SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

J2847-1 JUN2010

Issued 2010-06

Communication between Plug-in Vehicles and the Utility Grid

RATIONALE

SAE J2847/1 supports AC or DC energy transfer. SAE J2847/2 supports the additional messages for DC energy transfer and replaces SAE J2293. SAE J2847/3 supports RPF and this series is based upon requirements jointly developed by vehicle manufacturers, electric utilities, grid operators, technology suppliers, and other stakeholders. These requirements are reflected in SAE Information Report SAE J2836/1™, Use Cases for Communication between Plug-in Vehicles and the Utility Grid.

Whereas SAE J2293 focused on communication between the vehicle and local, off-board electric vehicle supply equipment (EVSE) with optional grid interaction, SAE J2847/1, /2, and /3 focuses on communication between the vehicle and grid. Additionally, while SAE J2293 included support for SAE J1773-based inductive charging and SAE J1850-based communication, these are obsolete and hence not supported by SAE J2847. In order to maintain information for existing systems, this task force has reaffirmed SAE J2293, preserving that specification at its last revision level.

This specification addresses major changes that have occurred since 1997 (when SAE J2293 was published) in the technologies of electric vehicles, the grid, and information processing, including: (1) support for bi-directional energy transfer between vehicle and grid (FPF and RPF, as defined above); (2) support for new local communications media between vehicle and EVSE (to replace SAE J1850), such as power line communication (PLC) and wireless transports (Zigbee, WiFi, etc.); (3) synchronizing with a major revision of SAE J1772™ which includes new connectors and signals between the vehicle and EVSE, and additional AC and DC power levels; (4) support for new vehicle architectures such as plug-in hybrid (PHEV) and plug-in fuel cell (PFCV) vehicles; (5) support for new rechargeable energy storage system (RESS) technologies and packaging methods; (6) support for vehicle telematic communication transports; and (7) support for new developments in both utility and customer premises equipment, such as advanced metering infrastructure (AMI) and home-area network (HAN) technologies.

The above changes and others require a new approach to vehicle-grid communications and provide the fundamental rationale for this specification.

TABLE OF CONTENTS

1. SCOPE

This SAE Recommended Practice SAE J2847/1 establishes requirements and specifications for communication between plug-in electric vehicles and the electric power grid, for energy transfer and other applications. Where relevant, this document notes, but does formally specify, interactions between the vehicle and vehicle operator.

1.1 Purpose

The primary purpose of SAE J2847/1 is *grid-optimized energy transfer for plug-in electric vehicles* – that is, ensuring that vehicle operators have sufficient energy for driving while enabling the delivery of that energy to vehicles in ways that minimize stress upon the grid. This can be accomplished, for example, by vehicle owners' voluntary participation in a utility controlled-charging program in return for incentives, and the specification therefore supports information flows that enable such mechanisms.[1]

This specification supports Forward Power Flow (FPF) energy transfer from the grid to the vehicle to charge the vehicle's rechargeable energy storage system (RESS). Implementation of SAE J2847/1 is encouraged for enabling utility- or premise Energy Management System-controlled charging load management and demand response incentive programs, and vehicle communication with home area network (HAN) communications capable electrical devices.

Reverse Power Flow (RPF) is the transfer of power from the vehicle to the grid and is used to provide the utility sources of power to augment ancillary and regulatory services to control the reliability of the grid, such as to prevent grid outages. PEV to Utility Grid communications for RPF is specified in SAE J2847/3.

Beyond its primary purpose of energy transfer, SAE J2847/1 enables other applications between vehicles and the grid, such as vehicle participation in a utility-controlled charging plan (as noted above), or participation in a home-area network (HAN) of communications-capable electrical devices. The SAE J2847/1 protocol is designed to be extensible, so that as new applications emerge, additional messages can be added while maintaining support for the existing message set.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J2836/1™ Use Cases for Communication Between Plug-in Vehicles and the Utility Grid

[1] Such programs exist for other large electrical loads, such as air conditioners, and it is an explicit goal of the specification to support information flows that enable such mechanisms for plug-in vehicles. This will enable systems that distribute the economic and environmental benefits of plug-in vehicles to all market participants, thereby ensuring faster market development.

2.1.2 IEC Publications

IEC Publications are also available from the American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

IEC 61968-1 Application integration at electric utilities – System interfaces for distribution management - Part 1: Interface architecture and general requirements

IEC 61968-2 Application integration at electric utilities – System interfaces for distribution management - Part 2: Glossary

IEC 61968-3 Application integration at electric utilities – System interfaces for distribution management - Part 3: Interface for network operations

IEC 61968-4 Application integration at electric utilities – System interfaces for distribution management - Part 4: Interfaces for records and asset management

IEC 61968-9 Application integration at electric utilities – System interfaces for distribution management - Part 9: Interfaces for meter reading and control

IEC 61968-13 Application integration at electric utilities – System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution

IEC 61986 UML CIM Users Group Unified Modeling Language (UML) Model

2.1.3 IEEE Standards

802.1AR IEEE P802.1AR/D2.2: Draft Standard for Local and Metropolitan Area Networks: Secure Device Identity http://employees.org/%7Eczmax/802.1AR/802-1ar-d2-2.pdf

2.1.4 IETF Standards

RFC 768 User Datagram Protocol http://tools.ietf.org/html/rfc768

RFC 792 Internet Control Message Protocol http://tools.ietf.org/html/rfc792

RFC 793 Transmission Control Protocol http://tools.ietf.org/html/rfc793

RFC 1042] A Standard for the Transmission of IP Datagrams over IEEE 802 Networks http://tools.ietf.org/html/rfc1042

RFC 1208 A Glossary of Networking Terms http://tools.ietf.org/html/rfc1208

RFC 2080 RIPng for IPv6 http://tools.ietf.org/html/rfc2080

RFC 2409 The Internet Key Exchange (IKE) http://tools.ietf.org/html/rfc2409

RFC 2119 Key words for use in RFCs to Indicate Requirement Levels http://tools.ietf.org/html/rfc2119

RFC 2460 Internet Protocol, Version 6 (IPv6) Specification
http://tools.ietf.org/html/rfc2460

RFC 2545 Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing
http://tools.ietf.org/html/rfc2545

RFC 2616 Hypertext Transfer Protocol -- HTTP/1.1
http://tools.ietf.org/html/rfc2616

RFC 2631 Diffie Hellman Key Agreement Method
http://tools.ietf.org/html/rfc2631

RFC 3117 IETF RFC 3117, On the Design of Application Protocols
http://tools.ietf.org/html/rfc3117

RFC 3748 Extensible Authentication Protocol (EAP)
http://tools.ietf.org/html/rfc3748

RFC 3766 IETF RFC 3766, Determining Strengths for Public Keys Used for Exchanging Symmetric Keys
http://tools.ietf.org/html/rfc3766

RFC 4279 Pre-Shared Key Ciphersuites for Transport Layer Security
http://tools.ietf.org/html/rfc4279

RFC 4291 IP Version 6 Addressing Architecture
http://tools.ietf.org/html/rfc4291

RFC 4302 IP Authentication Header
http://tools.ietf.org/html/rfc4302

RFC 4303 IP Encapsulating Security Payload (ESP)
http://tools.ietf.org/html/rfc4303

