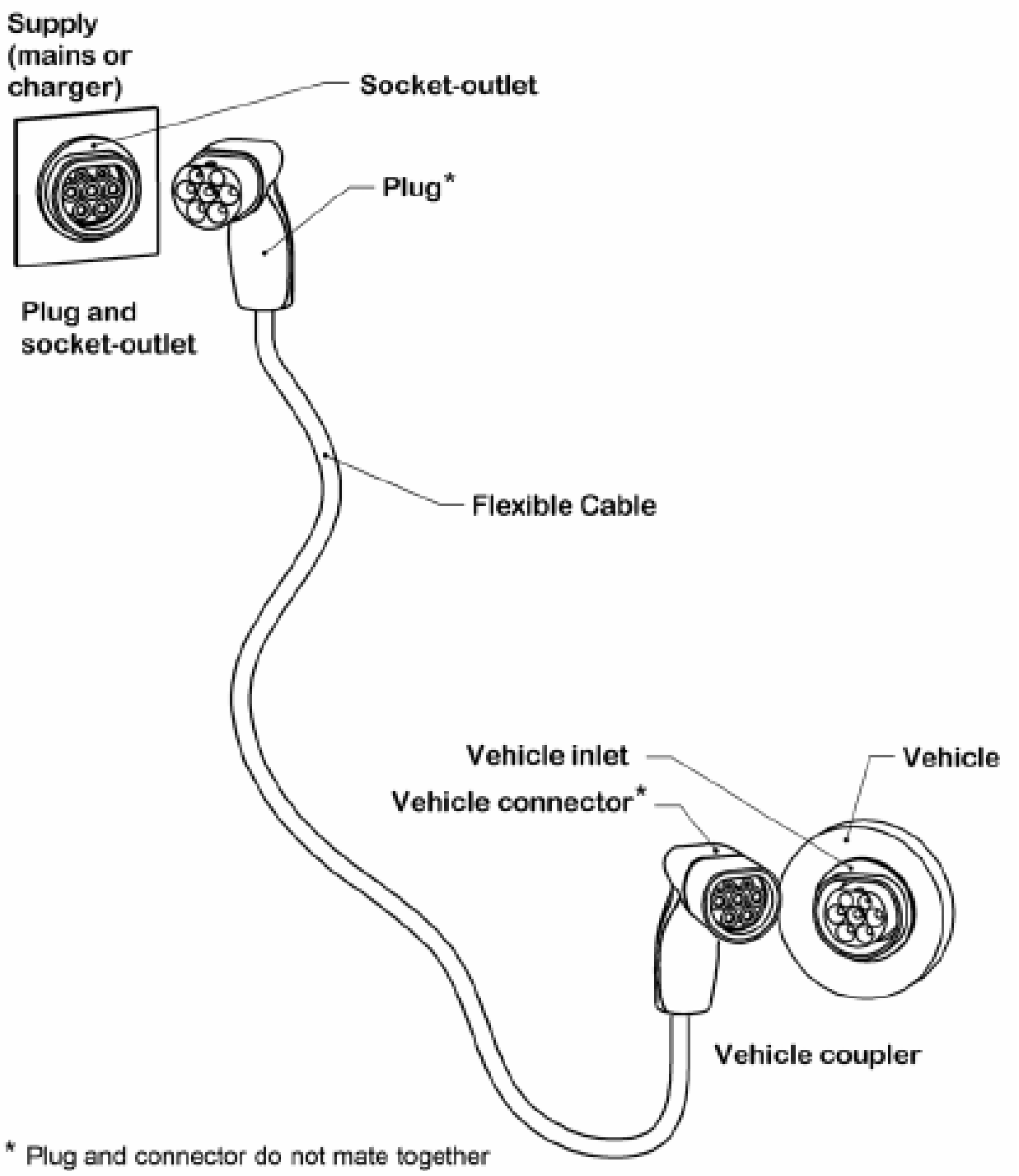
N1 – Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3500 kg.

N2 – Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3500 kg, but not exceeding 12000 kg.

N3 – Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12000 kg.

Appendix 2

Diagram showing the Charge Connector Components



Appendix 3

Definitions of Charging Modes and Charging Connection Cases from IEC 61851-1

Charging modes:

Mode 1 charging – Connection of the electric vehicle to the AC supply network utilising standardised socket outlets, rated up to 16A, at the supply side, single phase or three phase, and utilising phase(s), neutral and protective earth conductors. The use of Mode 1 charging depends on the presence of a residual current device (RCD) on the supply side. Where the presence of an RCD on the supply side cannot be ensured by national codes, Mode 1 charging is not possible.

