



SURFACE VEHICLE INFORMATION REPORT

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(R) Use Cases for Communication Between
Plug-in Vehicles and the Utility Grid

RATIONALE

The Use Cases described in the published version identify the requirements for direct communication to the utility and slight updates are to be made at this time. This update will also add (1) Indirect communication options to the utility that may include using a third party, and (2) Provider communication with a mobile service provider such as the EVSE site for locating available stations, making reservations, etc., that may be desired prior to the vehicle reaching a charging site.

SAE J2836-1 has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This SAE Information Report establishes Use Cases for communication between plug-in electric vehicles (PEVs) and the electric power grid, for energy transfer and other applications.

1.1 Purpose

The purpose of SAE J2836-1 is to document the set of Use Cases which must be supported by SAE Recommended Practice SAE J2847-1.

1.2 Use Case Methodology

Each Use Case is described by a “package” comprising several components:

- Brief written description of the Use Case, its actors, and intended purpose.
- Scenario matrix, specifying required and optional Use Case attributes.
- Equipment diagram, depicting actors and physical components of the Use Case.
- Communication path diagram, depicting communication transports and components.
- Activity diagram, depicting the interactions among Use Case actors.
- Sequence diagram, depicting the sequence of message flows in the Use Case.

Several of these concepts (notably actors and the activity and sequence diagrams) derive from EPRI Intelligrid methodology, which in turn is based on Unified Modeling Language (UML)¹.

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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J1772 SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler

¹ http://en.wikipedia.org/wiki/Unified_Modeling_Language.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1772	SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler
SAE J2836	Instructions for Using Plug-in Electric Vehicle (PEV) Communications, Interoperability and Security Documents
SAE J2836/5	Use Cases for Customer Communication for Plug-in Electric Vehicles
SAE J2847-1	Communication for Smart Charging of Plug-in Electric Vehicles Using Smart Energy Profile 2.0
SAE J2931/1	Digital Communications for Plug-in Electric Vehicles
SAE J2931/4	Broadband PLC Communication for Plug-in Electric Vehicles

2.2.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 1815-2012	IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)
IEEE 1815.1-2015	IEEE Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815(TM) [Distributed Network Protocol (DNP3)]
IEEE 2030.5	Standard for Smart Energy Profile Application Protocol 2.0 (SEP2)

2.2.3 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 15118-1	Road Vehicles - Vehicle to Grid Communication Interface - Part 1: General Information and Use-Case Definition
ISO 15118-2	Road Vehicles - Vehicle to Grid Communication Interface - Part 2: Network and Application Protocol Requirements
ISO 15118-3	Road Vehicles - Vehicle to Grid Communication Interface - Part 3: Physical Layer and Data Link Layer Requirements

2.2.4 Other Publications

OpenHAN Task Force of the utilityAMI Working Group under the OpenSG Subcommittee of the UCA® International Users Group, <http://www.utilityami.org/docs/UtilityAMI%20HAN%20SRS%20-%20v1.04%20-%200080819-1.pdf>.

3. DEFINITIONS

3.1 ALTERNATIVE ENERGY SUPPLIER (AES)

Competitive (or alternative) supplier of commodity service. See ESCO (3.34).

3.2 AVAILABLE LINE CURRENT (ALC)

The ALC 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 to ensure the vehicle current remains below the safe limits of the supply equipment wiring and premise circuit breaker as defined by Code.

3.3 ADVANCED METERING INFRASTRUCTURE (AMI)

Advanced metering infrastructure (AMI) 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.

3.4 BRIDGE COMMUNICATIONS

A communication bridge is where the communication protocol is not changed as it passes through a device. The messages are processed at the lower layers of the communication stack where the medium only is changed (e.g., WiFi to PLC).

3.5 CHARGER

The charger can either be on-board the vehicle or off-board. On-board chargers require AC energy transfer to the vehicle (either 120 V or 240 V single phase), and off-board chargers are within the EVSE and require DC energy transfer to the vehicle.

3.6 CLEARINGHOUSE

Organization that provides global PEV account services. Maintains information necessary to facilitate account validation and billing transaction when the customer is charging PEV at a location not served by the utility with which the customer is enrolled.

3.7 CONTROL

HAN application characteristics that respond to control commands.

- Direct: Turns load on or off.
- Cycling: Turns load on or off at configurable time intervals.
- Limiting: Turns load on or off based on configurable thresholds.

3.8 CONSUMER HAN DEVICES

These are devices within the architecture that are procured by the consumer or a third party which is not the utility. As an example, these devices include smart appliances, PCTs, and energy management systems.

3.9 CONTROL DEVICE

DLC programs enable utilities to remotely control and/or shut down participating customer equipment on a short notice. A control device is installed. The utility exercises its call option by first notifying the participant (to the control device which then sends the signal to the vehicle) that an event has been declared for the next day.

3.10 CONTROL FLOW

The representation of information, energy, or matter that is used to alter the behavior of a system. These are shown as dotted arrows on a DFD to indicate the source and destination of the flow. A flow may be both a data and a control flow, depending on how it is used by the system. This construct is used as a part of the functional decomposition process.

3.11 CONTROL SPECIFICATION (C-SPEC)

The description of a combinational or sequential logic operation, the results of which can be used as the input to a P-spec, or to describe when a process is to be operational. Types include DTs, STDs, and PATs. C-specs are shown as a single vertical bar on a DFD and are referenced by the DFD level they appear on, followed by an s-index (e.g., 2.3.3-s1, 4 s7). This construct is used as a part of the functional decomposition process.

3.12 CUSTOMER

The customer is the operator of a PEV and an electric customer of the home utility. The customer enrolls in an electric utility PEV program and has selected a PEV rate tariff. The customer is responsible for connecting PEV to an energy portal for charging.

3.13 CUSTOMER ACCOUNT

The customer account is assigned to the customer to collect charges for billing of energy usage.

3.14 CUSTOMER ENERGY MANAGEMENT SYSTEM

The customer energy management system can provide communication interface to PEV for communication of PEV status information (e.g., charging state, state-of-charge, charging rate, time to complete charge) on customer-viewable displays.

3.15 DATA FLOW

The representation of information, energy, or physical matter that is transformed by a system. These are shown as solid arrows on a DFD to indicate the source and destination of the flow. A flow may be both a data and a control flow, depending on how it is used by the system. This construct is used as a part of the functional decomposition process.

3.16 DATA FLOW DIAGRAM (DFD)

A diagram that shows the relationship between portions of a larger, more complex process as the process is decomposed. It captures the flow of data, energy, or physical matter between the portions. This construct is used as a part of the functional decomposition process.

3.17 DECISION TABLE (DT)

A type of C-spec that defines the conditions required to determine the value of a combinational logic function. A combinational logic function, as opposed to a sequential logic function, is one where its present value (output) is dependent only on the present value of its arguments (inputs). See STD (3.67).

3.18 DIRECT COMMUNICATION

Direct communication is where the vehicle transmits and receives messages directly from the utility, or the trustsource for the utility, such as an aggregator.

3.19 ELECTRIC SERVICE INTERFACE (ESI)

Provides security and, often, coordination functions that enable secure interactions between relevant HAN devices and the utility. Permits applications such as remote load control, monitoring and control of distributed generation, in-home display of customer usage, reading of non-energy meters, and integration with building management systems. Also provides auditing/logging functions that record transactions to and from HAN devices.

3.20 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).

3.21 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.

3.22 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

PEV connects to the grid using an EVSE. EVSE is the physical electrical cord and connectors that are specified by applicable SAE standards (e.g., SAE J1772, SAE J2836, and SAE J2847) that provide transfer of electrical energy from energy portal to PEV. This can be 120 V or 240 V AC, depending upon connection. Two type of connection include: (1) EVSE cordset, and (2) Premise-mounted version. The premise EVSE would not include the charger for AC (Level 2) energy transfer described in SAE J1772. This would expect the charger to be included with the vehicle. If the EVSE included a charger, DC (Level 3) energy transfer is expected and the vehicle would not include the charger, since it was within the EVSE. This EVSE that includes the charger may also be capable of AC energy transfer at both 120 V (Level 1) and 240 V (Level 2) levels as described in SAE J1772.

3.23 ELEMENTARY PROCESS

A process in a DFD that is not decomposed further. Its function or activity is described by a P-spec. This construct is used as a part of the functional decomposition process.

3.24 END USE METER (EUM)

An EUM function can be located anywhere in a zone from the PHEV and the branch circuit panel connection.

3.25 END USE MEASUREMENT DEVICE (EUMD)

The End Use Measurement Device (EUMD) is the device that measures and communicates energy usage information payload to the Energy Services Communication Interface (ESCI).

PEV EUMD shall provide PEV charging session info – PEV ID, Premise ID, interval kW·h/kW·h consumption.

PEV EUMD receives configuration information (e.g., interval for metering kW·h consumption) from utility. EUMD function can be located anywhere in a zone from the PEV and the branch circuit panel connection.

The EUMD shall employ appropriate security policies when communicating demand side management program-related messages.

The EUMD is always available for PEV charging. If not available, charging will proceed without incentive rates and with all energy charges accruing to the premise customer. This may or may not prevent certain charging status indicators/metrics being available to customer for presentation/display purposes.

3.26 ENERGY MANAGEMENT INTERFACE (EMI)

HMI is a subset of this.

3.27 ENERGY PORTAL

Energy portal is any charging point for a PEV. At a minimum, the energy portal is a 120 V, 15 A outlet, but can also be a 240 V EVSE outlet connected to the premise circuit.

3.28 ENERGY SERVICE COMMUNICATION INTERFACE (ESCI)

The ESCI is the communication device between the vehicle and the utility.

The ESCI shall exist at the customer premise and be capable of securely communicating between the utility and PHEV to facilitate exchange of demand side management information.

PEV shall be capable of communicating to the utility through an ESCI.

ESCI shall report all PEV charging session information and energy usage to utility ESCI communicates with and exchanges information between utility, PEV, and EUMD. ESCI shall provide PEV charging session information to the utility; PEV ID, interval kW·h/kW·h consumption. Passes energy information, including price signals, schedules, event messages, configuration, and security data from the utility to the PEV. This interface may or may not be facilitated by an AMI that includes a HAN.

ESCI shall employ appropriate security policies when communicating demand side management program-related messages.

3.29 ENERGY TRANSFER

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

3.30 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 the EV, and how the ETS shall be operated to accomplish this.

3.31 ENERGY TRANSFER SYSTEM (ETS)

A system that is distributed between an EV and the off-board 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.

3.32 ESCO

Competitive (or alternative) supplier of commodity service. See AES (3.1).

3.33 FIXED HAN DEVICES WITH METERING CAPABILITY (FHDMC)

This connects with the premise HAN and identifies itself and the account it is properly associated with to the utility, where premise owner's charges are reconciled. This Use Case also describes the scenario documented in the load and energy management Use Cases, in that the FHDMC may behave according to that Use Case. The following scenario is defined: bi-directional metering (i.e., distributed generation) and third-party (i.e., gas meter).

3.34 FORWARD POWER FLOW (FPF)

FPF means the direction of energy for charging a vehicle.

3.35 FUNCTIONAL DECOMPOSITION

A method used to describe the functional and behavioral requirements of a system, component, or device, captured as a model of the requirements. It involves the hierarchical break-down of complex requirements into simple, easy-to-describe pieces. The flow of information, energy, and matter between the pieces is captured, along with the process and control requirements.

3.36 GATEWAY COMMUNICATIONS

A communication gateway is where the communication protocol is changed as it passes through a device. The messages are read at the application layer of the communication stack and sent to the next device using a different protocol.

3.37 GUEST

Guest is a friend or family member who has permission to use a customer premise for charging a PEV. May be liable for PEV charging costs, depending upon customer preferences set up within PEV program.

3.38 GRID-TO-VEHICLE (G2V)

G2V means the transfer of energy from the electrical grid to charge a vehicle. See FPF (3.36).

3.39 HOME AREA NETWORK (HAN)

A HAN is a network contained within a user's home that connects a person's digital devices, from multiple computers and their peripheral devices to telephones, VCRs, televisions, video games, home security systems, "smart" appliances, fax machines, and other digital devices that are wired into the network.

3.40 HAN DEVICE

See consumer HAN devices (3.8), utility HAN devices (3.73), FHDMC (3.35), and MHDMC (3.49).

3.41 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.

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.

3.42 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).

3.43 INDIRECT COMMUNICATION

Indirect communication is where the vehicle transmits and receives messages to a third party, instead of directly from the utility.

3.44 IN-HOME DISPLAY DEVICE (IHD)

The IHD is the customer interface with the HAN.

3.45 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.

3.46 MEASUREMENT AND MONITORING

HAN application characteristics that provide internal data and status.

- Distributed Generation (DG): Local energy input/output (kW·h, kW, other energy values).
- Sub-Metering: Device specific, end-use energy consumption or production (e.g., consumer PHEV).
- Environmental State: Current local conditions (e.g., temperature, humidity, time, airflow, ambient light level, motion).
- Device State: The current or historical state of the device (e.g., lights/fans/compressor/motor/heater are on/off).

3.47 MOBILE HAN DEVICES WITH METERING CAPABILITY (MHDMC)

This connects with the premise HAN, identifies itself and the account it is properly associated with the utility. MHDMC's and premise owner's charges are reconciled, as applicable. This Use Case also describes the scenario documented in the load and energy management Use Cases, in that the MHDMC may behave according to that Use Case. The mobile (e.g., any consumer PHEV/EV) scenario is defined in this document.

3.48 OFF-BOARD/ON-BOARD BOUNDARY

The point where the ETS is divided into two physical parts. One part becomes realized within the off-board EVSE. The other part becomes realized within an EV. This boundary will be in different places, depending on the system architecture.