RFC 4306 Internet Key Exchange (IKEv2) Protocol
http://tools.ietf.org/html/rfc4306

RFC 4347 Datagram Transport Layer Security
http://tools.ietf.org/html/rfc4347

RFC 4443 Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification
http://tools.ietf.org/html/rfc4443

RFC 4492 Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security
http://tools.ietf.org/html/rfc4492

RFC 4862 IPv6 Stateless Address Autoconfiguration
http://tools.ietf.org/html/rfc4862

RFC 4919 IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals
http://tools.ietf.org/html/rfc4919

RFC 4944 Transmission of IPv6 Packets over IEEE 802.15.4 Networks
http://tools.ietf.org/html/rfc4944

RFC 5191 Protocol for Carrying Authentication for Network Access (PANA) Framework
http:/tools.ietf.org/html/rfc5193

RFC 5216 The EAP-TLS Authentication Protocol
http://tools.ietf.org/html/rfc5216

RFC 5238 Datagram Transport Layer Security (DTLS) over the Datagram Congestion Control Protocol (DCCP)
http://tools.ietf.org/html/rfc5238

RFC 5246 The Transport Layer Security (TLS) Protocol v1.2 (
http://tools.ietf.org/html/rfc5246

RFC 5247 Extensible Authentication Protocol (EAP) Key Management Framework
http://tools.ietf.org/html/rfc5247

RFC 5288 AES Galois Counter Mode (GCM) Cipher Suites for TLS
http://tools.ietf.org/html/rfc5288

RFC 5289 TLS Elliptic Curve Cipher Suites with SHA-256/384 and AES Galois Counter Mode (GCM)
http://tools.ietf.org/html/rfc5289

RFC 5340 OSPF for IPv6
http://tools.ietf.org/html/rfc5340

2.1.5 W3C Standards

EXI Efficient XML Interchange (EXI) Format 1.0
http://www.w3.org/TR/2008/WD-exi-20080919/

2.1.6 Additional References

REST Representational State Transfer
http://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

3. DEFINITIONS

3.1 Available Line Current (ALC)

Available Line Current is transmitted by the EVSE using the Pilot duty cycle identified in SAE J1772™. This indicates to the vehicle the maximum current draw for this premise. The purpose of this is for the vehicle not to request more current that this and to not trip the premise circuit breaker.

3.2 Advanced Metering Infrastructure (AMI)

AMI or Advanced Metering Infrastructure typically refers to the full measurement and collection system that includes meters at the customer site, communication networks between the customer and a service provider, such as an electric, gas, or water utility, and data reception and management systems that make the information available to the service provider.

3.3 Battery

See Electric Vehicle Storage Battery. Means a system that stores energy for delivery of electric energy and which is rechargeable. The terms Battery, ESS, and RESS are often used interchangeably.

3.4 Battery Electric Vehicle (BEV)

The BEV is a vehicle that receives its power solely from batteries, unlike a hybrid vehicle that may receive a portion of its power from a separately-fueled power source, such as an internal combustion engine (ICE).

3.5 Branch Circuit

The circuit conductors between the final overcurrent device protecting the circuit and the equipment supplied by the circuit. It is typically an unswitched circuit from the service equipment (fuse box) to an appliance. For this application, the appliance is the Electric Vehicle Supply Equipment (EVSE).

3.6 Electric Utility Power System (Utility)

The system that generates and delivers commercial electrical power to a residential or commercial building or facility. It extends to and includes a billing apparatus (electric meter).

3.7 Electric Utility/Local Load Management System (LMS)

A system that is responsible to monitor and control the load on some portion of the Utility or local premises' feeder and branch circuits. The goal of control may be to prevent overload or to reduce the cost of energy based on a specific billing agreement.

3.8 Electric Vehicle Storage Battery (Battery)

A group of electrochemical cells electrically connected in a series and/or parallel arrangement, the principal purpose of which is to provide DC electrical energy to propel the EV. Means a system that stores energy for delivery of electric energy and which is rechargeable. The terms Battery, ESS, and RESS are often used interchangeably.

3.9 Electric Vehicle Supply Equipment (EVSE)

The equipment from the branch circuit to, and including, the connector that couples to the electric vehicle inlet, the purpose of which is to transfer electric energy to an EV. This equipment is located off-board the vehicle.

3.10 End-Use-Measurement-Device (EUMD)

The End-Use-Measurement-Device (EUMD) is a revenue-grade submeter responsible for directly measuring energy delivered to a PEV. If a utility or electricity vendor wishes to offer a rate-advantaged program that requires specific metering of energy to a PEV, an EUMD must be present in the appropriate circuit. The physical form, location and ownership of the EUMD may be unique for different applications.

3.11 Energy Management System (EMS)

The Energy Management System refers to the device(s) or software that controls the energy transfer and use of smart loads throughout the home or premise. The EMS may take several different physical forms. For example, the utility itself may serve as the EMS, dispatching data and commands to loads in customers' homes. Conversely, the EMS may be a premise-installed device or software (ex. local management in a public building).

3.12 Energy Portal

Energy Portal is a 120 V standard outlet.

3.13 Energy Transfer

The process of flowing energy to the EV from the EVSE.

3.14 Energy Transfer Strategy

A strategy that accounts for all of the electrical energy needs of an EV and the present status of all on-board equipment, including the EV Storage Battery. It determines the rate that energy is to be transferred to and from the EV and how the ETS shall be operated to accomplish this.

3.15 Energy Transfer System (ETS)

A system that is distributed between an Electric Vehicle (EV) and the off-board Electric Vehicle Supply Equipment (EVSE), the purpose of which is to transfer electrical energy from the Utility Power System (Utility) to the EV Storage Battery and other vehicle loads. The EV and EVSE must be connected together for energy to be transferred.

3.16 Forward Power Flow (FPF)

Forward Power Flow means the direction of energy is flowing from the grid to the vehicle.

3.17 Home Area Network (HAN)

A HAN is an energy related network, contained within a premises used for communicating with devices within the premises. HANs do not necessarily require connectivity outside the premises, but may be connected to one or more external communication networks (e.g., Utility AMI, internet, cell phone network, etc.) using gateways, bridges and interfaces.

Homeplug powerline adapters are an alternative solution for having your house completely networked using existing power lines. The advanced Homeplug powerline adapter is capable of transmitting data at up to 200 Mbps channel data rate. The Homeplug powerline adapter delivers maximum range and speed for voice, Internet, video, and music throughout your home or office.

3.18 Human Machine Interface (HMI)

HAN application characteristics that provide local user input and/or output. These are based constrained and based on the data type.

- User Input - Provides consumers with a means to input data into an Application (e.g., Touch screen, Keypad)
- User Output - Provides an Application with a means to output data to the consumer (e.g., In-Home Display, text message)

3.19 In-Home Display

Refers generically to a device positioned somewhere in the home or premise that is used to display information to the customer. Information displayed may include, but is not limited to any combination of the following: home/premise energy/power usage, device energy/power usage, energy cost, estimated charge times, estimated completion times, historical charge data, etc. The display device may be a stand-alone unit, integrated into another communications-enabled device (e.g., a display on a smart meter, EVSE, or even a PC).