Mode 2 charging – Connection of the electric vehicle to the AC supply network utilising standardised socket outlets, single phase or three phase, and utilising phase(s), neutral and protective earth conductors together with a control pilot conductor between the electric vehicle and the plug or in-cable control box.

Mode 3 charging – Direct connection of the electric vehicle to the AC supply network utilising dedicated electric vehicle supply equipment where the control pilot conductor extends to equipment permanently connected to the AC supply network.

Mode 4 charging – Indirect connection of the electric vehicle to the AC supply network utilising an off-board charger where the control pilot conductor extends to equipment permanently connected to the AC supply.

Type of Charging Connection:

Case A – connection of an electric vehicle to the AC supply network utilising a supply cable and plug permanently attached to the electric vehicle.

Case B – connection of an electric vehicle to the AC supply network utilising a detachable cable assembly with a vehicle connector and AC supply equipment.

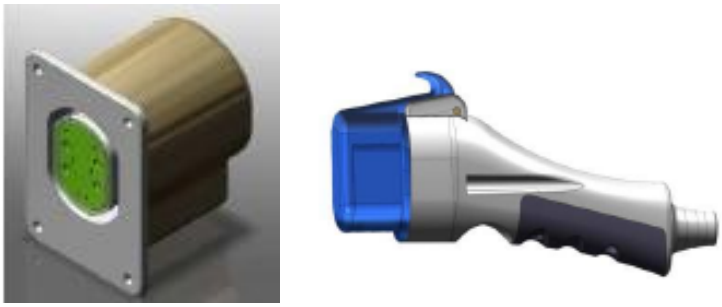
Case C – connection of an electric vehicle to the AC supply network utilising a supply cable and vehicle connector permanently attached to the supply equipment. Only case C is allowed for Mode 4 charging.

Appendix 4

Examples of Electric Vehicle Charge Connectors

SAE J1772 / IEC 62196-2 Type 1 Vehicle Inlet and Vehicle Connector
(Yazaki example shown)

IEC 62196-2 Type 2 Vehicle Inlet and Vehicle Connector
(Mennekes example shown)



IEC 62196-2 Type 3 Vehicle Inlet and Vehicle Connector
(SCAME example shown)