3.49 POWER FLOW

See FPF (3.36), RPF (3.59), G2V (3.40), V2H (3.76), and V2G (3.74) for further definitions.

3.50 POWER STAGE

A physical and/or logical section of power conversion equipment that can provide conversion over a portion of the total conversion power range of the equipment. The range of a specific power stage will overlap with its adjacent stages.

3.51 PROCESS

A function or activity that can be described as an input/output relationship or as the combination of simpler processes. A process is a basic building block of a DFD.

3.52 PROCESSING

HAN application characteristics that consume, process, and act on external and internal data. These accept data from external systems and HAN measurement and 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: Uses 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 CO₂ emissions related to consumer-specific load).

3.53 PROCESS ACTIVATION TABLE (PAT)

A type of C-spec that defines the exact conditions required for the indicated P-specs to be active. This construct is used as a part of the functional decomposition process.

3.54 PROCESS SPECIFICATION (P-SPEC)

The description of an elementary process. The description may include text, figures, and tables. The description captures the input/output relationship for all flows shown on its related DFD. A P-spec is shown as a circle on a DFD, and has no further “child” processes below it. This construct is used as a part of the functional decomposition process.

3.55 PROVIDER COMMUNICATION

Provider communication is when the vehicle requires information on EVSE locations and other information for charging stations that are available and within the driving range of the vehicle. BEV's that include high power charging (HPC) need a capability to reserve these HPC stations while traveling to it, not waiting until they connect. Estimated time of arrival, establish charging priority, identify power, energy and departure time (TCIN) requirements, and payment are information that needs exchanged. There are various actors that may be included, such as a Clearinghouse, charge point operator, eMobility service provider, and are further described in SAE J2836/5.

3.56 RECHARGEABLE ENERGY STORAGE SYSTEM (RESS)

Means a system that stores energy for delivery of electric energy and which is rechargeable.

3.57 REVERSE POWER FLOW (RPF)

RPF means the direction of energy for discharging a vehicle.

3.58 ROAMING UTILITY

Electric service provider that is supplying energy to PEV when PEV is outside of the customer's utility service territory.

3.59 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.

3.60 PLUG-IN VEHICLE

Plug-in electric vehicle (PEV). Plugs into an energy portal at a premise to charge vehicle. A PEV is also an EV that relies only on electric propulsion. A PEV is also a PHEV (plug-in-hybrid vehicle) that also includes an alternative source of propulsion power.

3.61 POWER FLOW

See FPF (3.36) and RPF (3.59).

3.62 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 powerline.

Electrical power is transmitted over high-voltage transmission lines, distributed over medium voltage, and used inside buildings at lower voltages. Powerline 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).

All power line communications systems operate by impressing a modulated carrier signal on the wiring system. Different types of powerline communications use different frequency bands, depending on the signal transmission characteristics of the power wiring used. Since the power wiring system was originally intended for transmission of AC power, the power wire circuits have only a limited ability to carry higher frequencies. The propagation problem is a limiting factor for each type of power line communications.

Data rates over a power line communication system vary widely. Low-frequency (10 to 480 kHz) carriers impressed on high-voltage transmission lines may carry one or two analog voice circuits, or telemetry and control circuits with an equivalent data rates from a few kb/s to greater than 100 kb/s; however, these circuits may be many miles (kilometers) long and include passing through the transformer. Higher data rates generally imply shorter ranges; a Local Area Network operating at millions of bits per second may only cover one floor of an office building, but eliminates installation of dedicated network cabling.

3.63 REGULATION SERVICES

Regulation services are used to continuously fine-tune the balance between power generation and demand, in terms of the voltage and the frequency of the grid. In many power markets, this function, called regulation or automatic generation control (AGC), is priced separately from power generation and procured as an ancillary service (another such service is spinning reserves). The grid operator needs to be able to ensure generators ramp output up or down in real time to meet customer reactive power needs, manage customer impact on system voltage, frequency, and system losses, and ensure that power-factor problems at one customer site do not affect power quality elsewhere in the system. Again, providing regulation services requires electricity generation capacity in excess of demand.

3.64 SMARTCHARGING

The ability for the utility to "load shape" and therefore optimize vehicle charging or discharging with grid capacity.

3.65 STATE TRANSITION DIAGRAM (STD)

A type of C-spec that defines the exact conditions required to determine the value of a sequential logic function. A sequential logic function, as opposed to a combinational logic function, is one where its present value (output) is dependent on the present value of its arguments (inputs) and some number of the previous values of the arguments (previous inputs). See DT 3.17).

3.66 SPINNING RESERVES

Spinning reserves refers to generating capacity that is up and running, and synchronized with the electricity grid (but not contributing power). Spinning reserves generators contribute to grid stability, helping to arrest the decay of system frequency when there is a sudden breakdown or loss of another generator. Again, typically, power plants that can provide fast response to the calls of the grid operator are the most suitable, e.g., gas turbines. The capacity required to provide spinning reserves can also be seen as an underutilized investment, although essential for managing market risks.

3.67 TRUSTSOURCE

Communication with a trustsource is intended to be the same as communication with the primary actor. The utility may be the primary actor and a utility aggregator could be the utility trustsource.

3.68 TYPE-A ARCHITECTURE

A form of the ETS where AC electrical energy is transferred, across the off-board/on-board boundary, via a conductive coupling.

3.69 TYPE-B ARCHITECTURE

A form of the ETS where DC electrical energy is transferred, across the off-board/on-board boundary, via a conductive coupling.

3.70 UTILITY

Utility typically refers to a collection of systems, business functions, and organizations which make up the electric utility that include the customer information system (CIS), the AMI, rates and revenue services, etc.

3.71 UTILITY HAN DEVICES

Within the premise these are the devices which are typically provided by the utility. As an example, these include metering devices (e.g., gas meter) and load control devices. Some of these devices are located within the consumer premise while others sit on the outside of the premise. Regardless of placement, the utility device always uses the utility-provided “secure” network.

Some devices can be provided by either the utility or the consumer. This decision is between the consumer, utility, and regulators. Further, this document provides architecture flexibility. That is, the utilityAMI 2008 HAN SRS supports any desired configuration.

3.72 VEHICLE-TO-GRID (V2G)

When vehicle power is fed into the electric grid, we refer to it as “vehicle-to-grid” power, or V2G. This could be home and remote locations and initiated for contract driven ancillary services (regulation, peak shaving, reserves, etc.)

3.73 VEHICLE-TO-LOAD (V2L)

Vehicle-to-load means the transfer of energy from the vehicle to a load. This is expected to support power to tools and other items not connected to a home or the grid.

3.74 VEHICLE-TO-HOME (V2H)

Vehicle-to-home means the transfer of energy from the vehicle to a home. This could be used for emergency power backup and/or home-based ancillary services (regulation, peak shaving, reserves, etc.). See RPF (3.59).

3.75 VEHICLE-TO-VEHICLE (V2V)

Vehicle-to-vehicle means the transfer of energy from one vehicle to another. This could be related to jump starting or other energy transfer needs between vehicles.

4. TECHNICAL REQUIREMENTS

The intent of this document is for plug-in vehicles to communicate with the utility so that the customer can take advantage of various incentive programs and charge their PEVs at times and rates to meet their needs.

There are several mediums and paths for communication that can be used and this document will identify both wireless and wired variations. Wireless can either be Wide Area Network (WAN) described as telematics shown as item 1 in Figure 1 or a Local Area Network (LAN) that may be WiFi or Cellular as shown as item 2 in Figure 1. Vehicles can also use the wired option using PLC as the medium and using the communication path from the PEV to the EVSE as shown as item 3 in Figure 1. PLC requires a communication module in the vehicle (Electric Vehicle Communication Controller - EVCC) and in the EVSE (Supply Equipment Communication Controller - SECC). Several mediums and paths may be used from the EVSE to the utility due to the variations of utility offerings and variations the customer may have within the home. Several location scenarios will also vary, as workplace, fleets, public charging, street charging, etc., are expected to vary dependant on utility territories and the EVSE installed. This document identifies the general info and process to accomplish this communication and SAE J2847-1 identifies the details of the messages used. Use cases were generated to identify the requirements and are included in Appendices A and B. Appendix A includes **top level Use Cases** and Appendix B includes **detail Use Cases**.

The primary actors for communication are the customer, PEV, utility, and EVSE. There are several variations to EVSE and the customer can choose several options to charge their vehicle with or without communications from each of these paths. The fundamental charging system is identified in SAE J1772 and it describes the EVSE and its functions. The EVSE is described in more detail in Section 3, where the control pilot controls the initialization of the vehicle and the rate of energy transmitted.

4.1 Direct Communication

Direct communication is shown in Figure 1 where the vehicle obtains messages directly from the utility (or utility trustsource) and the optional paths that could be used. The main purpose is to obtain price, demand response load control (DRLC) messages from the utility (or aggregator) when connecting the vehicle to the grid. The customer provides time charge is needed (TCIN) for the time they expect to use their vehicle again and the interface to the HAN is an optional interface, whereas either the HAN or vehicle could manage the charging time and power levels comparing the vehicle requirements to offboard loads and sources. The ESI is the trustsource for the utility or this could be part of the HAN or seperate.

- Path 1 is WAN connection to the vehicle using the OEM server and telematics.
- Path 2 is HAN connection using WiFi.
- Path 3 is PLC connection using the EVSE.
- Alt 1 is an optional path from the utility server to HAN.
- Alt 2 is another optional path from HAN to OEM server.

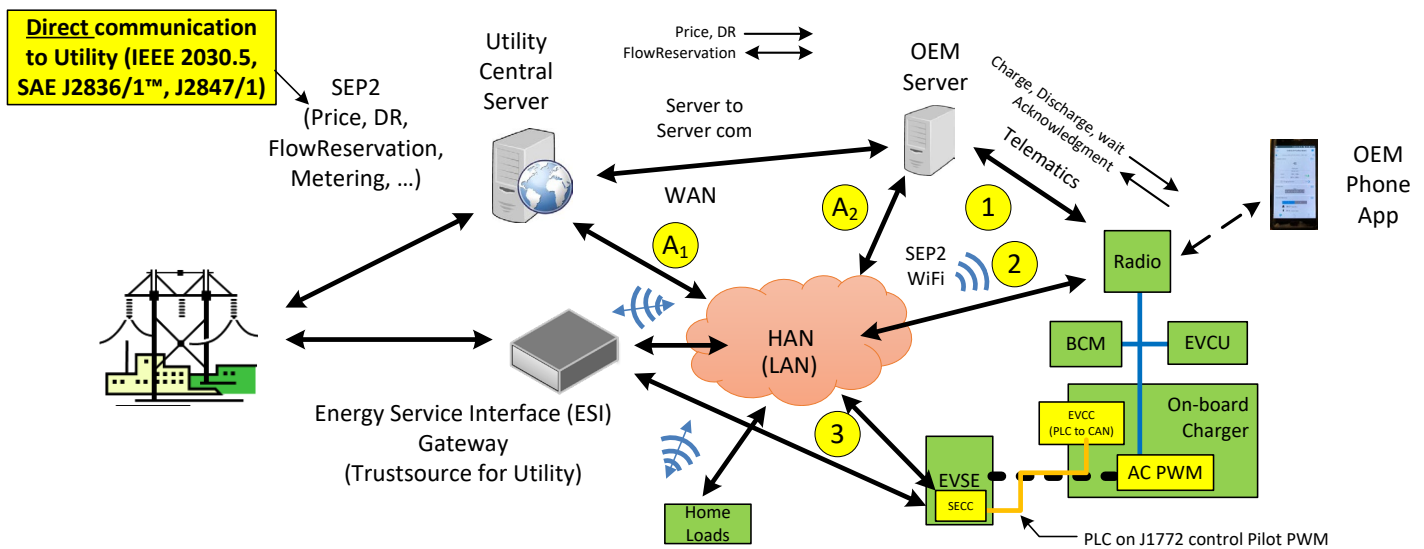


Figure 1 - Direct communication primary actors and optional paths

4.2 Indirect Communication

Indirect communication is shown in Figure 2, whereas the vehicle obtains messages from a third party instead of directly from the utility. This also requires more information from the vehicle to compare with utility issues for the third party to manage the system.

- Central Server obtains price, DR/LC, and grid issue information (frequency, temperature, voltage fluctuations) from the utility.
- Central Server obtains time charge is needed (TCIN) from customer/vehicle and GPS location, current SoC, energy desired, from vehicle when connecting and during the charging session.
- Central Server sends the vehicle info on any lower price periods available within TCIN and targets candidate vehicles for load reduction and/or delays if grid issues are present.
- Vehicle processes the Central Server messages to accept or override.
- If the charging variation is accepted the vehicle sends acknowledgement back to Central Server.
- Vehicle and utility (Central Server) periodically exchange updates to adjust time and power levels as needed for the energy session.