3.20 Interoperability

The condition where components of a system, relative to each other, are able to work together to perform the intended operation of the total system. As an example, a 10-mm box-end hand wrench and a 10-mm socket wrench are interoperable, relative to a 10-mm hex-head bolt. The wrench and the bolt are both parts of a fastening system. The fact that the system will perform as required with either wrench establishes the interoperability of the wrenches and the bolt.

3.21 Processing

HAN application characteristics that consume, process, and act on external and internal data. These accept data from external systems and HAN measurement & monitoring applications. In general, these applications that have a higher level of complexity and cost.

- Energy Cost - Calculates current and overall energy cost
- Energy Consumption - Calculates current and overall energy consumption
- Energy Production - Calculates current and overall energy production
- Energy Optimization - Utilizes external and HAN data to determine desired response based on a consumer configurable profile
- Energy Demand Reduction - Uses external and HAN data to reduce load based on a consumer configurable profile
- Environmental Impact - Calculates environmental impact of current energy consumption (e.g., Power Generation Plant CO_2 emissions related to consumer specific load)

3.22 Rechargeable Energy Storage System (RESS)

Means a system that stores energy for delivery of electric energy and which is rechargeable. The terms Battery, ESS, and RESS are often used interchangeably.

3.23 Reverse Power Flow (RPF)

Reverse Power Flow means the direction of energy is flowing from the vehicle back to the grid.

3.24 Peak Power

Peak power is required at times of day when high levels of demand are expected (e.g., hot summer afternoons when air conditioning demands are large). Typically, peak power is generated by power plants that can be switched on relatively quickly, such as gas turbines. However, because these plants are only utilized during the few hundred hours per year (i.e., less than 10% of the time) when demand is high, and are idle otherwise, they represent a relatively inefficient investment.

3.25 Power Flow

See Forward Power Flow and Reverse Power Flow.

3.26 Power Line Communication

Power line communication (PLC), also called power line carrier, mains communication, power line telecom (PLT) or power line networking (PLN) are terms describing several different systems for using electric power lines to carry information over the power line.

Electrical AC power is transmitted over high voltage transmission lines, distributed over medium voltage, and used inside buildings and homes at lower voltages. Power line communications can be applied at each stage. Most PLC technologies limit themselves to one set of wires (for example, premises wiring), but some can cross between two levels (for example, both the distribution network and premises wiring). In most cases, these technologies may be used on DC lines and in the absence of power.

Since the power wiring was designed for the transmission of power and not for communications, many challenges exist, such as faultless communications in the presence of noise and over long distances.

Power line communications systems operate using a variety of modulation techniques (including frequency, phase or OFDM modulation schemes), and in different frequency bands. In general, the lower band solutions (in the 10 – 490 KHz range) are used in applications with data rates less than 256 Kbps. The upper band (2 MHz and above), has been used for broadband applications. As there are many different incompatible proprietary, alliance specifications and standards, the issue of co-existence is a major concern. The medium can extend beyond the consumers premise and may be used for multiple different applications, from simple lighting control to video distribution in the home to communicating to the Utility electrical meter outside.

One example of a PLC technology is HomePlug. Founded in 2000, the HomePlug Powerline Alliance, Inc. is the global leading open-standards based organization developing interoperable powerline communications technologies and certifying powerline-based products. With 65 members and more than 4.5 million HomePlug-certified products shipped worldwide, the organization has developed HomePlug 1.0 and HomePlug AV and continues to develop the HomePlug Command and Control and HomePlug BPL specifications for use in both to-the-home networking.

3.27 Smart Charging

Smart Charging describes a system in which PEVs communicate with the power grid in an effort to optimize vehicle charging or discharging rate with grid capacity and time of use cost rates.

3.28 Utility

Utility provides electrical energy and typically refers to a collection of systems that include the Customer Information System (CIS), the Advanced Metering Infrastructure (AMI), Rates and Revenue. The utility makes available to PEV through the ESCI pricing tables or discrete events. The utility also supplies information such as tariff rate, interval for metered kWhr consumption, and validation of PEV program for PEV ID, etc.

3.29 V2G

When vehicle power is fed into the electric grid, we refer to it as “Vehicle-to-Grid” power, or V2G.

4. TECHNICAL REQUIREMENTS

4.1 System Definition

The messages within this document apply when the customer enrolls in one or more the following Utility programs. The use cases that describe these are per SAE J2836/1™.

U1: Time-Of-Use (TOU) Rates / Tariffs / Programs (Load Shifting)

U2: Direct Load Control Programs (Demand Response)

U3: Real Time Pricing (RTP: Load Shifting / Demand Response) (Active Management)

U4: Critical Peak Pricing (CPP / Load Shifting)

U5: Optimized Energy Transfer Programs (Demand Response, Regulation Services, etc.)

For each of the SAE Use Cases described below, only a subset of the messages described in this document may be required to be implemented. The table below shows which messages are required (Standard) to achieve the functionality described in each use case. For example, to implement a Time-of-Use program (U1), only those messages marked as "Standard" in the U1 column are required. Also note that multiple Use Cases may be implemented at once. For example, it is possible to have a customer enrolled in both Time-of-Use (U1) and Load Control/Demand Response (U2) programs. In this case, all messages marked as "Standard" in columns U1 *and* U2 are required to be supported. The messages within this document also apply when a PEV is connected to a 3rd party charging facility where the customer may not be directly enrolled in a utility program.

TABLE 1

Message	**Use Case Requirements** S = Standard, required to achieve functionality described by Use Case O = Optional, may be required to participate in advanced functions.				
	U1	**U2**	**U3**	**U4**	**U5**
Identifications					
Vehicle ID	S	S	S	S	S
Customer ID and/or PIN					
EUMD ID	S		S	S	S
Communications Authenticated	S	S	S	S	S
Smart PEV Present	S	S	S	S	S
EVSE Override Request	S	S	S	S	S
EVSE ID					
Premise ID					
Energy Requests					
Energy Request (amount)					S
Power Request (rate)					S
Energy Available (amount)					S
Power Available (rate)					S
Power Schedule					S
Energy Delivered (charge kWh)	S		S	S	S
Timing Information					
Time Charging to Start	S	S	S	S	S
Time Charging to End	S	S	S	S	S
Anticipated Charge Duration					S
Time Charge is Needed	S	S	S	S	S
Charging Profile					S
Actual Charge Start Time	S		S	S	S
Pricing					
Request Scheduled Prices			S		S
Publish Price			S		S
Define Rate Time Period	S			S	S
Rate Time Period Status Hash	S			S	S
Request Rate Time Period Info	S			S	S
Price for Rate Time Period	S			S	S
Load Control					
Load Control		S			
Cancel Load Control		S			
Report Event Status Request		S			
Report Event Status Response		S			
Request Scheduled Events		S			
Vehicle Info / Status					
Time at Connection	S	S	S	S	S
Battery SOC Start					O
Battery SOC End					O
Battery SOC Actual					O
Vehicle Type					O
Usable Battery Energy					O
Customer Mode Preference					S

4.2 Equipment and Devices

4.2.1 Automotive Modules

The automotive module has several hardware and software requirements to meet these communication criteria.

4.2.1.1 Communication Speed

The communication is expected to include a base or fundamental speed. Optional or higher rates are allowed.