Appendix 5

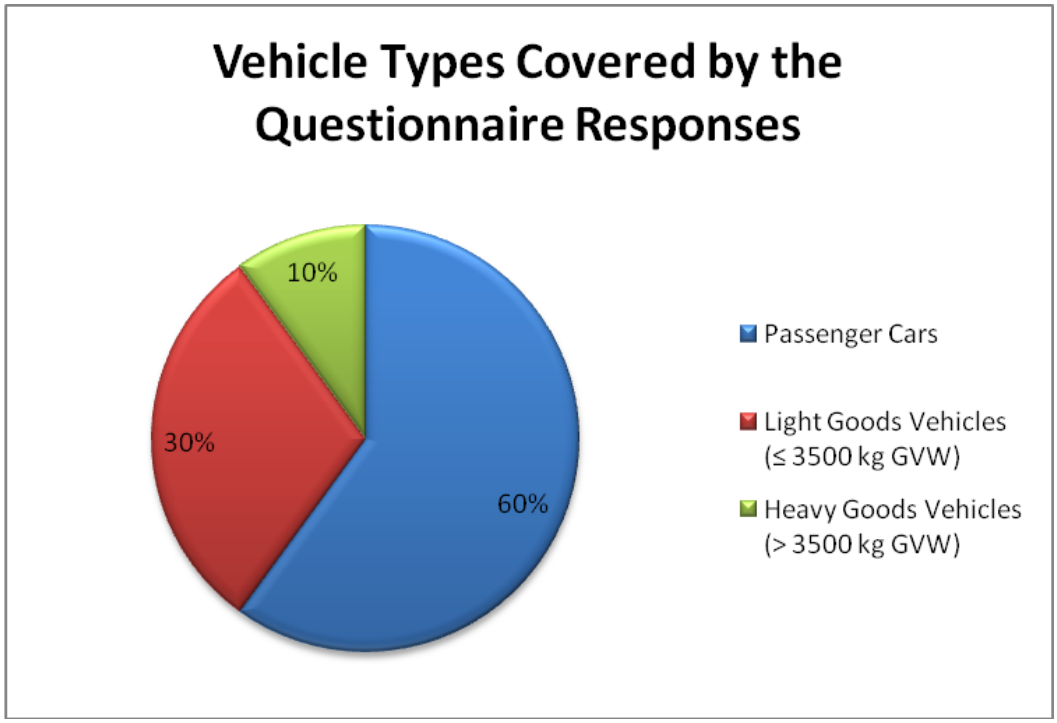
Summary of Charge Connector Ratings

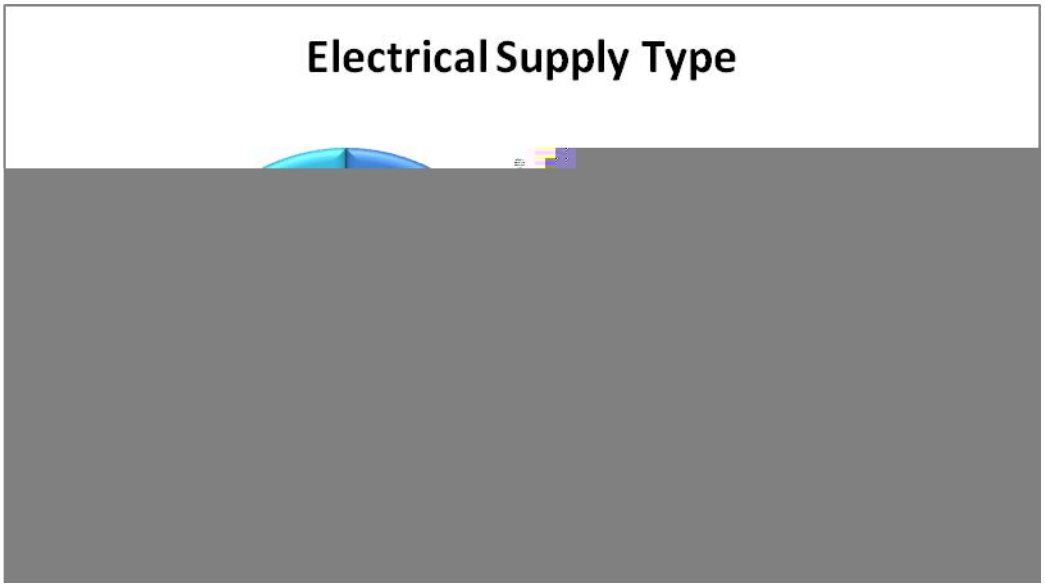
Connector Type	Single Phase / Three Phase	Rated Voltage	Rated Current
SAE J1772	Single phase	120V	12A
			16A
		208-240V	≤ 80A
IEC 62196 -2 Type 1	Single phase	250V	32A
			≤ 80A *
IEC 62196 -2 Type 2	Single phase	250V	20A
			32A
			63A
			70A
	Three phase	380-480V	20A
			32A
			63A
IEC 62196 -2 Type 3	Single phase	250V	16A
			32A
	Three phase	380-480V	32A