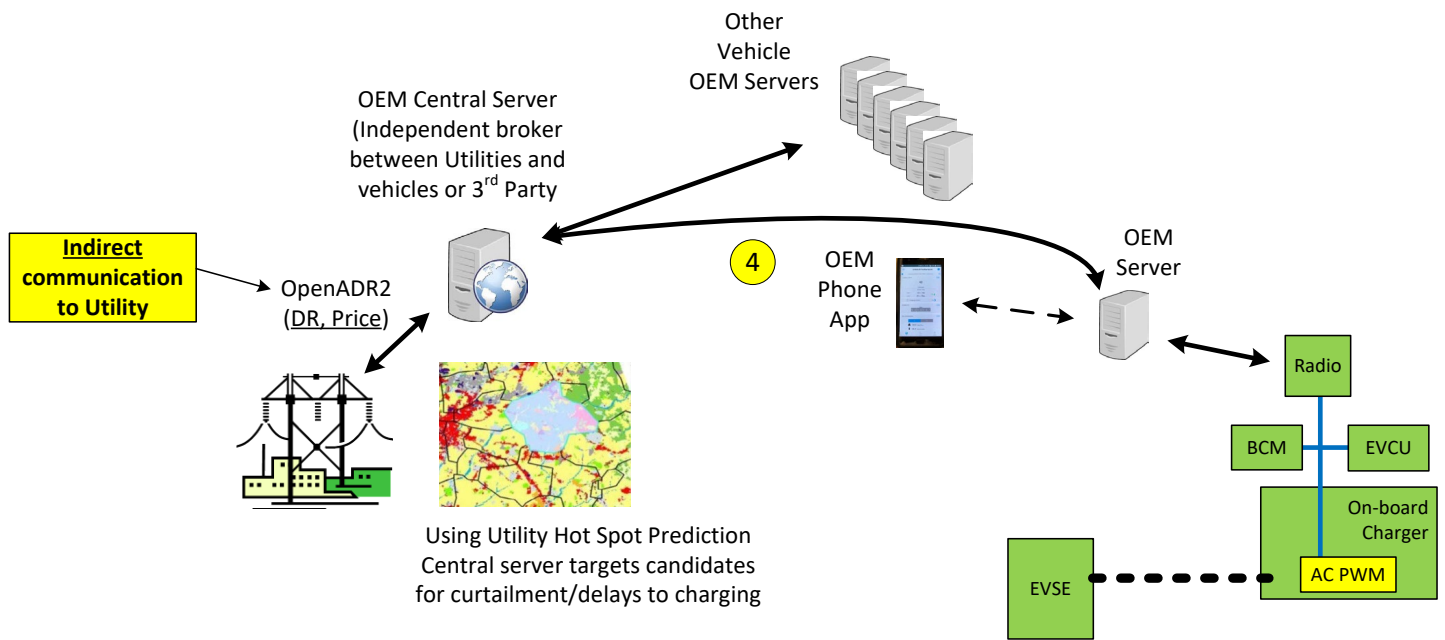


Figure 2 - Indirect communication primary actors

Figure 3 shows a more detail representation of modularizing the EVSE and options on obtaining access to both the utility and consumer networks, if used for either direct or indirect communication.

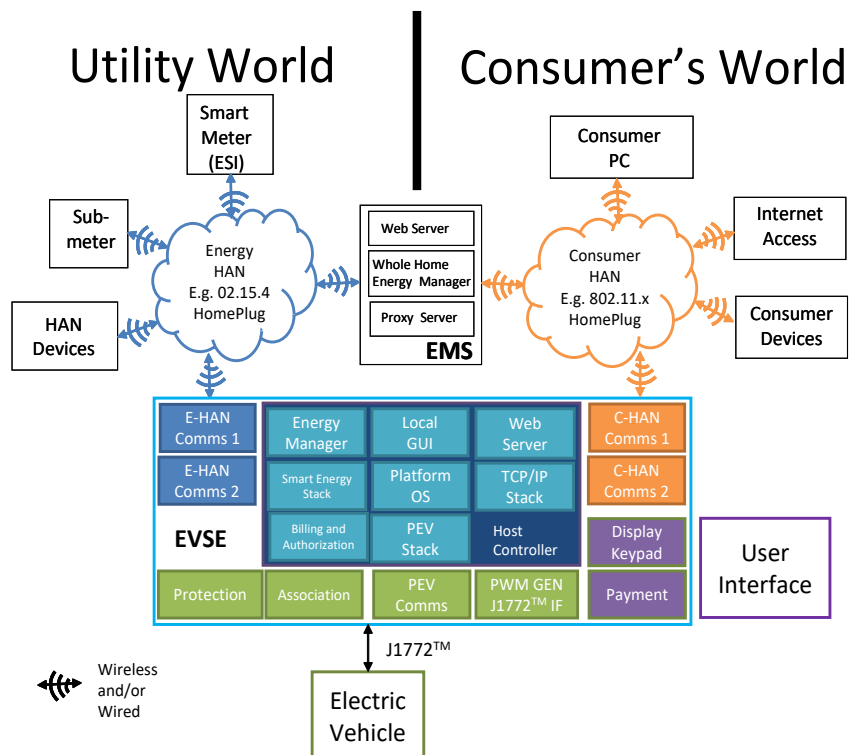


Figure 3 - EVSE modularization to utility and consumer networks

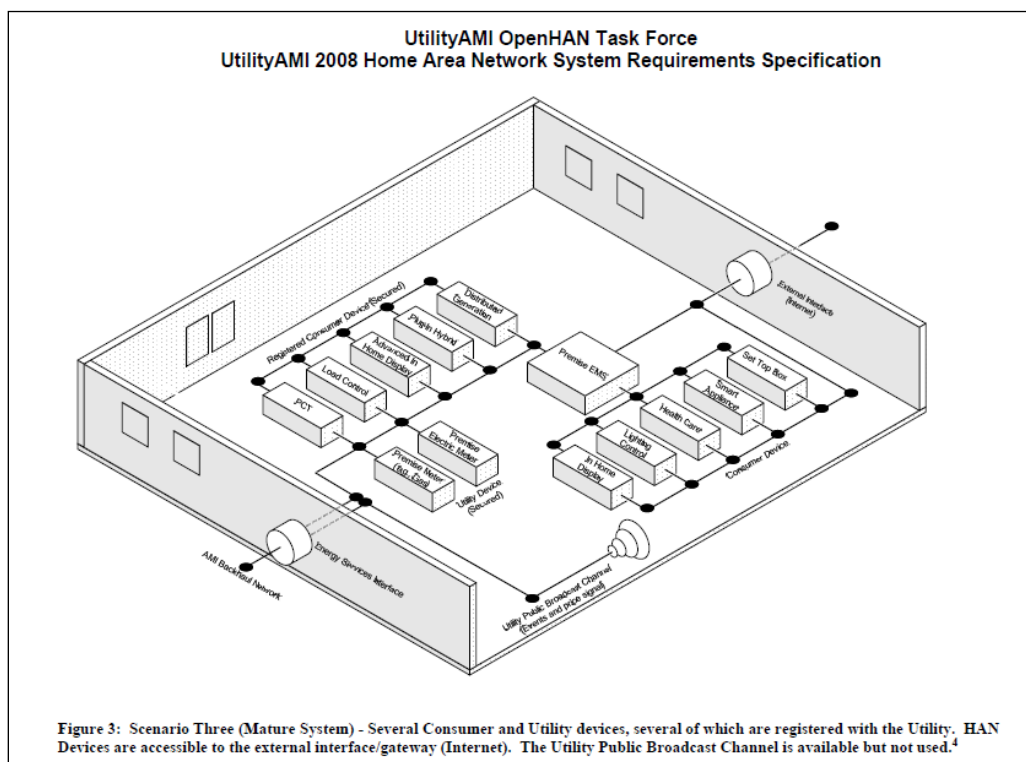


Figure 5 - The EVSE interacts with the utility

Figure 6 shows a basic HAN that would control vehicle charging and includes basic options in a home, such as the thermostat, and could also include stationary storage and solar.

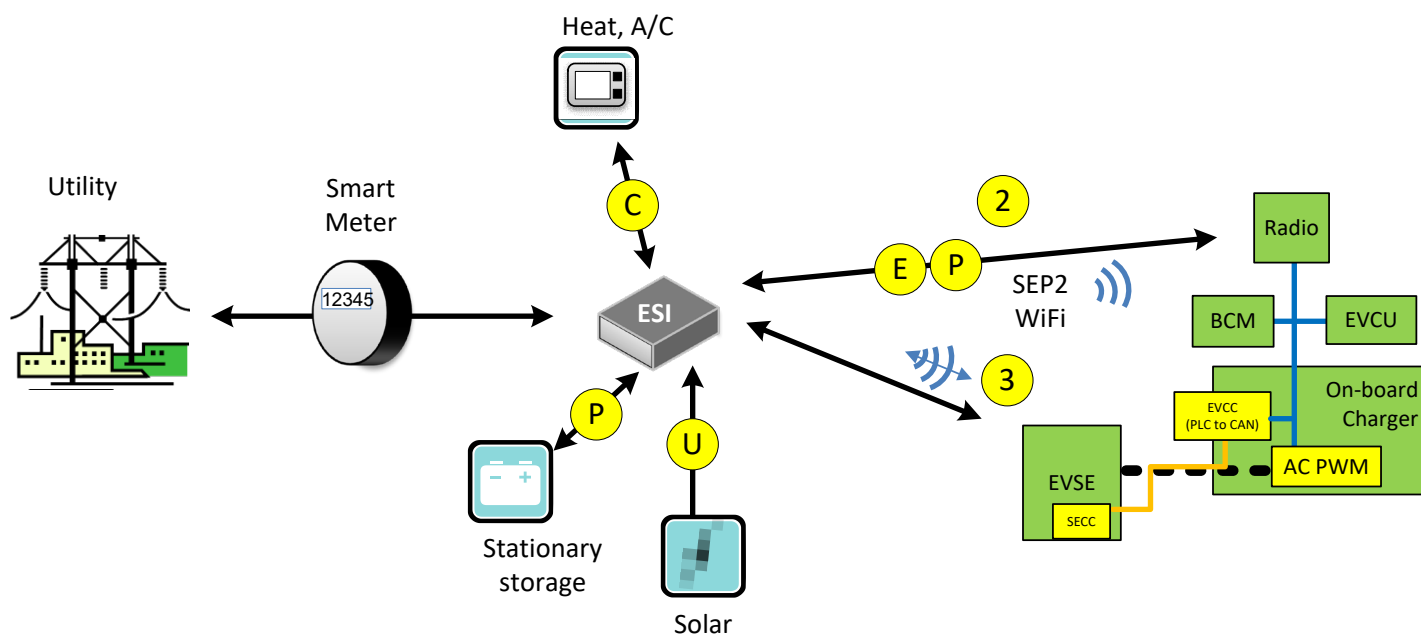


Figure 6 - The basic HAN/EMS for vehicle charging

The codes in Figure 6 includes the following categories:

- C = Controlled (not exclusive).
- E = Exclusivity (mutually controlled); e.g., no need to power the EVSE with AC.
- U = Uncontrolled source.
- P = Planned (controlled); wait to charge vehicle or stationary storage for negative price, solar to engage, etc.

Figure 7 (Case 1) expands these scenarios to more detail of a HAN that may have communication and control to other loads and sources.

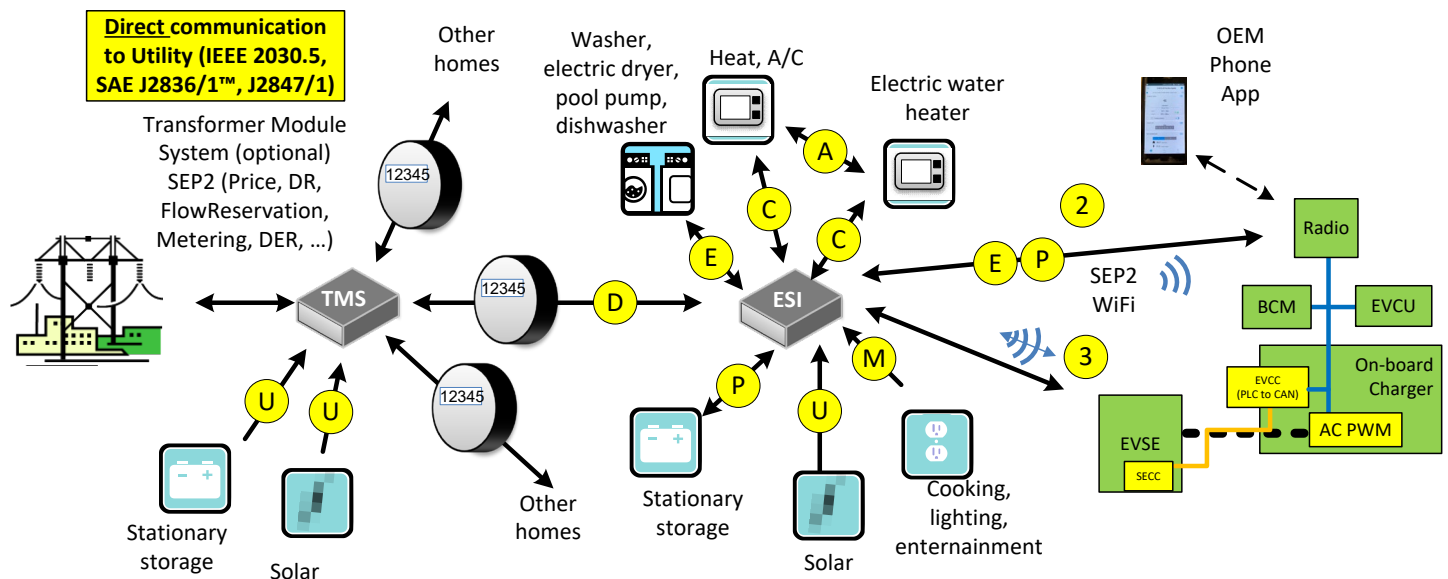


Figure 7 - Case 1 - The HAN/EMS is the interface to the utility

The full system shows an energy management system (ESI/EMS/HAN) as an extension to Figure 1, where the EVSE may also interact with the EMS. The ESI is the gateway to the utility and also consumer appliances (if applicable) and any other networks (URC, Wi-Fi, cell, etc.). The utility HAN is equipped with smart meters with Smart Energy 1.0 that may be capable of progressing to SEP2.0 with a firmware upgrade. Up to 80% of these may use ZigBee wireless. With this system, we expect the ESI to be the gateway.