4.2.1.2 Interrupts/Restarts

The automotive module needs to address interrupts and restarts from the utility, the vehicle or the customer. Delays and checks need to be included as to provide smoother transitions to re-instating energy transfer.

4.2.1.3 Security

Security is managed through the use of standard IETF security protocols and ciphersuites. Link layer security is supported through and Entity Authentication Protocol (EAP) (RFC 3748). Additional protocol support may also be supplied through the use of the Protocol for Carrying Authentication for Network Access (PANA) Framework (RFC 5191). These protocols, or a subset of them, shall be used for presentation of credentials and authentication of PEV devices joining the network.

Additionally, application layer security shall be enabled through the use of The Transport Layer Security (TLS) Protocol v1.2 (RFC 5246). Cipher suite support shall support one or more of the following (all standard within TLS): Diffie Hellman Key Agreement Method (RFC 2631), Pre-Shared Key Ciphersuites for Transport Layer Security (RFC 4279), Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security (RFC 4492), TLS Elliptic Curve Cipher Suites with SHA-256/384 and AES Galois Counter Mode (GCM) (RFC 5289) and the AES Galois Counter Mode (GCM) Cipher Suites for TLS (RFC 5288). Where UDP is utilized as the transport protocol for the application, the Datagram Transport Layer Security (DTLS) over the Datagram Congestion Control Protocol (DCCP) (RFC 5238) is supported.

Security is supported with a minimum 128 bit key. See IETF RFC 3766, Determining Strengths For Public Keys Used For Exchanging Symmetric Keys.

4.2.2 Energy Metering

If metering of the energy provided to the vehicle is required, there must be a revenue-grade submeter (EUMD) installed somewhere in the circuit connecting the PEV and grid. The EUMD may be a standalone device, installed in an EVSE/cordset, wall outlet, or other implementation, and is typically (though not necessarily) owned and controlled by the utility, in similar fashion as the main premise meter. The EUMD shall be responsible for providing all energy usage and timing data necessary for billing to the utility or other billing agent. The utility or other billing agent is responsible for reconciling the usage with a customer's account, vehicle, premise, etc.

4.3 Messages

This section describes the details of the messages required to implement the functionality described in the SAE J2836/1™ use cases.

In the context of Source and Destination listed for each message below, it is important to note that 'Utility' does not necessarily refer literally to the generating company, but rather generically to a grouping of entities responsible for providing services to the premise, which may include one or more of the utility, transmission operator, aggregator, energy services companies, etc..

4.3.1 Loss of Communications or Power

In the event that reliable data communication between the PEV/EVSE and Energy Management System cannot be established or are interrupted during the session, but power remains, it is understood that the PEV/EVSE shall have the discretion to revert to a default state in which it charges at the maximum rate allowed by the SAE J1772™ Pilot signal.

In the event that power is lost during the charging session, the PEV/EVSE may resume charging upon restoration of power, subject to the requirements in SAE J2894. SAE J2894 requirements must be met to prevent large, abrupt load swings, and reduce stress on the electrical infrastructure.

4.3.2 Energy Request / Response Messaging

Feature Summary for Energy Request / Response Messaging

The Energy Request / Response messages are intended to support functionality whereby the vehicle can request a certain amount of energy at a certain delivery rate (determined by the available line current or the charger capability) and an off-board charge scheduling system will respond to the PEV/EVSE with messaging indicating the available energy schedule. The off-board charge scheduling system may be an intelligent HAN-based Energy Management system which manages the power allocated to multiple devices in the home or premise (including the PEV). While Energy Requests may be of interest to the utility for statistical / data gathering purposes, the utilities may not wish to micromanage energy requests, and could choose to leave this function to a separate entity. The HAN-based Energy Management system could use additional messages from the utility and PEV driver in conjunction with vehicle energy requests in order to determine available energy schedules (e.g., the system might use an Energy Request from the PEV, the current pricing tables from the utility, and the customer's desired departure time to determine the Available Energy).

TABLE 2

Message	Units	Source / Destination R = Required O = Optional								Comms Phase			Use Case Requirements S = Standard, required to achieve functionality described by Use Case				
		PEV		EVSE		EUMD		EMS (HAN, Grid, etc)									
		Tx	Rx	Tx	Rx	Tx	Rx	Tx	Rx	Binding	Transfer	Closing	U1	U2	U3	U4	U5
Energy Requests																	
Energy Request (amount)	kWh	R		O	O				R	X	X						S
Power Request (rate)	kW	R		O	O				R	X	X						S
Energy Available (amount)	kWh		R		R			R		X	X						S
Power Available (rate)	kW		R		R			R		X	X						S
Power Schedule	(ID, kW, start time, duration)		R		R			R		X	X						S
Energy Delivered (charge kWh)	kWh (start time, duration)					R			R			X	S		S	S	S

4.3.2.1 Energy Available / Power Available

Source: Energy Management System, Utility
Destination: PEV/EVSE

The messages "Energy Available" and "Power Available" are sent together. They represent the amount of energy and the rate of energy transfer that the vehicle should expect to draw for the present charging cycle. The home or premise-based Energy Management System determines, based on information from the utility (possibly pricing, demand response, and other grid loading information) and based on the "Energy Request", "Power Request", and "Time Charge is Needed" information (along with other customer preferences TBD) the amount of energy it can deliver to the vehicle (in kWh) and the rate of energy transfer (in kW). The energy and power shall not exceed the values requested in "Energy Request" and "Power Request" respectively. The vehicle could respond to these signals by controlling the energy delivery through the on-board charger. Alternatively, the EVSE could respond to these signals by modulating the PWM signal to restrict the available line current to the vehicle as appropriate. The "Power Schedule" message structure offers an alternative to "Energy Available / Power Available" and the Management System may use one or the other.

4.3.2.2 Energy Delivered

Source: EUMD
Destination: Utility, In-home Display

The "Energy Delivered" message is transmitted by the EUMD at the completion of a charge cycle and represents the amount of energy (in kWh) delivered to the EVSE/PEV system. This is used for billing purposes by the utility and can also be used for display purposes in the PEV or in-home display. This message may be transferred periodically during the charging session as well. Since this message is between the EUMD and EMS/Utility, specific implementation requirements are left to those parties. If so required, this message may be implemented as a vector containing timestamp data, as well as energy, for billing purposes.

4.3.2.3 Energy Request

Source: PEV, EVSE
Destination: Energy Management System, Utility

This message is sent together with "Power Request". The Energy Request message refers to the amount of energy in kWh that the vehicle expects from the utility. The amount is computed by the vehicle and is determined based on several parameters including the charger efficiency, battery condition, and current battery SOC. It represents the total energy the entire PEV/EVSE system must draw from the utility, including energy required for battery maintenance or conditioning, and other vehicle systems (not simply the amount of energy needed by the battery). The expected response to this message is "Energy Available".

4.3.2.4 Power Request

Source: PEV, EVSE
Destination: Energy Management System, Utility

This message is sent together with "Energy Request". The Power Request message is sent by the vehicle and indicates the maximum expected energy transfer rate (in kW) for the energy requested in "Energy Request". This quantity is determined by the vehicle based on the observed PWM available line current signal and the charger's present capability (possibly based on battery conditions including battery temperature and ambient temperature). The home or premised-based Energy Management System is expected to use the values in "Energy Request" and "Power Request", along with "Time Charge is Needed" (see Timing section) to determine a charging schedule for the vehicle.

