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National Electric Transportation Infrastructure Working Council (IWC): 2013 Annual Report

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Technical Update, December 2013

EPRI Project Manager

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This is an EPRI Technical Update report. A Technical Update report is intended as an informal report of continuing research, a meeting, or a topical study. It is not a final EPRI technical report.

NOTE

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ABSTRACT

The National Electric Transportation IWC is a group of individuals whose organizations have a vested interest in the emergence and growth of electric transportation, in particular, the plug-in electric vehicle (PEV) industries, as well as truck stop electrification (TSE) and port electrification. IWC includes representatives from electric utilities, vehicle manufacturing industries, component manufacturers, government agencies, related industry associations, and standards organizations. The objective of IWC Meetings is to develop recommendations for PEV, truck stop electrification, and port electrification infrastructure standards and to serve as a forum for infrastructure problem solving and for information exchange between industries. The IWC is composed of the following four areas: Infrastructure Steering Committee, Non-Road Transportation Electrification, On-Road Codes and Standards, and Advanced Electric Transportation Infrastructure Technology.

Keywords

Plug-in hybrid electric vehicles
Truck stop electrification
Port electrification
Electric vehicles

EXECUTIVE SUMMARY

Background
The National Electric Transportation Infrastructure Working Council (IWC) was established to provide a forum for utilities, automotive manufacturers, suppliers, and other stakeholders to address issues regarding electric infrastructure for plug-in hybrid and electric vehicles. The IWC focuses on interoperability, safety, and simplicity of grid infrastructure as electrically powered vehicles enter the marketplace. The Electric Power Research Institute (EPRI) is well positioned to represent its members through support of the IWC and its activities to foster continued adoption of electric transportation technologies. The IWC is a group of individuals whose organizations have a vested interest in the emergence and growth of electric transportation, in particular, the plug-in electric vehicle (PEV) industries, as well as truck stop electrification and port electrification. The IWC includes representatives from electric utilities, vehicle manufacturing industries, component manufacturers, government agencies, related industry associations, and standards organizations.

Objectives
The primary objective of the IWC is to develop recommendations for PEV, truck stop electrification, and port electrification infrastructure standards and to serve as a forum for infrastructure problem solving and for information exchange between industries.

Approach
Face to face IWC meetings are held three times a year at various locations in North America. There are four primary areas of focus: Infrastructure Steering Committee (ISC), Non-Road Transportation Electrification, On-Road Codes and Standards, and Advanced Electric Transportation Infrastructure Technology.

Results
Infrastructure Steering Committee: Three IWC meetings were held in 2013. The ISC reviewed the results of the meetings of each of its committee and provided direction in the selection of topics for discussion. New voting members were added to the ISC to broaden stakeholder representation and replace members who had moved to other areas.

Non-Road Transportation Electrification Committee: There was limited activity in the non-road technology space with the non-road meeting time deferred at 3 of the 4 IWC meetings covered in this report. Two meetings were used to discuss future non-road topics and one meeting focused on scoping of requirements for truck and bus charging connectors.

On-Road Codes and Standards: The IWC worked with SAE J1772™ (Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler), dealing with charger configuration and ratings, terminology, coupler compatibility testing, a hybrid coupler design, and DC fast charge. The committee reviewed the work of the Society of Automotive Engineers (SAE)

Hybrid J2836, J2847, J2931 and J2953 Task Force which includes J2836/1 (information report including use cases) and J2847/1 (vehicle-utility communication). Updates were obtained on SAE standards related to the J2953/1 - Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE) committee and on wireless charging through the SAE J2954 Wireless Charging Task Force. Updates were also provided on the work of IEC TC69 WG4 (IEC 61851 series on EV conductive charging system). The IWC monitored the comments made on the proposed changes to the NEC including definitions, voltages, polarization, grounding pole, rating, cords and cables, and personnel protection systems, which were finalized by the NFPA on June 2013. A presentation was made on the planned NIST handbook on metrology related to EV fueling and EVSE metering.

Advanced Electric Transportation Infrastructure: The committee arranged presentations on various technologies including the Smart Energy 2.0 protocol, cost of infrastructure installations, sub metering of PEV energy usage, EVSE Interoperability, DC fast charging, fleet infrastructure, and vehicle-to-grid demonstrations. The IWC explored issues such as cyber security in relation to secure payment and smart metering, the role of EVs during storms and natural disasters, and vehicle charging at multi-unit dwellings.

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1 INTRODUCTION

The National Electric Transportation Infrastructure Working Council (IWC) is a group of individuals whose organizations have a vested interest in the emergence and growth of the electric vehicle (EV) and plug-in hybrid electric vehicle (PHEV) industries, as well as truck stop electrification (TSE) and port electrification. The IWC includes representatives from electric utilities, vehicle manufacturing industries, component manufacturers, government agencies, related industry associations, and standards organizations.

The purpose of the Infrastructure Steering Committee (ISC) is to direct the activities of the IWC. The objective for the IWC is to develop recommendations for EV, Plug-in Electric Vehicle (PEV), truck stop electrification, and port electrification infrastructure standards and to serve as a forum for infrastructure problem solving and for information exchange between industries.

IWC committees meet three times a year to address the main areas of transportation electrification infrastructure research and development. Other subcommittees or task forces are formed by the ISC on an as-needed basis. The IWC is composed of the following four areas: Infrastructure Steering Committee, Non-Road Transportation Electrification, On-Road Codes and Standards, and Advanced Electric Transportation Infrastructure Technology.

The IWC makes recommendations to such organizations as the Institute of Electrical and Electronic Engineers (IEEE), National Fire Protection Association (NFPA), American National Standards Institute, and the Society of Automotive Engineers (SAE). Recommendations focus on standards that promote widespread compatibility of PEV, truck stop electrification, and port electrification infrastructure; reduced cost; and consumer safety and convenience.

The IWC meeting is currently divided into three key sessions:

- Non-Road Transportation Electrification Activities
  - Codes and Standards Update
  - Port Electrification
  - Truck & Bus Electrification
  - Other Non-Road Activities and Relevant Electric Transportation Infrastructure
- On-Road Transportation Activities
  - Codes and Standards
  - Advanced Electric Transportation Infrastructure Technology
- Infrastructure Steering Committee (ISC)

Scope of This Report

IWC committees met three times in 2013 to address the main areas of EV, PEV, truck stop electrification, port electrification, and other transportation electrification infrastructure research and development. Due to EPRI's annual report cycle, the 3rd 2012 meeting (held in November) is documented in this report. Outlines of the expected presentations for the December 2013 IWC are included for reference and will be updated in the following year's annual IWC report.

Infrastructure Steering Committee: Three ISC meetings were held in the period covered this report (November 2012, March 2013 and July 2013). The ISC reviewed the results of the meetings of each of its committees and provided direction in the selection of topics for discussion. The ISC currently has approximately 23 voting members. During 2013, the ISC committee reached out to include new representatives from several non-US automotive OEMs, with these new representatives slated to join the ISC in 2014.

Non-Road Transportation: Non-road activity was very limited over the course of 2013. Some industry interest has been expressed for developing a truck and bus connector standard, but no SDO is active in this space as of this writing.

On-Road Codes, Standards and Recommended Practices: The IWC monitored and worked with a number of US and international standards bodies and industry alliance activities in 2013. These include:

The Society of Automotive Engineers (SAE) Recommended Practices

- SAE Hybrid J1772™ Task Force (Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler)
- SAE Hybrid J2836, J2847, J2931 and J2953 Task Force (Communications and Interoperability) (Some document published as Technical Information Reports)
- SAE Hybrid J2894 (Power Quality) (Recommended Practice)
- SAE Hybrid J2954 Task Force (Wireless Charging) (Being published initially as a Technical Information Report)

National Institute of Standards and Technology (NIST)

- US National Working Group on Electric Vehicle Fueling (Handbook 130; Handbook 44)
- NIST SGIP Priority Action Plan 22 (EV Sub-Metering)
- V2G DEWG

American National Standards Institute (ANSI)

- Electric Vehicle Standards Panel

National Fire Protection Association (NFPA)

- National Electric Code

ISO/IEC

- Technical Committee 69 (TC-69)

The Zigbee Alliance/HomePlug Alliance

- SEP 2.0

Advanced Electric Transportation Infrastructure Technology related to On-Road and Non-Road: The committee arranged presentations on various technologies which are detailed in Section 4 of this report. The next paragraph provides a high level summary of key activities of the year.

Meeting Highlights for the Report Period

Following are some highlights of key discussion topics. Detailed coverage of all IWC presentations is included in section 4.

Smart Energy Profile (SEP) 2.0:

The SEP2.0 standard was released during 2013. A December 2012 presentation highlighted the features and capabilities of the protocol while a July 2013 presentation detailed publication of the standard and next steps for its implementation. SEP 2.0 is the protocol SAE has chosen to support communication to the PEV via the electric vehicle supply equipment (EVSE) using HomePlug GreenPHY power line carrier technology. As of November 2013, IEEE has assumed ownership of SEP2.0 under the IEEE 2030.5 standard.

Electric vehicle supply equipment (EVSE):

There were a number of presentations related to various aspects of EVSE operation and installation. A December 2012 presentation addressed EPRI funded work on an installation cost study. The ultimate goal of the work is to develop a web based installation cost calculator, a task which has proven very difficult based on variability of installation cost data collected to date. Two presentations in March 2013 focused on the challenges and costs of installation of infrastructure for fleets.

Metering of PEV Energy Use:

The topic of metering (or sub metering) of vehicle energy use was addressed in several presentations. Two presentations in December 2012 looked at sub metering technologies and activities in the California Public Utility Commission (CPUC) related to sub metering. A March 2013 presentation discussed a National Institute of Standards and Technology (NIST) U.S. National Work Group (USNWG) on Measuring Systems for Electric Vehicle Fueling and Sub-metering (EVF&S). This NIST activity is developing model language for sale of electricity as a vehicle fuel that is published in the Code of Federal Regulations. US states adopt the language at their discretion into state laws governing weights and measures standards for vehicle fueling. Published as a part of NIST Handbook 130, this language would make state weights and measures authorities responsible for certification of energy metering devices used for vehicle fueling and stipulates requirements for device that manage the sale of the commodity. A July 2013 presentation gave an update on the NIST activity with the proposed Handbook 130 language to be voted on at the end of July. The draft language as presented at this July meeting was modified at the National Conference on Weights and Measures. A presentation is planned for the December 2013 IWC to provide an update on the actual language adopted into Handbook 130.

DC Fast Charging:

Several presentations from the reporting period focused on DC fast charging. A presentation at the December 2012 meeting discussed the deployment of a DC fast charging network by Tesla

Motors that uses a proprietary connector and protocol only usable by Tesla vehicles. In July 2013, the National Renewable Energy Lab gave an overview of their SPIDERS Microgrid vehicle to grid fast charging hardware. This was one of the first applications of the SAE J1772™ Combo connector, though the interface did not fully implement the SAE DC charging communications protocol. A panel discussion was held at the July 2013 IWC that focused on field deployment, standards – US and international and the business case for DC fast chargers.

Interoperability

Interoperability of EVSEs and PEVs was discussed from two perspectives: interoperability related to networks of EVSE and interoperability of the hardware pairing of different EVSEs with different PEVs. The issue of network interoperability was discussed in two separate presentations at the July IWC focusing on activities in Europe to develop open EVSE network standards and efforts to develop an open standard in the US. For hardware interoperability, the SAE J2953 sub-committee worked diligently in 2013 to finalize and publish interoperability documents prior to the end of the year. Updates from this committee were presented at several IWC meetings. The Sacramento Utility District presented at the March 2013 meeting regarding issues they had encountered with PEV responses to charge power control using the EVSE pilot wire. They encountered several makes of plug-in vehicles that did not follow J1772™, failing to manage charge power as would be expected.

2
NON-ROAD TRANSPORTATION ACTIVITIES

There has been very limited activity in the non-road area within the IWC over the last year. Lack of industry support for standards and gaps discussions became apparent during meeting planning sessions late in 2012 and this trend has persisted throughout 2013. Dedicated half-day non-road sessions have not been held since prior to the November 2012 IWC.

Previous non-road sessions within the IWC have focused on the following topics:

- Code and Standards Update
- – NFPA70, National Electric Code (NEC),
- Port Electrification
- – Shore power equipment and system standards through the IEC, ISO, and the IEEE.
- Truck and Bus Electrification
- EPRI Non-Road Advisory Committee updates
- Other Non-Road Activities and Relevant Electric Transportation Infrastructure

It is planned that during 2014, non-road IWC sessions will be held on an as-needed basis, when industry interest warrants. Open discussions during the opening session at two of the 2013 IWC meetings indicated that interest in developing a truck and bus connector for charging of commercial vehicles at power levels exceeding those specified in J1772 may be of interest in 2014.

The following section addresses updates to the National Electric Code (NEC) in the non-road space – an activity that has carried over from committee work completed in 2012. A single non-road presentation was held during the reporting period and is documented following the discussion of the NEC.

National Electrical Code, NFPA 70-2014

General

The *National Electrical Code* is a national code of rules that covers the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways for the following:

(1) Public and private premises, including buildings, structures, mobile homes, recreational vehicles, and floating buildings.

(2) Yards, lots, parking lots, carnivals, and industrial substations.

(3) Installations of conductors and equipment that connect to the supply of electricity

(4) Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings, that are not an integral part of a generating plant, substation, or control center.

It is the most widely adopted code in the United States, used in all 50 states and all U.S. territories, and enforced by the mandatory application by governmental bodies that exercise legal jurisdiction over electrical installations, including signaling and communications systems, and for use by insurance inspectors. The authority having jurisdiction for enforcement of the *Code* has the responsibility for making interpretations of the rules, for deciding on the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.

It is also a living document, constantly changing to reflect changes in technology; its use continues to grow, providing the best technical information, ensuring the practical safeguarding of persons and property from the hazards arising from the use of electricity.

The National Electrical Code, NFPA 70 is revised and updated every three years in Revision Cycles that begin each year and that normally take approximately two years to complete.

Each proposed change or addition to the NEC requires a statement of the problem and substantiation for the proposal. The proposal must identify the specific section number, table number or equivalent section to be revised (or added) and a complete text of the proposal showing the wording to be added, revised or deleted.

Article 626

EPRI's NEC Task Force (TF) has worked with various Original Equipment Manufacturer (OEMs), and related experts to prepare Code proposals and substantiations for the 2014 National Electrical Code. The TF proposed that the mention of EVSE be included in article 626.1 (Scope) and 626.2 (Definitions). A new article 626.5 was also considered to include mention of EVSE. These changes were ultimately rejected and not included in the 2014 NEC.

Non-Road Presentation Summaries for the July 2013 IWC Meeting (Hosted by EPRI in Palo Alto, CA)

SAE TMC EVS Interface Task Force (July 2013)

Charles Groeller, an independent industry consultant, gave an update on work within the American Trucking Associations' Technology & Maintenance Council related to consideration of standardizing a connector for truck and bus charging use. The effort is preliminary in nature and would likely involve work being carried out in the SAE Truck and Bus Council.

3
ON-ROAD TRANSPORTATION ACTIVITIES

2013 has been a very active year in the on-road electric transportation space. This section of the report covers on-road IWC sessions held in November 2012, March 2013 and July 2013. Outlines of presentations planned for the December 2013 IWC meeting are included for reference and will be updated for the following year's IWC report.

On an as needed basis, the following topics are included in the on-road agenda:

- On-Road Transportation Activities
- Codes and Standards
  - NEC Update
  - ISO/IEC Update
    - Mapping of efforts to SAE
    - SAE/ISO Joint Meeting Summary
  - SAE Update
    - Communication Update
      - J2836/J2847
      - J2931
    - Connector Update
      - J1772™ AC
      - J1772™ DC
    - Power Quality Update
      - J2894
    - Other SAE Efforts
      - J2953
      - J2954
  - UL Update
    - UL AC & DC Charging Review
- Electric Vehicle Supply Equipment (EVSE) Hardware and Standards Update
- Relevant Electric Transportation Technology and Implementation
- Infrastructure Implementation Updates
  - Modeling of large EVSE installations

    - EV Project
- Other Activities
    - PHEV Metering Issues
    - Workplace Charging Issues
    - Wireless Charging Technologies

The following sections provide details on IWC activities covering the November 2012 through November 2013 timeframe.

National Electrical Code, NFPA 70-2014

The National Electrical Code, NFPA 70 is revised and updated every three years in Revision Cycles that begin each year and that normally take approximately two years to complete.

During the 2010 to 2013 timeframe, the EPRI NEC Task Force reviewed the 2011 NEC to formulate change proposals for NEC 2014.

EPRI NEC Task Force 2014 code proposals included:

- Consideration for the inclusion of dc supply sources, such as battery banks
- Clarification and extended use of cord and plug type connections for Electric Vehicle supply equipment (EVSE) for equipment rated up to 250 volts and 40 amperes.
- Cable types and ampacity for the power supply cord and the output cable to the EV
- Location of the in-line personnel protection system device on a detachable cord set (cable unplugs at both ends and carried on-board the vehicle)
- Interactive systems, review of Articles 702 and 705.
- Ventilation requirements
- Reference to Article 220 to include EV charging as an additional standard load
- Clarification of the ADA height requirements

Early in 2011, NEC Code Making Panel (CMP) 12 decided to form a special task group of some CMP12 members to reorganize and rewrite Article 625 to update the format and consider changes that could be proposed as Temporary Interim Amendments (TIA) to the 2011 NEC and as proposals for the 2014 edition of the NEC. Amongst the reasons cited for the formation of the CMP 12 Task Group were to address the needs of builders, electrical contractors and building codes requirements including EV Ready requirements, pre-installation and site requirements, expedite permit and inspection process, expand the use of cord and plug connected EVSE, correctly identify the load being added, address load diversity and the use of energy management systems and so forth.

Gery Kissel, General Motors, CMP-12 member was selected to chair the Article 625 CMP 12 group. Greg Nieminski, chairman of EPRI's NEC Task Force, joined the CMP 12 a member and liaison between CMP 12 and EPRI's NEC TF.

Both groups met several times during 2011, with an interchange of ideas, proposals and comments concluding in a webcast meeting on October 30, 2011 when the last remaining concerns of EPRI's NEC TF were addressed in the CMP 12's final code proposal being submitted for consideration for the 2014 National Electrical Code.

Subsequent proposals based on the Report on Proposals (ROP) distributed in July, 2012 were submitted in October, 2012 in response to the Code Panel's Report on Proposals. After EPRI's Task Force's initial meeting in December 2010, the TF met again in August and September, 2012 at which time additional comments were made to the reported proposals and actions taken by CMP 12 for Article 625 of the 2014 NEC.

Greg Nieminski, Chair of EPRI's NEC TF attended the NEC CMP12's meeting in December 2012 where all of the comments regarding Articles 625 and 626 were reviewed and the final NEC Code Panel's actions taken.

The bulk of recommendations of the EPRI NEC Task Force for article 625 were accepted and integrated into the 2014[1] code. As noted previously, the modifications to article 626 were rejected by the NEC code panel. Some notable changes to 625 in the 2014 version include:

- The article has now been arranged into 3 sections and the article paragraphs were reordered to better align with other NEC code articles.
- The article scope was modified to add references to UL 2594 and UL 2202 standards.
- Article definitions were refined to clarify language.

International Electrotechnical Commission (IEC) Committee Nos. SC 23H, TC 69 and International Standards Organization (ISO) TC22/SC21 Update

Table 3-1 provides a list of IEC and ISO activities.

Table 3-1 Existing Activities in IEC SC 23H, IEC TC69, and ISO TC22/SC21

Subject	Document	Issued	Closing Date
IEC 62196-1 Ed. 3.0: Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements	23H/296/CDV	2013-08-16 3 month comment & ballot	2013-11-22
	Meeting to review comments		2013-12-09/13
IEC 62196-3 Ed. 1.0: Plugs, socket-outlets, and vehicle couplers - conductive charging of electric vehicles - Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and tube-type	23H/292/CDV 23H/295A/RVC	2013-01-11 2013-08-23 Awaiting publication of FDIS	2013-12

[1] Available for purchase at http://www.nfpa.org/catalog/product.asp?pid=7014SB&cookie_test=1

contact vehicle couplers			
IEC 61851-1/Ed. 3: Electric vehicle conductive charging system - Part 1: General requirements	69/250/2CD Meeting to review comments	2013-06-14	2013-09-20 2013-11-18/22
IEC 61851-21-1/Ed. 1: Electric vehicle conductive charging systems - Part 21-1: Electric vehicle onboard charger EMC requirements for conductive connection to an a.c./d.c. supply	69/266B/CD	2013-11-08	2014-01-03
IEC 61851-21-2/Ed.1: Electric vehicle conductive charging system -Part 21-2:EMC requirements for OFF board electric vehicle charging systems	69/220/CD	2012-07-06	2012-10-12
IEC 61851-23: Electric vehicle conductive charging system - Part 2-3: D.C electric vehicle charging station	69/227/CDV 69/252/RVC	2013-07-12 Awaiting publication of FDIS	12-2013
IEC 61851-24: Electric vehicle conductive charging system - Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging	69/223/CDV 69/246/RVC	2013-06-14 Awaiting publication of FDIS	12-2013
ISO 15118-1 Ed. 1.0: Road vehicles - Vehicle to grid communication interface - Part 1: General information and use-case definition		Published 04-2013	
ISO/IEC 15118-2 Ed. 1.0 Road vehicles - Vehicle-to-Grid Communication Interface - Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements	ISO/FDIS 15118-2	2 month ballot	03-2014
ISO 15118-3: Road vehicles — Vehicle to grid Communication Interface — Part 3: Physical and data link layer requirements	ISO/DIS 15118-3	3 month comment & ballot	12-2013
See next section for explanation of terms and actions.			