The codes in Figure 7 are expanded to include the monitoring, adjusting, and DER:

- M = Monitored only (not controlled); e.g., lighting, cooking, entertainment.
- C = Controlled (not exclusive).
- E = Exclusivity (mutually controlled); e.g., no need to power the pool pump with the dishwasher, EVSE with AC.
- U = Uncontrolled source.
- P = Planned (controlled); wait to charge vehicle or stationary storage for negative price, solar to engage, etc.
- A = Adjusting (dual or adjusting priority); e.g., if showering, may not want power reduced to hot water heater, due to the direct temperature variation; otherwise, don't care.
- D = DER commands (external to home).

This particular depiction of the EMS shows a HAN that is being identified by the Association of Home Appliance Manufacturers (AHAM). This group is producing the home appliances and establishing the communication to them. The approach is to use the same PLC to the EVSE as SAE is recommending, with Smart Device Open Control Protocol (SDOCP) as an option to the consumer devices as defined by AHAM.

Note that the utility HAN encompasses the ESI and EMS.

The public EVSE version of this would view the EMS as the master interface to the utility. Associated or slave EVSEs would be viewed as “other appliances” and send their info to the master EVSE for the primary control.

Figure 8 (Case 2) identifies communication from the utility to the EVSE to control charging time and power level.

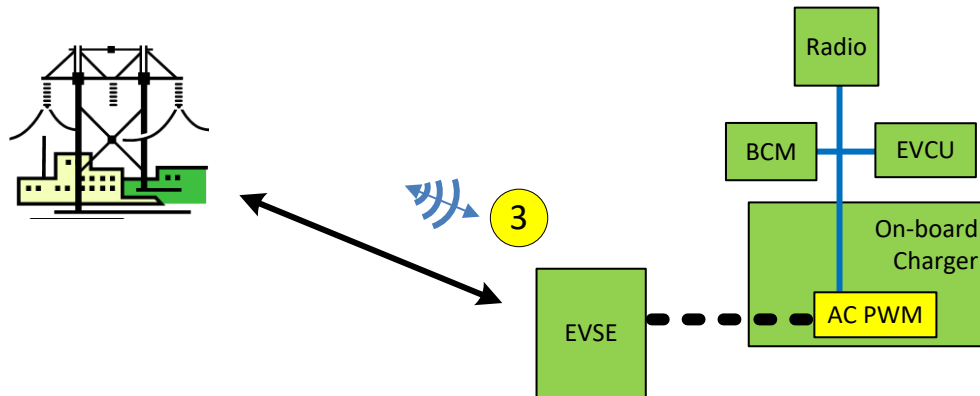


**Figure 8 - Case 2 - The EVSE is the interface to the utility
(EVSE has charging control of the vehicle)**

Figure 8 is the most basic system with communication between the PEV and the grid. The EV charging time and power is controlled using the EVSE Control Pilot. Delays to start charging is when the EVSE stays in State B1 as described in SAE J1772. When the EVSE/utility desires the charge to start the EVSE changes the pilot to State B2 and if the vehicle has “gone to sleep,” after initial connection, it can wake up on this change and start charging. The power level can also be adjusted downward as desired by reducing the PWM to a value that can approach 6A and max of the initial PWM rate. This approach does not require any communication between the utility or EVSE to the vehicle.

An alternative (or Case 2a) to this is if the EVSE has manual control (no interface with the utility) and the customer can press a stop and start button, if included, to manually determine when the delayed charging session would start. This however offers no control of the PWM for power reduction. This is referred to as scheduled charging, not smart charging. Scheduled charging is further defined in Case 3 as shown in Figure 8 as it applies to the EV control of a charging delay or power reduction (instead of through the EVSE).

Figure 9 (Case 3) has no communication to the utility, whereas the customer can still control the charge cycle by using the EVSE (display panel, etc., per Case 2a) or the PEV (Case 3 - onboard controls, phone app, etc.).

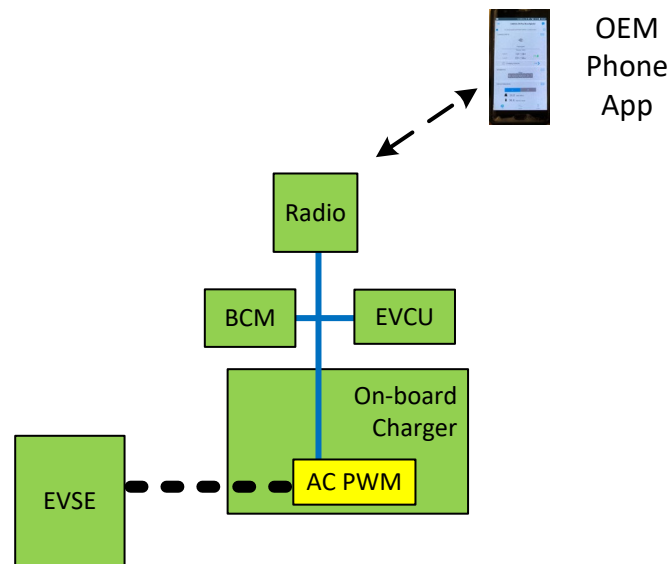


Figure 9 - Case 3 - No EVSE communication to the utility (EV scheduled charging)

This shows no utility network control. This would be based on the customer knowing the delay in start time is desired due to a lower price schedule from their utility. The power level would be lowered if they knew full power would cause issues with other loads operating at the same time.

PEV Scheduled Charge Override

If the vehicle has a scheduled charge feature and connects to a EVSE that does not have scheduled charge (e.g., the PEV scheduled charge is 2 AM (expected to be at home) but is connected to a workplace EVSE at 8 AM, the next morning), the workplace EVSE will stay in State B2 when connected, the vehicle initially wakes up when connected, but goes to sleep until the vehicle scheduled charge time is obtained, then the vehicle would wake up and move to State C to charge.

In order to override the vehicle scheduled charge and charge now, one approach is to “double-plug” or connect the EVSE connector, remove it quickly, then reconnect. This could be included in the vehicle programming to override the PEV scheduled charge and “charge now.”

Another approach is to include a switch in the vehicle or on a phone app, that commands the vehicle to “charge now.”

4.4 Bridge versus Gateway Function of the EVSE Control Module

If the EVSE is the communication path to the vehicle, direct communication using SEP2.0 is a bridge function as shown in Figure 10. The communication protocol is not changed whereas the medium is changed at the lower levels of the communication stack (e.g., WiFi to PLC). The messages are still encrypted, and are not read or otherwise altered.

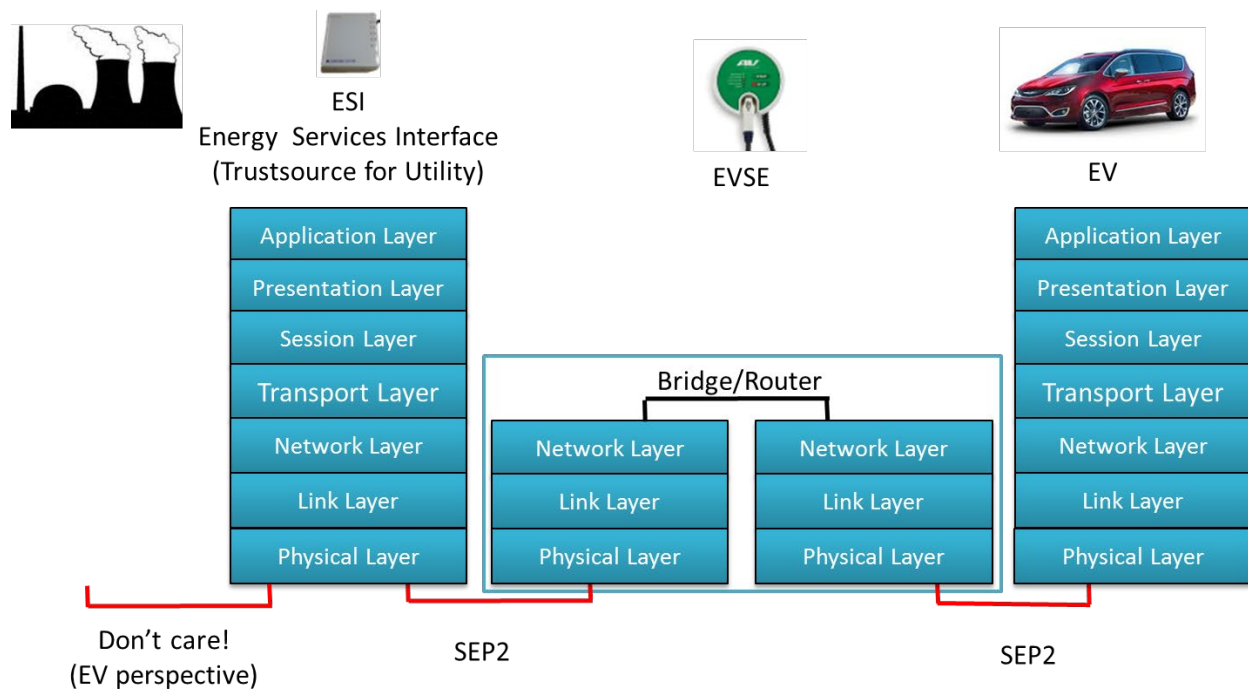


Figure 10 - EVSE has a communication bridge between the vehicle and ESI

Indirect communication is where the protocol is changed and is a gateway function as shown in Figure 11. The communication protocol is changed and the messages are decrypted, read, and sent out using the secondary protocol.

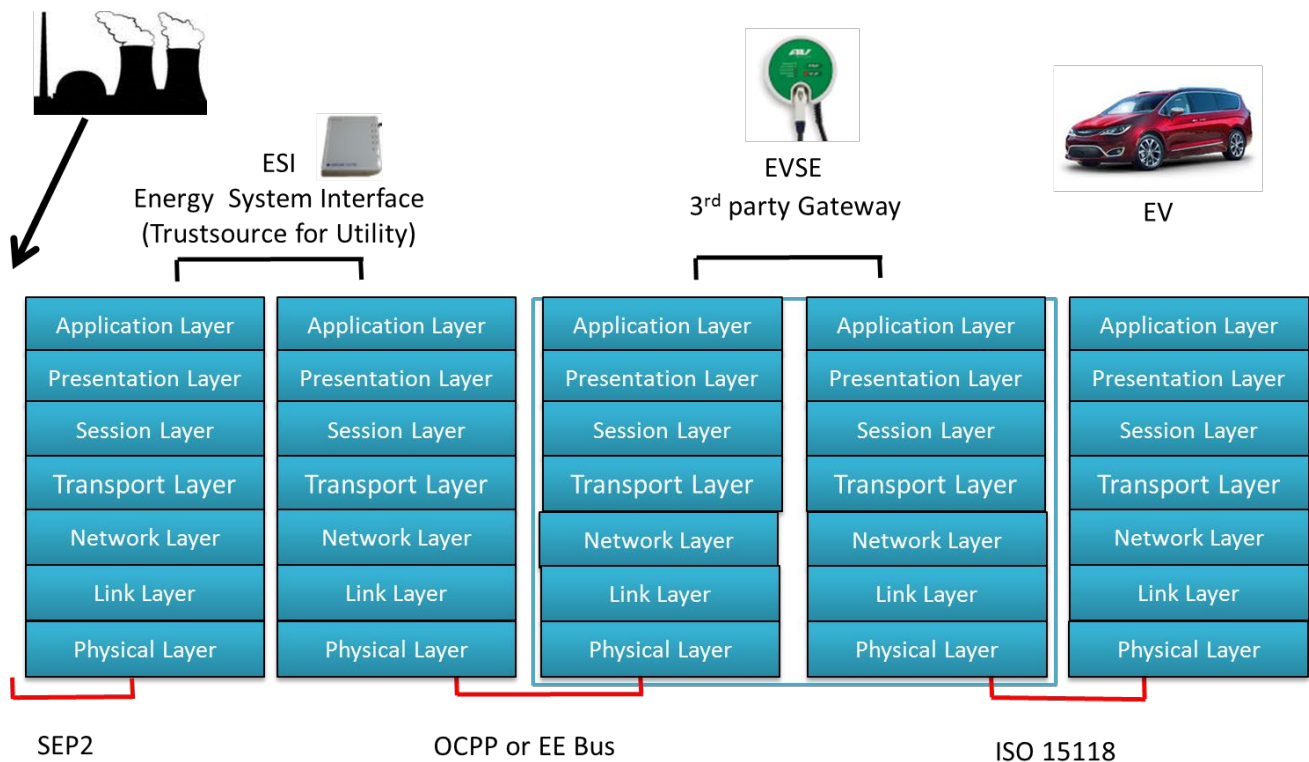


Figure 11 - EVSE has a communication gateway between the vehicle and ESI

4.5 Use Cases

Use Cases have been developed to identify the requirements for the communication system. The messages resulting from these Use Cases are included in SAE J2847-1 and reflect the function sets in IEEE 2030.5.

4.5.1 Top-Level Use Cases

The top-level Use Cases included in Appendix A are as follows:

- PEV0: Customer attributes (Version 3.3).
- PEV1: Utility provides services to PEV customer (Version 3.1).
- PEV2: Customer connects PEV to premise energy portal (Version 5.1).
- PEV3: Customer enrolls in a PEV3 demand side management program (Version 5.1).

These Use Cases describe the general requirements and various scenarios for the PEV to interact with the utility.

4.5.2 Detail Use Cases

The detail Use Cases included in Appendix B are as follows:

The intent of these were to separate the various utility programs (U1-5) and the connection approaches identified in SAE J1772 (S1-3). The general enrollment that applies to all the utility programs is included in E and the different locations are included in L1-4. PR1 includes the charging process and PR2-4 are under development and apply to reverse energy flow (PR2), diagnostics (PR3), and VM-specific (PR4).