4.3.2.5 Power Schedule

Source: Energy Management System, Utility
Destination: PEV/EVSE

The "Power Schedule" message offers an alternative to the "Energy Available / Power Available" messages. Based on the vehicles request for energy and power (through "Energy Request" and "Power Request") the Energy Manager may compute an energy delivery schedule that it could communicate to the EVSE/PEV using the "Power Schedule" message. The Power Schedule message consists of the signals Event ID, kW, Start Time, and Duration. Each Power Schedule message indicates the particular energy delivery rate (in kW) beginning at Start Time (in UTC) and lasting for a time specified by Duration in minutes. Upon receiving a sequence of "Power Schedule" messages, the EVSE or PEV could populate a scheduling table to charge/not charge as appropriate through the duration of the charge cycle.

4.3.3 Identification Messaging

The Identification messages are useful for identifying the vehicle, the driver, and the charging location to the utility. In order to ensure that a valid vehicle (registered in a utility PEV program) is connected, the utility needs to confirm the vehicle's ID. For billing purposes, the utility may need to know the particular customer driving the vehicle (especially true in shared vehicles, such as rental cars) and the location that the vehicle is charging.

TABLE 3

Message	Units	Source / Destination R = Required O = Optional — PEV Tx	PEV Rx	EVSE Tx	EVSE Rx	EUMD Tx	EUMD Rx	EMS (HAN, Grid, etc) Tx	EMS (HAN, Grid, etc) Rx	Comms Phase — Binding	Transfer	Closing	Use Case Requirements S = Standard, required to achieve functionality described by Use Case — U1	U2	U3	U4	U5
Identifications																	
Vehicle ID	char string	R							R	X	X	X	S	S	S	S	S
Customer ID and/or PIN	char string	O		O					O	X	X	X					
EUMD ID	char string					R			R	X	X	X	S		S	S	S
Communications Authenticated	boolean		R		R			R		X	X		S	S	S	S	S
Smart PEV Present	boolean	R			R					X	X	X	S	S	S	S	S
EVSE ID	char string			O					O	X	X	X					
Premise ID	char string					O			O	X	X	X					

4.3.3.1 Communications Authenticated

Source: Energy Management System, Utility
Destination: PEV, EVSE

Once the vehicle, customer, premise, and EUMD IDs have been validated by the utility, the utility shall send a message to the vehicle indicating that communications are now established and binding was successful.

4.3.3.2 Customer ID and/or PIN

Source: PEV/EVSE (possibly via driver input)
Destination: Energy Management System, Utility

Each customer will have a unique ID and/or PIN (Personal Identification Number). A vehicle may have more than one driver, where each driver maintains a separate account with a utility for billing purposes; this scenario is especially apparent for rental cars, fleet cars, or other shared vehicles. A customer ID may also be used in public charging scenarios to provide the customer with access to features that may or may not have been prearranged with the meter provider.

The customer ID would uniquely indentify a customer to a utility—it could be, for instance, the account number the customer has with the utility. There may be an additional PIN (e.g., 4-digit code) added to this ID for roaming billing features. The PIN could be entered through the EVSE, through the NAV, or through another interface device.

4.3.3.3 EUMD ID

Source: EUMD
Destination: Energy Management System, Utility

Each EUMD will have a unique ID which will be communicated to the utility at the start of a charging or communications session, likely a MAC address. In order to successfully bind to the utility at the start of a session, the EUMD ID and Vehicle ID (and possibly the premise ID, customer ID and EVSE ID) would need to be validated by the utility.

4.3.3.4 Premise ID

Source: Premise meter
Destination: Energy Management System, Utility

The premise ID shall uniquely identify the premise location where the charging session occurs (e.g., customer's home, public charging station, employer's address, etc.). The premise ID may be used by the utility for billing purposes. One important application of the premise ID is in PEV roaming scenarios—if a PEV charges at a location different from the PEV's home location, the cost for the charging could be added to the driver's bill (based on the customer ID) and subtracted from the premise owner's bill (based on the premise ID).

4.3.3.5 Vehicle ID

Source: PEV
Destination: Energy Management System, Utility

This will be an ID that uniquely identifies the vehicle. Potential candidates for the vehicle ID are the Vehicle Identification Number (VIN) or the HAN MAC address. One advantage of the VIN is that it uniquely identifies the vehicle for its entire life, while a MAC address could change if the communications module were replaced.

4.3.3.6 EVSE ID

Source: EVSE
Destination: Energy Management System, Utility

This will be an ID that uniquely identifies the EVSE. Since there may be multiple vehicles attached to multiple EVSEs behind any single EUMD, there may be a need to uniquely identify the EVSE to the utility.

4.3.3.7 Smart PEV Present

Source: PEV
Destination: EVSE

There exist different physical implementations of electric vehicles wherein SAE J2847/1 message support, and therefore control of the charging session (determination of charge times, user's preferences, etc.) may reside either in the EVSE or the PEV. In the case where both devices support SAE J2847/1 messages, and are capable of managing the session, it shall be assumed that the PEV will be the default controlling device. Immediately upon connection, a PEV wishing to take control of and manage the charging session shall transmit this message to the EVSE. Upon receipt of this message, the EVSE shall disable any functionality and communications related to utility messaging, shall gateway all messaging from the EMS to the PEV, and shall allow the PEV to control the session.

The table below indicates the expected outcomes for the various scenarios.

TABLE 4

Case	PEV Supports SAE J2847/1 Messaging	EVSE Supports SAE J2847/1 Messaging	Result
1	NO	NO	No “smart charging” support. PEV charges at rate provided by SAE J1772™ pilot, or internally allowable, whichever is lower.
2	NO	YES	EVSE is “smart charging” enabled, and computes charge schedule. EVSE manipulates charging by controlling SAE J1772™ pilot. PEV charges at rate provided by SAE J1772™ pilot, or internally allowable, whichever is lower.
3	YES	NO	PEV is “smart charging” enabled, and computes charge schedule. PEV charges at internally-computed rate, upper-bounded by SAE J1772™ pilot signal.
4	YES	YES	Both devices are “smart charging” capable. Upon connection, PEV transmits “*Smart PEV Present*” message, and EVSE becomes passive gateway. Charging progresses as in Case 3. It is advisable for vehicle manufacturers to include an easily accessible option for selecting immediate charging at public locations.

4.3.4 Load Control / Demand Response Messaging

The set of Load Control / Demand Response messages are intended to allow the utility to send a request to an EVSE/PEV to reduce or shed its load (i.e., reduce the rate of charging or cease charging entirely) whenever the utility identifies a present or anticipated future need for a reduction in the network load. It is understood that load control / demand response events would be a relatively infrequent occurrence and would be used only when the anticipated load on the utility approaches critical levels. It is further understood that the customer shall be permitted the option to decline to comply with Load Control / Demand Response requests, but that doing so may result in a non-compliance with a utility rate program (if the customer is registered in one), which may result in an increased cost to the customer.