Table 3-2 New Activities in IEC SC23H, IEC TC69, and ISO TC22/SC21

Subject	Document	Issued/Approved	Est. Public. Date
IEC 62196-2 Ed. 2.0: Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories	23H/299/RR	2013-09-20	2015--05
IEC/TS 61851-3-1: Electric Vehicles conductive power supply system - Part 3-1: General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems	69/221/NP 69/237/RVN	2012-08-24 2013-01-04	2015-07
IEC/TS 61851-3-2: Electric Vehicles conductive power supply system - Part 3-2: Requirements for Light Electric Vehicles (LEV) DC off-board conductive power supply systems	69/221/NP 69/237/RVN	2012-08-24 2013-01-04	2015-07
IEC/TS 61851-3-3: Electric Vehicles conductive power supply system - Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems	69/221/NP 69/237/RVN	2012-08-24 2013-01-04	2015-07
IEC/TS 61851-3-4: Electric Vehicles conductive power supply system - Part 3-4: Requirements for Light Electric Vehicles (LEV) communication	69/221/NP 69/237/RVN	2012-08-24 2013-01-04	2015-07
IEC 61980-1: Electric vehicle wireless power transfer systems (WPT) - Part 1: General requirements	69/178/NP 69/194/RVN	2010-09-23 2011-07-15	2014-12
IEC/TS 61980-2: Electric vehicle wireless power transfer (WPT) systems - Part 2 specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems	69/234/NP 69/257/RVN	2012-12-14 2013-08-23	2017-01
IEC/TS 61980-3: Electric vehicle wireless power transfer (WPT)	69/235/NP 69/258/NP	2012-12-14 2013-08-23	2017-01

systems - Part 3 specific requirements for the magnetic field power transfer systems.			
ISO/IEC 17409: Electrically propelled road vehicles - Connection to an external electric power supply - Safety specifications	69/263/CDV	2013-09-06 3 month comment & ballot	2014-10

The Standards Document Process for ISO/IEC Technical Committees

International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies. These serve as a basis for national standardization and as references when drafting international tenders and contracts.

Through its members, the IEC promotes international cooperation on all questions of electrotechnical standardization and related matters, such as the assessment of conformity to standards, in the fields of electricity, electronics and related technologies.

The IEC charter embraces all electrotechnologies, and energy production and distribution, as well as associated general disciplines such as terminology and symbols, electromagnetic compatibility, measurement and performance, dependability, design and development, safety and the environment.

Over 80 countries participate in the IEC work through their National Committees (NC). Technical Committees (TC) are formed under the rules of the ISO/IEC Directives that define the basic procedures to be followed in the development of International Standards and other publications. Technical Experts are assigned to work on a Project by their National Committees and participate as national delegations.

An International Standard is the result of an agreement between the member bodies of IEC and/or ISO. It may be used as such, or may be implemented through incorporation in national standards of different countries. International Standards are developed by IEC technical committees (TC) and subcommittees (SC) by a six-step process (typical time table shown in Table 3-3):

- **Proposal stage**
  The first step in the development of an International Standard is to confirm that a particular International Standard is needed. A new work item proposal (NP) is submitted for vote by the members of the relevant TC or SC to determine the inclusion of the work item in the program of work.
- The proposal is accepted if a majority of the members of the TC/SC votes in favor and if at least five P-members (countries) declare their commitment to participate actively in the project. At this stage a project leader responsible for the work item is normally appointed.

- **Preparatory stage**
  Usually, a working group of experts, the chairman (convener) of which is the project leader, is set up by the TC/SC for the preparation of a working draft. Successive working drafts may be considered until the working group is satisfied that it has developed the best technical solution to the problem being addressed. At this stage, the draft (WD) is forwarded to the working group's parent committee for the consensus-building phase.

- **Committee stage**
  As soon as a first committee draft (CD) is available, it is registered by the IEC. It is distributed for comment and, if required, voting by the P-members of the TC/SC. Successive committee drafts may be considered until consensus is reached on the technical content. Once consensus has been attained, the text is finalized for submission as a draft International Standard (CDV).

- **Enquiry stage**
  The draft International Standard (CDV) is circulated to all IEC member bodies by the IEC for voting and comments within a period of five months. It is approved for submission as a final draft International Standard (FDIS) if a two-thirds majority of the P-members of the TC/SC are in favor and not more than one-quarter of the total number of votes cast are negative. If the approval criteria are not met, the text is returned to the originating TC/SC for further study and a revised document will again be circulated for voting and comment as a draft International Standard. In ISO, the draft International Standard (CDV) is referred to as (DIS).

- **Approval stage**
  The final draft International Standard (FDIS) is circulated to all IEC member bodies by the IEC Central Office for a final Yes/No vote within a period of two months. If technical comments are received during this period, they are no longer considered at this stage, but registered for consideration during a future revision of the International Standard. The text is approved as an International Standard if a two-thirds majority of the P-members of the TC/SC is in favor and not more than one-quarter of the total number of votes cast are negative. If these approval criteria are not met, the standard is referred back to the originating TC/SC for reconsideration in light of the technical reasons submitted in support of the negative votes received.

- **Publication stage (IS)**
  Once a final draft International Standard has been approved, only minor editorial changes, if and where necessary, are introduced into the final text. The final text is sent to the IEC Central Office which publishes the International Standard.

Table 3-3 ISO/IEC Standards Work Product Descriptions

Project Stage	Associated Document Name	Abbreviation	Minimum Timeline (for comment and/or voting)
Proposal stage	New Work Item Proposal	NP	3 months for voting

Preparatory stage	Working draft	WD	12 months recommended
Committee stage	Committee draft	CD	2-4 months for comment
Enquiry stage	Enquiry draft	IEC/CDV	5 months for comment and voting
Approval stage	Final Draft International Standard	FDIS	2 months for voting
Publication stage	International Standard	IS for IEC or ISO/IEC	1.5 months

SAE J1772™ Coupler Standard

While the SAE J1772™ committee has been actively working throughout 2013 on revision of the J1772™ document, no new revision of the document were released in 2013. The current revision of J1772™ remains the October 2012 version.

Charging Scenarios/Mode Overview

SAE has defined three levels of AC and three levels of DC charging (see Figure 3-2):

- AC Level 1: Common household circuit rated to 120 volts AC and 12 or 16 amperes. (1.44 or 1.92kW)
- AC Level 2: Permanently wired electric vehicle supply equipment used especially for electric vehicle charging; rated at 240 volts AC, up to 80 amps, and up to 19.2 kilowatts.
- AC Level 3: TBD.
- DC Level 1: 200-500V DC, ≤ 80 amp; ≤ 40kW
- DC Level 2: 200-500V DC, ≤ 200 amp; ≤ 100kW
- DC Level 3: TBD.

It should be noted that DC Level 2 charging is often improperly referred to as “level 3” charging. SAE has no formal definition of AC or DC level 3 charging as of this writing.

SAE Charging Configurations and Ratings Terminology			
	**AC level 1** (SAE J1772™) PEV includes on-board charger 120V, 1.4 kW @ 12 amp 120V, 1.9 kW @ 16 amp Est. charge time: PHEV: 7hrs (SOC* - 0% to full) BEV: 17hrs (SOC – 20% to full)		**DC Level 1** (SAE J1772™) EVSE includes an off-board charger 200-500 V DC, up to 40 kW (80 A) Est. charge time (20 kW off-board charger): PHEV: 22 min. (SOC* - 0% to 80%) BEV: 1.2 hrs. (SOC – 20% to 100%)
	AC level 2 (SAE J1772™) PEV includes on-board charger (see below for different types) 240 V, up to 19.2 kW (80 A) Est. charge time for 3.3 kW on-board charger PEV: 3 hrs (SOC* - 0% to full) BEV: 7 hrs (SOC – 20% to full) Est. charge time for 7 kW on-board charger PEV: 1.5 hrs (SOC* - 0% to full) BEV: 3.5 hrs (SOC – 20% to full) Est. charge time for 20 kW on-board charger PEV: 22 min. (SOC* - 0% to full) BEV: 1.2 hrs (SOC – 20% to full)		**DC Level 2** (SAE J1772™) EVSE includes an off-board charger 200-500 V DC, up to 100 kW (200 A) Est. charge time (45 kW off-board charger): PHEV: 10 min. (SOC* - 0% to 80%) BEV: 20 min. (SOC – 20% to 80%)
Voltages are nominal configuration voltages, not coupler ratings Rated Power is at nominal configuration operating voltage and coupler rated current Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack			
*Notes: 1) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100% 2) PHEV can start from 0% SOC since the hybrid mode is available. ver. 10162012			

Figure 3-1 SAE Charging Configurations and Ratings Terminology

Future Activity

Revision activity for SAEJ1772™ started in January of 2013. This work continues with the expectation that a new revision of J1772™ will be published in early 2014.

SAE J2836™/2847/J2931/J2953 Communication Standards

The SAE J2836™, J2847, J2931 & J2953 Communication Committee continues to work toward standardized communications for plug-in electric vehicles (PHEV). One of the first demonstrations of application of the new SAE communications standards was carried out in early 2013 and is described in an SAE Congress paper by Argonne National Laboratory[2].

2013 Activities

Key efforts in 2013 include:

[2] Harper, J., "Development and Implementation of SAE DC Charging Digital Communication for Plug-in Electric Vehicle DC Charging," SAE Technical Paper 2013-01-1188, 2013, doi:10.4271/2013-01-1188. Available for purchase at http://papers.sae.org/2013-01-1188/.

- J2836/4 Version 1 – Diagnostic Use Cases
    - Old hold awaiting completion of J2953/1 & /2 documents
- J2836/5™ Version 1 – Use Cases for Customer to PEV communications (Telematics)
    - Use case development underway
    - Expected publishing date is not set
- J2836/6 Version 1 – Wireless Charging Use Cases
    - Published Q2 2013
- J2847/1 Version 4 – Utility Messages
    - Added updates from SEP2
    - Now published (Q4 2013)
- J2847/2 Version 3 – DC Charging
    - Adding updates to harmonization with updated DIN 70121 specification
    - Harmonizing with ISO/IEC 15118–1, 2 & 3
    - Identify common AC charging signals (with 5% PWM)
    - Expect balloting Q1 2014
    - Expect publishing Q2 2014
- J2847/3 – Version 1 – PEV as Distributed Energy Resource (DER)
    - Use case development underway
    - In SAE ballot process
    - Expected publishing Q1 2014
- J2847/4 – Version 1 – Diagnostics
    - Awaiting completion of J2836/4 and J2953/1 & /2
- J2847/5 – Version 1 – Customer to PEV
    - Awaiting completion of J2847/5
- J2847/6 – Version 1 – Wireless charging messages.
    - Use case development underway
    - Aligning with ISO/IEC 15118–6, 7 & 8
    - Expected publishing date is not set
- J2931/7 – Version 1 – Security
    - Committee restarted in August 2013
    - Expected publishing date is not set

- J2953/1 – Version 1 – Interoperability
    - Now published (2013)
    - Work on version started in November 2013 - adding DC charging
    - Version 3 expected to include digital communication
- J2953/2 – Version 1 – Interoperability
    - Aligned with ISO/IEC 15118-4 & 5
    - In SAE ballot process
    - Expected publishing date Q1 2014
    - New versions expected to follow lead of J2853/1

Communication Standards Structure and Breakdown

The task force has four distinct document numbers with several slash sheets for the various functions (see summary in Figure 3-3):

- J2836™ - Use Cases
- J2847 – Corresponding Requirements (to use cases)
- J2931 – Communication Requirements
- J2953 - Interoperability

There are six major Use Case documents in J2836™. These establish the requirements and are then fed into the corresponding J2847 document that includes more detail for messages, sequences and detail info.

The J2931 series of documents identifies the communication protocol and security requirements and J2953 identifies the interoperability requirements for both the J1772™ control pilot and digital communications in J2847. Figure 4-2 shows the summary of these four standards and the various slash sheets and their specific function.

The SAE J2836™, J2847, J2931 & J2953 recommended practices document interaction is shown in Figure 4-3 for these along with specific implementation examples in Figures 4-4 and Figure 4-5. The six slash sheets of J2836™ Use cases, correspond to the slash sheets of J2847 to include the signals, messages, diagrams and other requirements.

J2931/1 includes the protocol requirements for all the J2847 documents and PLC is shown for the "wired" communication requirement for (1) association and (2) DC charging/discharging as J2931/2, /3 and /4.

J2931/5 includes telematics protocol requirements and is used primarily for the J2836/5™ and J2847/5 documents but is also a means to communicate for the other functions. This is the same for the /6 series as it applies to wireless charging.

These are then wrapped by the J2953 documents for interoperability and then an overall wrap for security is included in J2931/7. The security may vary slightly as it applies to the utility messages with a subset also included for DC charging. The wireless charging approaches that already use DSRC may have yet another variation for security and this medium is also used for Vehicle to Vehicle (V2V) or Vehicle to Beacon communication and is being proposed for wireless charging since the vehicle could be charged while mobile.

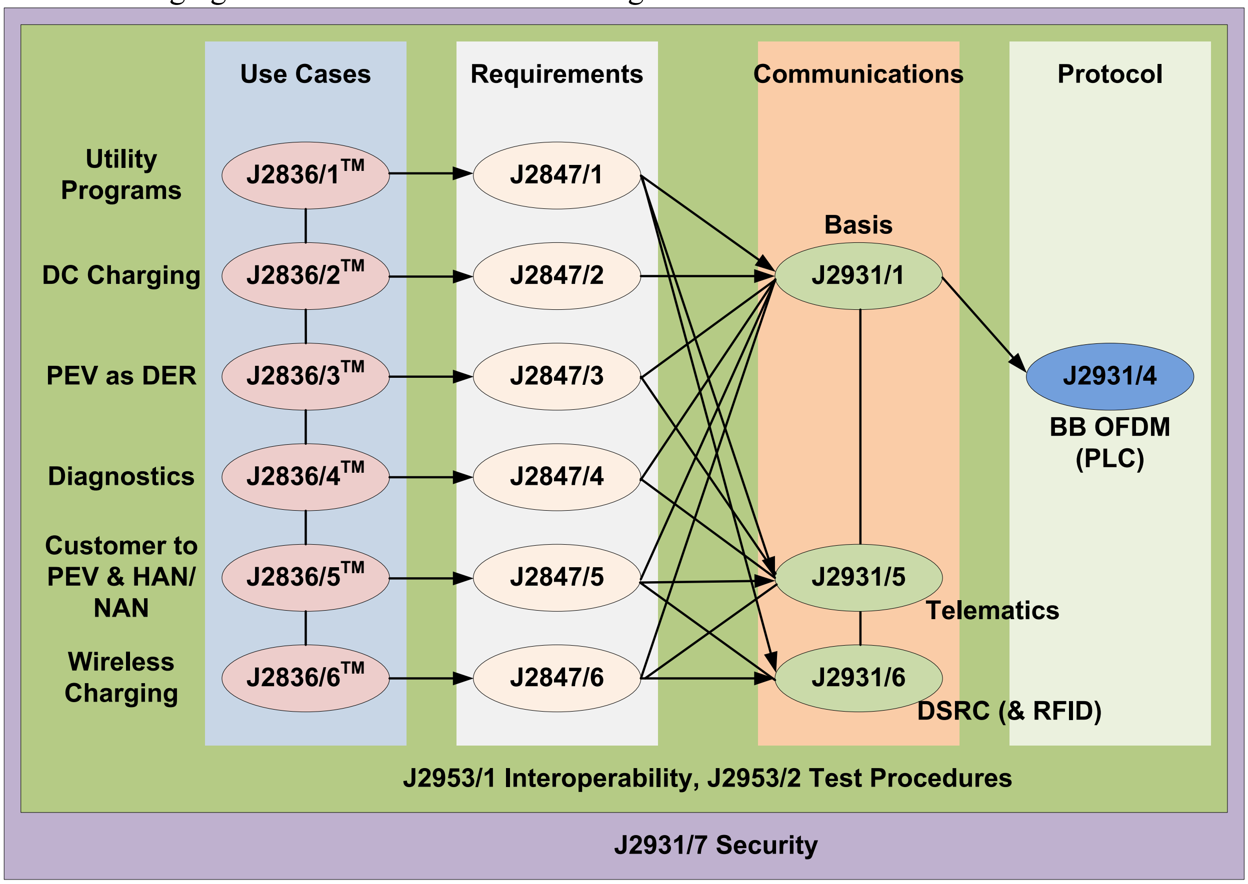

Figure 3-2 Summation of SAE Communication Standards

Figure 3-4 shows an example for DC Charging. The primary documents would be J2836/2™, J2847/2 and J2931/1 but if Diagnostics and Customer to PEV interaction is included, then the /4 & /5 documents would be applicable. These are stand-along documents and yet build on each other and in certain cases are combined. This does require PLC wired communication for control of the off-board charger but can also include diagnostics and customer to PEV communication using telematics and potentially DSRC.

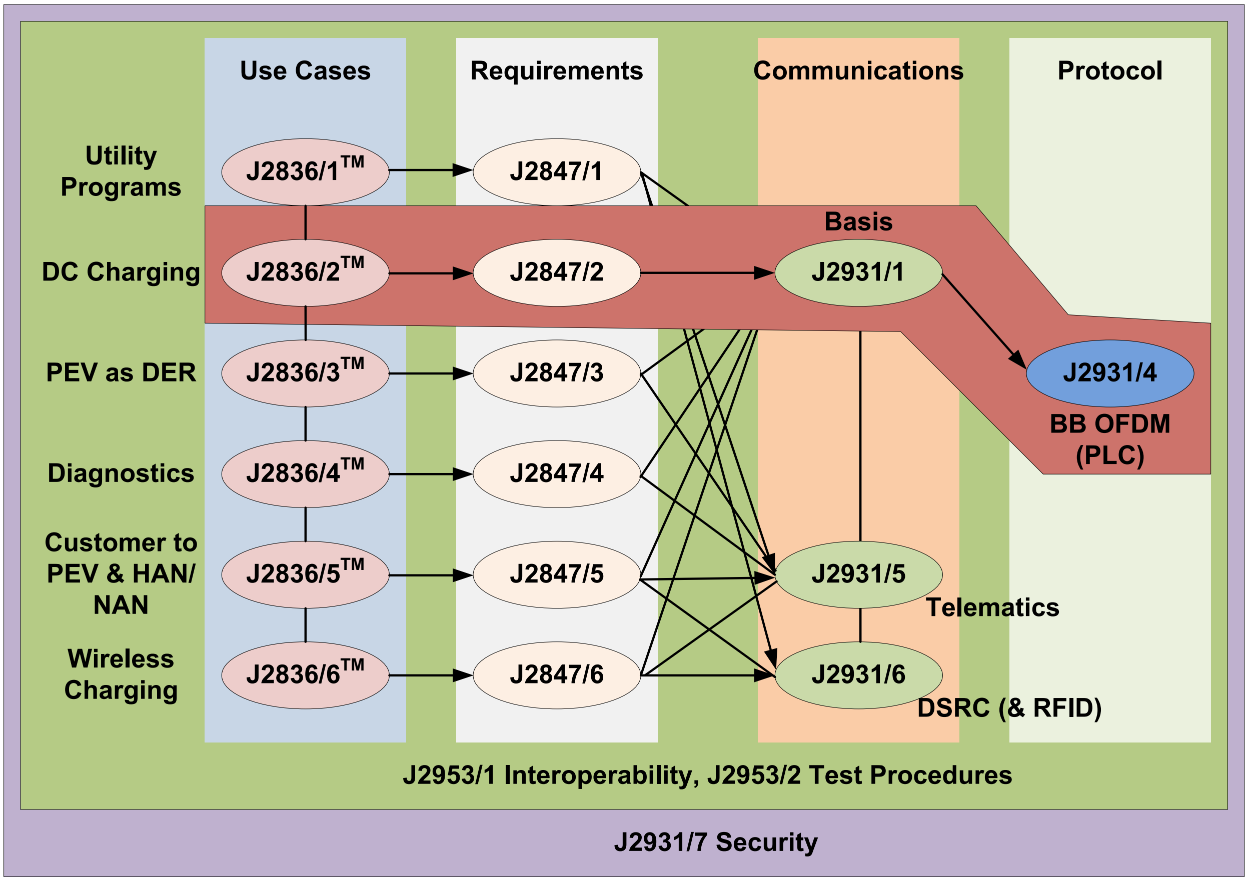

Figure 3-3 DC Charging Interaction

Figure 3-5 shows how the documents can build on each other in the case of the Plug-In Vehicle used as a Distributed Energy Resource, with on-board conversion. Off-board conversion would also use the basis of DC Charging (since this is DC discharging) and combine with the DER communications in the /3 set of documents. With on-board conversion, the /2 set of documents would not be included.

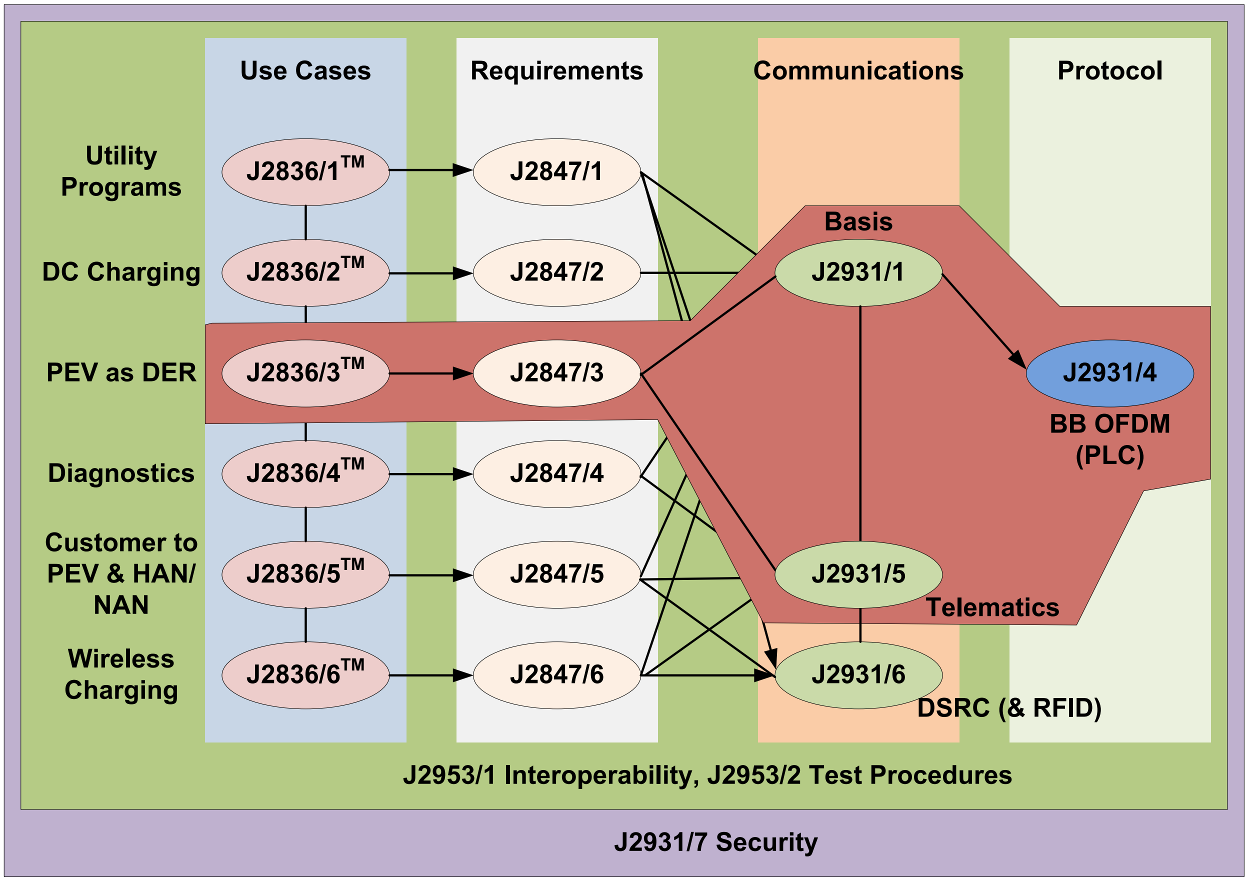

Figure 3-4 Reverse Energy Flow with off-board conversion

Interoperability- J2953

This subcommittee was tasked with developing requirements for interoperability of electric vehicle supply equipment with plug-in electric vehicles. The committee completed work on the J2953/1 requirements document in Q2 of 2013 and the document was published in Q3 2013. Work was completed on the J2953/2 test procedures document and was submitted for balloting in August of 2013. The document has not been published as of this writing.