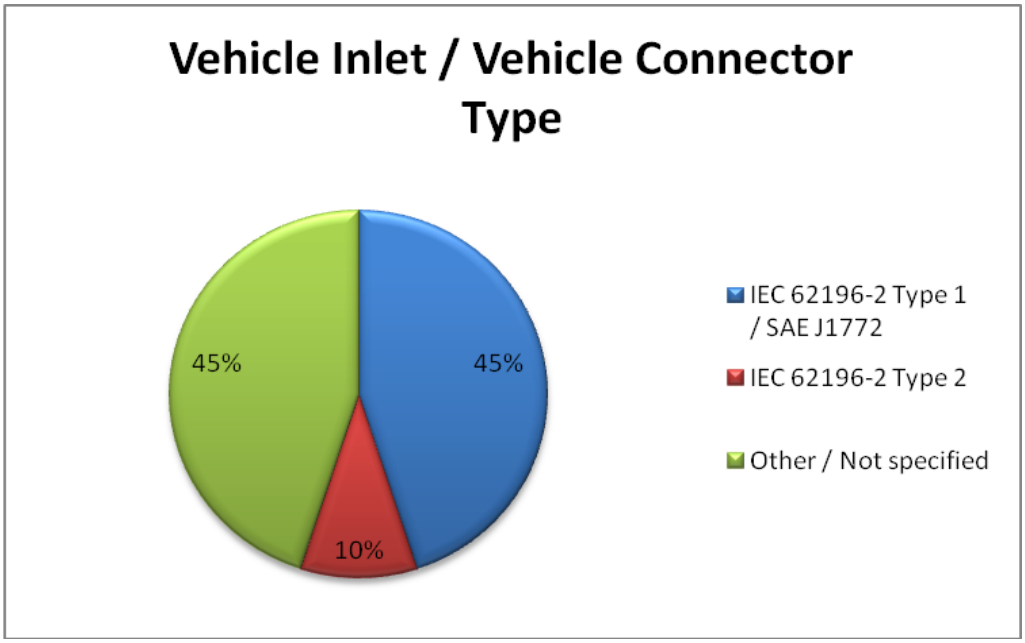
* For US only

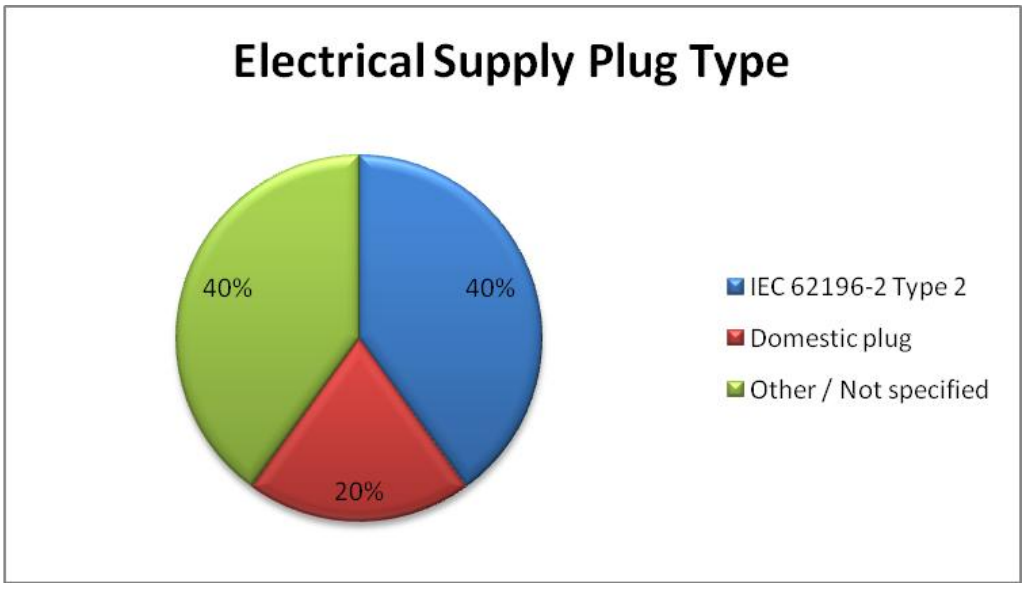
Appendix 6

SMMT Charger Survey: Summary of Responses to Main Points






Vehicle Inlet / Vehicle Connector Type
45%
45%
10%
IEC 62196-2 Type 1 / SAE J1772
IEC 62196-2 Type 2
Other / Not specified


Electrical Supply Plug Type
40%
40%
20%
IEC 62196-2 Type 2
Domestic plug
Other / Not specified

Appendix 7

SMMT Charger Survey: Full Summary of Responses

	Electric Passenger Car 1	**Electric Passenger Car 2**	**Electric Passenger Car 3**	**Electric Passenger Car 4**	**Electric Passenger Car 5**
Supply type	Single phase 13A	Single phase 13A	Single phase 16A	Single phase 16A / 13A	Single and three phase up to 63A
Vehicle inlet type	Cable attached to vehicle	IEC 62196-2 Type 1 SAE J1772 Yazaki	IEC 62196-2 Type 1 SAE J1772 Yazaki	SAE J1772 Yazaki	IEC 62196-2 Type 2
Vehicle connector type	Cable attached to vehicle	IEC 62196-2 Type 1 SAE J1772 Yazaki	IEC 62196-2 Type 1 SAE J1772 Yazaki	SAE J1772 Yazaki	IEC 62196-2 Type 2
Plug type	IEC 62196-2 Type 2	Domestic	Domestic	Domestic, IEC 62196-2 Type 2 or 3	IEC 62196-2 Type 2
Supply voltage	Information not supplied	230V	230V +10% / -6%	240V	Information not supplied
Charge cable rating	Information not supplied	Information not supplied	16A	240V 16A 3.3kW	Information not supplied
Battery charging capability	Information not supplied	Information not supplied	400V 150A	Single phase AC -16A DC – 500V	Information not supplied
Other information	Planning AC fast charging up to 43 kW	Also capable of DC charging using CHAdeMO protocol	Also capable of DC charging using CHAdeMO protocol	Also capable of DC charging using CHAdeMO protocol	Planning AC fast charging up to 43 kW
	Electric Passenger Car 6	**Plug-in Hybrid Passenger Car 1**	**Electric Passenger Car 7**	**Plug-in Hybrid Passenger Car 2**	**Electric Passenger Car 8**
Supply type	Single phase 13A	Single phase 12A	Single phase 13A	Single phase 13A / 16A	Single or three phase 32A
Vehicle inlet type	IEC 62196-2 Type 1	SAE J1772 Yazaki	SAE J1772 Yazaki	SAE J1772	Information not supplied
Vehicle connector type	IEC 62196-2 Type 1	SAE J1772 Yazaki	SAE J1772 Yazaki	SAE J1772	SCAME 086
Plug type	IEC 62196-2 Type 2	Domestic	IEC 62196-2 Type 2	Domestic	SCAME