TABLE 5

Message	Units	Source / Destination R = Required O = Optional								Comms Phase			Use Case Requirements S = Standard, required to achieve functionality described by Use Case				
		PEV		EVSE		EUMD		EMS (HAN, Grid, etc.)									
		Tx	Rx	Tx	Rx	Tx	Rx	Tx	Rx	Binding	Transfer	Closing	U1	U2	U3	U4	U5
Load Control																	
Load Control	(ID, start time, duration, level, percentage)		R		R			R		X	X			S			
Cancel Load Control	(ID, cancel time)		R		R			R		X	X			S			
Report Event Status Request	ID		R		R			R		X	X			S			
Report Event Status Response	(ID, status)	R		R					R	X	X			S			
Request Scheduled Events	(start time, number of events)	R		R					R	X	X			S			

4.3.4.1 Cancel Load Control

Source: Energy Management System, Utility
Destination: PEV, EVSE

This message contains the signals Event ID and Cancel Time. The Event ID signal serves to identify which load control information is supposed to be cancelled: it is associated with the matching Event ID (sent in the "Load Control" frame). The Cancel Time specifies the time (in UTC) when the "Load Control" event with the specified Event ID should be cancelled. So for instance, if Cancel Time = Start Time, then the entire load control event is cancelled. If Cancel Time > Start Time, then the load control event does take place, but terminates earlier than scheduled (assuming Cancel Time – Start Time > Duration).

4.3.4.2 Load Control

Source: Energy Management System, Utility
Destination: PEV, EVSE

The load control frame contains the following signals: Event ID, Start Time, Duration, Criticality Level, and Load Reduction Request. Each "Load Control" frame has a unique Event ID which allows for the subsequent modification of data previously communicated (e.g., it allows the utility to cancel a previously scheduled load control event by referencing the appropriate Event ID). The Start Time (in UTC time) indicates the time that the load control event is intended to begin and the Duration (in minutes) indicates how long the load control event will last. The Criticality Level indicates the severity of the load control event—customers may receive more monetary incentives for participating depending upon the criticality level of the event. The Load Reduction Request is a percentage which indicates how much of the load should be reduced (where 100% would be a complete shedding of the load, while non-100% values would correspond to an appropriate reduction in the charging rate). A utility could send several "Load Control" frames corresponding to different individually scheduled load control events. The PEV/EVSE could populate a table in memory with scheduled events and could use these to plan charging.

4.3.4.3 Report Event Status Request

Source: Energy Management System, Utility
Destination: PEV/EVSE

This message allows the utility to request an update from the PEV on the status of a load control event (with a specified Event ID)—specifically if the PEV is following the event or if the operator has chosen to override the event.

4.3.4.4 Report Event Status Response

Source: PEV/EVSE
Destination: Energy Management System, Utility

This message consists of the signals Event ID and Status. The PEV shall send this message to the utility when responding to a "Report Event Status Request" message from the utility or whenever the owner has chosen to override a utility request (e.g., when the driver has chosen to "charge now" and to ignore the current utility initiated delay or demand response). The Event ID corresponds to the utility-initiated load control event. The status field shall be a state-encoded value that indicates whether the PEV is following the request, and if not, whether the failure to honor the request is a result of a customer decision versus other, possibly technical limitations (e.g., yes following request, partially following request by reducing charge rate but still charging, complete operator override, etc.). In order to effectively administer rate programs, the utility may need to be able to determine whether a failure to honor a Load Control request is the result of a customer choice.

4.3.4.5 Request Scheduled Events

Source: PEV/EVSE
Destination: Energy Management System, Utility

This frame consists of the following signals: Start Time, and Number of Events. The PEV/EVSE would send this frame to the utility when it wished to update the load control events stored in memory. The PEV/EVSE could request the next “N” events (with N = Number of Events) from a particular Start Time. The PEV might request an update to its scheduled events upon connection or upon a loss of memory fidelity, for instance.

4.3.5 Pricing Messaging

Feature Summary for Pricing Messaging

The pricing messages included here are intended to provide a framework for the PEV/EVSE to request pricing information from the utility and for the utility to provide this pricing information. The pricing messages are formulated to allow for either “real-time” variable pricing or “tiered/register” pricing.

Using the real-time pricing messages, the utility could publish pricing schedules that change frequently (up to minute-by-minute, although an hourly pricing schedule might be a practical limit at present) and that reflect the instantaneous bulk rate of electricity. Upon connection, the PEV/EVSE could request and download the real-time pricing information for the next 24-hour period (or another smaller/greater period of time). Real-time pricing is achieved using the “Publish Price” and “Request Scheduled Prices” messages.

The tiered or register pricing messages would allow the utility to specify the price of electricity for certain fixed times of the day. Currently utilities often have several blocks of time during the day with different electricity prices (e.g., peak time, mid-peak time, and off-peak time) and these messages are formulated to allow for the definition of prices during these times. The expectation is that the price in each pricing tier/register would not change frequently and that the information would not need to be downloaded each time the vehicle was plugged in. A hash function of current tier/register information would permit the PEV/EVSE to verify that the pricing information stored in its memory was up to date. Tiered/Register pricing is achieved using the “Define Tier”, “Tier Status Hash”, “Request Tier Info”, and “Price for Tier” messages.

Note that in either the real-time pricing or tier/register pricing frameworks, a PEV/EVSE or a HAN-based Energy Manager could utilize the pricing information along with certain user preferences (e.g., “Time Charge is Needed”) to determine when to charge the vehicle.

TABLE 6

Message	Units	Source / Destination R = Required O = Optional PEV		EVSE		EUMD		EMS (HAN, Grid, etc.)		Comms Phase			Use Case Requirements S = Standard, required to achieve functionality described by Use Case				
		Tx	Rx	Tx	Rx	Tx	Rx	Tx	Rx	Binding	Transfer	Closing	U1	U2	U3	U4	U5
Pricing																	
Request Scheduled Prices	(start time, number of prices)	R		R					R	X	X				S		S
Publish Price	(ID, price, start time, duration)		R		R			R		X	X				S		S
Define Rate Time Period	(RTP ID, start time, duration, day)		R		R			R		X	X		S			S	S
Rate Time Period Status Hash	numeric		R		R			R		X	X		S			S	S
Request Rate Time Period Info	boolean	R		R					R	X	X		S			S	S
Price for Rate Time Period	(RTP ID, price)		R		R			R		X	X		S			S	S

4.3.5.1 Define Rate Time Period

Source: Energy Management System, Utility
Destination: PEV/EVSE

This message is for Rate Time Period pricing support. The “Define Rate Time Period” frame consists of the following signals: RTP ID, Start Time, Duration, and Day. This message allows a utility to define a pricing period or tier which represents a particular block of time on a particular day of the week (e.g., Tuesdays from 8am to 6pm might be a peak time, Saturdays from 8am to 6pm might be amid-peak time). The RTP ID provides a unique identifier for the defined pricing tier/period that allows the utility to reference a particular period (for instance, to match a price to a period). The Start Time signal specifies when the period is defined to begin (in UTC time), and Duration indicates how long the period lasts (in minutes). The Day corresponds to the day of the week for which the period is defined. A sequence of “Define Rate Time Period” messages could be sent to the PEV to populate a table in memory with period begin/end times. The expectation is that these begin/end times would change very infrequently and the period information would not need to be downloaded from the utility upon every connection.