Argonne National Laboratory has developed an interoperability test lab (update presented to IWC in March 2013) for PEV/EVSE pairings. A DOE funded activity with SAE had tasked ECOtality's ETEC Lab with performing a round robin test matrix of PEVs and EVSEs that was scheduled to occur in Q4 of 2013. Issues with obtaining vehicles and EVSE hardware and the bankruptcy of ECOtality in September 2013 have delayed this effort into 2014. ECOtality's ETEC Lab was purchased from the bankruptcy court by Intertek Labs. DOE is still considering their options on how to best move forward with the interoperability testing as of this writing.

Communication Technologies – J2931/X

SAE has defined two communications technologies for EVSE/PEV communications. For wired charging using the J1772™ AC or J1772™ Combo connectors, the standard specifies use of power line carrier (PLC) communications. For wireless charging using the J2954 standard, SAE has specified the use of dedicated short range communications (DSRC):

- Power line carrier (PLC) communication over the J1772™ Pilot wire. This relies on the National Electric Code requirement that specifies an EVSE must be used to supply power to a plug-in electric vehicle. Since the Pilot wire only goes between the EVSE and PEV, communications beyond the EVSE will require an additional communications interface in the EVSE.
- Within the draft version of J2931/6, DSRC technology is being considered as the main control communications technology. Wireless charging also requires an additional "alignment" function to locate the charging pads for the PEV and EVSE. The use of RFID communications is being considered for the alignment function.

Wired communication is required for the PEV association and control of any off-board conversion equipment (off-board chargers or dischargers). Figure 3-6 and Figure 3-7 shows these variations. SAE is standardizing on the communication and using the J1772™ control pilot for wired communication using Power Line Carrier (PLC). This includes the EVSE as a bridging device to the Energy Service Interface (ESI) and any off-board conversion device.

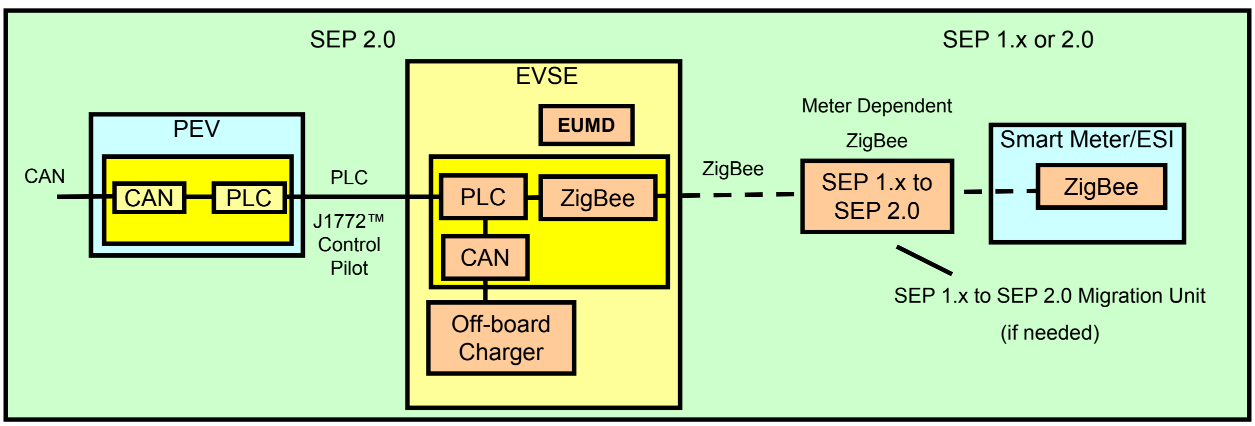

Figure 3-5 Wired PEV and Wireless ESI

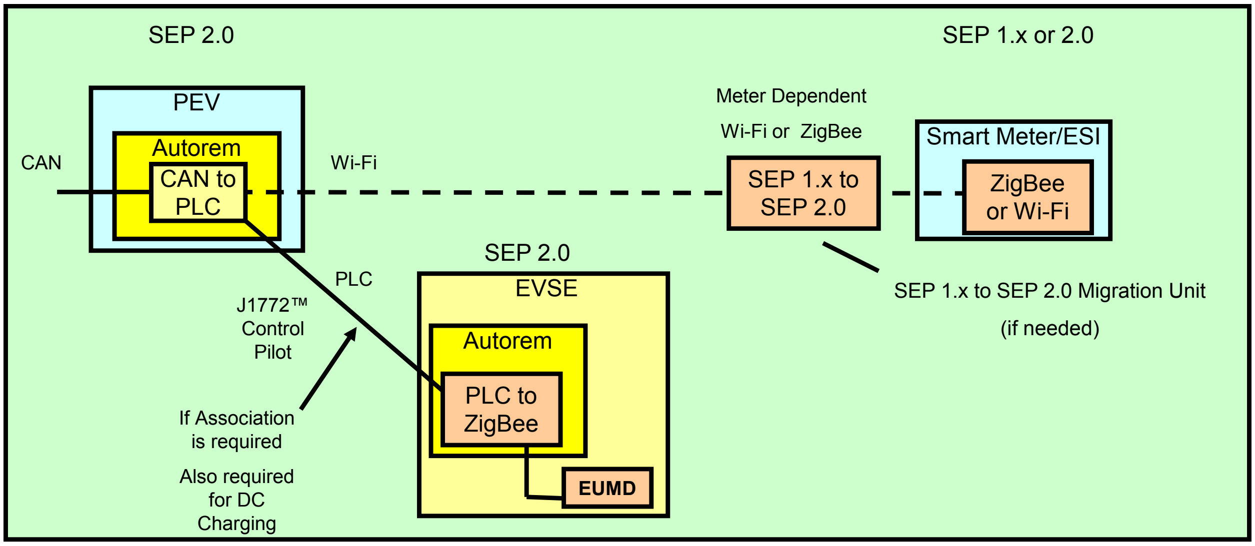

Figure 3-6 Wireless PEV and ESI

Use Cases for Customer to PEV Communications (Telematics) (J2836/5(TM))

This document is being developed to include use cases for customer/PEV communication interactions via telematics systems. This expands the U1 through U5 Use Cases found in J2836/1 and U6 through U7 found in J3836/3 with two additional cases:

Use Case U8 (Customer Convenience Functions)

These scenarios are under development for Version 1 of the document:

- Remotely Start/Stop Charge
- Precondition Cabin
- Obtain Charge Status
- Schedule Charging Preferences
    - (e.g. charge start, end, duration; battery charge level)
- Public charging – locate/reserve EVSEs
- Display Energy Usage History
- Payment/Billing

Use Case U9 (Network Synchronization)

These scenarios are planned for inclusion in version 2 of this document:

- Resolve conflict between customer preferences set in EV and EVSE
- Resolve conflict between consumer preferences in EV, EVSE and/or HAN, and utility program

Smart Energy Profile 2.0 (Now IEEE 2030.5)

Smart Energy V2.0 (SEP2.0) was released in Q2 2013 by the Zigbee Alliance[3]. The Chair of the Zigbee Alliance presented an update of SEP2.0 at the July 2013 IWC meeting. At that time that ownership of the SEP2.0 standard was being transferred to the IEEE under IEEE standard 2030.5. IEEE has assumed ownership and published IEEE 2030.5 in November 2013. This first version under IEEE is an unmodified version of the SEP2.0 protocol as transferred from the Zigbee Alliance. Future updates to the IEEE 2030.5 will be managed through the IEEE standards process in the SEP2 - Smart Energy Profile 2.0 Standards Development Working Group. Certification and compliance testing of SEP2.0 products continues to be managed by an industry group called the Consortium for SEP 2 Interoperability (CSEP)[4]. CSEP maintains a low public profile but continues to conduct interoperability workshops every few months.

SEP2.0 offers an IP-based control solution for various environments including home area networks (HAN). In addition to all the services offered by SEP1.0, SEP2.0 includes features such as:

- Control over Plug-In Electric Vehicle Charging
- Prepay Services
- Support for Wired and Wireless HANs

SEP 2.0 works in conjunction with multiple communication technologies (physical layers)

- IEEE 802.15.4 (or ZigBee)
  - Low power WPAN
  - Up to 100-250 kbit/s, Mesh
- IEEE 802.11
  - WiFi physical layer - WLAN
  - Will become popular for consumer driven applications
  - Participated in a public live demonstration
- PLC
  - Competing standards – P1901.1 and 1901.2 and G.hn
  - HP-GP (SAE/ISO Electric Vehicle Charging)
- Other
  - DECT
  - Bluetooth
  - Ethernet

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[3] Available for free download at www.zigbee.org/smartenergy
[4] CSEP activities can be followed at http://www.csep.org/

ANSI STANDARDS UPDATE

In the spring of 2011 American National Standards Institute (ANSI) held an *ANSI Workshop: Standards and Codes for Electric Drive Vehicles* resulting in a summary document, *Standardization Roadmap for Electric Vehicles, Ver. 1.0,* which was published in April, 2012. A revised document, *Standardization Roadmap for Electric Vehicles, Version 2.0*[5] was released in May of 2013.

The EVSP continues to meet periodically to provide updates regarding the Standards work ongoing by the various EV related committees.

Underwriters Labs (UL)/Council for Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA) Harmonization Efforts

The harmonization between the US, Canada and Mexico for personnel protection (UL2231 series), EV connectors/inlets (UL2251) and EV supply equipment for PEVs (UL2594) was completed in late 2012 or early in 2013. The next steps to improve and further update these Standards, to include new products and applications, higher ratings for fast charging and other technical improvements including the changes needed for the revised Electrical Codes, will get under way in early 2014.

Work will also be initiated to consider modification to utilize related IEC requirements and test to reduce the differences between these North American CANENA and the International IEC Standards.

SAE J2894 Power Quality Standard

Society of Automotive Engineers (SAE) Recommended Practice J2894/1 – "Power Quality Requirements for Plug-In Electric Vehicle Chargers" was approved in June 2011 and is based on recommendation developed within the IWC to address PEV charging equipment operational recommendations for power quality (see summary of requirements in Table 3-4). The test procedures document J2894/2 was completed in Q2 of 2013 but has not entered the SAE ballot process as of this writing. Based on the typical SAE document timeline, J2894/2 is not likely to be published before Q2 of 2014.

Table 3-4 Summary of J2894 PQ Requirements

Recommended Displacement Power Factor Values		
AC Level 1	**AC Level 2**	**DC**
95%	95%	95%
Recommended Full Power Conversion Efficiency		

[5] Available for download at: http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_May_2013.pdf

AC Level 1	**AC Level 2**	**DC**
90%	90%	90%
Recommended Maximum Total Harmonic Current Distortion		
AC Level 1	**AC Level 2**	**DC**
10%	10%	10%
Recommended Maximum Inrush Current (At Maximum Nominal Current)		
AC Level 1	**AC Level 2**	**DC**
120% (in excess of 50ms)	120% (in excess of 100μs)	120% (in excess of 100μs)
AC Service Limits		
Parameter	**AC Level 1**	**AC Level 2**
Voltage Range	90% - 110% of nominal	90% - 110% of nominal
Voltage Swell	175% of nominal for Min. ½ cycle (8 ms)	175% of nominal for Min. ½ cycle (8 ms)
Voltage Surge	6 kV minimum ANSI C62.41 & C62.45	6 kV minimum ANSI C62.41 & C62.45
Voltage Sag	Down to 80% of nominal for 2 seconds	Down to 80% of nominal for 2 seconds
Voltage Distortion	5%	5%
Momentary Outage	0 volts for 12 cycles	0 volts for 12 cycles
Frequency Variations	2% of nominal	2% of nominal

SAE J2954 Wireless Power Transfer

The SAE J2954 Wireless Charging Task Force has been active throughout the reporting period. The task force held more than 25 meetings including full team and the various sub-committee meetings. The task force structure is diagramed in Figure 3-8. The J2954 task force published a press release to announce two key parameter selections were agreed to at a face-to-face meeting held in early November 2013:

- The wireless power transfer frequency of operation was selected as nominally 85 kHz (allows for 81.38 kHz - 90.00 kHz)
- Determined three power classes for light duty vehicles, Wireless Power Transfer (WPT) 1, 2 and 3, as defined in Table 3-5.

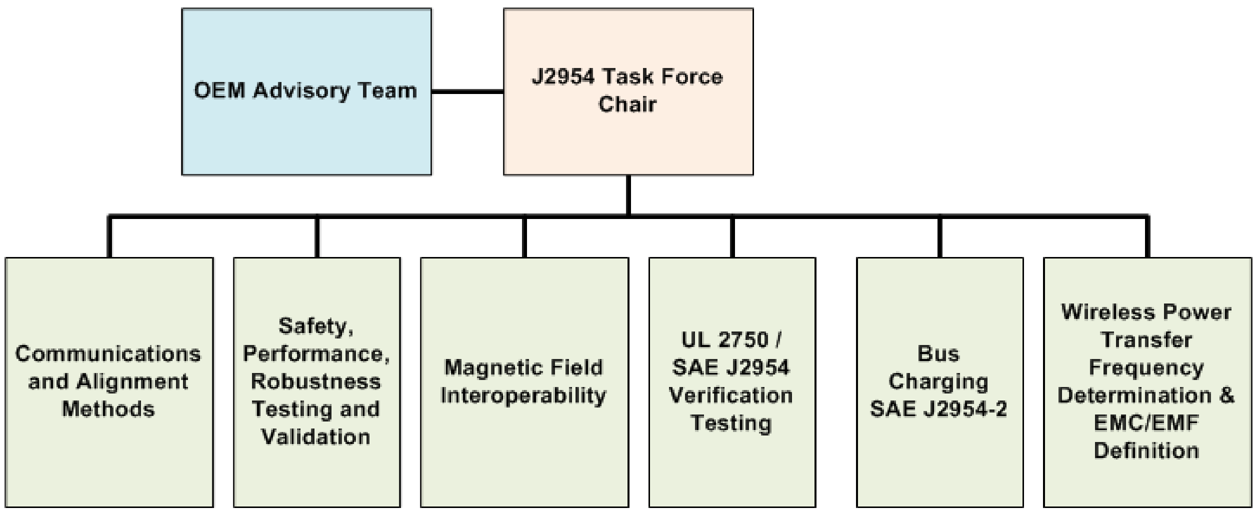

Figure 3-7 J2954 Wireless Charging Task Force Structure

Table 3-5 J2954 Power Level Definitions

Classification	SAE TIR J2954™ WPT Power Class		
	WPT1	**WPT2 Private/Public Parking**	**WPT3 L.D. Fast Charge**
Maximum Input WPT Power Rating	**3.7 kW**	**7.7kW**	**22 kW**

Electric Vehicle Supply Equipment (EVSE) Hardware and Standards Update - Current State of EVSE Technology

Thousands of AC charging stations have now been deployed in the US along with hundreds of DC fast chargers. A precise census of EVSEs is difficult to determine as many of the deployed units are privately owned. The National Renewable Energy Laboratory (NREL) maintains a database of alternative fuel fueling stations and now tallies over 6,800 public electric vehicle charging stations and Recargo, a company that maintains the PlugShare EVSE mapping website claims they now have over 20,000 charging stations mapped[6] (which includes residential stations where the consumer is willing to share their charge station with other drivers). A broad variety of products operating under the SAE J1772 standard have been deployed, primarily AC level 2 systems rated at 30A. Also being deployed are DC fast chargers that follow the Japanese CHAdeMO standard, DC fast chargers that implement a proprietary Tesla Motors standards and DC fast chargers that follow the new SAE Combo DC fast charging standards. As the SAE DC standards are still a work in progress, only a handful of these installations exist with most being vehicle testing or special demonstration sites. SAE DC charging standards are nearing completion with publication expected in late 2013 or very early 2014.

Automotive original equipment manufacturers (OEMs) have been providing level 1 cord sets with each vehicle sold. This cord set allows charging from a dedicated 15A or 20A, 120V ac outlet. OEMs recommend a dedicated circuit in order to prevent overloading of the circuits. Most level 1 EVSEs are rated to provide up to 12A charging. Starting in 2013, GM modified the Volt charging system to default to an 8A charge current unless overridden by the consumer.

Currently, available units vary in design from simple, no-frills, J1772™ compliant AC power sources to units with communications, access control, and external control options. A few vendors are now offering external networking capability offering a range of EVSE management services and data collection options. DC fast charge stations tend to be more complex and have more external control and communication capabilities to manage on-board power conversion electronics.

During the year, two vendors that offered networked EVSE services filed for bankruptcy: Better Place and ECOtality. Better Place operated both battery swapping systems (primarily in Israel) and networked EVSEs (primarily in Hawaii). OpConnect, an Oregon based EVSE network vendor purchased the Better Place Hawaii charging network approximately 2 months prior to Better Place's bankruptcy announcement. ECOtality's assets were sold under bankruptcy court supervision with the Blink Network (ECOtality's branded EVSE network) being purchased by Car Charging Group, Inc. (a Florida based EVSE networking company). The Blink network (which includes about 8000 residential and 4000 public

EVSE are now available for sale through a number of retail channels with prices varying from just under $500 to over $5000. Residential units tend toward simplicity and low cost, while commercial outdoor rated units tend toward complex futures and higher cost. In general, wall mount units are less costly than pedestal mounted EVSE. Installation costs will also vary widely and can be a significant portion of the full budget for an EVSE installation.

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[6] See maps at http://www.recargo.com/news/infographics/the_rise_of_electric_car_charging/

EVSE / Connector Vendor Overview

EPRI has identified nearly 50 vendors of AC EVSE hardware and 23 vendors of DC EVSE hardware. Of these vendors, as of November of 2013, there are 33 AC EVSE vendors and 11 DC EVSE vendors that have products listed by a Nationally Recognized Test Laboratory (NRTL) to UL standards. Several figures follow highlighting both EVSE and connector vendors:

- Figure 3-8 – AC EVSE Vendors, Part 1
- Figure 3-9 – AC EVSE Vendors, Part 2
- Figure 3-10 – DC EVSE Vendors
- Figure 3-11 – AC J1772 Connector Vendors
- Figure 3-12 – DC CHAdeMO Connector Vendors
- Figure 3-13 – DC SAE J1772 Combo Connector Vendors

North American AC EVSE Product List, Page 1

RED Text Indicates Some Products Listed to UL Standards

- ABB (AC Level 2)
- AddEnergie Technologies (AC Level 1 & 2)
- Advanced Charging Technologies (A.C.T.) (AC Level 2)
- Aerovironment (AC Level 2)
- AVCON Corporation (AC Level 2 Legacy)
- Bosch (formerly SPX, Inc) (AC Level 2)
- BTCPower (AC Level 1 & 2)
- CarCharging Group (Formerly ECOtality) (AC Level 2, charging network)
- ChargePoint (AC Level 1 & 2, charging network)
- ClipperCreek (AC Level 1 & 2)
- DBT EV Charging Solutions (AC Level 1 & 2)
- Delta Electronics, Inc (AC Level 2)
- Delphi Automotive Systems (AC Level 1)
- Eaton Corporation (AC Level 2)
- Electric Vehicle Institute (EVI) (AC Level 2)
- Evatran (AC Level 2)
- EV-Charge America (AC Level 1 & 2)
- EVextend (AC Level 1 Enclosure)
- EVSE LLC (Control Module Ind.) (AC Level 1 & 2; Circuit sharing device)
- General Electric (AC Level 2)
- GoSmart Technologies (AC Level 2)
- Green Garage Associates (AC Level 2)
- GridBot, LLC (AC Level 1 & 2)
- Ingeteam Inc. (AC Level 2)
- Keba AG (AC Level 2)
- Lite-On Clean Energy Technology, Corp (AC Level 2)
- Lear Corp. (AC Level 1 & 2)
- Legrand/Pass & Seymour (AC Level 1 & 2)
- Leviton (AC Level 1 & 2)
- meritCharge (eVergo) (AC Level 2)
- Milbank (AC Level 2)
- North Shore Safety (?)
- Optimization Technologies (OpConnect) (AC Level 1 & 2)
- Panasonic Corporation (Panasonic Electric Works Co. Ltd. (AC Level 1)

Figure 3-8 Part 1 - Listing of AC EVSE Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

North American AC EVSE Product List, Page 2

RED Text Indicates Some Products Listed to UL Standards

- ParkPod LLC (AC Level 1 & 2)
- PEP Stations, LLC (AC Level 2)
- Plug Smart (AC Level 1)
- Poulsen Hybrid, LLC. (AC Level 2)
- Schneider Electric (AC Level 2)
- SemaConnect (AC Level 1 & 2)
- Shanghai Viasystems EMS CO LTD (AC Level 2)
- ShorePower (AC Level 1 & 2)
- Siemens Energy Inc. (AC Level 1 & 2)
- Signet Systems, Inc (AC Level 2)
- Telefonix, Inc (AC Level 1 Public)
- Tesla Motors (AC 240V, 72A Proprietary)
- Volta Charging (AC Level 2; charging network)
- Walther Electric (?)
- Yazaki North America, Inc. (AC Level 1)

33 Companies Now Have Some NRTL Listed/Recognized AC EVSE Products

49 Companies Total

Figure 3-9 Part 2 - Listing of AC EVSE Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