U1-5 may be offered by utilities and may include slight variations for a particular territory. These include the general requirements that may apply to all utilities. One or all of these could apply to each charging cycle/location.

S1-3 is exclusive for each connection cycle and describes the three EVSEs identified in SAE J1772.

Locations identified in L1-4 are also exclusive for that connection point.

Any specific Use Case would include E, then U1-5 as applicable, then either S1, S2, or S3, then L1, L2, L3, or L4. PR1 would complete this set if charging is desired. PR1 is the fundamental function to charge the vehicle (forward energy flow). PR2 is an advanced function for reverse energy flow and is under development. PR3 diagnostics could occur either during forward or reverse energy flow. PR4 VM-specific functions could also occur with forward or reverse energy flow. PR3 and PR4 are also under development and not available at this time.

The detail Use Cases included in Appendix B are as follows:

- E: General Registration and Enrollment Process.
- U1: TOU Program.
- U2: Discrete Event Program.
- U3: Real-Time Pricing (RTP) Program.
- U4: Critical Peak Pricing (CPP) Program.
- U5: Optimized Energy Transfer Program.

- S1: Cordset.
- S2: Premise EVSE.
- S3: Premise EVSE (that includes the charger).
- L1: Customer Connects PEV at Home - Premise.
- L2: Customer Connects PEV at Another Home.
- L3: Customer Connects PEV Outside Home Territory.
- L4: Customer Connects PEV at Public Location.
- PR1: Customer Charges the PEV.

Figure 12 shows the mapping of the detail Use Cases.

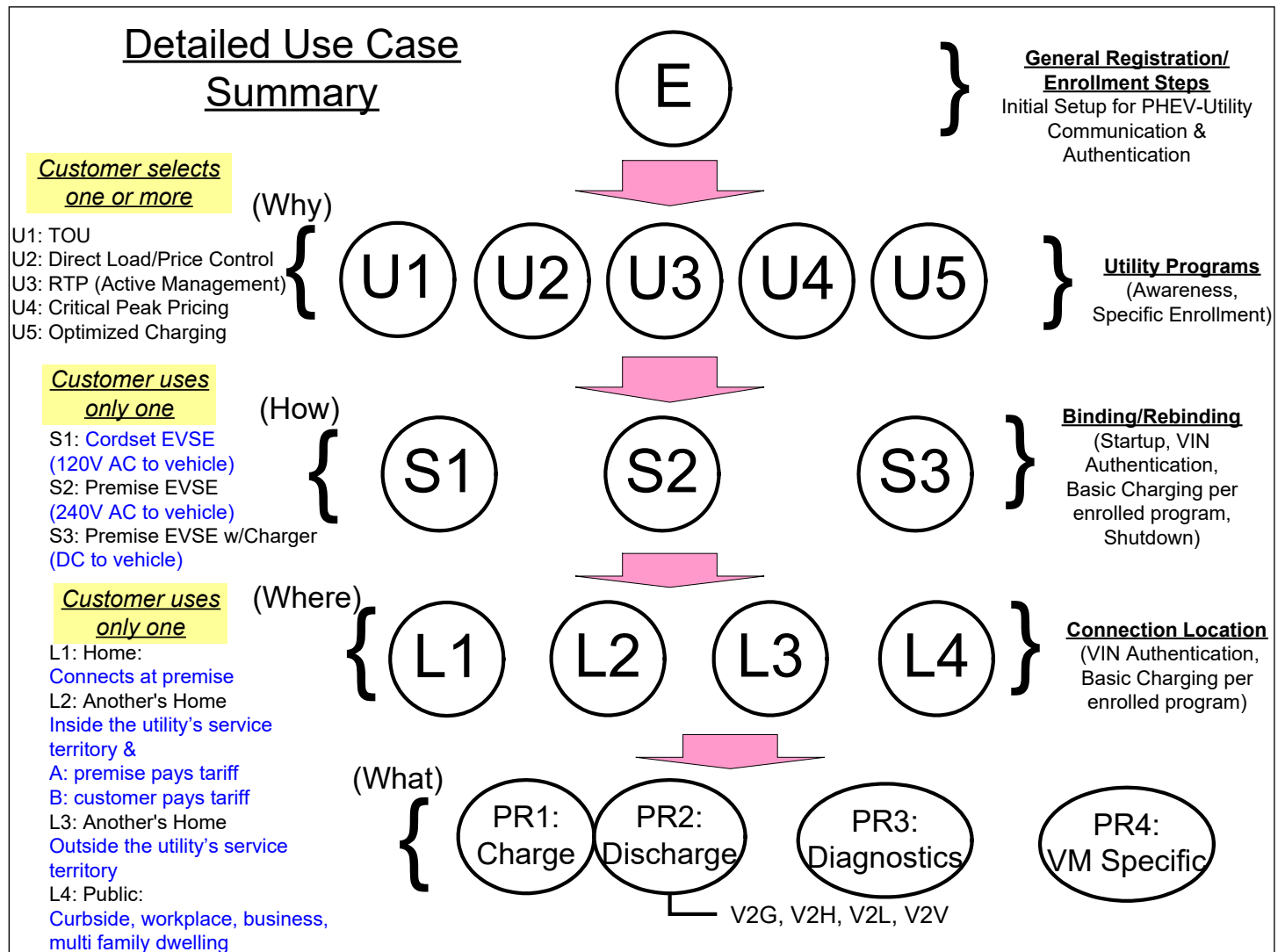


Figure 12 - Detail Use Case summary

4.6 Equipment and Devices

4.6.1 Automotive Modules

The utility programs can be implemented by the ESI/HAN interfacing with the EVSE. However, if the communication extends to the PEV, there are various issues related to hardware and software that need to be identified for these automotive module(s) that are defined in SAE J2847-1.

4.6.2 Electric Vehicle Supply Equipment (EVSE)

The EVSE diagrams are shown in Use Cases S1 through S3 in Appendix B.

The vehicle always connects to the grid using an EVSE as described in SAE J1772. This document identifies the utility criteria using both a cordset EVSE (Level 1) and a premise-mounted version EVSE (Level 2). The cordset is a mobile device and is expected to stay with the vehicle and used in both home, work, and public locations. The third version of EVSE is one that includes an off-board charger and delivers DC energy to the vehicle. This EVSE would also be capable of Level 2 and may also include an outlet for Level 1. The additional messages for DC energy transfer are described in SAE J2836-2 and SAE J2847-2. DC energy transfer requires additional messages and hardware for both the PEV and EVSE. The SAE J1772 control pilot is also at 5% PWM, instead of the 10 to 96% values identified in SAE J1772 for Levels 1 and 2 associated with the ALC values for AC energy transfer. If this EVSE and PEV are unable to transmit the required messages for DC energy transfer, the EVSE then reverts back to the AC levels described for Levels 1 or 2.

Vehicles that include an on-board charger could use the cordset but also connect to the grid using the Level 2 premise-mounted EVSE. Vehicles with larger on-board chargers may primarily connect using the premise-mounted EVSE, but also use the cordset to obtain lower power levels from the energy portals.

SAE J1772 goes into the details of the EVSE and its pilot circuit, but it is important to understand the basic functions, as this pilot is used to wake up the vehicle, then start its PWM generator to establish the initial signals from the vehicle and the EVSE. The following sequence describes the steps in this process.

1. When the EVSE has power from the grid, it sends a 12 V signal on the pilot circuit.
2. When the EVSE is then connected to the vehicle, this 12 V signal is reduced to 9 V through a vehicle resistor.
3. The pilot signal wakes up the vehicle for it to latch on vehicle power.
4. This reduction to 9 V tells the EVSE a vehicle is connected. It is also used by the EVSE that is also detecting the output of this circuit to start its PWM generator.
5. The PWM generator magnitude is then transitioning from +9 V to -12 V magnitude, and the rate matches the chart for ALC identified in SAE J1772.
6. The vehicle reads this PWM signal and if the on-board charger can draw more current, it will scale back to this ALC to overload the circuit on the premise. (i.e., a 15-A EP provides 12 A and the PWM is 20%, 240-V power levels are higher PWM rates).
7. If additional communication is expected between the vehicle and the grid, the PWM changes from the ALC value, to a 5% PWM rate. This is an expected state for a premise-mounted EVSE, but not for a cordset version. The cordset would either provide a 20% PWM for a 15-A outlet, or a 26.6% PWM for a 20-A 120-V outlet.
8. When the vehicle is ready to accept energy, another resistor is switched into the pilot circuit that drops the +9 V to either 6 V or 3 V. 6 V means the EVSE does not have to turn on ventilation at the premise, and 3 V means it does. This voltage drop signals the EVSE to close its switches and allow power to flow to the vehicle.
9. When the vehicle charge is complete, it opens the "vehicle ready switch" and the EVSE opens its power switches. The vehicle powers down and the EVSE returns to the state in item 1.

The basic control of the charge cycle can be accomplished by controlling the EVSE control pilot. The utility can install a demand response device that provides input to the EVSE control pilot and the customer can still take advantage of the utility program without the PEV communication. The more advanced cases, however, are where the PEV communicates.

4.7 Optimized Charging

4.7.1 Bulk Charging

Scheduled and basic Smart charging intends to merely shift the charging time to a period within the connected session to a time where the price is known to be lower or the magnitude of the charging power is not as disruptive to the stability of the grid.

Figure 13 shows an initial conditions of average home loads along with potential price variations and demand response messages that are provided from the utility for this charging session. The connected time spans from initial connection to TCIN.

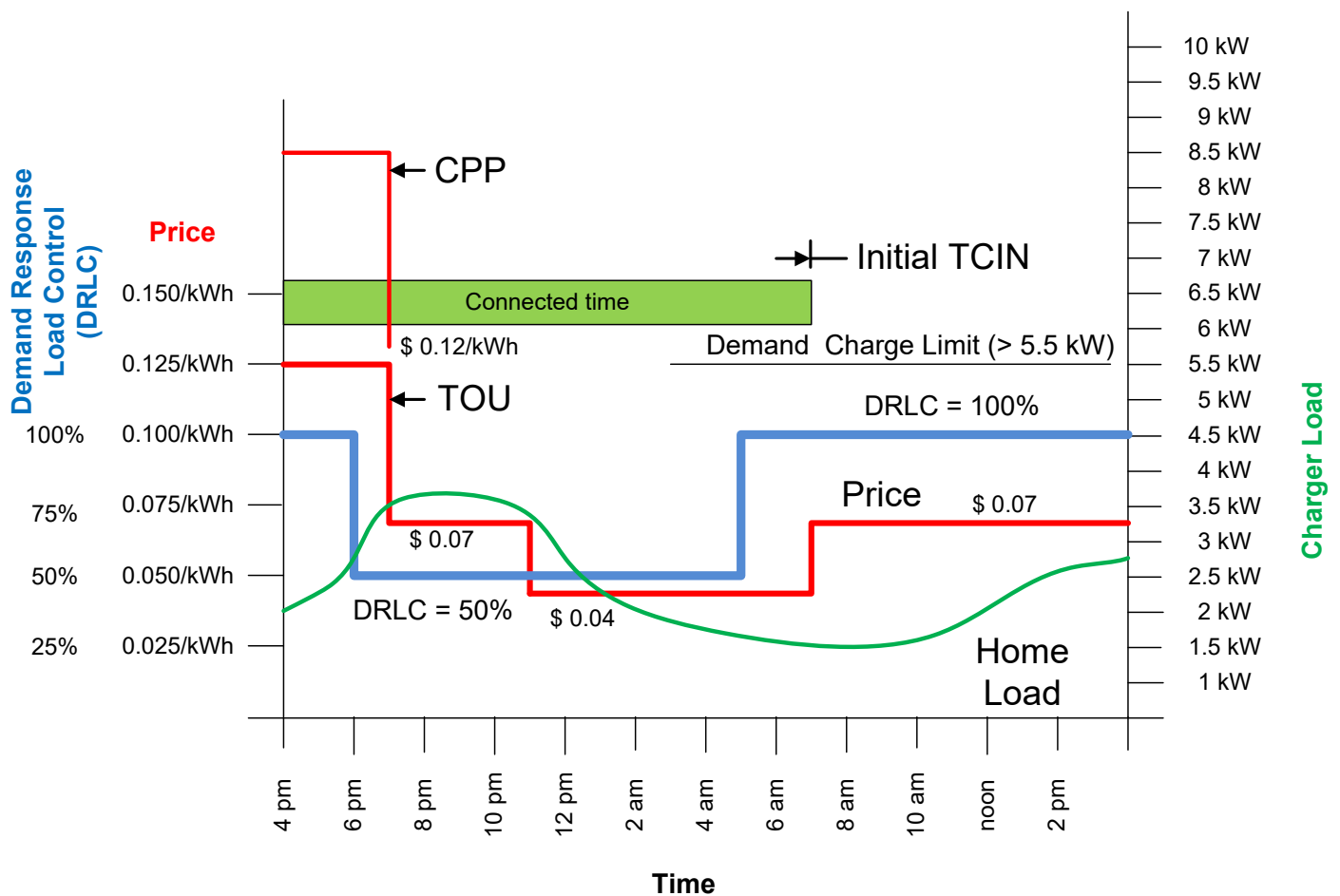


Figure 13 - Status when vehicle connects to the home

Figure 14 shows some of the choices for the customer to charge their vehicle if charging starts immediately (fastest or at the highest price) or delays until the lower price is available (cheapest) or optimized where both price and DRLC are included. The TCIN transmitted back to the utility is adjusted to the end of charging (no longer the time the vehicle needs to leave) along with power and energy required using the SEP2.0 FlowReservation function set in IEEE 2030.5