4.3.5.2 Price for Rate Time Period

Source: Energy Management System, Utility
Destination: PEV/EVSE

This message is for Rate Time Period pricing support. The “Price for Rate Time Period” frame contains the signals RTP ID and Price. As specified in the “Define Rate Time Period” message, each price period/tier will have a unique period ID. The “Price for Rate Time Period” message is used to assign a price to each defined period. This message allows the utility to update the prices in the periods/tiers without having to redefine the structures of the periods.

4.3.5.3 Publish Price

Source: Energy Management System, Utility
Destination: PEV/EVSE

This message is for pricing support. Each publish price frame consists of the following signals: Event ID, Price, Start Time, and Duration. The Event ID serves as a unique identifier for the current frame of real-time pricing information (in the case that information needs to be cancelled or modified, a unique Event ID provides a simple way to reference the information). The Price signal represents the price for electricity (e.g., in cents / kWh) for the particular time period specified in the frame. The Start Time signal represents the time at which the stated price takes effect (UTC time) and the Duration signal indicates the duration (in minutes) of the price. Effectively this leaves open the potential for minute-by-minute price schedules. It is expected that a sequence of "Publish Price" frames would be formulated such that there would be no "gaps" in the pricing schedule. A sequence of N appropriately formulated "Publish Price" frames would provide the PEV/EVSE with the necessary data to populate a table in memory with up to date pricing information limited only by the available memory and the utility's ability to accurately predict the price.

4.3.5.4 Request Scheduled Prices

Source: PEV/EVSE
Destination: Energy Management System, Utility

This message is for pricing support. Upon connection or upon loss of memory, the PEV may need to request an update to its stored real-time pricing information. The PEV would send a "Request Scheduled Prices" frame which contains the signals Start Time and Number of Prices. The Start Time indicates the time (in UTC time) starting at which the PEV wishes to receive pricing data (a default of all zeros, for instance, could indicate starting "now"). The Number of Prices indicates the number of "Publish Price" frames the PEV wishes to receive. The expected response from the utility is a sequence of "Publish Price" frames corresponding to the requested "number of prices".

4.3.5.5 Request Rate Time Period Information

Source: PEV/EVSE
Destination: Energy Management System, Utility

This message is for Rate Time Period pricing support. The PEV can send a message to the utility requesting an update to the pricing period information. The intent of pricing periods is that they would not change frequently. Upon most connections, the PEV would compare the "Rate Time Period Status Hash" to its own computed hash and would determine that its period information was current and correct. Thus it would not need to request an update. If the hashes did not match, the PEV could request an update to its period/tier information using this message.

4.3.5.6 Rate Time Period Status Hash

Source: Energy Management System, Utility
Destination: PEV/EVSE

This message is for Rate Time Period pricing support. The PEV requires a way to determine if any period schedule or pricing information has changed since it last connected to the utility. The "Rate Time Period Status Hash" message consists of the result of a hash function that the utility can compute on its current tier schedule and pricing information. This hash is sent to the PEV upon plug-in. The PEV will likewise compute a hash (using the same hash function) of the period schedule and pricing information it has stored. If the hash matches the information in "Rate Time Period Status Hash" then the PEV does not need to update its period/tier information. Note that two separate hash functions could be used—one for the tier structures and one for the pricing.

4.3.6 Timing Information Messaging

Timing Information messaging is used primarily by the PEV or EUMD to communicate timing requirements and history to the utility and/or premise HAN-based energy manager. The PEV can communicate to the HAN-based energy manager a time at which the charge is required, based on input into the PEV/EVSE by the customer. The PEV/EUMD can also communicate charge timing information (start times, end times, and rates of charge) which may possibly be collected for statistical purposes and/or used for display purposes by either the utility or HAN-based energy manager.

TABLE 7

Message	**Units**	**Source / Destination** R = Required O = Optional **PEV**		**EVSE**		**EUMD**		**EMS (HAN, Grid, etc.)**		**Comms Phase**			**Use Case Requirements** S = Standard, required to achieve functionality described by Use Case				
		Tx	Rx	Tx	Rx	Tx	Rx	Tx	Rx	**Binding**	**Transfer**	**Closing**	**U1**	**U2**	**U3**	**U4**	**U5**
Timing Information																	
Time Charging to Start	UTC time	R		R					R	X	X		S	S	S	S	S
Time Charging to End	UTC time	R		R					R	X	X		S	S	S	S	S
Anticipated Charge Duration	seconds	R		R					R	X	X						S
Time Charge is Needed	UTC time	R		R					R	X	X		S	S	S	S	S
Charging Profile	(kW, seconds)		R		R			R		X	X						S
Actual Charge Start Time	UTC time					R			R		X	X	S		S	S	S

4.3.6.1 Charging Profile

Source: PEV/EVSE
Destination: Energy Management System, Utility

The Charging Profile frame is a periodic message containing the following signals: Present Rate of Charge and Current Time. The Present Rate of Charge indicates average charge rate (in kW) since the previous “Charging Profile” frame was sent. The Current Time is a timestamp for this charge rate. This information could be gathered by either the PEV or the EUMD. It is intended to be used by the utility for statistical data gathering and future planning purposes (but is not intended to be used for instantaneous feedback or requests to modify charging schedules). If the charging profile is transmitted by either the PEV or the EUMD it makes redundant the data in “Time Charging Starts” and “Time Charging Ends”

4.3.6.2 Time Charge is Needed

Source: PEV/EVSE (from PEV driver input)
Destination: Energy Management System, Utility

This message captures input from the vehicle driver who can indicate (upon plug-in) when the charging cycle is expected to be complete (e.g., the driver could indicate that he expects the vehicle will be fully charged by 6am the following morning). This information is required for any charge scheduling functions, whether they take place on-board or off-board the vehicle. This message could be used internally by the PEV (with an on-board charging scheduler) or could be sent as a UTC time to an off-board home or premise-based Energy Management System.

4.3.6.3 Time Charging to Start / Time Charging to End

Source: PEV/EVSE
Destination: Energy Management System, Utility

The Time Charging to Start frame indicates to the utility the UTC time that charging is estimated to begin. Similarly the Time Charging to End frame indicates when the charging is estimated to be complete. These estimated values are formulated by the vehicle, charger, or energy management system using other available parameters such as pricing, LC/DR tables, user preferences, etc. as inputs.

There may be situations where estimated parameters such as Time Charging to Start/End prove to be incorrect. This may occur either as a result of user input, or external inputs, such as changing energy prices, sudden demand response requests, etc. It is comprehended that errors in estimated parameters resulting from external inputs may confuse or frustrate customers. It is left to the discretion of the OEM to determine which, if any, historical data, such as prices, demand response requests, etc., should be retained in order to assist customers in explaining deviations.

4.3.6.4 Actual Charge Start Time

Source: EUMD
Destination: Energy Management System, Utility

This message communicates the UTC time that charging actually began. It is transmitted by the EUMD, or device that is responsible for performing revenue-grade metering. It can be transferred as soon as the metering device detects that energy begins flowing to the PEV. Since this message is between the EUMD and EMS/Utility, specific implementation details are left to those parties.