DC EVSE/Charger Product List

11 Companies Now Have Some NRTL Listed/Recognized DC Charging Products

- ABB (DC Level 2 - CHAdeMO)
- AddEnergie Technologies (DC Level 2 & 3 planned)
- Advanced Charging Technologies (A.C.T.) (DC Level 2 – dual cable CHAdeMO/Combo)
- Aerovironment (DC Level 2 - CHAdeMO & DC Level 3)
- Aker Wade (DC Level 2 - CHAdeMO)
- Andromeda Power (Portable DC Level 2 – CHAdeMO)
- BTCPower (DC Level 2)
- Blink (ECOtality) (DC Level 2 CHAdeMO, charging network)
- Coulomb Technology (DC Level 2, charging network)
- DBT EV Charging Solutions (DC Level 2 - CHAdeMO)
- Delta Electronics, Inc. (DC Level 2 – CHAdeMO)
- Eaton Corporation (DC Level 2 CHAdeMO)
- Efacec (DC Level 2 – CHAdeMO and Combo)
- Epyon (DC Level 2) (Now part of ABB)
- EVTEC AB (Mobile DC Level 2 – CHAdeMO) Fuji (DC Level 2 - CHAdeMO)
- Fuji (DC Level 2 – CHAdeMO, 25kW)
- IES Synergy (DC Level 2 – CHAdeMO and Combo)
- JFE Engineering Corporation (DC Level 2 – CHAdeMO)
- Nichicon (DC Level 2 – CHAdeMO)
- Nissan (DC Level 2 - CHAdeMO)
- Primearth EV Energy CO., LTD. – maybe CHAdeMO??
- Schneider Electric (DC Level 2 – CHAdeMO, 50kW)
- Signet Systems, Inc (DC Level 2 – CHAdeMO)

Figure 3-10 Part 3 - Listing of DC EVSE Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

RED Indicates Recognized to UL 2251

- Actuant Electrical, DBA Marinco (60A-240V - Connector)
- Amphenol Tuchel (30A-240V - Connector; 3A-240V, 30A - Inlet)
- BizLink Technology, Inc. (30A-600V, 50A-600V - Connector; 50A-600V - Inlet)
- Chung Kwang Electric Wire & Cable, CO LTD (18A-300V, 25A-300V, 30A-600V – Connector & Inlet)
- Delphi Corporation (15A-120V, 15A-240V, 20A-240V, 30A-240V – Connector; 15A-120V, 15-240V, 30A-240V – Inlet)
- General Cable Corporation (20A-240V, 30A-240V, 65A-240V, 80A-240V - Connector)
- Integro, LLC (30A-240V - Breakaway)
- ITT Veam, LLC (16A-120V – Connector; 15A-120V, 15A-240V, 20A-120V, 20A-240V, 30A-240V, 40A-240V, 75A-240V - Connector & Inlet)
- Korea Electrical Terminal CO LTD (16A-240V - Inlet)
- Lear Corp (rating not specified - Connector & Inlet)
- Leviton (15A-120V, 20A-240V, 30A-240V, 40A-240V - Connector)
- Marechal Electric SA (87A-250V - Connector & Inlet) (Not sure if J1772)
- Method Electronics, Inc. (30A-300V - Connector)
- Pass & Seymour (rating not specified – Connector)
- Philatron (?)
- Phoenix Contact (rating not specified – Connector)
- Rema USA, LLC (16A-240V, 30A-240V, 50A-600V - Connector & Inlet)
- Sumitomo Wiring Systems, LTD (12A, 15A - Connector; 15A, 32A - Inlet)
- Suzhou Chilye Green Technology Co LTD (15A-240V, 20A-240V, 30A-240V - Connector; 30A-240V - Inlet)
- Tesla Motors (80A-240V – J1772 to Tesla Inlet Adapter)
- Tyco Electronics Corp (TE Connectivity) (18A-240V, 30A-240V - Connector)
- Yazaki Parts Company, LTD (12A-240V, 13A-240V, 13A-280V, 15A-240V, 15A-280V, 20A-240V, 20A-280V, 30A-240V, - Connector; 15A-240V, 20A-240V, 20A-280V, 30A-240V, 40A-240V, 40A-280V - Inlet)
- Zhangjiagang Youcheng Technology & Engine CO LTD (16A-240V, 30A-240V – Connector; 16A-240V, 30A-240V - Inlet

Figure 3-11 Listing of J1772 AC Vehicle Connector Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

- Dyden Corporation (125A-500V - Connector)
- Japan Aviation Electronics Industry LTD (120A-500V; 125A-500V - Connector)
- Sumitomo Electric Industries, LTD (125A-500V - Connector)
- Yazaki Corporation (120A-500V - Connector; 100A-500V, 120A-500V, 125A-500V - Inlet)

Figure 3-12 Listing of CHAdeMO DC Vehicle Connector Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

- Rema USA, LLC (150A-600V, 174A-600V - Connector; 30A/150A, 30A/174A, 600V Inlet)
- Korea Electrical Terminal CO LTD (16A-240Vac/150A-600V - Inlet)

Figure 3-13 Listing of SAE J1772 Combo Vehicle Connector Suppliers for the US Market; Names Highlighted in Red Indicate that this Supplier has Some Products Listed to UL Standards

DC Level 2 Combo Coupler Availability

In July 2012, REMA announced availability of a UL listed (UL2251) DC level 2 Combo-coupler. The coupler is rated for 174 A (protective earth is rated for 200 A) using #2 AWG wires for power circuits. REMA remains the only company with a listed vehicle connector and vehicle inlet. KET offers a listed vehicle inlet.

DC Level 2 Combo EVSE Availability

A number of manufacturers have announced DC EVSE products based on the use of the SAE Combo connector. As of November 2013, only Efacec offers a Combo connector based DC EVSE that is listed to UL standards (UL 2202). It is expected that additional manufacturers may offer listed products by the end of 2013. Several manufacturers have shown dual port charging products that offer both a Combo and CHAdeMO charge interface in one enclosure.

EVSE Standards

There are several Standards Development Organizations (SDO) and industry alliances performing work that influences EVSE space:

- SAE – EVSE function from a vehicle perspective
- UL – equipment safety standards
- NFPA – National Electrical Code addressing safe installation and application of EVSE
- NEMA – EVSE functional specifications (such as sub-metering)
- Open Charge Alliance – Industry alliance overseeing development of the Open Charge Point Protocol – an EVSE control communications protocol
- Zigbee Alliance/HomePlug Alliance – Smart Energy Profile (SEP) 2.0 - communications protocol

Society of Automotive Engineers Standards for EVSE

The SAE focuses on vehicle recommended practices. As such, SAE documents tend to address EVSE in a peripheral fashion, primarily addressing needs from the vehicle perspective. The primary SAE document which addresses hardware signaling and functionality for EVSE is SAE J1772™. A number of other standards within SAE are addressing the communications messaging, physical media and message structure for communications from the vehicle to the

EVSE and enable communications beyond the EVSE. In addition, communications to allow for off-board charging using DC to the vehicle are being developed.

SAE is not considering any recommended practices related to EVSE external functionality or communications capabilities, as the EVSE is not a vehicle system, but the communications standards are likely to have a strong influence on EVSE design and function.

Interoperability of EVSEs and PEVs is being addressed within the SAE J2953 committee.

UL Standards for Electric Vehicle Supply Equipment

There are a number of UL standards used for certification purposes that are applicable to both the full EVSE and to EVSE subsystems. UL standards focus on product safety and generally do not address product functionality. The key UL standards for EVSE are:

UL 969: Marking and Labeling Systems – describes requirements for external marking of equipment

UL 1449: Surge Protective Devices – standard for surge protection devices

UL 1998: Software in Programmable Components – standard for use of software in safety systems (such as an automatically resetting ground fault protection system)

UL 2202: Electric Vehicle (EV) Charging System Equipment – standard for all PEV chargers (AC to DC conversion devices)

***UL2231-1 (NMX-J-668/1-ANCE):** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements – standards for ground fault and ground monitoring protection

***UL 2231-2 (NMX-J-668/2-ANCE):** Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems - standards for ground fault and ground monitoring protection

***UL 2251 (NMX-J-678-ANCE):** Plugs, Receptacles and Couplers for Electric Vehicles – standard applicable to all Plugs, Receptacles and Couplers for Electric Vehicles, used with the EV supply or charging equipment, both AC and DC

***UL 2594 (NMX-J-677-ANCE):** Electric Vehicle Supply Equipment – standard for AC EVSE (formerly an Outline Investigation Document – released as a standard in 2012); note that AC EVSE listed prior to the adoption of UL 2594, generally hardware developed before early 2012, may be have been listed to UL 2202.

***Note:** These UL standards are now co-published by Association of the Electrical Sector (ANCE)

On-Road Presentation Summaries for the November 2012 IWC Meeting (Hosted by EPRI in Palo Alto, CA)

Smart Energy 2.0

Michael Bourton, Grid2Home, gave an overview of Smart Energy Profile (SEP) 2.0, which is a networking and application integration platform for messages between customer devices and energy service providers. SEP 2.0 allows peak load shaving, real time energy usage information for the consumer, real time or time-of-use pricing, and the management of residential loads including PEVs. SEP 2.0 is the protocol that enables the smart grid Home Area Network (HAN). The SEP 2.0 standard involves specifications released by Zigbee Alliance, Wi-Fi, and HomePlug. Mr. Bourton described the physical layers, connectivity, and status of standardization. He described the SEP 2.0 block diagram and layers 5 and 6 in particular. He explained resource discovery, device discovery, gradual reveal walkthrough, and push/pull data mechanisms in relation to sleepy devices. He reviewed the SEP 2.0 function sets and end-to-end security. End-to-end security refers to security between original client and server with no intermediate nodes. He also provided a comparison between SEP 2.0 and ISO/IEC 15118.

During discussion, Mr. Bourton noted that even if a utility does not implement HAN or AMI, SEP 2.0 can still be implemented over the internet, but it would not be customer zero configuration. PEVs may use about 70% of the function sets and V2G would support all. If public utility commissions decide that data is private, HTTPS would be used instead of HTTP. SAE does not have to define this since the server supports both and the client device discovers which one it is. One can define a new function as long as it is understood by the client and server, but ideally the new function should be submitted to SEP 2.0 to make it public and official. In the architecture, a PEV is considered a guest until it is verified as registered, since only registered PEVs will be charged. If the PEV is registered, the EVSE becomes a bridge that allows the PEV and the Energy Service Interface (ESI) to communicate directly. Mr. Bourton explained that SEP 2.0 defines the protocol between customer devices and the utility whereas ISO/IEC 15118 is between the PEV and EVSE. Thus, SEP 2.0 is a client-server relationship while ISO/IEC 15118 is a command-response relationship. SEP 2.0 and ISO/IEC 15118 have been aligned as much as possible, but they cannot be fully harmonized because of the basic difference in philosophies between the two. Moreover, ISO/IEC 15118 only applies to PEVs while SEP 2.0 is a more generic protocol. Interoperability, common certification, and testing is under the Consortium for SEP 2.0 (CSEP) which includes PLC.

PowerHydrant Charging System

Kevin Leary, PowerHydrant, presented PowerHydrant’s robotic charging system as applied to PEVs. He showed a video of their automated system and described a robotic conductive charging use case. He also explained the technology of embedded vision and PowerHydrant’s implementation of the technology, including mechanical design, sensors and image processing, robot kinematics, connector and inlet details, and other design elements. The PowerHydrant base can support fours cars in a parking area. During discussion, he estimated the retail cost of their system at about $1,200 for a four-vehicle charging base. They selected the European connector as being sufficient for their requirements and found the SAE J1772™ DC connector as too big and asymmetric for their needs.

Installation Cost Study

Enid Joffe, Clean Fuel Connection, presented reported on EPRI’s installation cost study, which seeks to understand the factors affecting installation costs, develop baseline data, and estimate near term and long term costs for the future. The study is retrospective, looking at data since 1996, as well as prospective. It is also national in coverage and deals with residential and commercial installations including those at multifamily dwellings. Ms. Joffe listed the types of data requested. Data will be aggregated by EPRI and sanitized to provide privacy. So far, she has contacted potential data sources (ARRA-funded programs are excluded). Several hundred records have been received from utilities and are being evaluated. It seems that utilities do not have as much detailed data. She also summarized the next steps. During discussion, she explained that past studies showed that an order of magnitude cost estimate could be based simply on the age of a house and its square footage. She pointed out that permit costs in California have doubled from 1990 to the present with all other costs remaining nearly the same. The hope is to be able to provide a web-based installation cost calculator. Mr. Lambert encouraged utilities to continue providing data for the study.

Heavy Duty Vehicle Charging Requirements

Paul Scott, TransPower, reviewed automotive charging standards and compared it to the needs of a class 8 truck. He then described the current charging practices of Balqon, BYD, Complete Coachworks, Freightliner, Proterra and Smith heavy-duty vehicles. He described TransPower's current and future vehicles and their onboard inverter-charger unit. Mr. Scott reported on developments in China regarding cars with new energy technology and China's large investments in battery-swapping. The key issue is how to minimize costs while providing convenience and safety. He suggested that either J1772 DC charging or the Chinese standard could provide adequate power for overnight charging. TransPower's onboard charger approach may result in lower system costs. Demand charges are a significant problem.

Tesla Fast Charging Network

Troy Nergaard and Greg Callman, Tesla, presented on their privately funded Tesla "Supercharger" charging infrastructure network. They showed a map highlighting the six charging stations that are already in place in California with a total of eight ready by the end of 2012. Many other stations are planned for 2013. The New York Times recently published an article about a 530-mile all-electric road trip using their largest battery pack last September 24. They showed the state of charge profile for that trip. Mr. Callman described the collaborative deployment of the Supercharger involving PG&E, SCE, SMUD, and various property owners in California. He showed photos of various projects including the Tejon Ranch with its 20kW solar array, a large battery system, and the potential for charging six Tesla vehicles. During discussion, he pointed out that their chargers all use a Tesla connector, which has the same interface for AC and DC charging. Their charging stations all use DC fast chargers and are free to their customers. Since the stations have been funded by Tesla customers they are not open to the public. The photovoltaic/battery system can provide grid services and helps alleviate demand charges. Mr. Nergaard explained that their deployment plan is aimed at connecting major cities. He appreciated feedback from the participants suggesting better choices for installation sites between corridors. In their map, the rings around each site are about 300 miles. Vandalism is a concern, which they try to minimize through site selection. He said that they are willing to share information on costs.

Sub-metering Review

Dan Bowermaster, EPRI, provided a summary of the sub metering workshop. He summarized the concerns that were raised during the workshop and the results of brainstorming, showing 15 brainstorming ideas and their corresponding pros and cons. As a next step, the SGD&E draft documents should be reviewed and the proceedings of the workshop will be distributed to the participants. During discussion, participants suggested prioritizing the different scenarios that came out of the workshop. Mr. Bowermaster concluded that the issue is complex with a lot of gaps that need to be addressed. The workshop was useful in starting the discussion of the technology aspects of sub-metering in relation to PEVs.

Sub-metering – CPUC Overview

J.C Martin, San Diego Gas & Electric, presented the California protocol for customer-owned PEV sub-meters used in billing by California's three investor owned utilities. In California, EVSEs and PEV Service Providers (EVSPs) are not regulated by the CPUC, but retail electricity sales to EVSPs are regulated. California utilities cannot own public PEV charging equipment. The CPUC guidance on the sub-metering protocol requires, among others, adherence to all existing and applicable national standards for measurement and communication functions. CPUC regulates meters used in the billing process. Mr. Martin discussed the subtractive billing arrangements, 17 sub-metering use cases, the various actors and their roles, and two specific use case examples. He presented the outlines of two "straw person" draft standards: a rule for PEV sub-metering and technical requirements. Mr. Martin also described SDG&E's experimental PEV rates and their experience in subtracted billing for over 400 customers. He discussed lessons learned including data challenges and customer education. During discussion, he reported that almost all residences in SDG&E territory already have smart meters. One advantage of the sub-meter is that customers do not have to buy electricity at the highest marginal price for their PEVs. SDG&E does not work with EVSPs to handle the PEV portion of the bill since doing so would raise technical and policy issues such as what happens if the bill does not get paid.

AMI – Smart Metering Systems

Aaron Snyder, EnerNex, gave an overview of AMI and smart metering systems. He showed photos and technical specifications of several ANSI meters: Echelon, Elster, GE, Itron, OpenWay, CENTRON, Landis+Gyr, and Sensus. He noted that there are at least 20 meter forms in use with optical ports found at different locations. ANSI Form C12-10 focuses on the back side of the meter. He also discussed the AMI meshed and point-to-multipoint solutions and presented a matrix of metering technologies. Mr. Snyder discussed the organizational changes that have come about with automated meter reading (AMR) and the implications of AMI and smart meters. He also reviewed IEC standards, the reference AMI architecture, and NIST conceptual model. Finally, he noted the limitations in the scope of the ANSI C12 metering standards and the importance of participation by the PEV and EVSE sector in standards development.

Cyber Security / Privacy

Galen Rasche, EPRI, presented activities and challenges related to cyber security and gave examples of failure scenarios. There has been increased attention of late in cyber security. The Smart Grid Interoperability Panel-Cyber Security Working Group and SAE J2931/7 deal with security issues. Key research challenges involve technology domains—such as monitoring risk, protective measures, managing incidents, and legacy systems—as well as testing and simulation. Among specific areas of concern are secure payment, smart metering, communication systems, grid management and privacy. Mr. Rasche gave examples of failure scenarios and what is needed to prevent, detect, respond and recover from incidents. Collaboration between stakeholders is key to managing security.

NEMA EVSE Interoperability Standard

Richard Lowenthal, ChargePoint, discussed PEV charging network interoperability. He highlighted the issues facing PEV drivers today and what they want, pointing to the examples of the worldwide interoperability of cell phones and automatic teller machines. The ANSI roadmap analysis identified gaps, many of which were assigned to NEMA. He described four use cases of PEV driver roaming, including the use of network-value radio frequency identification (RFID) cards, home-network initiated mobile apps, and vehicle telematics initiated service. He presented the NEMA road map with a goal to develop a set of near term standards in 2013. During discussion, he pointed out that credit cards are "anonymous" and most customers want authentication. The technologies that are already available include RFID and smart phones. The RFID standard is similar to transponder standards used at toll roads. The smart phone will communicate with the home network provider, which in turn will communicate to the EVSE.

New Definition of the Role of EVSEs

Richard Lowenthal, ChargePoint, presented the role of EVSE networks in energy services, including load leveling and frequency regulation. PEV service providers have relationships with premise owners and rate payers in shared charging. He reviewed six use cases, pointing out the relationships between actors in each case. For example, in a multi-business property, the landlord is the ratepayer and the driver has a billing relationship with the business. In the case of Walgreens, the EVSE is owned by a third party and the driver has a billing relationship with that EVSP. During discussion, Mr. Lowenthal explained that charging station maps will let the user know the rates and a user may be able to opt in or opt out knowing the demand charges. Pricing algorithms are incorporated so the user could charge at the cheapest rates. Parking enforcement is the solution in situations where a PEV spot is taken by a non-PEV or by a PEV that is not charging. Reservations will be the future.

J2894 Update

John Halliwell, EPRI, gave an update on EPRI's surge testing wherein EVSEs are connected to a surrogate load and transients are injected into the AC mains to the EVSE. The purpose of the surge test is to simulate results of a lightning strike although surges can also come from capacitor switching. EPRI found that MOVs (metal oxide varistors) protect the device from surges as expected. However, EPRI also noticed some EVSE circuit board failures, which would be a more difficult and costly repair. EPRI's goal is to ensure that the devices are robust. During discussion, it was pointed out that the IEEE Surge Protective Devices committee now has a PEV surge protection subgroup. EPRI is working with the SAE J2894 Committee and will report additional results at future meetings.

Safety & Standards for Adapters – RV Parks

Greg Nieminski, EPRI consultant, began by reviewing NEC Article 551 for recreational vehicle (RV) and RV parks. He then gave examples of different power supply assemblies and pointed out the potential for misuse. For example, he showed RV cord sets terminating in pigtails, heavy-duty power cords with no ground, replacement cord ends/ plugs and adaptors that defeat over current protection, and other adaptors that can result in overloading or use of unsafe extension cords. He explained why RVs ended up using many different adaptors leading to the use of cheap “cheater” cords that the NEC recognizes as a problem. For PEVs, these devices would defeat many safety features, allow improper charging rates, and increase the likelihood of electrical failures and faults. He described how IEC standards and UL certification standards could address this problem. PEV manufacturers should be aware of the potential misuse of common adaptors and extension cords and should design unique, non-interchangeable connection components to prevent bypassing safety features. PEV standards should include specific requirements to prevent misuse.

Wireless Charging – SAE J2954 Update

Jesse Schneider, BMW, gave an update on the SAE TIR J2954 Wireless Charging Task Force. He reviewed the scope, the main group and sub teams, and the milestone timeline for J2954. He described the maximum power and efficiency rating for different wireless power transfer (WPT) classifications and showed the functional elements of WPT. He also discussed magnetic air gap vs. mechanical air gap, testing and validation, the status of alignment and communications, and a survey of vehicle locations for WPT. Another key issue is determining the frequency band to be used, of which five are potentially available below 150 kHz. Determining the frequency is a major topic at the moment. During discussion, Mr. Lambert mentioned that a panel on hands-free charging is planned for the next IWC meeting. Mr. Schneider suggested informing the SAE Task Force.

NEC CMP / IEC Updates

Greg Nieminski, EPRI consultant, presented NEC and IEC updates. He reviewed the comments submitted by the IWC to the National Fire Protection Association (NFPA) on September 28 2012. The Code Making Panel 12 begins meeting on November 28 2013 to review the comments. Mr. Nieminski gave an update on TC18, SC23H, and TC69 standards. Work has started on a new third edition for IEC61851-1. A New Work item was approved and Joint Working Group 28 was formed with regards to the communications interface for high voltage shore connection systems under IEC/ISO/IEEE 80005-2. With regards to the combined interface coupler that allows AC and DC to be supplied with the same connector/inlet contacts, the concept has not yet been accepted pending a single fault analysis review by TC69 WG4. Mr. Nieminski reported that an MOU has been signed between IEC and ISO that will lead to the separation of the 61851 Series documents such that IEC TC 69 will handle off-board charging equipment and ISO TC22/SC21 will deal with electrical requirements on the vehicle during charging. EMC-related requirements will be under 61851-21. A New Work proposal has been approved for user identification in EVSE using smart cards and for PEV battery exchange infrastructure safety requirements.

SAE J2836/J2847/J2931 Update

Rich Scholer, Chrysler, gave an update on the PEV/EVSE Communication Task Force. He began by reviewing the four major documents and the corresponding ISO/IEC Standards. He then reviewed utility use cases 1-5, use cases 6 and 7 dealing with the PEV as a distributed energy resource, and use cases 8 and 9 on customer to PEV and HAN communications. He also reviewed the status of DC charging, noting that the combo coupler is UL certified and that efforts are now focused on implementation. With regards to wireless charging, the use cases are almost ready for balloting. In relation to the work on interoperability, J1772TM Control Pilot and DC charging are the highest priorities. He reviewed the SAE PEV/EVSE interoperability testing under Argonne National Lab/DOE. They plan to restart meetings on J2931/7 dealing with security. Under J2836/4 regarding diagnostics, control pilot and proximity failures are documented. Mr. Lambert commented that a lot of work has been accomplished by the Task Force.