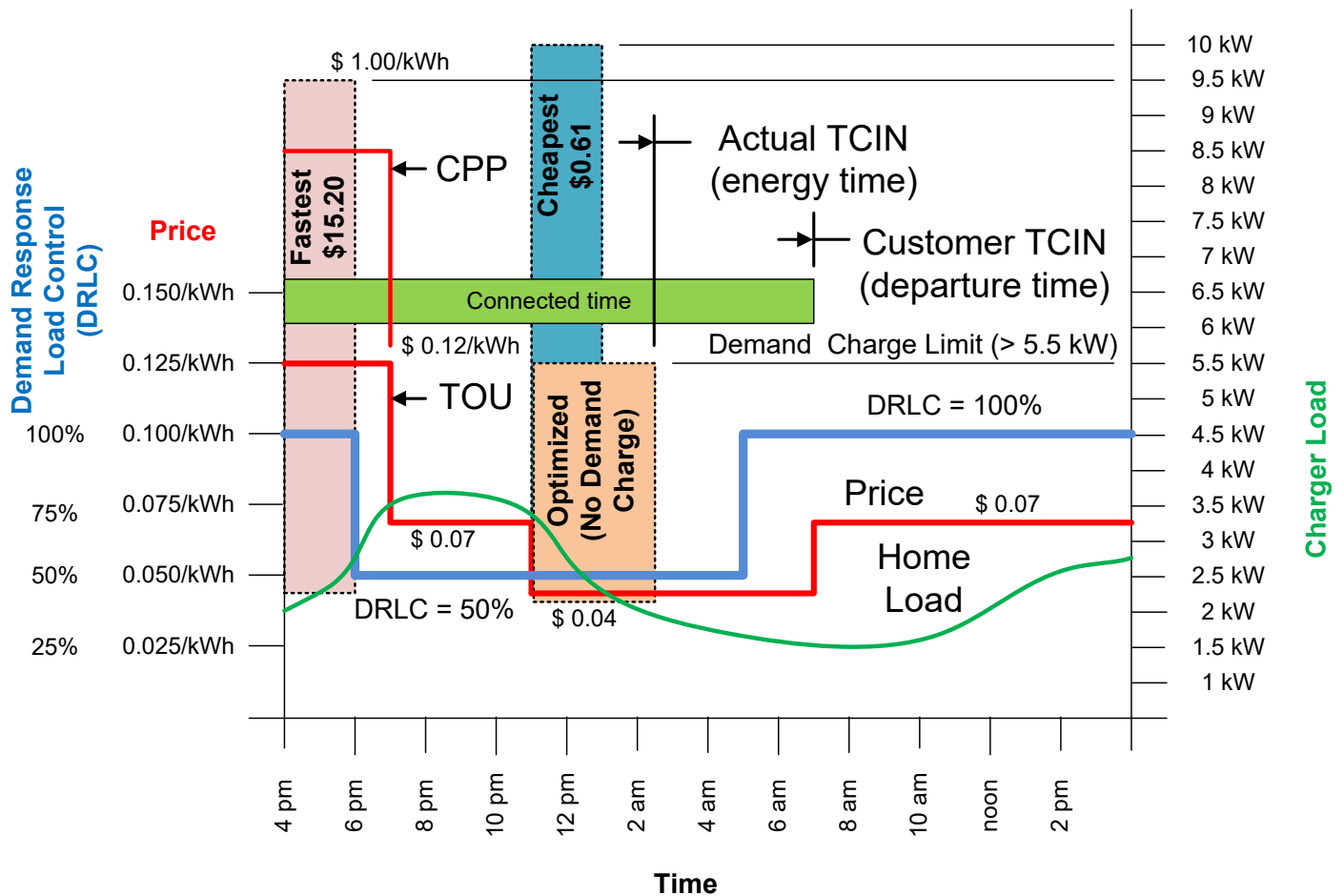


Figure 14 - Options for charging period

Up to this point, the charging has been “bulk charging” and the power level not continuously as shown in Figure 15. Optimized charging would use continued message updates to the HAN combining the SEP2.0 FlowReservation function set and include the distributed energy resources (DER) function set (or V2G), from the vehicle to flatten the home loads during peak load periods.

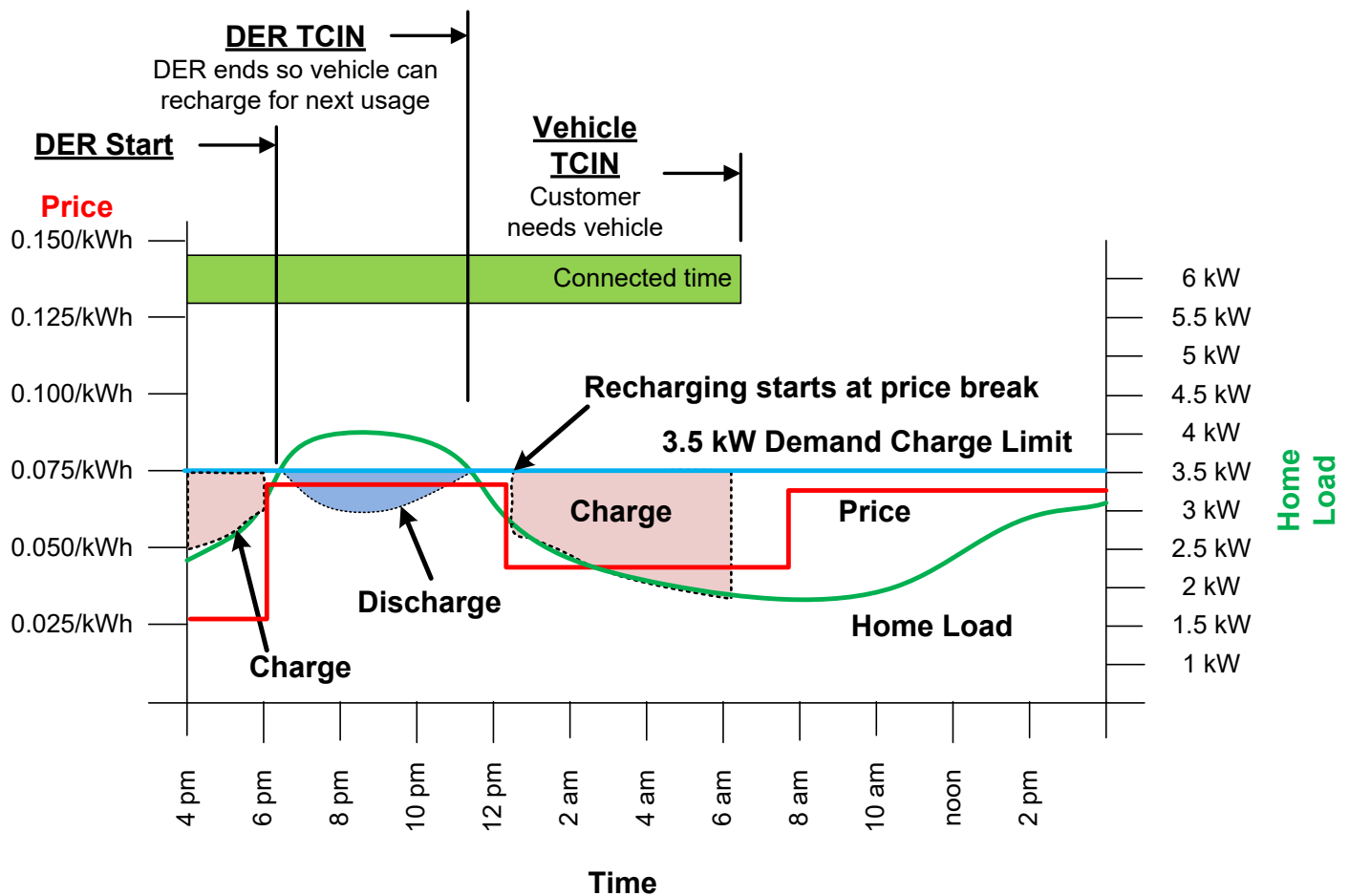


Figure 15 - Optimized charging that includes DER functions

Optimized charging (instead of bulk) is where the vehicle charge loads are matched with other load to maintain a flat or steady load to the grid. This is an approach to be able to plan the charge event to match the grid stability requirements rather than to cause issues that require reactionary mechanisms when a high population of PEVs are charging at a location. The grid has areas where a 25 kVA transformer feeds five to eight homes and three or four vehicles may be able to charge during peak periods; however, more than that will cause avoidable issues. When extended range vehicles are also included the home charging may not be every day and the time to charge them could increase to 10 to 12 hours (instead of 2 hours daily) as shown in Figure 16. Optimized charge management at these power and duration levels is required so the grid is not overloaded.

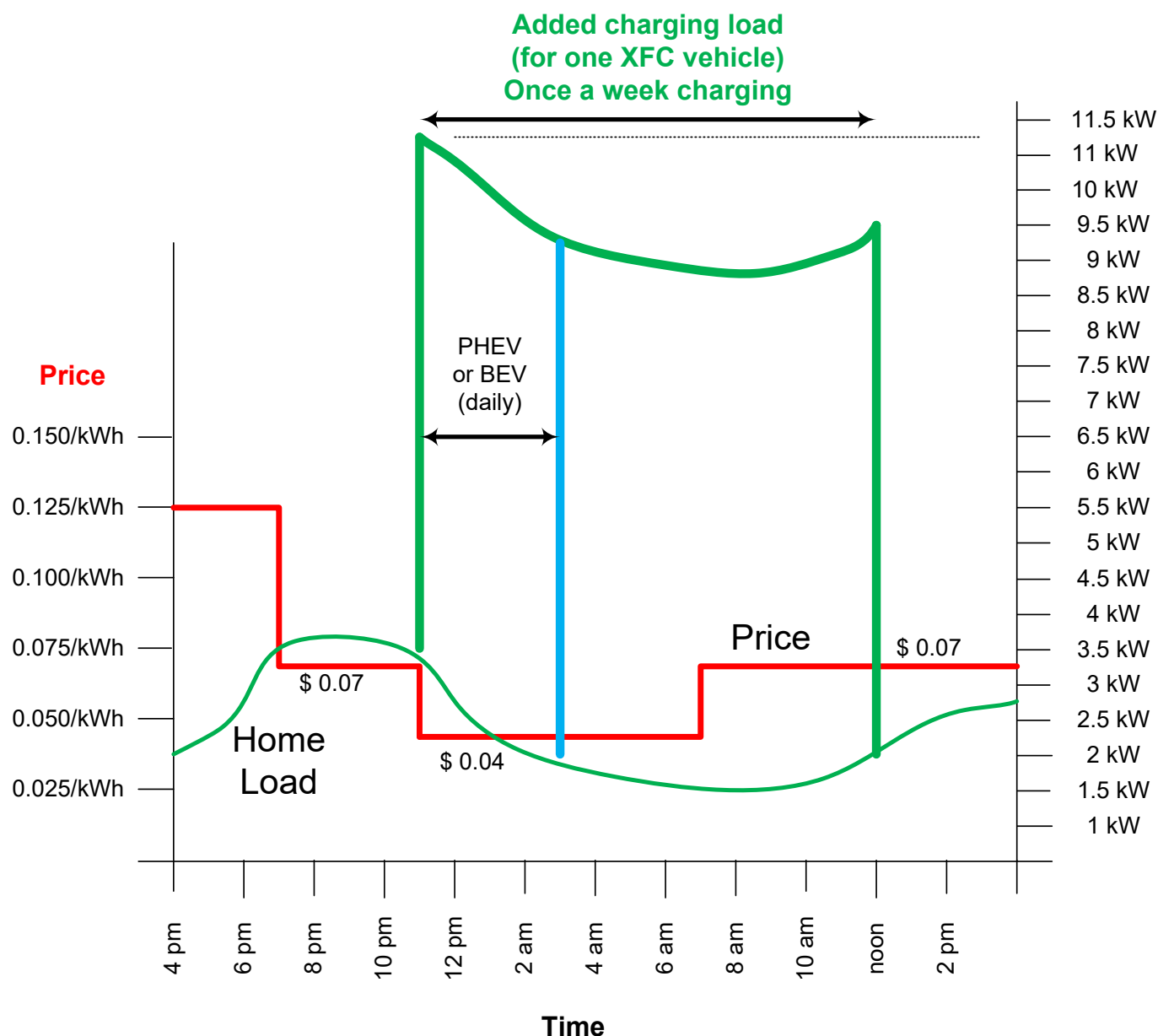


Figure 16 - Bulk charging - Daily versus once a week

5. NOTES

5.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE HYBRID TECHNICAL COMMITTEE

APPENDIX A - TOP-LEVEL USE CASES

A.1 PEV0 - CUSTOMER ATTRIBUTES

Document History

Revision History

Revision Number	Revision Date	Revision/ Reviewed By	Summary of Changes	Changes Marked
(#)	(yymmdd)	(Name)	(Describe change)	(Y/N)
1.0	1-30-09	Rich Scholer	Incorporated comments from Mike Bourton, Kostas Tolios, and Arindam Maitra.	Y
1.1		Rich Scholer	Added customer response steps.	Y
2.0	2-3-09	Rich Scholer	Incorporated comments from Nate Littrell.	Y
2.1	2-12-09	Rich Scholer	Incorporated comments from David Brown.	Y
3.0	3-2-09	Rich Scholer	Added functional requirements 1 through 5 (4.1).	Y
3.1	3-4-09	Rich Scholer	Updated 4.1 requirements to agree with ZBHP MWG definitions. Added requirements for mobile and fixed EUMDs.	Y
3.2	3-7-09	Rich Scholer	Added HAN device definitions to 2.2. Updated requirements for EUMD in 3.3 and added system diagram in 5.3.	Y
3.3	3-19-09	Rich Scholer	Updated per Gerald Gray's comments on ESCI and U4 definitions. Added step 5 to 3.1.1.	Y

Approvals

This document requires the following approvals.