Supply voltage	230V +10% / -6%	230V +10% / -6%	Information not supplied	230V	240V or 440V
Charge cable rating	230V 16A	230V 12A	Information not supplied	Information not supplied	440V 32A
Battery charging capability	230V 16A	230V 12A	Information not supplied	Information not supplied	440V 32A 10kW
Other information	Anticipating single phase 230V / 32A charging, with three phase at a later date		Planning to change to IEC 62196-2 Type 2 vehicle inlet and connector, allowing single and three phase charging up to 63A		Currently reviewing future charging options
	Electric Passenger Car 9	**Electric Passenger Car 10**	**Electric Light Commercial Vehicle 1**	**Electric Light Commercial Vehicle 2**	**Electric Light Commercial Vehicle 3**
Supply type	Single phase 70A	Single phase 13A	Single phase 13A	Single phase 13A	Three phase 16A
Vehicle inlet type	Vehicle specific	Not yet defined	SAE J1772 Yazaki	IEC 62196-2 Type 1	IEC 62196 Type 2
Vehicle connector type	Vehicle specific	Not yet defined	SAE J1772 Yazaki	IEC 62196-2 Type 1	IEC 62196 Type 2
Plug type	IEC 60309	Not yet defined	IEC 62196-2 Type 2	IEC 62196-2 Type 2	IEC 62196 Type 2
Supply voltage	208 – 230V +10% / -10%	120 – 240V	Information not supplied	230V +10% / -6%	400V -5%
Charge cable rating	200-250V 32A 8kW	Not yet defined	Information not supplied	230V 16A	Up to 11 kW
Battery charging capability	250V 70A 17.5kW	> 30kW	Information not supplied	230V 16A	400V 16A 6.6kW
Other information	Might switch to SAE J1772 connectors for future vehicles, also planning DC fast charging		Planning to change to IEC 62196-2 Type 2 vehicle inlet and connector, allowing single and	Anticipating single phase 230V / 32A charging, with three phase at a later date	

			three phase charging up to 63A		
	Electric Light Commercial Vehicle 4	**Electric Light Commercial Vehicle 5**	**Electric Light Commercial Vehicle 6**	**Electric Heavy Commercial Vehicle 1**	**Electric Heavy Commercial Vehicle 2**
Supply type	Single phase 32A	Three phase 32A	Three phase 32A	Three phase 32A	Three phase 63A
Vehicle inlet type	Mennekes Type 831	Mennekes Type 412	Marechal 6168017264	Mennekes Type 834	Mennekes Type 3658
Vehicle connector type	Mennekes Type 3888	Mennekes Type 3907	Marechal 6164017264	Mennekes Type 3907	Mennekes Type 1121
Plug type	Mennekes Type 3830	Mennekes Type 3853	GEWISS GW60042	Mennekes Type 3853	Mennekes Type 1114
Supply voltage	230V +10%	415V +10%	400V +/- 10%	415V +10% / -6%	415V +10% / -6%
Charge cable rating	600V 32A	600V 32A	400V 32A	600V 32A	600V 63A
Battery charging capability	320V DC 18.75A	320V DC 37.5A	Information not supplied	320V DC 18.75A	320V DC 18.75A
Other information	Working to comply with J1772 connector requirements	Working to comply with J1772 connector requirements		Working to comply with J1772 connector requirements	Working to comply with J1772 connector requirements

Appendix 8

Electric Vehicle Charge Connector Suppliers

Supplier Name	Connector Types / Standards	Comments
Yazaki	SAE J1772	Components currently available.
Delphi	SAE J1772	Components due to go into production before the end of 2010.
FCI	SAE J1772 IEC 62196-2 Type 1	Components due to go into production before the end of 2010.
Mennekes	IEC 62196-2 Type 2	Components currently available.
Bals Elektrotechnik	IEC 62196-2 Type 2	Components currently available.
FCT Group	IEC 62196-2 Type 2	Components due to go into production before the end of 2010.
SCAME	IEC 62196-2 Type 3	Components due to go into production before the end of 2010.

Appendix 9

Examples of Typical Electric Vehicle Charging Points

Typical UK Charging Point

Typical US Charging Point

Typical German Charging Point

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