SAE J1772 Update

Gery Kissel, GM, gave an update on J1772TM and the NFPA report on comments. The fifth revision of SAE J1772 TM was approved by the Motor Vehicle Council on October 3 and published on October 15. The plan to work on the sixth revision will begin in January 2013 and Task Force members are invited to submit comments. The Revision 6 plan includes control pilot transition definitions and updating of the DC contents to harmonize with IEC documents. Gery commented with regards to the NFPA, the Report on Comments meeting which takes place November 28 2013 to December 1 2013, and the PEV Task Force on Article 625 reformat will meet November 28 2013.

On-Road Presentation Summaries for the March 2013 IWC Meeting (Hosted by Salt River Project in Tempe, AZ)

NIST Working Group on EV Fueling

Mark Buttler, NIST, gave a presentation on standards for PEV fueling and submetering. His work focuses on the regulation of commercial measuring systems used to determine payment. Although there are no federal regulations and NIST is a non-regulatory agency, NIST has developed Handbooks 44 and 130, which are implemented at the State and local level. Handbook 130 on uniform laws and regulations is developed through the National Conference on Weights and Measures and available on the NIST website. Handbook 44 is on legal metrology requirements for devices. Responding to requests for regulating commercial EVSEs, NIST established the US National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering (USNWG EVF&S), which has 65 members. Their task is to develop NIST Handbook 130 Method of Sale Regulation for Electricity Vehicle Fuel. Mr. Buttler gave a status on the development of the handbook, uniform standards for measuring devices, and field testing procedures.

Future of Alternative Fuel Vehicles/Ford's Technology Roadmap for Vehicle-to-X

Dave McCreadie, Ford, presented his company's perspective on the trends in "Energi" including their long term vision for CO_2 reduction. He summarized Ford's PEV portfolio, the cost of charging, and infrastructure development. As cities and regions develop, the key to success is product flexibility. He and Jeanette Clute showed Ford's Vehicle-to-X roadmap, which included Time of Use (TOU) rates to set vehicle charging times, incorporation of renewable energy, workplace charging, ancillary services, subtractive billing, V2H, and V2G. Ford worked with Georgia Tech on the MyEnergi Lifestyle project to demonstrate smarter energy use in a home with an PEV, solar panels, and other devices. The model showed 60% reduction in energy costs and 8,000 kg CO_2 saved from a single home. During discussion, Mr. McCreadie explained that the baseline home was 1,800 sq. ft. for a family of four with two gasoline vehicles driving 37 miles a day each. The use of photovoltaics had a significant positive impact. Joel Pointon, SDG&E, suggested a phased start time for charging based on the state of charge and when the vehicle is needed in order to prevent all PEVs starting to charge at the same time.

FedEx PEV Infrastructure

Keshav Sondhi, FedEx Express, discussed some of the infrastructure challenges and needs of FedEx.

Fleet PEV Infrastructure

Efrain Ornelas, PG&E, presented the challenges and lessons learned from their fleet vehicle charging systems. Mr. Ornelas gave an overview of the project, the steps for planning, evaluation criteria, and siting decisions. He also showed photos of the new heavy duty materials handler trucks with Electric Worksite Idle Management Systems (eWIMS). Among the key lessons were that costs were always higher than anticipated, the availability of fleet-style EVSE and charging pedestal products is an issue, local planning and permitting agencies are often unaware of codes and standards, parking lot politics can be a hindrance, and no one solution fits for fleet charging systems. Planning is a key to success.

V2G DEWG

Krishnan Gowri, PNNL, presented the history, value proposition, and technical activities of the Smart Grid Interoperability Panel (SGIP), which created various Domain Expert Working Groups (DEWG) including Vehicle-to-Grid (V2G). He described the scope, vision, mission, subgroups, and current activities of the V2G DEWG. There is a new Priority Action Plan proposal on submetering for mobile and stationary applications. There are biweekly DEWG meetings, quarterly SGIP e-meetings, and an annual conference. Anyone interested can sign up at the NIST TWiki website.

PEV Charging Infrastructure Usage Patterns – 60M Miles

Jim Francfort, INL, described DOE's Advanced Vehicle Testing Activity with ECOtality as the project lead, and INL's data collection methods. He presented the EV Project results to date. The EV Project has 44 databases, algorithms generating 56,000 data parameters, and a complicated blend of multiple data streams. Mr. Francfort presented charts showing, among others, vehicle miles, EVSE usage, charge energy, and other national data. He also showed trends relating to average miles per day and miles per charge, residential EVSE Level 2 use, public Level 2 EVSE use, and fee structures. Average residential installation costs $1,375. For commercial charging, ADA, permit fees, and demand charges significantly drive costs. Mr. Francfort summarized results to date of the ChargePoint America ARRA Project. He discussed infrastructure testing of conductive charging and wireless charging. The results so far showed that EV Project vehicles were connected longer than needed to recharge, customers are price sensitive to TOU rates, and DC fast charging has significant demand impacts. During discussion, some members noted the sudden increase in charging at midnight and encouraged OEMs to incorporate optimized charging schedules. Mark Duvall, EPRI, noted that departure-based charging could still result in a high peak. Others suggested incentivizing customers to charge after midnight or service providers staggering their charging times. This is not just a peak shifting issue, but could also be an issue affecting local transformers.

Vehicle to Grid, Home, and Load – Panel Session

Watson Collins, Northeast Utilities, argued that vehicle-to-other (V2X) is cleaner and better than small engine generators and opens new business opportunities. During disasters, PEVs could play significant roles in emergency shelters, communication sites, wastewater pumping stations, temporary medical clinics, etc. He showed a matrix and examples for different connection approaches for V2X with the inverter on or off the vehicle. In the case of vehicle to home (V2H) or building (V2L) with the inverter on the vehicle, a 50A NEMA to a permanently installed inlet connector or a J1772 connector to an EVSE with possibly an isolation transformer may be needed. The V2L with an inverter off-board could be connected directly to the load via extension cords or connected using the SAE Combo / CHAdeMO / J1772 (DC Level 1) to a portable outlet box. A V2H with inverter off-board could be part of an energy management system. The IWC should identify preferred approaches and standards gaps.

Rich Scholer, Chrysler, gave an overview of a DOE project and the role of Chrysler PHEVs.

Discussions centered on the compatibility of connectors, the use of auto transformers instead of isolation transformers, and demand charges. Ray Strods, Siemens, noted that many solutions have already been developed in earlier work related to solar generation. Mr. Collins stated that utilities do not view V2H or V2L as competing with electrical utilities, but rather as providing customer resiliency during storms. The value proposition for utilities is strong performance and helping customers survive disasters. Another advantage of PEVs is that the infrastructure to provide backup energy has to be done by qualified electricians and is therefore safer than an emergency generator. Moreover, using an automotive connector that has gone through compliance testing and provides protection from back-feed adds another measure of safety. Arindam Maitra, EPRI, added that a long term benefit is voltage regulation, but a different mode of inverter would be needed.

Duke-Toyota Smart Charging Pilot

Steve Hinkel, Duke Energy, presented a collaborative project with other partners to test SAE J2931 at a lab and in the field. Duke energy is using three function sets of the SEP 2.0 protocol stack: time, pricing, and demand response functions. They use a simulated whole-house tariff to observe consumer behavior. Among the early lessons is initial confusion regarding SEP 2.0 terminology and other issues. Duke Energy is now discussing with other parties to expand functionality. Akihisa Yokoyama, Toyota, summarized the main features of the field testing in Indiana using a cloud-assisted system for analyzing and controlling the optimized charge settings. He described the data flow and communication architecture between the utility, internet, and vehicle. All the customer has to do is connect the charging cable to the PEV and optimal charging is set automatically. Notification pops up in the customer's iPad. He gave examples of five charging cases. The tests currently involve five Duke Energy employees for the first half of 2013 followed by five regular customers. During discussion, Mr. Hinkel stated that the test participants are given the PEV, EVSE, and iPad. He explained that some of the confusion had to do with the complicated whole-house rate and 21 different riders in the tariff. With regards to the communications options, HomePlug Green PHY was selected since they want to use existing technologies.

Utility Smart Charging Initiatives

John Halliwell, EPRI, reported on the results of an online survey on smart charging initiatives among utilities. He highlighted the smart charging projects of Arizona Public Service, FirstEnergy, Northeast Utilities, New York Power Authority, and Southern Company. They include a project integrating photovoltaics, ZnBr flow battery, and PEV chargers; PEV smart charging with a Chevy Volt; a smart charging interface to the grid using light and medium duty PHEVs; evaluation of smart grid analysis tools; cost and implementation issues associated with PEV specific TOU rates; public charging EVSE with the ability to respond to peak load management signals; and a residential load-flattening project using off peak rates for customers with registered PEVs.

Pricing Strategies to Manage Charging

John Halliwell, EPRI, along with Watson Collins, NU, and Dwight MacCurdy, SMUD, collaborated on the presentation, which was the result of a discussion at the last ISC meeting on the value proposition for managed charging. They presented various value proposition scenarios and cost benefit assessments for the utility, the consumer, and the OEM. They are asking for input. Given the diversity of utility structures, climates, and regulatory regimes, can utilities be categorized in a systematic way to narrow the value proposition options? How does consumer value vary across utilities? Is the OEM value proposition consistent across utilities? They are looking for utilities to present their perspectives. During discussion, it was suggested that the value proposition to EVSE manufacturers should also be considered.

EVSE Interoperability Testing – SMUD Pilot

Denver Hinds, SMUD, presented on SMUD's EV Innovator pilot program testing, which is part of the DOE Smart Grid Investment Grant. The SmartSacramento grant is divided into 7 domains, the largest of which is AMI/smart meters. Smart Charging is under the Customer & Partnerships domain. The EV Innovator project seeks to conduct a pilot program with up to 180 residential PEV participants, conduct market research on PEV driver attitudes, test interoperability of EVSE with the Demand Response Management System (DRMS), and measure EVSE electricity use. Mr. Hinds described the three study groups of 60 customers each and their charging and tariff rates. They are testing interoperability from the PEV to the DRMS. He explained the two phases of EVSE unit testing, end-to-end system testing, and interoperability test procedures. Of the nine EVs tested, six passed their interoperability tests, and three failed. The impact of incompatibility with J1772™ includes reduced demand response and disgruntled PEV and utility customers. During discussion, Mr. Hinds explained that the study groups can opt-in to the study and are notified via email, text or call the day before a conservation event.

Notification and Multi-Unit Dwelling Vehicle Charging

Joel Pointon, SDG&E, compared PEV charging loads with those for household appliances, described SDG&E's PEV TOU rates, and listed the different phases of notification. They get fewer notifications from PEV buyers. Notifications from permitting depend on the communities and notifications from rebate information require CARB and owner permissions. They are able to get information from the Department of Motor Vehicles after they notify the owners, but OEMs need to let them know how to read the vehicle identification number information to determine if the vehicle is a plug-in. They may also be able to detect PEV loads through algorithms using AMI. Mr. Pointon discussed a multi-unit dwelling case study of a midrise luxury condominium community. The property managers and residents wanted a billing arrangement that allowed residents to pay for energy usage directly. However, parking spaces were far from the residents' individual meters and the common area meters were on commercial rates and subject to demand and TOU impacts. Mr. Pointon described the technical challenges and compromise solution. A process of consensus building allowed residents to have a choice and resulted in a solution that is scalable over time. Mr. Pointon co-chairs the California PEVC Multi-Unit Dwelling Workgroup.

Plug-in-Cord Connected EVSE

Jordan Smith, SCE, described the failure of a 240V receptacle. The incident involved a failure of a plug-in receptacle installed on a cement brick wall exposed to the weather. From their investigations they found one of the sleeves was loose, causing micro arcing in the sleeve and subsequent degradation of the plastic insulation due to heating. The pin of the plug had missing material. SCE's PEV technical center then conducted an immediate inspection of all receptacles and plugs and replaced all receptacles. They also instituted a regular inspection program with replacements at the life cycle limit. His recommendations include requiring a rugged and long lived plug/receptacle pair, a means to prevent an unintentional disconnect, and discouragement of mobile EVSE. During discussion, Mr. Smith explained that the assembly was outdoor rated and involved insertion and removal of the plug only a few times a month. During inspection, they found five receptacles that were not in good shape. They measured the insertion/removal forces as well as the spade dimensions.

SAE J2894 Update

Richard Hodson, SCE, gave an update on the J2894-2, Power Quality Test Procedures for PEV Chargers, described the test system boundaries, and the procedures for power quality parameters and grid events such as voltage swells, surges, and sags. The voltage distortion procedure is being finalized and the voltage surge test references IEC 61000-4-5. He also explained the procedure for energy efficiency tests based on standardized battery capacity test discharges. Recommendations for energy efficiency parameters will be based on test results. He explained that they did not use a "standardized" EVSE since test results are specific to the whole system of which the EVSE is a part. During discussion, Jordan Smith explained that they felt the best place to address energy efficiency of the PEV system was under SAE J2894 even though energy efficiency depends on the battery. A suggestion was made to change the name of the standard to reflect that the tests pertain to the system as a whole and not just the charger.

NEC/IEC Updates

Greg Nieminski, EPRI consultant, said that the results of the NEC Report on Comments, issued in March 2013, can be viewed and downloaded from the NFPA website[7]. Final actions will take place during the NFPA meeting in Chicago this June. Mr. Nieminski reported that work has been completed to transform UL's PEV standards into tri-national (US, Canada, Mexico) standards containing common requirements identified as UL/CSA/ANCE Standards. Nieminski also reported on a new project under IEC TC69 for Light Electric Vehicles (LEV) including electric motorcycles, scooters, etc. They will be covered under a future IEC 61851-3 with subparts dealing with general requirements, off-board conductive power supply systems, battery swap systems, and communications. A similar project team will be established for connectors and inlets for these applications. Anyone interested should contact Mr. Nieminski.

NEC 2014 Changes / SAE J1772 Updates

Gery Kissel, GM, gave an update on J1772TM and J2894. The J1772TM document was reopened in January 2013 to allow harmonization with IEC 61851-x and 62196-x. The estimated publication for Version 6 is end of 2013 or early 2014. SAE J2894-1 on power quality requirements was completed in December 2011. J2894-2 on test procedures has been delayed, but the publication date for Version 1 is estimated to be the third quarter of 2013. Mr. Kissel also gave an update on the changes to NEC Article 625, noting that his summary is only for guidance and may not contain the final text of the publication. Changes were made to the layout, scope, definitions, voltages, polarization, grounding pole, rating, cords and cables, personnel protection systems, and other provisions.

SAE J2836/J2847/J2931 Update

Rich Scholer, Chrysler, reviewed the open and active documents and summarized the SAE communications standards and document interactions. He then listed all the use case documents as Technical Information Reports (TIR), signals/messages documents as Recommended Practice (RP), requirements and protocol documents as TIRs, and interoperability documents as RPs. He noted that TIRs can later be upgraded to RPs. During discussion, differences between compliance vs. compatibility vs. interoperability were noted.

SAE J2953 Update

Ted Bohn, ANL, presented the status of ANL activities related to SAE J2953 PEV-EVSE Interoperability. Fifty authors are involved in the work. The goal is to have J2953-1 requirements ready for comments in 30 days, J2953-2 on procedures ready by the end of summer, and J2953-1 v2 on DC communications started at the end of summer. The three tiers of interoperability involve normal, non-normal, and optional test cases. He discussed interoperability benchmarking, validation of testing standards, and DC charging communication interoperability, as well as an AC/DC charging communication controller and a wireless charging fixture developed by ANL. During discussion, Mark Duvall, EPRI, suggested that public charging stations with wireless connections should also include a J1772™ connector to insure that

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[7] http://www.nfpa.org/categoryList.asp?categoryID=124&URL=Codes%20&%20Standards

everyone can charge. Mr. Bohn offered to present on safety and human exposure issues in the future.

On-Road Presentation Summaries for the July 2013 IWC Meeting (Hosted by EPRI in Palo Alto, CA)

EVSE Metering – NIST Handbook 130

Richard Lowenthal, ChargePoint, described the model standards on weights and measures developed by the National Institute of Standards and Technology (NIST) under the Department of Commerce. These model standards are often adopted or used as a basis for enforceable state laws. NIST Handbook 130 (HB130) deals with methods of sale (e.g., sale by kWh or time) and NIST Handbook 44 (HB44) deals with the equipment. For 2013, proposals to modify HB130 for electric vehicles have been submitted for a vote. Mr. Lowenthal presented the actual proposed text modifications for HB130 Parts 1-3. NIST's US National Working Group on electric vehicles will begin discussing changes to HB44 soon. Without HB130 and HB44, states would go in different directions. During discussion, he noted that these standards are applicable in any charging place where commerce is involved. The issue is now on the agenda of the California Department of Food and Agriculture. States typically take about six months to adopt so enforcement could be as early as January 2014. He also explained labeling requirements.

SPIDERS Microgrid V2G Charging Station

Mike Simpson, NREL, described the Smart Power Infrastructure Demonstration for Energy, Reliability and Security (SPIDERS), a DoE-DoD project at three military bases. The Fort Carson installation is a 2-3 MW micro-grid involving a solar array, 5 medium duty PEVs, and a bi-directional charging station. Mr. Simpson described the PEV charge interface, the off-board DC V2G testbed, the bi-directional EVSE, and the SPIDERS test set-up. The V2G interconnection test procedure was based on IEEE 1547.1. Early test results show that the EVSE meets key interconnection compliance criteria. High power V2G tests involve the J1772TM combo connector. The test quantifies potential operational problems before field deployment. During discussion, Mr. Simpson explained that they plan to have a grid-tied micro-grid to test ancillary service. Arindam Maitra, EPRI, noted that serious issues arise regarding safety during islanding as well as overcurrent protection. Mr. Simpson noted that they did not find any fault current concerns, but would be interested in collaborating with EPRI in looking at catastrophic failures. He added that the SPIDERS project deals with commercially available systems.

"Grid on Wheels" – V2G PJM Demonstration

Tom Gage, EV Grid, gave a history of V2G from its initial conception in 1997 to the present. It included a V2G demonstration in 2002, a real time grid regulation demonstration in 2007, and the availability in 2013 of V2G-capable BMW Mini-Es with J1772TM connectors and a $1,000 bi-directional EVSE for hour-ahead regulation markets and third party aggregation. Fifteen cars are being deployed to users in summer 2013. Mr. Gage discussed key elements for grid integrated vehicles, V2G project needs, and the value per vehicle. He gave an example of ISO and vehicle real-time responses. During discussion, he mentioned that a minimum of 20 kWh is needed for surplus capacity. With the experience of BMW as well as Tesla and Taiwan, he stated that the concept is now well understood. As the country adds more renewable resources, there will be greater need for storage and regulation.

Future of Alternative Fuel Vehicles - GM

George Bellino, GM, discussed global energy demand, international emissions outlook, fuel efficiency, GM's propulsion strategy, and technologies for advanced fuel saving. He discussed the benefits of bio fuels, CNG and LPG fuel systems, and LPG for high cube and shuttle applications. Electric drive vehicles offer the best long-term solution. He discussed the benefits of hydrogen fuel cells and GM's Project Driveway, the largest market test of fuel cell vehicles beginning in 2007. During discussion, he suggested that some OEMs may have fuel cell cars around 2017, but a lot depends on funding and development of the hydrogen infrastructure. Standards groups have been working on requirements regarding hydrogen purity for the last decade. The outlook for CNG and LPG infrastructures is improving due to government support and environmental concerns. Energy density is an important consideration in determining which is best for an application.

EVSE Interoperability

Andreas Pffeiffer, Hubject, began by showing a video on e-mobility (www.intercharge.eu). He presented the status of e-mobility in Europe and the spider web of relations needed to make the market efficient. Banking is an example of an interoperable market structure. The current European market is basically comprised of islands of e-mobility. The intercharge symbol represents interoperability that works with smart phones, RFID, and plug-and-charge, with 90% of users using RFID. He explained the architecture, showing the role of the charge point operator (e.g., a city or private owner), e-mobility provider (who negotiates contracts with customers and sets price), and Hubject, which facilitates the linkage through service level agreements and serves as a clearinghouse and provides roaming and a smart infrastructure platform. They use Open InterCharge Protocol (OICP). During discussion, he explained that the operator provides the assets and Hubject gets money from the e-mobility provider. Even though OICP has not been adopted by any international body, Hubject offers it as an open proposal compliant with Open Charge Point Protocol (OCCP).

Open Standards-Based Charging Stations

Craig Rodine, Greenlots, presented their cloud-based platform for PEV charging. In the development of the PEV infrastructure market, charging infrastructure funded mainly by governments led to a few proprietary networks for public infrastructure. These proprietary networks limited open access and the choice of technologies and business models, and resulted in higher costs due to "vendor lock in". When a network went out of business it left hundreds of stranded assets. Mr. Rodine explained the benefits of open standards: flexibility, providing a level playing field, and competitive pricing. He described the EPRI/Greenlots project architecture and roadmap. They support Open Charge Point Protocol (OCCP) version 1.5. During discussion, he explained that OCCP can work with a variety of vendors and is being adopted by Autodesk and BC Hydro.

DC Fast Charging – Panel Session

Field Deployment Plans

Cedric Daniels, Southern Company, presented an electric utility perspective. Based on their past experience, Southern Company wants to invest prudently in DC fast charging; their enthusiasm is tempered by due diligence and the viability of a business case. With respect to 208V 3-phase vs. 480V 3-phase, the latter is three times more expensive since it is much more common to find 208V 3-phase infrastructure. Demand charges are a significant barrier. As for multi-family dwelling charging, DC fast charging maybe a possibility for exclusive, high-end multi-family locations. Mr. Daniels also addressed the issue of free vs. fee for charging. The unique DC fast charging model of Tesla is getting much public attention and utilities continues to get questions about Tesla. During discussion, Mr. Daniels explained that utilities simply cannot change or waive demand charge rates since utilities are regulated. With regards to multi-family dwellings, various utilities shared their experiences showing that there is no single approach. The solutions for new installation vs. retrofitting for multi-family charging are different.

Combo vs. CHAdeMO

Ron Thompson, Eaton, stated that he would not be able to provide detailed information for proprietary reasons. Eaton has been working on the CHAdeMO connector. Eaton is awaiting the standards, but they expect to support both the CHAdeMO and the Combo connectors.