4.3.6.5 Anticipated Charge Duration

Source: PEV/EVSE
Destination: Energy Management System, Utility

The Anticipated Charge Duration message is an estimation of the length of time for which the vehicle will be charging. It is an estimation computed by the PEV or EVSE based on available vehicle, charge and pricing parameters, such as battery SOC, current charge rate, pricing, customer preferences, etc. It is provided to the home or premised-based Energy Management System for the purpose of planning control of other loads (PEVs or otherwise) throughout the premise. It may also be of interest to the utility for short-term demand forecasting.

There may be situations where estimated parameters such as Anticipated Charge Duration prove to be incorrect. This may occur either as a result of user input, or external inputs, such as changing energy prices, sudden demand response requests, etc. It is comprehended that errors in estimated parameters resulting from external inputs may confuse or frustrate customers. It is left to the discretion of the OEM to determine which, if any, historical data, such as prices, demand response requests, etc., should be retained in order to assist customers in explaining deviations.

4.3.7 Vehicle Information and Charging Status Messaging

Before, during, and after a charge cycle, the vehicle will continuously monitor many parameters, some of which may be of interest to a customer for display purposes, or to the utility for statistical purposes. Additional charging status information may need to be exchanged through the course of a charge event and these messages also capture this information.

TABLE 8

Message	Units	Source / Destination R = Required O = Optional: PEV		EVSE		EUMD		EMS (HAN, Grid, etc.)		Comms Phase			Use Case Requirements S = Standard, required to achieve functionality described by Use Case O = Optional, may be required to participate in advanced functions.				
		Tx	Rx	Tx	Rx	Tx	Rx	Tx	Rx	Binding	Transfer	Closing	U1	U2	U3	U4	U5
Vehicle Info / Status																	
Time at Connection	UTC time		R		R		R	R		X			S	S	S	S	S
Battery SOC Start	%	O		O	O				O	X							O
Battery SOC End	%	O		O	O				O	X							O
Battery SOC Actual									O								O
Vehicle Type									O								O
Usable Battery Energy	kWh	O		O	O				O	X							O
Customer Mode Preference	numeric	R		R					R	X	X						S

4.3.7.1 Usable Battery Energy

Source: PEV
Destination: Energy Management System, Utility

This provides the usable energy of the battery in kWh. It can be used for in-home display purposes at the OEM's discretion.

4.3.7.2 Battery SOC Start / Battery SOC End

Source: PEV
Destination: Energy Management System, Utility

The Battery SOC Start message indicates the State of Charge of the **usable** energy storage system when charging began. The Battery SOC End message indicates, at the time of connection, the expected SOC of the usable energy storage system when charging is complete. It should be specifically noted that this signal is to refer to usable capacity only. That is, a signal value of 0% SOC indicates that the energy system has no usable energy left (but in actuality, the energy storage system may contain some non-usable amount of charge, as designed by the manufacturer, to protect the battery). In most cases, the Battery SOC End predicted value may be 100%, however in certain applications, such as high-speed charging, the fast-charge may be considered complete when the SOC reaches a lower value (ex. 80%). It may also be of interest to the utilities to monitor SOC at the beginning and ending of a charge cycle in order to gather usage statistics for long-term grid management planning purposes. It is not the intent of the SOC messages to be used by the utilities for delivering charge to individual PEVs.

4.3.7.3 Battery SOC Actual

Source: PEV
Destination: Energy Management System, Utility

The PEV will transmit the actual battery SOC at least every minute during the charging cycle. This may be used by the EMS to manage the charging cycle during U5. The SOC will be across the usable storage range in the same scale as Battery SOC Start and Battery SOC End.

4.3.7.4 Vehicle Type

Source: PEV
Destination: Energy Management System

The vehicle may use this signal to designate whether it is a BEV or PHEV. This information can be a used by the Energy Management System in prioritizing power allocations during any demand cutbacks. This may be particularly important for an EMS to know when allocating power among several vehicles at large public charging facility.

4.3.7.5 Customer Mode Preference

Source: PEV/EVSE
Destination: Energy Management System, Utility

This message is intended to convey how the customer has selected to charge the PEV. Depending upon the configuration, it could be specified by the customer through the PEV, through an in-home display, or through a home or premise-based Energy Management System. The customer could choose to "charge now" (independent of utility incentives), charge based on pricing information, charge based on an energy request, or charge based on other yet to be defined customer selections.

4.3.7.6 Time at Connection

Source: Energy Management System, Utility
Destination: PEV/EVSE

Upon connection, all communicating devices (including the PEV, the EUMD, possibly the EVSE and possibly the home or premise-based Energy Management System) must ensure that they are time synchronized to ensure the correct action on all time-sensitive messaging (e.g., price, demand response). The utility shall act as the master clock and all devices will synchronize their internal clocks to the current utility broadcast UTC time.

4.4 Communication Layers

The ZigBee Smart Energy 1.0 Network Model is currently being deployed in smart meters but can be upgraded to 2.0 as it develops. Smart Energy 1.0 attributes are shown in Figure 1 while Smart Energy Profile 2.0 (SEP 2.0) is shown in Figure 2. Smart Energy 2.0 is still in development and as the modeling, testing and other aspects are completed this document will be updated accordingly.

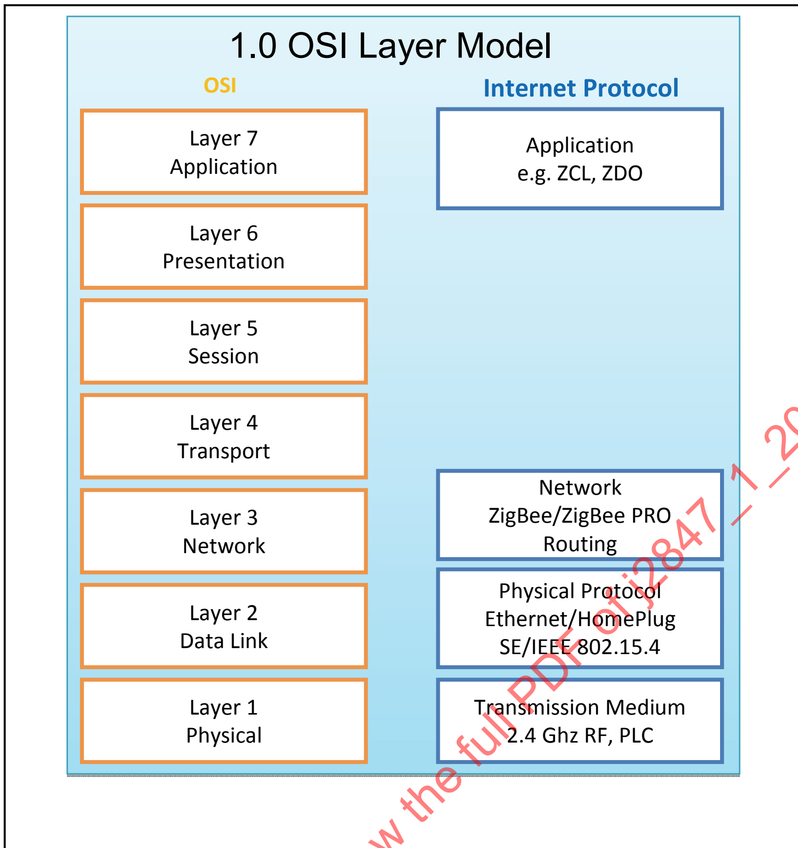

FIGURE 1 - SMART ENERGY 1.0