Name	Title

1. USE CASE DESCRIPTION

1.1 Use Case Title

PEV - Customer Attributes

Customer enrolls in PHEV program, completes initial setup for PEV, and implements connection and charging cycles.

1.2 Use Case Summary

Customers, vehicle manufacturers (VM), and utilities are interested in fueling vehicles with electricity. EVs, PEVs, and PHEVs are emerging transportation options for consumers. Electric utilities desire to support these emerging loads with electricity at times when energy costs are lower and generation and power delivery assets are underutilized. PEV manufacturers are interested in working with utilities to develop customer rates/programs which could provide consumers with an increased incentive to purchase a PEV. To enable utility customer rates/programs specifically to customers with PEVs, the utility must offer special services for these customers. These services include the ability to enroll, register, and initially setup communications between a PEV and the utility, or an AES (one-time setup), the ability to repeatedly re-establish communications for each PEV charging session (repeat communications/re-binding), the ability to provide PEV charging (and other) status information to customer information channels (e.g., web, display devices), and the ability to correctly bill PEV customers according to their selected rates/programs.

1.3 Use Case Detailed Narrative

The utility or AES, may offer the customer a tariff that provides a low rate for off-peak charging and a higher rate for on-peak charging. The utility or AES must provide services to support energy supplied to customer PEV. These services include enrollment into a PEV program, PEV communications session binding, PEV energy billing, and PEV information services. The utility or AES will implement an enrollment system for customers with a PEV, including registration and commissioning. The utility's or AES's ESCI shall allow for the establishment of a communications session (communications binding), at a premise location each time a PEV plugs in for charging. Energy supplied to the PEV is reported to the utility or AES, for billing and presentation to the customer. The following scenarios describe the sequence of events for this customer to utility interface:

1. **E: Basic Enrollment:** General registration/enrollment steps and initial setup for PEV-utility authorization and authentication.
2. **U: Specific Enrollment:** Utility programs (awareness, etc.).
3. **S: PEV Connection and Energy Transfer:** Binding/rebinding (startup, PEV authentication, basic charging per enrolled program, communication, and shutdown).
4. **L: Location Variations:** Connection location (PEV authentication, basic charging per enrolled program).
5. **PR: Specific Functions:** Charging, discharging, diagnostics, and VM-specific applications.

1.4 Business Rules and Assumptions

- PEV customer has an account with utility and electrical service at a premise served by the utility.
- PEV and utility may have communications capabilities, enabled by utility-provided ESCI.
- The customer awareness of the utility and vehicle programs is prompted by both the utility providers and the vehicle manufacturers.
 - The utility offers PEV programs and services for its customers and will provide the necessary support processes for enrollment, communications, and billing.
 - The vehicle manufacturers would provide information to the customer about fuel and/or emission gains of the vehicles offered, and promote the utility and convenience of connecting to the grid.

- Utility shall maintain information on all customers and PEVs enrolled in the PEV programs, including demand side management programs, associated PEV IDs, customer IDs, and premise IDs.
- In the absence or failure of PEV-utility communications, or if PEV ID validation fails, PEV charging will always proceed; however, without the incentive rates and with all energy charges accruing to the premise customer according to the premise customer's default rate/service plan.
- The actual PEV charging processes, including scenarios for intra- and inter-utility roaming, are covered in Use Case P2.
- EUMD, either fixed or mobile, is always available for energy validation of PEV charging. If not available, charging will proceed, but with limitations on incentive rates and with all energy charges accruing to the premise customer. This may or may not prevent certain charging status indicators/metrics being available to customer for presentation/display purposes.
- EUMD function can be inclusively located anywhere in a zone from the PEV and the branch circuit panel connection.
- To allow for possibility of the EUMD being a part of/within the PEV, PEV is a sub-meter to the primary utility billing meter at any premise (as opposed to being a separate service account with dual meter socket adapter).
- The PEV and utility will communicate to implement one or more the previously described utility programs (details of which are covered in 3.3).

2. ACTORS AND DEFINITIONS

2.1 Actors

These are the actors or objects in these Use Cases. Sequence diagrams are included to visualize the steps these actors take in the energy transfer process.

Actor Name	Actor Type (Person, Device, System, etc.)	Actor Description
AES - See ESCO	Organization	AES.
Charger	Device	The charger can either be on-board the vehicle or off-board. On-board chargers require AC energy transfer to the vehicle (either 120 V or 240 V single phase) and off-board chargers are within the EVSE and require DC energy transfer to the vehicle.
Clearinghouse	Organization	Organization that provides global PEV account services. Maintains information necessary to facilitate account validation and billing transaction when customer is charging PEV at a location not served by the utility that the customer is enrolled with.
Control Device	Device	DLC programs (see 3.2, U2 program) enable utilities to remotely control and/or shut down participating customer equipment on a short notice. A control device is installed. The utility exercises its call option by first notifying the participant (to the control device which then sends the signal to the vehicle) that a event has been declared for the next day.
Customer	Person	Customer is the operator of a PEV and an electric customer of the home utility. Customer enrolls in an electric utility PEV program and has selected a PEV rate tariff. Customer is responsible for connecting PEV to an energy portal for charging.
Customer Account	System	Customer account is assigned to customer to collect charges for billing of energy usage.
Customer Energy Management System	System	Customer energy management system can provide communication interface to PEV for communication of PEV status information (e.g., charging state, state-of-charge, charging rate, time to complete charge) on customer-viewable displays.

Actor Name	Actor Type (Person, Device, System, etc.)	Actor Description
EVSE	Device	PEV connects to the grid using an EVSE. EVSE is the physical electrical cord and connectors that are specified by applicable SAE standards (e.g., SAE J1772, SAE J2836, and SAE J2847) that provide transfer of electrical energy from energy portal to PEV. This can be 120 V or 240 V AC, depending upon connection. The two types of connection include: (1) EVSE cordset, and (2) premise-mounted version. The premise EVSE would not include the charger for AC (Level 2) energy transfer described in SAE J1772. This would expect the charger to be included with the vehicle. If the EVSE included a charger, DC (Level 3) energy transfer is expected and the vehicle would not include the charger since it was within the EVSE. This EVSE that includes the charger may also be capable of AC energy transfer at both 120 V (Level 1) and 240 V (Level 2) levels as described in SAE J1772.
Energy Portal (EP)/Smart Energy Portal (SEP)	Device	Energy portal is any charging point for a PEV. At a minimum, the energy portal is a 120 V, 15 A outlet, but can also be a 240 V EVSE outlet connected to the premise circuit.
ESCI	System	ESCI is the communication device between the vehicle and the utility. ESCI shall exist at the customer premise and be capable of securely communicating between the utility and PHEV to facilitate exchange of demand side management information. PEV shall be capable of communicating to the utility through an ESCI. ESCI shall report all PEV charging session information and energy usage to utility. ESCI communicates with and exchanges information between utility, PEV, and EUMD. ESCI shall provide PEV charging session information to the utility, e.g., PEV ID, interval kW·h consumption, and passing energy information, such as price signals, schedules (including time zone and charge "period"), event messages, configuration, and security data from the utility to the PEV. This interface may or may not be facilitated by an AMI that includes a HAN. ESCI shall employ appropriate security policies when communicating demand side management program-related messages.
ESI	System	ESI provides security and, often, coordination functions that enable secure interactions between relevant HAN devices and the utility. Permits applications such as remote load control, monitoring and control of distributed generation, in-home display of customer usage, reading of non-energy meters, and integration with building management systems. Also provides auditing/logging functions that record transactions to and from HAN devices.
EUMD	Device	EUMD is a HAN device that measures energy consumed by a PEV and communicates the information to the ESI.
ESCO - See AES	Organization	Competitive (or alternative) supplier of commodity service.
Guest	Person	Guest is a friend or family member who has permission to use a customer premise for charging a PEV. May be liable for PEV charging costs depending upon customer preferences set up within PEV program.
PEV, EV, PHEV	System	PEV. Plugs into an energy portal (see actor definition) at a premise to charge vehicle. A PEV is also an EV that relies only on electric propulsion. A PEV is also a PHEV that also includes an alternative source of propulsion power.
Roaming Utility	Organization	Electric service provider that is supplying energy to PEV when PEV is outside of the customer's utility service territory.
Utility	Organization	Utility typically refers to a collection of systems, business functions, and organizations which make up the electric utility that include the CIS, the AMI, rates and revenue services, etc.

2.2 Definitions

The following definitions describe items within this Use Case.

HAN devices are owned by a consumer, utility, or other third party (i.e., ownership agnostic), and registered on the utility-secured HAN communication channel HAN.

They can be either consumer or utility devices and can include either fixed or mobile metering capability. The EUMD contains the metering capability that would be within the HAN device as applicable.

- Consumer HAN devices are devices within the architecture that are procured by the consumer or a third party which is not the utility. As an example, these devices include smart appliances, PCTs, and energy management systems.
- Utility HAN devices within the premise are those devices which are typically provided by the utility. As an example, these include metering devices (e.g., gas meter) and load control devices. Some of these devices are located within the consumer premise while others sit on the outside of the premise. Regardless of placement, the utility device always uses the utility provided "secure" network.
- Some devices can be provided by either the utility or the consumer. This decision is between the consumer, utility, and regulators. Further, this document provides architecture flexibility. That is, the utilityAMI 2008 HAN SRS supports any desired configuration.
- The FHDMC connects with the premise HAN and identifies itself and the account it is properly associated with to the utility, where premise owner's charges are reconciled. This Use Case also describes the scenario documented in the load and energy management Use Cases, in that the FHDMC may behave according to that Use Case. The following scenario is defined: bi-directional metering (i.e., distributed generation) and third-party (i.e., gas meter).
- The MHDMC connects with the premise HAN, identifies itself and the account it is properly associated with the utility. MHDMC's and premise owner's charges are reconciled, as applicable. This Use Case also describes the scenario documented in the load and energy management Use Cases, in that the MHDMC may behave according to that Use Case. The mobile (e.g., any consumer PHEV/EV) scenario is defined in this document.
- Energy cost applications are not intended to reconcile costs displayed on HAN devices with bills generated by a utility billing system. There are other elements associated with billing and revenue-grade metering that are outside the scope of these requirements (e.g., revenue-grade certification, rate recovery).
- RESS is any energy storage system that has the capability to be charged and discharged (i.e., batteries, capacitors, and electro-mechanical flywheels).
- State of charge (SOC) is the ratio of available capacity as compared to the total capacity of an RESS.

3. STEP-BY-STEP ANALYSIS OF EACH SCENARIO

3.1 Scenario Description

E: Basic Enrollment

Purpose: Utility provides services to PEV customer. To enable utility customer rates/programs specifically to customers with PEVs, the utility must offer special services for these customers. These services include the ability to enroll, register, and initially setup the utility programs (one-time setup).

This scenario describes the most common sequence (basic process) of the utility enrolling a PEV customer into a utility program/service specifically for customers with PEVs. This involves basic enrollment of the PEV.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a PEV program. The customer may be prompted by the dealer, VM, retail store, utility, and more in the awareness cycle.	Customer	Customer has a PEV and wishes to enroll in PEV program; utility offers PEV programs to its customers.	Customer then selects specific utility programs offered within the territory or the vehicle travel area.

3.1.1 Steps for this Scenario

Step #	Actor	Description of the Step	Additional Notes
1	Customer	Customer is presented by the utility with PEV program information and PEV program selections.	
2	Customer	Customer initiates request to enroll PEV in a PEV program by contacting utility.	PEV ID could be the PEV VIN # or HAN device MAC ID.
3	Customer	Customer provides customer and PHEV information (i.e., customer account information, PHV ID, etc.).	
4	Customer	Customer fills the enrollment form and return to utility via web, phone, mail, or retailer.	
5	Utility	Utility authenticates customer, customer account, and premise information, and collects PEV information, including PEV ID.	
6	Utility	Utility confirms customer's basic enrollment is accepted and complete.	The specific program functions may be included with this step or be a subsequent set of actions as described in next sequence of events.

3.2 Scenario Description

U: Specific Enrollment:

The following five categories of utility programs are designed to entice PEV customers to consume energy during times of lower grid loadability.

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/Demand Response)

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

U1: TOU rates are designed to entice utility customers to consume energy during times of lesser grid impact. The cost of energy associated with these rates is typically dependent on the season, day of the week, time of day, weekday versus weekend, etc. These rates reward behaviors that “shift load” to a more favorable time of day and penalize those that have greater system impact. Typically, the energy provider does not have control over the load and sets the cost of the service annually.

Scenario U1-A assumes that a single, vertically integrated utility provides bundled residential premise service exclusively, and that TOU is available on a self-selected basis (voluntary, that is; TOU is not mandatory, it is an option). Default rate is an old traditional/conventional flat rate.

Primary Scenario (U1-A): Customer enrolls in TOU program. The vertically integrated utility provides bundled residential premise services exclusively and that TOU is available on a self-selected basis.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a TOU program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in TOU program; utility offers PEV programs to its customers. Assumes that a single, vertically integrated utility provides bundled residential premise service exclusively, and that TOU is available on a self-selected basis.	The utility has successfully enrolled a customer PEV in a TOU program.

Scenario U1-B assumes that customer can have unbundled residential premise service. He gets the delivery service from the utility and commodity service from ESCO. If customer takes bundle service, then process is the same as previous case. Otherwise, the illustrated processes are involved. Utility installs TOU meter.

Alternative Scenario (U1-B): Customer enrolls in TOU program - customer taking commodity from ESCO.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a TOU program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in TOU program; gets delivery services from the utility and commodity service from ESCO.	ESCO has successfully enrolled a customer PEV in a TOU program.