Utility Business Case

Morgan Davis, EPRI, focused on five main aspects of DC fast charging based on EPRI's modeling work. EPRI's GIS analysis came up with maps showing the potential locations for a national charging network. EPRI also found that the cost of installation (excluding the cost of the fast charger) is significantly higher for 480V compared to a medium voltage fast charge installation. EPRI studies projected low usage of DC fast charging and thus, small impacts at the substation level. The market size decreases with range, but the willingness to pay increases for multi-car households. The peak demand is about 90% of the charger power in most cases with utilization above 4-5 customers on the busiest day of the month. In effect, DC fast chargers are providing time and convenience. During discussion, Ms. Davis explained that some of the assumptions in the EPRI study are near worst case. The highest demand takes place during bulk charging when the charge is operating in current mode. Topping off is at a lower demand and the charger operates in voltage mode. Craig Childers, CARB, suggested that co-locating DC fast charging with other services (e.g., rest area, toilets, food, etc.) may be a better business case.

International Standards

Serge Roy, IEC TC69, gave an update on international standards. DC charging could refer to both slow and fast charge. The IEC deals with the charging station and ISO deals with PEV requirements. He showed a simplified isolation system and distinguished between regulated vs. non-regulated and isolated vs. non-isolated. Three isolated and regulated DC charging systems are in the standards. IEC TC69 61851 parts 23 & 24 deal with DC charging and communication between the DC charger and PEV. IEC TC23 SC23H 62196 part 3 deals with interchangeability requirements for dedicated DC and combined AC/DC couplers. He explained the standards development schedule. The new trend among European charger manufacturers is to offer dual or triple arm chargers to accommodate multiple standards. During discussion, he explained that Chinese standards deal with bulk charging, onboard charging, and charging in battery exchange stations. IEC 61851-1 is delayed to 2014. With regards to triple-arm chargers, the standards allow charging multiple cars but only one at a time using some charging management system.

Nissan Business Case

Brendan Jones, Nissan, explained how DC fast charging can build range confidence. By March 2014, Nissan expects to have over 600 DC fast chargers (CHAdeMO standard) in the US. The service will be primarily provided through their dealerships. The average cost is about $45,000-$47,000 per location. DC fast charging could be installed in malls, gyms and gas stations in a suburban setting or on major highways and service areas as pathway charging between cities. Site host identification and costs are major issues. Mr. Jones showed signage as a PEV awareness and educational tool that could build range confidence. During discussion, Mr. Jones mentioned that turning down the charger after the batteries have reached a certain state of charge is one way to eliminate queuing. About 90% of their vehicles are sold with a CHAdeMO connector. Mr. Jones said that they have option codes with the VIN which can tell if the vehicle can use the CHAdeMO.

DC Fast Charging – Panel Session Discussion

Joel Pointon polled the Japanese manufacturers on which standards they are using. Toyota, Honda and Mitsubishi are using the CHAdeMO connector, but are also using standards applicable in other countries. Of the OEMs, VW, BMW and Chevy Smart are bringing out fast charging with the Combo connector. Mr. Jones felt that the debate on standards is a distraction and negatively impacts PEV adoption, but others felt that knowing which standards OEMs are going to follow allows utilities to plan for long-term stability of the infrastructure. Discussion centered on Ms. Morgan's installation cost data. Mr. Daniels asked if there was a power level that might be just enough for consumer needs, as had been the case for fast charging of industrial lift trucks. Participants also discussed the potential for wireless charging, but neither the IEC nor SAE are ready for a wireless standard. Mr. Roy explained that his presentation did not make reference to North American standards since he was only trying to explain the process and dynamics of creating standards. Unlike Europe, the US does not create a national standard. Mr. Childers noted, however, that standards like J1772TM become de facto standards in states. Participants agree that there is a need to understand what concepts should be conveyed to users for them to understand DC fast charging.

SEP 2.0 Executive Summary

Tobin Richardson, ZigBee Alliance, gave a high level presentation of Smart Energy Profile IP version 2.0 (SEP 2.0). He discussed the scope, focus, and relevance to electric vehicles. The SEP 2 application profile has been completed and is available at www.zigbee.org/smartenergy which includes a one hour tutorial. Regarding certification, there is a Consortium for SEP 2.0 Interoperability (CSEP) which provides a certification program across any MAC/PHY. SEP 2.0 is being adopted into the Catalogue of Standards of the Smart Grid Interoperability Panel. Under IEEE P2030, a version of SEP 2.0 is currently in sponsor ballot.

IEC Updates

Greg Nieminski, EPRI Consultant, reviewed all existing PEV related standards of the IEC. He provided a list of IEC standards and their titles. He also provided a table showing charging equipment standards (shown in red) and official dates. He also pointed out some new items (shown with a blue background in the table) including IEC 62196-4 dealing with two or three wheeled vehicles. US experts are needed for the new committee. IEC 61980 are technical specifications for wireless charging. Technical specifications are working documents in preparation for the development of a standard in the future.

SAE J1772 Updates

Gery Kissel, GM, gave an update on J1772™ and J2894. SAE J1772™ was reopened for Version 6. The coupler drawings currently use the XY dimensional coordinate system. The drawings are being redone using the geometric dimensioning and tolerancing (GD&T) coordinate system. J2894-2 on power quality test procedures has been delayed due to discussions on efficiency test methods. The overall efficiency requirement is still under review. During discussion, Mr. Kissel mentioned that Jim Francfort, INL, is involved in the process.

SAE J2836/J2847/J2931 Update

Rich Scholer, Chrysler, first showed a graphic on how the various SAE documents interact. He then reviewed the SAE activities on open and active documents. Use cases for customer to PEV communications (telematics) are being developed under J2836/5TM V1. Items that were not included in J2847/2 V2 are now being captured in V3 along with harmonization with DIN 70121. J2847/3 is a new document on PEV as a distributed energy resource. He gave examples of home energy management and frequency regulation and discussed interconnection issues. Coordinating variations between US, European, and Japanese DSRC for communication is needed for J2847-6 (wireless charging messages). J2931/7 on security restarts in August. J2953/1 &/2 deal with interoperability starting with control pilot and prox followed by DC and utility communication. Mr. Scholer described ANL's EVSE interoperability center, which opened on July 18. He presented a summary of use case documents, signal/message documents, requirements and protocol documents, and interoperability documents. During discussion, he explained that if they find EVSEs that are not compliant they give feedback to the team and also propose changes to the document to clarify items in order to ensure interoperability in the future.

On-Road Presentation Outlines for upcoming December 2013 IWC Meeting (Hosted by Nissan North America in Franklin, TN)

- Update on NIST USNWG on EV Fueling
- Two automotive OEMs (BMW and Nissan) will provide an update on their future alternative fuel vehicle plans.
- A discussion and overview of Public Service Commissions and Public Utility Commission activities related to plug-in electric vehicles.
- What's happening on the regulatory front for PEVs?

- Idaho National Lab will present data they've collected on wireless PEV charging systems.
- Nissan will provide a tour of their on-site solar charging station.
- A panel discussion of the pros and cons of the use of Level 1 AC (120V) vehicle charging.
- RWE will discuss their experience in Germany with utility managed smart charging.
- A discussion of EVSE networks.
- Updates on SAE and ISO/IEC standards work

4

CODES & STANDARDS FOR NON-ROAD & ON-ROAD TRANSPORTATION

Figure 4-1 provides a graphic representation of the pertinent codes and standards bodies related to the IWC. Table 4-1 provides an exhaustive list of codes and standards along with a status, a web link if available and a brief description of the document for all relevant codes and standards related to the IWC.

Japanese Automotive Research Institute (JARI)
- JEVA (Japanese Electric Vehicle Association)

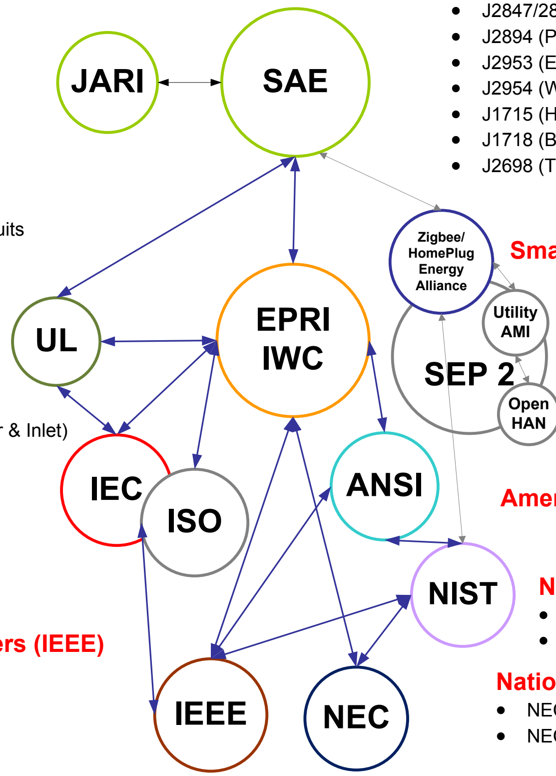
Infrastructure Working Council (IWC)
- Utility-funded stakeholder group
- Identify and address needs for codes and standards
- Not a standards body

Underwriters Laboratories (UL)
- UL 2202 (EV Chargers)
- UL2231 Personnel Protection Systems for EV Supply Circuits
- UL2251 Plugs, Receptacles, and Couplers for Evs
- UL Subject 2594 - Electric Vehicle Supply Equipment

Intl Electrotechnical Comm (IEC)
- TC69 (Charge Infrastructure)
- TC18/MT26 (HVSC Shore to Ship Electrification)
- SC23H/MT8 & PT62196 (EV Plug, Receptacle, Connector & Inlet)

Intl Standards Organization (ISO)
- TC22/ SC3 (Electrical Control & Communications)
- TC22/SC21 (Road Vehicles)

Institute of Electrical and Electronic Engineers (IEEE)
- IEEE 1547 (Grid Tie)
- IEEE P2030 (Smart Grid)



Society of Automotive Engineers (SAE)
- J1772 (Connector)
- J2847/2836/2931 (Communications)
- J2894 (Power Quality)
- J2953 (EVSE Compatibility)
- J2954 (Wireless Power Transfer)
- J1715 (HEV & EV Terminology)
- J1718 (Battery-Powered Passenger Cars)
- J2698 (Truck and Bus)

Smart Energy Profile (SEP)

American National Standard Institute (ANSI)

National Institute of Science and Technology (NIST)
- Priority Action Plan 11 (Electric Transportation)
- Priority Action Plan 15 (Communication)

National Electric Code (NEC)
- NEC625 (EV Charging Systems)
- NEC 626 (Electrified Truck Parking Spaces)

Figure 4-1 Code and Standard Committees for On-Road and Non-Road Transportation

Table 4-1 Standard Activity Updates[8]

Document	Title	Status	URL	Document Abstract
Relevant SAE Documents – Recommended Practices and Technical Information Reports				
SAE J1711	*Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-in Hybrid Vehicles*	Issued 2010	http://standards.sae.org/j1711_201006	This SAE Recommended Practice establishes uniform chassis dynamometer test procedures for hybrid-electric vehicles (HEVs) that are designed to be driven on public roads.
SAE J1715	*Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology*	Issued 2008	http://standards.sae.org/j1715_200802	This SAE Information Report contains definitions for electric vehicle terminology. It is intended that this document be a resource for those writing other electric vehicle documents, specifications, standards, or recommended practices. Hybrid electric vehicle terminology will be covered in future revisions of this document or as a separate document.
SAE J1718	*Measurement of Hydrogen Gas Emissions from Battery-Powered Passenger Cars and Light Trucks During Battery Charging*	Cancelled Nov 2008	http://standards.sae.org/j1718_200811	This SAE Recommended Practice describes a procedure for measuring gaseous hydrogen emissions from the aqueous battery system of a battery-powered passenger car or light truck.
SAE J1772™	*SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler*	Revision Issued October 2012	http://standards.sae.org/j1772_201210	This SAE Recommended Practice covers the general physical, electrical, functional and performance requirements to facilitate conductive charging of EV/PEV vehicles in North America. This document defines a common EV/PEV and supply equipment vehicle conductive charging method including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector. It has been revised to include DC vehicle connectors and couplers.
SAE J1773	*SAE Electric Vehicle Inductively Coupled Charging*	Issued 2009	http://www.sae.org/technical/standards/J1773_200905	This SAE Recommended Practice establishes the minimum interface compatibility requirements for electric vehicle (EV) inductively-coupled charging for North America.
SAE J1797	*Recommended Practice for Packaging of Electric Vehicle Battery Modules*	Issued 2008	http://www.sae.org/technical/standards/J1797_200806	This SAE Recommended Practice provides for common battery designs through the description of dimensions, termination, retention, venting system, and other features required in an electric vehicle application. The document does not provide for performance standards. Performance will be addressed by SAE J1798. This document does provide for guidelines in proper packaging of battery modules to meet performance criteria detailed in J1766
SAE J1798	*Recommended Practice for Performance Rating of*	Issued	http://standards.sae.org/j	This SAE Recommended Practice provides for common test and verification methods to determine Electric Vehicle battery module performance. The document creates the

[8] Descriptive abstracts were obtained from Standards organization websites – links provided.

	Electric Vehicle Battery Modules	2008	1798_200807	necessary performance standards to determine (a) what the basic performance of EV battery modules is; and (b) whether battery modules meet minimum performance specification established by vehicle manufacturers or other purchasers. Specific values for these minimum performance specifications are not a part of this document
SAE J2288	*Life Cycle Testing of Electric Vehicle Battery Modules*	Issued 2008	http://www.sae.org/technical/standards/J2288_200806	This SAE Recommended Practice defines a standardized test method to determine the expected service life, in cycles, of electric vehicle battery modules. It is based on a set of nominal or baseline operating conditions in order to characterize the expected degradation in electrical performance as a function of life and to identify relevant failure mechanisms where possible.
SAE J2289	*Electric-Drive Battery Pack System: Functional Guidelines*	Issued 2008	http://www.sae.org/technical/standards/J2289_200807	This SAE Information Report describes common practices for design of battery systems for vehicles that utilize a rechargeable battery to provide or recover all or some traction energy for an electric drive system. It includes product description, physical requirements, electrical requirements, environmental requirements, safety requirements, storage and shipment characteristics, and labeling requirements. It also covers termination, retention, venting system, thermal management, and other features.
SAE J2293 / 1	*Energy Transfer System for Electric Vehicles – Part 1: Functional Requirements and System Architectures*	Issued 2008	http://www.sae.org/technical/standards/J2293/1_200807	SAE J2293 establishes requirements for Electric Vehicles (EV) and the off- board Electric Vehicle Supply Equipment (EVSE) used to transfer electrical energy to an EV from an Electric Utility Power System (Utility) in North America. This document defines, either directly or by reference, all characteristics of the total EV Energy Transfer System (EV-ETS) necessary to insure the functional interoperability of an EV and EVSE of the same physical system architecture. The ETS, regardless of architecture, is responsible for the conversion of AC electrical energy into DC electrical energy that can be used to charge the Storage Battery of an EV, as shown.
SAE J2293 / 2	*Energy Transfer System for Electric Vehicles – Part 2: Communication Requirements and Network Architecture*	Issued 2008	http://www.sae.org/technical/standards/J2293/2_200807	SAE J2293 establishes requirements for Electric Vehicles (EV) and the off-board Electric Vehicle Supply Equipment (EVSE) used to transfer electrical energy to an EV from an electric Utility Power System (Utility) in North America. This document defines, either directly or by reference, all characteristics of the total EV Energy Transfer System (EV-ETS) necessary to insure the functional interoperability of an EV and EVSE of the same physical system architecture.
SAE J2344	*Guidelines for Electric Vehicle Safety*	Issued 2010	http://www.sae.org/technical/standards/J2344_201003	This SAE Information Report identifies and defines the preferred technical guidelines relating to safety for Electric Vehicles (EVs) during normal operation and charging. Guidelines in this document do not necessarily address maintenance, repair, or assembly safety issues. The purpose of this SAE Information Report is to provide introductory safety guidelines information that should be considered when designing electric vehicles for use on public roadways. This document covers electric vehicles having a gross vehicle weight rating of 4536 kg (10 000 lb) or less that are designed for use on public roads
SAE J2380	*Vibration Testing of Electric Vehicle Batteries*	Issued 2009	http://www.sae.org/technical/standards/J2380_200903	This SAE Recommended Practice describes the vibration durability testing of a single battery (test unit) consisting of either an electric vehicle battery module or an electric vehicle battery pack. For statistical purposes, multiple samples would normally be subjected to such testing. Additionally, some test units may be subjected to life cycle testing (either after or during vibration testing) to determine the effects of vibration on battery life. Such life testing is not described in this procedure; SAE J2288 may be used for this purpose as applicable

SAE J2464	*Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing*	Issued 2009	http://www.sae.org/technical/standards/J2464_200911	This SAE Recommended Practice is intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances. It describes a body of tests which may be used as needed for abuse testing of electric or hybrid electric vehicle batteries to determine the response of such batteries to conditions or events which are beyond their normal operating range. This document is derived from a similar document originally developed by the U.S. Advanced Battery Consortium. (See 2.2.1.)
SAE J2698	*Primary Single Phase Nominal 120 VAC Wiring Distribution Assembly Design - Truck and Bus*	Issued 2008	http://standards.sae.org/j2698_200801	This SAE Recommended Practice covers the design and application of primary on-board wiring distribution system harnessing for surface vehicles. This document is intended for single phase nominal 120 VAC circuits that provide power to truck sleeper cab hotel loads so that they may operate with the main propulsion engine turned off. The power supply comes from alternative sources such as land-based grid power, DC-AC inverters and auxiliary power generators. The circuits may also provide power to improve vehicle performance through charging batteries or operating cold-weather starting aids.
SAE J2735	*Dedicated Short Range Communications (DSRC) Message Set Dictionary*	Issued 2009	http://standards.sae.org/j2735_200911/	This SAE Standard specifies a message set, and its data frames and data elements specifically for use by applications intended to utilize the 5.9 GHz Dedicated Short Range Communications for Wireless Access in Vehicular Environments (DSRC/WAVE, referenced in this document simply as “DSRC”), communications systems. Although the scope of this Standard is focused on DSRC, this message set, and its data frames and data elements have been designed, to the extent possible, to also be of potential use for applications that may be deployed in conjunction with other wireless communications technologies. This Standard therefore specifies the definitive message structure and provides sufficient background information to allow readers to properly interpret the message definitions from the point of view of an application developer implementing the messages according to the DSRC Standards.
SAE J2758	*Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle*	Issued 2007 Under Revision	http://www.sae.org/technical/standards/J2758_200704	This document describes a test procedure for rating peak power of the Rechargeable Energy Storage System (RESS) used in a combustion engine Hybrid Electric Vehicle (HEV). Other types of vehicles with non fossil fuel primary engines, such as fuel cells, are not intended to use this test procedure
SAE J2836 / 1	*Use Cases for Communication between Plug-In Vehicles and the Utility Grid*	Issued 2010	http://standards.sae.org/j2836/1_201004	This SAE Information Report J2836 /1 establish use cases for communication between plug-in electric vehicles and the electric power grid, for energy transfer and other applications.
SAE J2836 / 2	*Use Cases for Communication between Plug-In Vehicles and the Supply Equipment (EVSE)*	Issued 2011	http://standards.sae.org/j2836/2_201109	This SAE Information Report J2836 / 2 establishes use cases for communication between plug-in electric vehicles and the electric vehicle supply equipment, for energy transfer and other applications
SAE J2836 /3	*Use Cases for Communication Between Plug-In Vehicles and the Utility Grid for Reverse Power Flow*	Issued 2013	http://standards.sae.org/wip/j2836/3	This SAE Information Report J2836/3 establishes use cases for communication between plug-in electric vehicles and the electric power grid, for reverse power flow.
SAE J2836 /4	*Use Cases for Diagnostic*	Under	http://standards.sae.org/	This SAE Information Report J2836/4 establishes diagnostic use cases between plug-in

	Communication for Plug-in Vehicles	Develop ment	wip/j2836/4	electric vehicles and the EV Supply Equipment (EVSE). As Plug-In Vehicles (PEV) are deployed and include both Plug-In Hybrid Electric (PHEV) and Battery Electric (BEV) variations, failures of the charging session between the EVSE and PEV may include diagnostics particular to the vehicle variations. This document will describe the general information required for diagnostics and J2847/4 will include the detail messages to provide accurate information to the customer and/or service personnel to identify the source of the issue and assist in resolution. Existing vehicle diagnostics can also be added and included during this charging session regarding issues that have occurred or are imminent to the EVSE or PEV, to assist in resolution of these items.
SAE J2836 /5	*Use Cases for Communication between Plug-in Vehicles and their customers.*	Under Develop ment	http://standards.sae.org/wip/j2836/5	This SAE Information Report J2836/5™ establishes use cases between Plug-In Vehicles (PEV) and their customer. The customer will be able to interact with the PEV as it charges/discharges. Information and control for each session, including status, updates and potential changes are identified in this document as they use private or public scenarios to connect their vehicles to the utility grid.
SAE J2836 /6	*Use Cases for Wireless Charging Communication for Plug-in Electric Vehicles*	Issued 2013	http://standards.sae.org/j2836/6_201305/	This SAE Information Report SAE J2836/6™ establishes use cases for communication between plug-in electric vehicles and the EVSE, for wireless energy transfer as specified in SAE J2954. It addresses the requirements for communications between the on-board charging system and the Wireless EV Supply Equipment (WEVSE) in support of detection of the WEVSE, the charging process, and monitoring of the charging process. Since the communication to the charging infrastructure and the power grid for smart charging will also be communicated by the WEVSE to the EV over the wireless interface, these requirements are also covered. However, the processes and procedures are expected to be identical to those specified for V2G communications specified in SAE J2836/1.
SAE J2841	*Utility Factor Definitions for Plug-In Hybrid Vehicles Using Travel Survey Data*	Issued 2010	http://standards.sae.org/j2841_201009	The total fuel and energy consumption rates of a Plug-In Hybrid Electric Vehicle (PHEV) vary depending upon the distance driven. For PHEVs, the assumption is that operation starts in battery charge-depleting mode and eventually changes to battery charge-sustaining mode. Total distance between charge events determines how much of the driving is performed in each of the two fundamental modes. An equation describing the portion of driving in each mode is defined. Driving statistics from the National Highway Transportation Survey are used as inputs to the equation to provide an aggregate "Utility Factor" (UF) applied to the charge-depleting mode results.
SAE J2847 /1	*Communication for Smart Charging of Plug-in Electric Vehicles using Smart Energy Profile 2.0*	Issued 2013	http://standards.sae.org/j2847/1_201311/	This document describes the details of the Smart Energy Profile 2.0 (SEP2.0) communication used to implement the functionality described in the SAE J2836/1™ use cases. Each use case subsection includes a description of the function provided, client device requirements, and sequence diagrams with description of the steps. Implementers are encouraged to consult the SEP2.0 Schema and Application Specification for further details. Where relevant, this document notes, but does formally specify, interactions between the vehicle and vehicle operator.
SAE J2847 / 2	*Communication Between Plug-in Vehicles and Off-Board DC Chargers*	Issued 2012	http://standards.sae.org/j2847/2_201208	This SAE Recommended Practice SAE J2847-2 establishes requirements and specifications for communication between PLUG-IN ELECTRIC VEHICLE (EVCC)s and the DC Off-board charger. Where relevant, this document notes, but does not formally specify, interactions between the vehicle and vehicle operator. This document applies to the off-board DC charger for conductive charging, which supplies DC current to the RESS of the electric vehicle through a SAE J1772™ coupler. Communications will be on the J1772 Pilot line for PLC communication. The details of PLC communications are found in SAE J2931/4. The specification supports DC energy transfer via Forward Power Flow

				(FPF) from source to vehicle.
SAE J2847 / 3	*Communication between Plug-In Vehicles and the Utility Grid for Reverse Power Flow*	Under Develop ment	http://standards.sae.org/wip/j2847/3	This SAE Recommended Practice J2847/3 establishes the communication structure between plug-in electric vehicles and the electric power grid, for reverse power flow. This document identifies the equipment (system elements) and interactions to support grid-optimized AC or DC energy transfer for plug-in vehicles using Reverse Power Flow
SAE J2847 / 4	*Diagnostic Communication for Plug-in Vehicles*	Under Develop ment	http://standards.sae.org/wip/j2847/4	This SAE Recommended Practice J2847/4 establishes the communication requirements for diagnostics between plug-in electric vehicles and the EV Supply Equipment (EVSE) for charge or discharge sessions. It takes the use case and general information identified in J2836/4™ and provides the detail messages and diagrams to implement the communication.
SAE J2847 / 5	*Communication between Plug-in Vehicles and their customers*	Under Develop ment	http://standards.sae.org/wip/j2847/5	This SAE Recommended Practice J2847/5 establishes the communication requirements between plug-in electric vehicles and their customers for charge or discharge sessions. It takes the use case and general information identified in J2836/5™ and provides the detail messages and diagrams to implement the communication. This document identifies the customer interface requirements and interactions to charge or discharge plug-in vehicles. This includes Vehicle Manufacturer specific messages regarding the plug-in vehicle and its operation.
SAE J2847 / 6	*Wireless Charging Communication between Plug-in Electric Vehicles and the Utility Grid*	Under Develop ment	http://standards.sae.org/wip/j2847/6	This SAE Recommended Practice J2847/6 establishes signals and messages for communication between plug-in electric vehicles and the electric power grid, for wireless energy transfer. This is the 1st version of this document and completes step 1 effort that captures the initial objectives of the SAE task force. The intent of step 1 was to record as much information on "what we think works" and publish. The effort continues however, to step 2 that allows public review for additional comments and viewpoints, while the task force also continues additional testing and early implementation. Results of step 2 effort will then be incorporated into updates of this document and lead to a republished version.
SAE J2894 / 1	*Power Quality Requirements for Plug-In Electric Vehicle Chargers*	Issued 2011	http://standards.sae.org/j2894/1_201112/	The intent of this document is to develop a recommended practice for PEV chargers, whether on-board or off-board the vehicle, that will enable equipment manufacturers, vehicle manufacturers, electric utilities and others to make reasonable design decisions regarding power quality. The three main purposes are as follows: 1. To identify those parameters of PEV battery charger that must be controlled in order to preserve the quality of the AC service. 2. To identify those characteristics of the AC service that may significantly impact the performance of the charger. 3. To identify values for power quality, susceptibility and power control parameters which are based on current U.S. and international standards. These values should be technically feasible and cost effective to implement into PEV battery chargers. SAE J2894/2 Power Quality Requirements for Plug-In Electric Vehicle Chargers – Test Methods will describe the test methods for the parameters / requirements in this document.
SAE J2894 / 2	*Power Quality Requirements for Plug-In Vehicle Chargers – Part 2: Test Methods*	Under Develop ment	http://standards.sae.org/wip/j2894/2	This Recommended Practice is based on EPRI"s TR-109023 - EV Charging Equipment Operational Recommendations for Power Quality. The document will enable vehicle manufacturers, charging equipment manufacturers, electric utilities and others to make reasonable design decisions regarding power quality that are technically feasible and cost effective to implement. —Will address bi-directional energy flow. This Recommended

				Practice will include guidelines for: —Total Power Factor —Power Conversion Efficiency —Total Harmonic Current Distortion —Current Distortion at Each Harmonic Frequency —Plug in Electric Vehicle Charger Restart After Loss of AC Power Supply —Charger / Electric Vehicle Supply Equipment AC Input Voltage Range —Charger / Electric Vehicle Supply Equipment AC Input Voltage Swell —Charger / Electric Vehicle Supply Equipment AC Input Voltage Surge (Impulse) —Charger / Electric Vehicle Supply Equipment AC Input Voltage Sag —Charger / Electric Vehicle Supply Equipment AC Input Frequency Variations —In-Rush Current —Momentary Outage Ride-Through
SAE J2907	*Hybrid Motor Ratings*	Under Develop ment	http://standards.sae.org/wip/j2907	This work will support ongoing efforts with J2908 to define and establish unified requirements for measuring hybrid and plug in hybrid electric power levels.
SAE J2908	*Hybrid Electric Powertrain Power Test Methods and Definitions*	Under Develop ment	http://standards.sae.org/wip/j2908/	This SAE Recommended Practice provides recommended test options for measuring and defining total powertrain power and electric power levels for hybrid electric vehicles (including plug-in hybrids).
SAE J2931 / 1	*Digital Communications for Plug-in Electric Vehicles*	Issued 2012	http://standards.sae.org/j2931/1_201209/	This SAE Information Report SAE J2931 establishes the requirements for digital communication between Plug-In Vehicles (PEV), the Electric Vehicle Supply Equipment (EVSE) and the utility or service provider, Energy Services Interface (ESI), Advanced Metering Infrastructure (AMI) and Home Area Network (HAN). This is the second version of this document and completes the step 2 effort that specifies the digital communication protocol stack between Plug-in Electric Vehicles (PEV) and the Electric Vehicle Supply Equipment (EVSE).
SAE J2931 / 2	*Inband Signaling Communication for Plug-in Electric Vehicles*	Under Develop ment	http://standards.sae.org/wip/j2931/2	This SAE Recommended Practice J2931/2 establishes the requirements for physical layer communications using Inband Signaling between Plug-In Vehicles (PEV) and the EVSE. This also enables the onward communications via an EVSE bridging device to the utility smart meter or Home Area Network (HAN). This is known as Frequency Shift Keying (FSK) and is similar to Power Line Carrier (PLC) but utilizes the J1772™ Control Pilot circuit.
SAE J2931 / 3	*PLC Communication for Plug-in Electric Vehicles*	Under Develop ment	http://standards.sae.org/wip/j2931/3	This SAE Recommended Practice J2931/3 establishes the requirements for physical layer communications using Power Line Carrier (PLC) between Plug-In Vehicles (PEV) and the EVSE. This also enables the onward communications via an EVSE bridging device to the utility smart meter or Home Area Network (HAN). This is known as Orthogonal frequency-division multiplexing (OFDM) and is Power Line Carrier (PLC) that can be transmitted using either the J1772™ Control Pilot circuit or the mains (AC or DC power circuits).
SAE J2931 / 4	*Broadband PLC Communication for Plug-in Electric Vehicles*	Issued 2012	http://standards.sae.org/wip/j2931/4_201207	This SAE Technical Information Report SAE J2931/4 establishes the specifications for physical and data-link layer communications using broadband Power Line Communications (PLC) between the Plug-In Vehicle (PEV) and the Electric Vehicle Supply Equipment (EVSE) DC off-board-charger. This document deals with the specific modifications or selection of optional features in HomePlug Green PHY v1.1 necessary to support the automotive charging application over Control Pilot lines as described in SAE J1772™. PLC may also be used to connect directly to the Utility smart meter or Home Area Network (HAN), and may technically be applied to the AC mains, both of which are outside the scope of this document.

SAE J2931 / 5	*Telematics Smart Grid Communications between Customers, Plug-In Electric Vehicles (PEV), Energy Service Providers (ESP) and Home Area Networks (HAN)*	Under Develop ment	http://standards.sae.org/wip/j2931/5	This SAE Recommended Practice J2931/5 establishes the security requirements for digital communication between Plug-In Electric Vehicles (PEV), the Electric Vehicle Supply Equipment (EVSE) and the utility, ESI, Advanced Metering Infrastructure (AMI) and/or Home Area Network (HAN). This is the 1st version of this document and completes step 1 effort that captures the initial objectives of the SAE task force. The intent of step 1 was to record as much information on "what we think works" and publish. The effort continues however, to step 2 that allows public review for additional comments and viewpoints, while the task force also continues additional testing and early implementation. Results of step 2 effort will then be incorporated into updates of this document and lead to a republished version.
SAE J2931 / 6	*Digital Communication for Wireless Charging Plug-in Electric Vehicles*	Under Develop ment	http://standards.sae.org/wip/j2931/6	This SAE Recommended Practice J2931/6 establishes the digital communication protocol requirements for wireless charging between Plug-In Vehicles (PEV), the Electric Vehicle Supply Equipment (EVSE) and the utility, ESI, Advanced Metering Infrastructure (AMI) and/or Home Area Network (HAN). This is the 1st version of this document and completes step 1 effort that captures the initial objectives of the SAE task force. The intent of step 1 was to record as much information on "what we think works" and publish. The effort continues however, to step 2 that allows public review for additional comments and viewpoints, while the task force also continues additional testing and early implementation. Results of step 2 effort will then be incorporated into updates of this document and lead to a republished version.
SAE J2931 / 7	*Security for Plug-in Electric Vehicle Communications*	Under Develop ment	http://standards.sae.org/wip/j2931/7	Develop and document the functional and technical requirements for a standard telematics application programming interface that facilitates two way communications between the PEV telematics service provider and the Energy Services Provider. The telematics interface will provide access to consumer specific usage data e.g. instantaneous usage, consumption usage, volts, amps, VAR, power factor, etc. The telematics common interface solution will encompass, at minimum, four key interfaces: Aggregation, Control, TOU Rates, and Vehicle Information inclusive of interconnectivity with utility energy management systems, utility back office networks, ISOs, RTOs, and consumer home area networks. Use Cases are to be developed to define the attributes of key interface requirements and functionality. Requirements for implementation shall include compliance and/or interoperability with J2847 series of recommended practices, and with Smart Energy Profile 2.0 and/or OpenADR/OpenADE application standards.
SAE J2945	*Dedicated Short Range Communication (DSRC) Minimum Performance Requirements*	Under Develop ment	http://standards.sae.org/wip/j2945/	This document specifies the minimum communication performance requirements of the DSRC Message message sets, the associated data frames and data elements defined in SAE J2735 DSRC Message Set Dictionary. The document consists of multiple sections. Each section describes a specific message set's requirements. For example, J2945-1 represents Basic Safety Message communication minimum performance requirements.
SAE J2953/1	*Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)*	Issued 2013	http://standards.sae.org/j2953/1_201310/	This SAE Recommended Practice J2953/1 establishes requirements and specification by which a specific Plug-In Electric Vehicle (PEV) and Electric Vehicle Supply Equipment (EVSE) pair can be considered interoperable. The test procedures are further described in J2953/2.
SAE J2953/2	*Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)*	Under develop ment	http://standards.sae.org/j2953/1_201310/	This SAE Recommended Practice J2953/1 establishes requirements and specification by which a specific Plug-In Electric Vehicle (PEV) and Electric Vehicle Supply Equipment (EVSE) pair can be considered interoperable. The test procedures are further described in J2953/2.

SAE J2954	*Wireless Charging of Electric and Plug-in Hybrid Vehicles*	Under Development	http://standards.sae.org/wip/j2954/	Establishes minimum performance and safety criteria for wireless charging of electric and plug-in vehicles. Team to create a technology matrix to initially evaluate multiple technologies (Inductive, Magnetic resonance, etc.) and end up on common approach. -Charging Locations: Residential, On-Road (Parking Lot, Roadway) -Level 1,2,3 Charging
SAE J2990	*Hybrid and EV First and Second Responder Recommended Practice*	Issued 2012	http://standards.sae.org/j2990_201211/	EVs involved in incidents present unique hazards associated with the high voltage system (including the battery system). These hazards can be grouped into 3 categories: chemical, electrical, and thermal. The potential consequences can vary depending on the size, configuration and specific battery chemistry. Other incidents may arise from secondary events such as garage fires and floods. These types of incidents are also considered in the recommended practice (RP). This RP aims to describe the potential consequences associated with hazards from xEVs and suggest common procedures to help protect emergency responders, tow and/or recovery, storage, repair, and salvage personnel after an incident has occurred with an electrified vehicle. Industry design standards and tools were studied and where appropriate, suggested for responsible organizations to implement. Nickel metal hydride (NiMH) and lithium ion (Li-ion) batteries used for vehicle propulsion power are the assumed battery systems of this RP. These battery chemistries are the prevailing technologies associated with high voltage vehicle electrification today and the foreseeable future. The hazards associated with these specific battery chemistries are addressed in this RP. Other chemistries and alternative propulsion systems including Fuel Cells are not considered in this version of SAE J2990.
Relevant UL Standards (Note that other UL standards may apply depending on a product's design)				
UL 50	*Standard for Enclosures for Electrical Equipment*	Issued	http://ulstandardsinfonet.ul.com/scopes/	This standard applies to enclosures for electrical equipment intended to be installed and used in non-hazardous locations in accordance with the Canadian Electrical Code, Part I, CSA C22.1, the provisions of the National Electrical Code, NFPA 70, and the provisions of Mexico's Electrical Installations, NOM-001-SEDE, as follows: a) Enclosures for indoor locations, Types 1, 2, 5, 12, 12K, and 13; and b) Enclosures for indoor or outdoor locations, Types 3, 3R, 3S, 4, 4X, 6, and 6P.
UL 1439	*Determination of Sharpness of Edges on Equipment*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements cover a test procedure to be used to determine the potential personal injury related to the sharpness of edges that are part of or associated with appliances and equipment
UL 1449	*Standard for Surge Protective Devices*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements cover Surge Protective Devices (SPDs) designed for repeated limiting of transient voltage surges as specified in the standard on 50 or 60 Hz power circuits not exceeding 1000 V and designated as follows: Type 1 - Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and Molded Case SPDs intended to be installed without an external overcurrent protective device. Type 2 - Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device; including SPDs located at the branch panel and Molded Case SPDs. Type 3 - Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord

				connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected. See marking in 64.2. The distance (10 meters) is exclusive of conductors provided with or used to attach SPDs. Type 4 Component Assemblies - Component assembly consisting of one or more Type 5 components together with a disconnect (integral or external) or a means of complying with the limited current tests in 39.4. Type 1, 2, 3 Component Assemblies - Consists of a Type 4 component assembly with internal or external short circuit protection. Type 5 - Discrete component surge suppressors, such as MOVs that may be mounted on a PWB, connected by its leads or provided within an enclosure with mounting means and wiring terminations.
UL 1998	*Standard for Software in Programmable Components*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements apply to non-networked embedded microprocessor software whose failure is capable of resulting in a risk of fire, electric shock, or injury to persons.
UL 2202	*Standard for Electric Vehicle (EV) Charging System Equipment*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements cover conductive charging system equipment intended to be supplied by a branch circuit of 600 volts or less for recharging the storage batteries in over-the-road electric vehicles (EV). The equipment includes off board and on board chargers. Off-board equipment may be considered for indoor use only or indoor/outdoor use. On board equipment is always considered outdoor use. Off board equipment is intended to be installed in accordance with the National Electrical Code, NFPA 70.
UL 2231-1 (NMX-J-668/1-ANCE)	*Standard for Safety for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements cover devices and systems intended for use in accordance with Annex a, Ref. No. 1, to reduce the risk of electric shock to the user from accessible parts, in grounded or isolated circuits for charging electric vehicles. These circuits are external to or on board the vehicle.
UL 2231-2 (NMX-J-668/2-ANCE)	*Standard for Safety for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems*	Issued	http://ulstandardsinfonet.ul.com/scopes/	This Standard is intended to be read together with Annex a, Ref. No. 1. The requirements of Annex a, Ref. No. 1 apply unless modified by this Standard.
UL 2251 (NMX-J-678-ANCE)	*Standard for Plugs, Receptacles, and Couplers for Electric Vehicles*	Issued	http://ulstandardsinfonet.ul.com/scopes/	These requirements cover plugs, receptacles, vehicle inlets, vehicle connectors, and breakaway couplings, rated up to 800 amperes and up to 600 volts ac or dc, intended for conductive connection systems, for use with electric vehicles. These devices are for use in either indoor or outdoor nonhazardous locations in accordance with Annex A, Ref. No. 1.
UL 2594 (NMX-J-677-ANCE)	*Standard for Electric Vehicle Supply Equipment*	Issued	http://ulstandardsinfonet.ul.com/scopes/	This Standard covers conductive electric vehicle (EV) supply equipment with a primary source voltage of 600 V ac or less, with a frequency of 60 Hz, and intended to provide ac power to an electric vehicle with an on-board charging unit. This Standard covers electric vehicle supply equipment intended for use where ventilation is not required.
Relevant ISO and IEC Documents (International)				
ISO/IEC 15118-	*Road vehicles - Vehicle to*	Issued	http://www.iec.ch/dy	Part 1 specifies the communication between electric vehicles (EV), (this term includes

1	*grid communication interface - Part 1: General information and use-case definition*	04-2013	n/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,ISO/IEC%2015118-1%20Ed.%201.0	Battery Electric Vehicles as well as Plug-In Hybrid Electric Vehicles) and the electric vehicle supply equipment (EVSE). The communication parts of this generic equipment are the electric vehicle communication controller (EVCC) and the supply equipment communication controller (SECC). ISO/IEC 15118 is oriented to the charging of electric road vehicles.
ISO/IEC 15118-2	*Road vehicles - Vehicle-to-Grid Communication Interface - Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements*	Under Development FDIS Stage Estimated publication date: 04-2014	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,ISO/IEC%2015118-2%20Ed.%201.0	Part 2 specifies the communication between battery electric vehicles (BEV) or plug-in hybrid electric vehicles (PHEV) and the Electric Vehicle Supply Equipment. The purpose of this Part of ISO/IEC 15118 is to detail the communication between an EV (BEV or a PHEV) and an EVSE. Aspects are specified to detect a vehicle in a communication network and enable an Internet Protocol (IP) based communication between EVCC and SECC.
ISO/IEC 15118-3	*Road Vehicles - Vehicle to grid communication interface - Part 3: Physical layer and Data Link layer requirements*	Under Development CDV Stage Estimated publication date: 12-2013	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,ISO/IEC%2015118-3%20Ed.%201.0	Part 3 specifies the physical and data link layer for a high level communication, directly between battery electric vehicles (BEV) or plug-in hybrid electric vehicles (PHEV), and the fixed electrical charging installation (Electric Vehicle Supply Equipment (EVSE)), used in addition to the Basic Signaling. It covers the overall information exchange between all actors involved in the electrical energy exchange. It is applicable for (manually) connected conductive charging.
IEC/ISO 17409	*Electrically propelled road vehicles -- Connection to an external electric power supply -- Safety requirements*	Under Development (will replace IEC 61581-21) Estimated publication date: 10-2014	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,ISO/IEC%2017409%20Ed.%201.0	Specifies electric safety requirements for conductive connection of electrically propelled road vehicles to an external electric power supply.
ISO/IEC/IEEE 80005-1:2012	*Utility connections in port -- Part 1: High Voltage Shore Connection (HVSC) Systems -- General requirements*	Issued 2012	http://www.iso.org/iso/catalogue_detail.htm?csnumber=53588	IEC/ISO/IEEE 80005-1:2012(E) describes high voltage shore connection (HVSC) systems, on board the ship and on shore, to supply the ship with electrical power from shore. This standard is applicable to the design, installation and testing of HVSC systems and addresses: - HV shore distribution systems; - shore-to-ship connection and interface equipment; - transformers/reactors; - semiconductor/rotating convertors; - ship distribution systems; and - control, monitoring, interlocking and power management systems. It does not apply to the electrical power supply during docking periods, e.g. dry docking and other out of service maintenance and repair.

IEC 60870-6-503	*Telecontrol equipment and systems - Part 6-503: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Services and protocol*	2nd Edition Issued 04-2002 3rd Edition under development Estimated publication date: 05-2014	http://webstore.iec.ch/webstore/webstore.nsf/	The Telecontrol Application Service Element (TASE.2) protocol (also known as Inter-Control Centre Communications Protocol, ICCP) allows for data exchange over Wide Area Networks (WANs) between a utility control centre and other control centers, other utilities, power pools, regional control centers, and Non-Utility Generators. Data exchange information consists of real-time and historical power system monitoring and control data, including measured values, scheduling data, energy accounting data, and operator messages. This data exchange occurs between one control centre's Supervisory Control And Data Acquisition/Energy Management System/Distribution Management System (SCADA/EMS/DMS) host and another centre's host, often through one or more intervening communications processors. This part of IEC 60870 defines a mechanism for exchanging time-critical data between control centers. In addition, it provides support for device control, general messaging and control of programs at a remote control centre. It defines a standardized method of using the ISO 9506 Manufacturing Message Specification (MMS) services to implement the exchange of data. The definition of TASE.2 consists of three documents. This part of IEC 60870 defines the TASE.2 application modeling and service definitions. IEC 60870-6-702 defines the application profile for use with TASE.2. IEC 60870-6-802 defines a set of standardized object definitions to be supported.
IEC 61334-1-1	*Distribution automation using distribution line carrier systems*	Issued 11-1995	http://webstore.iec.ch/webstore/webstore.nsf/	Describes the structure of distribution networks for both medium and low-voltage levels and presents the architecture of a distribution automation system using distribution line carrier systems. This publication has the status of a Technical Report - type 3.
IEC 61850 IEC61850-1 IEC61850-2 IEC61850-3 IEC61850-4 IEC61850-5	*Communication networks and systems in substations* *Part 1: Introduction and overview* *Part 2: Glossary* *Part 3: General requirements* *Part 4: System and project management* *Part 5: Communication requirements for functions and device models*	 Issued 2003 Issued 2003 Issued 2002 Issued 2002 Issued 2003	http://webstore.iec.ch/webstore/webstore.nsf/	IEC 61850 consists of the following parts, under the general title Communication networks and systems in substations: Is a technical report applicable to substation automation systems. Defines the communication between intelligent electronic devices in the substation and the related system requirements. Gives an introduction and overview of the IEC 61850 standard series; refers to and includes text and figures from other parts of the IEC 61850 series. Contains the glossary of specific terms and definitions used in the context of Substation Automation Systems which are standardized in the various parts of the IEC 61850 series. Describes the requirements of the system and project management process and of special supporting tools for engineering and testing. Describes the requirements of the system and project management process and of special supporting tools for engineering and testing. Applies to substation automation systems and standardizes the communication between intelligent electronic devices and the related system requirements. Refers to the communication requirements of the functions being performed in the substation

				automation system and to device models.
IEC61850-6	*Part 6: Configuration description language for communication in electrical substations related to IEDs*	Issued 2009		IEC 61850-6:2009(E) specifies a file format for describing communication-related IED (Intelligent Electronic Device) configurations and IED parameters, communication system configurations, switch yard (function) structures, and the relations between them. The main purpose of this format is to exchange IED capability descriptions and SA system descriptions between IED engineering tools and the system engineering tool of different manufacturers in a compatible way. The main changes with respect to the previous edition are as follows: - functional extensions added based on changes in other Parts of IEC 61850, especially in IEC 61850-7-2 and IEC 61850-7-3; - functional extensions concerning the engineering process, especially for configuration data exchange between system configuration tools, added; - clarifications and corrections. This publication is of core relevance for Smart Grid.
IEC61850-7-1	*Part 7-1: Basic communication structure for substation and feeder equipment - Principles and models*	Issued 2003		Provides an overview of the architecture for communication and interactions between substation devices such as protection devices, breakers, transformers, substation hosts, etc. Uses simple examples of functions to describe the concepts and methods applied in the IEC 61850 series. Also describes the relationships between other parts of the IEC 61850 series and defines how inter-operability is reached.
IEC61850-7-2	*Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)*	Issued 2010		IEC 61850-7-2:2010(E) applies to the ACSI communication for utility automation.
IEC61850-7-3	*Part 7-3: Basic communication structure for substation and feeder equipment - Common data classes*	*Issued 2003*		Specifies common attribute types and common data classes related to substation applications. Specifies particularly: common data classes for status information, for measured information, for controllable status information, for controllable analogue set point information, for status settings, for analogue settings and attribute types used in these common data classes. Is applicable to the description of device models and functions of substations and feeder equipment.
IEC61850-7-4	*Part 7-4: Basic communication structure - Compatible logical node classes and data object classes*	*Issued 2010*		IEC 61850-7-4:2010(E) specifies the information model of devices and functions generally related to common use regarding applications in systems for power utility automation. It also contains the information model of devices and function-related applications in substations. In particular, it specifies the compatible logical node names and data object names for communication between intelligent electronic devices (IED). This includes the relationship between logical nodes and data objects.
IEC61850-8-1	*Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*	*Issued 2004*		Specifies a method of exchanging time-critical and non-time-critical data through local-area networks by mapping ACSI to MMS and ISO/IEC 8802-3 frames. MMS services and protocol are specified to operate over full OSI and TCP compliant communications profiles. The use of MMS allows provisions for supporting both centralized and distributed architectures. This standard includes the exchange of real-time data indications, control operations, report notification.

IEC61850-9-1	*Part 9-1: Specific Communication Service Mapping (SCSM) - Sampled values over serial unidirectional multidrop point to point link*	*Issued 2003*		Lays down the specific communication service mappings for the communication between bay and process level; specifies a mapping on a serial unidirectional multidrop point to point link in accordance with IEC 60044-8. Applies to the communication between merging units of electronic current or voltage-transformers and bay devices such as protection relays.
IEC61850-9-2	*Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3*	*Issued 2004*		Defines the Specific Communication Service Mapping for the transmission of sampled values according to the abstract specification in IEC 61850-7-2. The mapping is that of the abstract model on a mixed stack using direct access to an ISO/IEC 8802-3 link for the transmission of the samples in combination with IEC 61850-8-1.
IEC61850-10	*Part 10: Conformance testing*	*Issued 2005*		Specifies standard techniques for testing of conformance of implementations, as well as specific measurement techniques to be applied when declaring performance parameters. The use of these techniques will enhance the ability of the system integrator to integrate IEDs easily, operate IEDs correctly, and support the applications as intended.
IEC 61581 series	*Electric vehicle conductive charging system – Part 1: General requirements*	2nd Edition Issued November 2010 Under revision	http://webstore.iec.ch/webstore/webstore.nsf/	IEC 61851-1:2010 applies to on-board and off-board equipment for charging electric road vehicles at standard a.c. supply voltages (as per IEC 60038) up to 1 000 V and at d.c. voltages up to 1 500 V, and for providing electrical power for any additional services on the vehicle if required when connected to the supply network. It includes characteristics and operating conditions of the supply device and the connection to the vehicle; operators and third party electrical safety, and the characteristics to be complied with by the vehicle with respect to the a.c./d.c. EVSE, only when the EV is earthed. This second edition cancels and replaces the first edition published in 2001.
	Electric Vehicles conductive power supply system - Part 3-1: General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems	Under development Estimated publication date: 07-2015	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC/TS%2061851-3-1%20Ed.%201.0	General Requirements for Light Electric Vehicles (LEV) AC and DC conductive power supply systems Part 3 together with part 1, applies to the equipment for the conductive transfer of electric power from the supply network to the light electric vehicle (LEV) for purposes of supply electric power to the LEV RESS or traction-battery and/or maintaining other on-vehicle electrical systems in an operational state when connected to the supply network, at standard supply voltages per IEC 60038 with a rated voltage up to 1000 V a.c. and up to 1500 V d.c.. Light electric vehicles includes, electric bicycles, scooters, motorcycles and various low speed vehicles for transporting people and goods.
	Electric Vehicles conductive power supply system - Part 3-2: Requirements for Light Electric Vehicles (LEV) DC off-board conductive power supply systems	Under development Estimated publication date: 07-2015	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC/TS%2061851-3-2%20Ed.%201.0	Requirements for Light Electric Vehicles (LEV) DC off-board conductive power supply systems
	Electric Vehicles conductive	Under	http://www.iec.ch/dy	Requirements for Light Electric Vehicles (LEV) battery swap systems

	power supply system - Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems	development Estimated publication date: 07-2015	n/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC/TS%2061851-3-3%20Ed.%201.0	
	Electric Vehicles conductive power supply system - Part 3-4: Requirements for Light Electric Vehicles (LEV) communication	Under development Estimated publication date: 07-2015	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC/TS%2061851-3-4%20Ed.%201.0	Requirements for Light Electric Vehicles (LEV) communication
	Part 21 Electric vehicle requirements for conductive connection to an AC/DC supply	Issued 2010 Under revision (To be replaced by IEC/ISO 17409)	http://webstore.iec.ch/webstore/webstore.nsf/	This part of IEC 61851 together with part 1 gives the electric vehicle requirements for conductive connection to an a.c. or d.c. supply, for a.c. voltages according to IEC 60038 up to 690 V and for d.c. voltages up to 1 000 V, when the electric vehicle is connected to the supply network.
	Electric vehicle conductive charging system - Part 21-1 Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply	Under Development – in CD Stage Estimated publication date: 01-2015	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC%2061851-21-1%20Ed.%201.0	Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply
	Electric vehicle conductive charging system - Part 21-2: EMC requirements for OFF board electric vehicle charging systems *Part 22 - AC electric vehicle charging station*	Under Development Estimated publication date: 03-2014 Combined with 61851-1, 3rd Edition. To be	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC%2061851-21-2%20Ed.%201.0 http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_P	EMC requirements for OFF board electric vehicle charging systems IEC 61851-22, together with part 1, gives the requirements for AC electric vehicle charging stations for conductive connection to an electric vehicle, with AC supply voltages according to IEC 60038 up to 1000 V .

		withdrawn	ROJECT:25,20,1255,IEC%2061851-22%20f1%20Ed.%202.0	
	Part 23: D.C electric vehicle charging station	Under Development FDIS Stage Estimated publication date: 04-2014	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC%2061851-23%20Ed.%201.0	IEC 61851-23, together with part 1, gives the requirements for DC electric vehicle (EV) charging or supply stations for conductive connection to the vehicle, with an AC or DC input voltage, up to 1000 V AC and up to 1500 V DC according to IEC60038.This part covers DC output voltages up to 1500 V.
	Part 24: Digital communication between a dc EV charging station and an electric vehicle for control of d.c. charging	Under Development FDIS Stage Estimated publication date: 04-2014	http://www.iec.ch/dyn/www/f?p=103:38:0::::FSP_LANG_ID,FSP_APEX_PAGE,FSP_ORG_ID,FSP_PROJECT:25,20,1255,IEC%2061851-24%20Ed.%201.0	This part of IEC 61851, together with part 2-3, applies to control communication protocol between off-board d.c. charging system and electric road vehicle, with an a.c. supply input voltages up to 1000 V and d.c. output voltages up to 1500 V for the conductive charging procedure (for d.c. supply to d.c. charger). This standard covers the physical layer, the data link layer, the application layer and other layers if needed.
IEC 61968	*Application integration at electric utilities-system interfaces for distribution management (Data Models being extended with SmartEnergy 2.0)*	Issued 10-2013	http://webstore.iec.ch/webstore/webstore.nsf/	IEC 61968-9:2009(E) specifies the information content of a set of message types that can be used to support many of the business functions related to meter reading and control. Typical uses of the message types include meter reading, meter control, meter events, customer data synchronization and customer switching. Although intended primarily for electrical distribution networks, IEC 61968-9 can be used for other metering applications, including non-electrical metered quantities necessary to support gas and water networks
IEC 61970-1	*Energy Management System Application Program Interface*	Issued 12-2005	http://webstore.iec.ch/webstore/webstore.nsf/	Provides a set of guidelines and general infrastructure capabilities required for the application of the EMS-API interface standards. Describes typical integration scenarios where these standards are to be applied and the types of applications to be integrated. Defines a reference model and provides a framework for the application of the other parts of these EMS-API standards.
IEC 61980 series	*Part 1: Electric vehicle wireless power transfer systems (WPT) - Part 1: General requirements* *Part 2: Electric vehicle wireless power transfer (WPT) systems - Part 2 specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems* *Part 3: Electric vehicle*	Under Development. Estimated publication date: Part 1: 12-2014 Part 2: 01-2017	http://www.iec.ch/dyn/www/f?p=103:14:0::::FSP_ORG_ID,FSP_LANG_ID:8538,25 http://www.iec.ch/dyn/www/f?p=103:14:0::::FSP_ORG_ID,FSP_LANG_ID:10157,25	Part 1 covers equipment for the wireless transfer of electric power from the supply network to electric road vehicles for purposes of supplying electric energy to the RESS (Rechargeable energy storage system) and/or other on-board electrical systems in an operational state when connected to the supply network, at standard a.c. supply voltages per IEC 60038 up to 1000V a.c. and up to 1500 V d.c. 285 Part 2 covers communications between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems with an a.c. supply input voltages up to 1000 V, with Annexes containing descriptions of dedicated command/control and communications for WPT systems.

	wireless power transfer (WPT) systems - Part 3 specific requirements for the magnetic field power transfer systems	Part 3: 01-2017	http://www.iec.ch/dyn/www/f?p=103:14:0::::FSP_ORG_ID,FSP_LANG_ID:10159,25	Part 3 covers specific requirements for magnetic field power transfer systems, including the characteristics and operational conditions of the wireless power transfer system, requirements for electromagnetic compatibility, electrical safety, operational characteristics and functional characteristics.
IEC 62196 series	*Plugs, socket-outlets, vehicle couplers and vehicle inlets - Conductive charging of electric vehicles - Part 1: General requirements*	Issued: October 2011 Under revision Estimated publication date: 09-2014	http://webstore.iec.ch/webstore/webstore.nsf/	IEC 62196-1 specifies the requirements for plugs, socket-outlets, connectors, inlets and cable assemblies as described in IEC 61851-1. Some charging can be achieved by direct connection from an electric vehicle to common mains socket outlets. Some modes of charging require a dedicated supply and charging equipment incorporating control and communication circuits. It is applicable to plugs, socket-outlets, connectors, inlets and cable assemblies for electric vehicles, herein referred to as “accessories”, intended for use in conductive charging systems which incorporate control means, with a rated operating voltage not exceeding 690 V AC, 50 - 60 Hz, at a rated current not exceeding 250 A; and 1,500 V DC, at a rated current not exceeding 400 A. This standard covers the mechanical, electrical and performance requirements for dedicated plugs, socket outlets, vehicle connectors and vehicle inlets for interfacing between such dedicated charging equipment and the electric vehicle.
	Part 2: Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories.	Issued: October 2011 Under revision	http://webstore.iec.ch/webstore/webstore.nsf/	IEC 62196-2 applies to plugs, socket -outlets, vehicle connectors and inlets with pins and contact -tubes of standardized configurations, herein referred to a s accessories. They have a nominal rated operating voltage not exceeding 500 V AC, 50 – 60 Hz, and a rated current not exceeding 63 A three-phase or 70 A single phase, for u se in conductive charging of electric vehicles. This standard covers the basic interface accessories for vehicle supply as specified in IEC 62196-1, and intended for u se in conductive charging systems for circuits specified in IEC61851-1.
	Part 3: Dimensional compatibility and interchangeability requirements for dedicated d.c and combined a.c./d.c. pin and contact-tube vehicle couplers.	Under Development Estimated publication date: 03-2014	http://www.iec.ch/dyn/www/f?p=103:14:0::::FSP_ORG_ID,FSP_LANG_ID:6619,25	IEC 62196-3 is applicable to vehicle couplers with pins and contact-tubes of standardized configuration, intended for use in electric vehicle (EV) conductive charging systems which incorporate control means, with rated operating voltage up to 1 500 V d.c. and rated current up to 250 A, and 1 000 V a.c. and rated current up to 250 A. This standard applies to high power d.c. interfaces and combined a.c./d.c. interfaces of vehicle couplers specified in IEC 62196-1:2011, and intended for use in conductive charging systems for circuits specified in IEC 61851-1:xxxx, and IEC 61851-23, (both under development by IEC TC69 WG4).
IEC 62210	*Power system control and associated communications- Data and Communication*	Issued 05-2003 Under	http://webstore.iec.ch/webstore/webstore.nsf/	Applies to computerized supervision, control, metering, and protection systems in electrical utilities. Deals with security aspects related to communication protocols used within and between such systems, the access to, and use of the systems. Discusses realistic threats to the system and its operation, the vulnerability and the consequences of intrusion,

	Security	Revision		actions and countermeasures to improve the current situation
IEC 62325	*Framework for Deregulated Electricity Market Communications*	TR 62325-101 issued 02-2005 Under Development	http://webstore.iec.ch/webstore/webstore.nsf/	Gives technology independent general guidelines applicable for e-business in energy markets based on Internet technologies providing: a description of the energy market specific environment; a description of the energy market specify requirements for e business; an example of the energy market structure; an introduction to the modeling methodology; network configuration examples; a general assessment of communication security.
IEC 62351 Parts 1-8	*Security for Protocols, network and system management, role based access control*	62351 Series Issued 04-2013	http://webstore.iec.ch/webstore/webstore.nsf/	Provides an introduction to the remaining parts of the IEC 62351 series, primarily to introduce the reader to various aspects of information security as applied to power system operations. The scope of the IEC 62351 series is information security for power system control operations. Its primary objective is to undertake the development of standards for security of the communication protocols defined by IEC TC 57, specifically the IEC 60870-5 series, the IEC 60870-6 series, the IEC 61850 series, the IEC 61970 series, and the IEC 61968 series
IEC/TR 62357	*Part 1: Power systems management and associated information exchange - Part 1: Reference architecture* *Interoperability within TC57 in Long Term*	Issued 10-2012	http://webstore.iec.ch/webstore/webstore.nsf/	IEC/TR 62357-1:2012(E) specifies a reference architecture and framework for the development and application of IEC standards for the exchange of power system information. This technical report provides an overview of these standards as well as guidelines and general principles for their application in distribution, transmission, and generation systems involved in electric utility operations and planning. The future multi-layer reference architecture described in this technical report takes into account new concepts and evolving technologies, such as semantic modelling and canonical data models, in order to build on technology trends of other industries and standards activities to achieve the interoperability goals of the Smart Grid.
IEC 62613 series	*High-Voltage Plugs, Socket-Outlets, Ship Connectors and Ship Inlets for High-Voltage Shore Connection Systems (HVSC systems) - Part 1 -General Requirements* *Part 2 - Interchangeability requirements for accessories to be used by various types of ship*	Issued: June 2011 Issued: November 2011	http://webstore.iec.ch/webstore/webstore.nsf/ http://webstore.iec.ch/webstore/webstore.nsf/	IEC 62613 addresses the needs of IEC/ISO/IEEE 60092-510 High Voltage Shore Connection Systems standard, in terms of plugs, socket-outlet, ship connectors and ship inlets, herein referred to as “accessories”, to deliver electrical power to ships in ports. IEC 62613 defines requirements that allow compliant ships to connect to compliant high-voltage shore power supplies through a compatible shore to ship connection rated currents not exceeding 500 A and rated operating voltages not exceeding 12 kV, 50/60 Hz. This standard applies to accessories with three-phase (3 poles and earth) with up to three pilot contacts, and a single-pole (Neutral) contact. Part 2 defines the interface details and dimensions so that accessories of like ratings from different manufacturers can be used interchangeably.
Relevant IEEE Documents				
IEEE 1547	*Standard for Interconnecting Distributed Resources with the Electric Power System*	Issued 2003	http://grouper.ieee.org/groups/scc21/dr_shared/	This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).This document provide a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.
IEEE 519	*IEEE Recommended*	Issued	http://ieeexplore.ieee.org/	This guide applies to all types of static power converters used in industrial and commercial

	Practices and Requirements for Harmonic Control in Electrical Power Systems	1992	xpl/freeabs_all.jsp?arnumber=44238	power systems. The problems involved in the harmonic control and reactive power compensation of such converters are addressed, and an application guide is provided. Limits of disturbances to the AC power distribution system that affect other equipment and communications are recommended.
IEEE 1901	*IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications*	Issued 2010	http://grouper.ieee.org/groups/1901/	A standard for high-speed communication devices via electric power lines, so called broadband over power line (BPL) devices, is defined. Transmission frequencies below 100 MHz are used. All classes of BPL devices can use this standard, including BPL devices used for the first-mile/last-mile connection to broadband services as well as BPL devices used in buildings for local area networks (LANs), Smart Energy applications, transportation platforms (vehicle) applications, and other data distribution. The balanced and efficient use of the power line communications channel by all classes of BPL devices is the main focus of this standard, defining detailed mechanisms for coexistence and interoperability between different BPL devices, and ensuring that desired bandwidth and quality of service may be delivered. The necessary security questions are addressed to ensure the privacy of communications between users and to allow the use of BPL for security sensitive services.
IEEE P1901.2	*IEEE Approved Draft Standard for Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications*	Issued 2013	http://www.techstreet.com/ieee/products/1857561	A worldwide standard for narrow band power line communications via AC, DC, and non-energized electric power lines using frequencies below 500 kHz. Data rates of up to 500 kbps are supported. The field-of-use includes Smart Grid applications. Coexistence mechanisms that can be used by other PLC technologies operating below 500 kHz are also included. These coexistence mechanisms may be used separately from the rest of the standard.
IEEE 2030	*Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads*	Issued 2011	http://grouper.ieee.org/groups/scc21/2030/2030_index.html	This document provides guidelines for smart grid interoperability. This guide provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and loads. The guide discusses alternate approaches to good practices for the smart grid.
IEEE P2030.1	Draft Guide for Electric-Sourced Transportation Infrastructure	Under Development	http://grouper.ieee.org/groups/scc21/2030.1/2030.1_index.html	This document provides guidelines that can be used by utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles and related support infrastructure in addressing applications for road-based personal and mass transportation. This guide provides a knowledge base addressing terminology, methods, equipment, and planning requirements for such transportation and its impacts on commercial and industrial systems including, for example, generation, transmission, and distribution systems of electrical power. This guide provides a roadmap for users to plan for short, medium, and long-term systems.
IEEE P2030.2	Draft Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure	Under Development	http://grouper.ieee.org/groups/scc21/2030.2/2030.2_index.html	This document provides guidelines for discrete and hybrid energy storage systems that are integrated with the electric power infrastructure, including end-use applications and loads. This guide builds upon IEEE Std P2030 Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation With the Electric Power System (EPS), and End-Use Applications and Loads.

IEEE P2030.3	Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications	Under Development	http://grouper.ieee.org/groups/scc21/2030.3a/2030.3_index.html	This standard establishes test procedures for electric energy storage equipment and systems for electric power systems (EPS) applications. It is recognized that an electric energy storage equipment or systems can be a single device providing all required functions or an assembly of components, each having limited functions. Components having limited functions shall be tested for those functions in accordance with this standard. Conformance may be established through combination of type, production, and commissioning tests. Additionally, requirements on installation evaluation and periodic tests are included in this standard.
IEEE 2030.5	IEEE Adoption of Smart Energy Profile 2.0 Application Protocol Standard	Issued 2013	http://standards.ieee.org/findstds/standard/2030.5-2013.html	The 'APPLICATION' layer with TCP/IP providing functions in the 'TRANSPORT' and 'INTERNET' layers is defined in this standard. Depending on the physical layer in use (e.g., IEEE 802.15.4(TM), IEEE 802.11(TM), IEEE 1901(TM)), a variety of lower layer protocols may be involved in providing a complete solution. Generally, lower layer protocols are not discussed in this standard except where there is a direct interaction with the application protocol. This standard defines the mechanisms for exchanging application messages, the exact messages exchanged including error messages, and the security features used to protect the application messages. With respect to the OSI network model, this standard is built using the four-layer Internet stack model. The defined application protocol is an IEC 61968 common information model [61968] profile, mapping directly where possible, and using subsets and extensions where needed, and follows an IETF RESTful architecture [REST].
Relevant ANSI Documents				
ANSI	*Standardization Roadmap for Electric Vehicles, Version 2.0*	Issued May 2013	http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_May_2013.pdf	The ANSI EVSP was convened to conduct the standardization needs assessment for EVs, with a view to assuring that the technologies and infrastructure are effective, safe, and ready to accommodate a major shift in our national automotive landscape. Drawing participants from the automotive, utilities, and electrotechnical sectors as well as from standards developing organizations (SDOs) and government agencies, the Panel is a continuation of a series of standards coordinating activities where ANSI has brought together stakeholders from the private and public sectors to work in partnership to address national and global priorities. As ANSI itself does not develop standards, the Panel is strictly a coordinating body intended to inventory and assess but not duplicate current work. The actual development of standards for EVs and related infrastructure is carried about by various SDOs.
Relevant NFPA Documents				
NFPA 70	*Electric Vehicle Charging System*	2014 NEC Issued	http://www.nfpa.org/catalog/	Includes reorganized Article 625, with changes to allow additional cord and plug connected units, use of load management systems, additional options for flexible cord and cable types for power supply cord and output cable to EV, recognition of special provisions for isolated charging systems, identification of EV ready circuits and outlets, etc.

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