U2: Discrete event (direct load control) programs are designed to incentivize customers whom are willing to give the energy provider control over their load. More specifically, these programs allow energy providers to interrupt customer loads during critical grid events. Usually, the energy provider offers a vast array of options with programs varying in the quantity of events and length of interrupt periods.

A direct device control (DDC) service involves a call option on one or more devices on the premises. A single price schedule applies to total premise metered service (uniform or TOU if that was selected). A discount is applied to the base service for each device enrolled in DDC. Prices are firm, but service is not. The utility exercises its call option by first notifying the participant (to the control device which then sends the signal to the vehicle) that a event has been declared for the next day. Utility exercises its call option by sending a signal that either shuts off electricity to the device (or devices), or restricts its usage during the event.

U2: Primary Scenario: Customer enrolls in discrete event demand side management program.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a direct load control program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in DDC program; utility offers PEV programs to its customers. Assumes that a single, vertically integrated utility provides bundled residential premise service exclusively, and that DDC is available on a self-selected basis.	The utility has successfully enrolled a customer PEV in a DDC program.

U3: Variations on the basic TOU structure include CPP, VPP, and RTP.

RTP is similar to TOU rates in that customers make consumption decisions based on the price of energy. This is also considered an active management program. However, unlike TOU rates, where the costs are previously established, RTP rates vary daily and by time of day based on day-ahead forecasts. Customers are generally provided a signal that informs them of the “real time” price. Although the interval and type of the signal may vary among utilities, the concept is the same nationwide. RTP-DA (day-ahead) service provides daily price schedules (one price, \$/kW·h) to participants the day before they are effective. Once delivered, the prices are firm - they are not subject to revision. The hourly prices are applied to the corresponding hour's metered energy usage (kW·h). Under these rates, the utility or energy provider does not have direct control to the customer's load.

Primary Scenario (U3-A): Customer enrolls in RTP program. The vertically integrated utility provides bundled residential premise services exclusively and that RTP is available on a self-selected basis.

The enrollment steps are identical to those to TOU for bundled utility and unbundled EPSO service. Each day, the retailer (utility or ESCO) prepares and delivers the price schedule for the next day to the participant (by a specified time), and participant acknowledges receipt of the schedule (by a specified time).

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a RTP program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in RTP program; utility offers PEV programs to its customers. Assumes that a single, vertically integrated utility provides bundled residential premise service exclusively, and that RTP is available on a self-selected basis.	The utility has successfully enrolled a customer PEV in a RTP program.

Alternative Scenario (U3-B): Customer enrolls in RTP program - customer taking commodity from ESCO.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a RTP program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in RTP program; gets delivery services from the utility and commodity service from ESCO.	ESCO has successfully enrolled a customer PEV in a RTP program.

U4: Variations on the basic TOU structure include CPP, VPP, and RTP.

CPP rates are similar to TOU rates in that they both have an established cost schedule based on the season, day of the week, time of day, weekday versus weekend, etc. Critical peak pricing is a mechanism whereby normal flat² or TOU rates are in effect, except for certain peak days, when pre-specified higher prices are superimposed on the normal TOU rate. CPP prices are used during system contingencies or during periods of high wholesale electricity prices for a limited number of days or hours per year. Although the quantity of events are limited and only during a particular season (i.e., summer or winter), the customer has the choice to reduce or not reduce their load during the “called” event. However, the consequence for not reducing load during peak hours will typically result in higher rates for that day. Under these rates, the utility or energy provider does not have direct control to the customer's load.

Primary Scenario (U4-A): Customer enrolls in CPP program. The vertically integrated utility provides bundled residential premise services exclusively and that CPP is available on a self-selected basis.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a CPP program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in CPP program; utility offers PEV programs to its customers. Assumes that a single, vertically integrated utility provides bundled residential premise service exclusively, and that CPP is available on a self-selected basis.	The utility has successfully enrolled a customer PEV in a CPP program.

Alternative Scenario (U4-B): Customer enrolls in CPP program - customer taking commodity from ESCO.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in a CPP program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll in CPP program; gets delivery services from the utility and commodity service from ESCO.	ESCO has successfully enrolled a customer PEV in a CPP program.

U5: Optimized energy transfer programs are designed to incentivize customers who are willing to give the energy provider control over their load. More specifically, these programs allow energy providers to reduce or interrupt customer loads during critical grid events. The idea is that the energy provider based on the grid event can actively manage the charging load by either reducing or interrupting it. In either case, the active management will support turn off those who have higher SOC, while only reducing the charge rate of those that have lower SOC. Usually, the energy provider offers a vast array of options, with programs varying in the quantity of events and length of reduction or interruption periods. These include regulation services and taking advantage of spinning reserves.

² A single price (\$/kW·h) applies to all metered energy (kW·h) consumption during each billing period. The simplest rate structures include a flat energy rate and a customer charge, a fixed dollar amount. This simple rate structure is most common for residential and small commercial customers.

Scenario: Customer enrolls in an optimized energy program.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and contacts the utility to enroll in an optimized energy program. The customer may be prompted by the dealer, VM, retail store, utility, and more for specific programs.	Customer	Customer has a PEV and wishes to enroll an optimized energy program; utility offers PEV programs to its customers.	The utility has successfully enrolled a customer PEV in an optimized energy program.

3.2.1 Steps for this Scenario

Step #	Actor	Description of the Step	Additional Notes
1	Customer	Customer is informed of the program's cost and/or benefits.	
2	Customer	Customer applies and starts to enroll in a specific program.	
3	Customer	Customer makes a decision of when and where to use the program (based on need and cost).	
4	Customer	Customer completes enrollment form, returns to utility or ESCO via web or mail.	This step is dynamic and adjustments are allowed as customer preferences or actual comparisons are realized.
5	Utility	Utility confirms enrollment is complete and advises of any next steps.	
6	Customer	Customer determines whether to use a cordset EVSE or premise unit, and purchases from vehicle dealership, retail store, or from utility or ESCO, as available.	
7	Customer	Customer can self-install EVSE, or contract this installation.	
8	Utility	Additional control devices, dependant on the utility program, would also be installed at this time.	An example is the DLC. A control device has to be installed for TOU/RTP/CP. A meter has to be installed by the utility.
9	Customer	Customer inputs program presets to vehicle/EVSE/HAN to accept program objectives based on options selected.	Some of this information may be exchanged within the binding or rebinding events as described next.

3.3 Scenario Description

S: PEV connection and energy transfer: Binding/rebinding (startup, PEV authentication, basic charging per enrolled program, communication, and shutdown)

The following three architectures are the methods for the customer to connect the PEV to the utility.

S1: Cordset EVSE (120 V AC)

S2: Premise EVSE (240 V AC)

S3: Premise EVSE (DC)

The customer connects an EVSE cord to the PEV and the premise at home, to charge the PEV. The customer wants to take advantage of one or more of the utility programs.

Some of the utility programs require an EUMD. This is expected to be a HAN device that measures energy consumed by a PEV and communicates the information to the ESI.

Each binding and rebinding between the PEV and the ESI will include the EUMD ID. It is expected for a HAN device to contain a MAC ID that is correlated with the PEV ID and ESI ID for each energy transfer session. The definition for the HAN device is identified in 2.2. A system diagram is shown in 5.3.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
Customer connects EVSE cord to PEV.	Customer	Customer has enrolled PEV with home utility, purchased and installed at least one EVSE (customer could have both cordset and premise EVSE).	The utility has a record of the energy agreement related to the customer premise and the associated PEV ID. PEV binds or rebinds with utility.

3.3.1 Steps for this Scenario

Step #	Actor	Description of the Step	Additional Notes
1	Customer	Customer connects EVSE cordset to energy portal at premise, then to PEV if cordset is used. If premise EVSE is used, customer connects EVSE cord to PEV.	
2	Customer	Customer may observe that EVSE power is indicated and PEV indicator is activated - that confirms charge will commence.	PEV and utility exchange/confirm PEV ID, energy request versus available, and details of specific utility program(s).
3	PEV/Utility	Communication session is started and messages are sent and received by various actors. The PEV could send ID and message requests to the utility or intermediate devices. The utility and other premise devices may simply send messages to the EVSE that would control the PEV energy needs by using the EVSE pilot PWM.	Customer has the option to override any of these programs and receive energy at the available conditions.
4	Customer	Customer returns to vehicle, observes charge is complete or interrupts cycle, then disconnects EVSE cord.	

3.4 Scenario Description

L: Location variations: Connection location (PEV authentication, basic charging per enrolled program)

The following four location variations are the alternatives for the customer to connect the PEV to the utility.

L1: Home: Connects at premise

L2: Another's home inside the utility's service territory and (a) premise pays tariff, or (b) customer pays tariff

L3: Another's home outside the utility's service territory

L4: Public: Curbside, workplace, business, multi-family dwelling

Primary Scenario (L1): Customer connects PEV at their premise location using either EVSE cordset or premise-mounted EVSE.

This scenario describes the most common sequence of customer charging their PEV at their own premise.

Primary Scenario (L2-A): Customer connects PEV to energy portal at another premise and premise customer pays for energy use.

This scenario describes what happens if a customer plugs PEV into another premise (not his own, but one serviced by the same utility), where the premise owner is responsible for the cost of energy delivered to the PEV charged at the premise.

Alternative Scenario (L2-B): Customer connects PEV to energy portal at another premise and PEV customer pays for energy use.

This scenario describes what happens if customer plugs PEV into another premise (not his own, but serviced by the same utility), where the PEV operator is responsible for the cost of energy delivered to the PEV charged at the premise.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using either EVSE cordset or premise EVSE for charging.	PEV	Customer has enrolled PEV with home utility. Enrollment and initial setup steps.	The utility has a record of the energy purchased transactions related to the customer premise and the associated PEV ID.

Primary Scenario (L3): Customer connects PEV to energy portal at another premise outside the enrolled utility's service territory.

This scenario describes what happens if customer plugs PEV into another premise (not his own, and not serviced by the same utility (i.e., roaming utility)), where the PEV operator is responsible for the cost of energy delivered to the PEV charged at the premise.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using either EVSE cordset or premise EVSE for charging.	PEV	Customer has enrolled PEV with home utility. Enrollment and initial setup steps. Both home and foreign/roaming utility participate in inter-utility Clearinghouse.	The foreign/roaming utility and the Clearinghouse have record of the energy purchased transactions related to the customer premise, the PEV ID, the customer ID, and the utility ID.

Primary Scenario (L4-A): Customer connects PEV to energy portal at curbside location.

This scenario describes what happens if customer plugs PEV into a curbside location.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using an EVSE cordset for charging.	PEV	Customer may or may not have enrolled PEV with curbside energy provider.	Prior enrollment may entitle customer to special rates and/or conditions.

Alternative Scenario (L4-B): Customer connects PEV to energy portal at workplace location.

This scenario describes what happens if customer plugs PEV at a worksite location.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using either EVSE cordset or premise EVSE for charging.	PEV	Customer may or may not be an employee at this location.	Employment may entitle customer to special rates and/or conditions.

Alternative Scenario (L4-C): Customer connects PEV to energy portal at business location.

This scenario describes what happens if customer plugs PEV at a business location.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using either EVSE cordset or premise EVSE for charging.	PEV	Customer may or may not be a shopper.	Shopping may entitle customer to special rates and/or conditions.

Alternative Scenario (L4-D): Customer connects PEV to energy portal at multi-family dwelling location.

This scenario describes what happens if customer plugs PEV at a multi-family dwelling location.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer plugs in the PEV using either EVSE cordset or premise EVSE for charging.	PEV	Customer may or may not be a resident.	Residency may entitle customer to special rates and/or conditions.

3.4.1 Steps for this Scenario

Step #	Actor	Description of the Step	Additional Notes
1	Customer	Customer needs to meet billing variations dependent on location and services provided.	

3.5 Scenario Description

PR: Specific Functions: Charging, discharging, diagnostics, and VM-specific applications.

The following four location variations are the alternatives for the customer to connect the PEV to the utility.

PR1: Charging

PR2: Discharging

PR3: Diagnostics

PR4: VM-Specific

PR1: Charging

Purpose: The fundamental function is to charge the PEV using the utility grid. The rate and time can be adjusted as needed to meet the customer's connection and use criteria and match the grid's capabilities.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and desires to use electrical energy rather than other fuel.	Customer	Customer is able to connect to an EVSE.	Customer receives the amount of energy desired.

PR2: Discharging.

Purpose: An alternative function of the PEV is to discharge the RESS. The customer can take advantage of rate or opportunity aspects by using this feature.

Discharges fall into the following four categories:

D1: Vehicle-to-Grid (V2G). This allows the customer the option of returning power to the grid. This may have an advantage to the grid, if it is operating at peak loads.

D2: Vehicle-to-Home (V2H). This allows the customer the option of powering a home in the event of a grid outage. This function would have to include the same safety features as a home generator.

D3: Vehicle-to-Load (V2L). This allows the customer the option of powering devices that are not connected to the grid. This could be portable power at a construction site, or islanding where the vehicle may be providing power to a variety of devices.

D4: Vehicle-to-Vehicle (V2V). This has a couple of aspects, such as jump-starting another vehicle, or providing power in parallel with other vehicles for a higher power level of islanding.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer acquires a PEV and desires to use electrical energy as a source for offboard power.	Customer	Customer is able to connect to an EVSE.	Customer delivers the amount of energy desired.

PR3: Diagnostics.

Purpose: The customer may desire to diagnose issues with the EVSE or the PEV.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer detects a failure in the EVSE or PEV.	Customer	Customer has a PEV and has connected to an EVSE.	The customer was able to have the failure transmitted by the means selected (vehicle display, AMI, EVSE screen, etc.).

PR: VM-Specific.

Purpose: The customer may desire to transport info to or from the PEV.

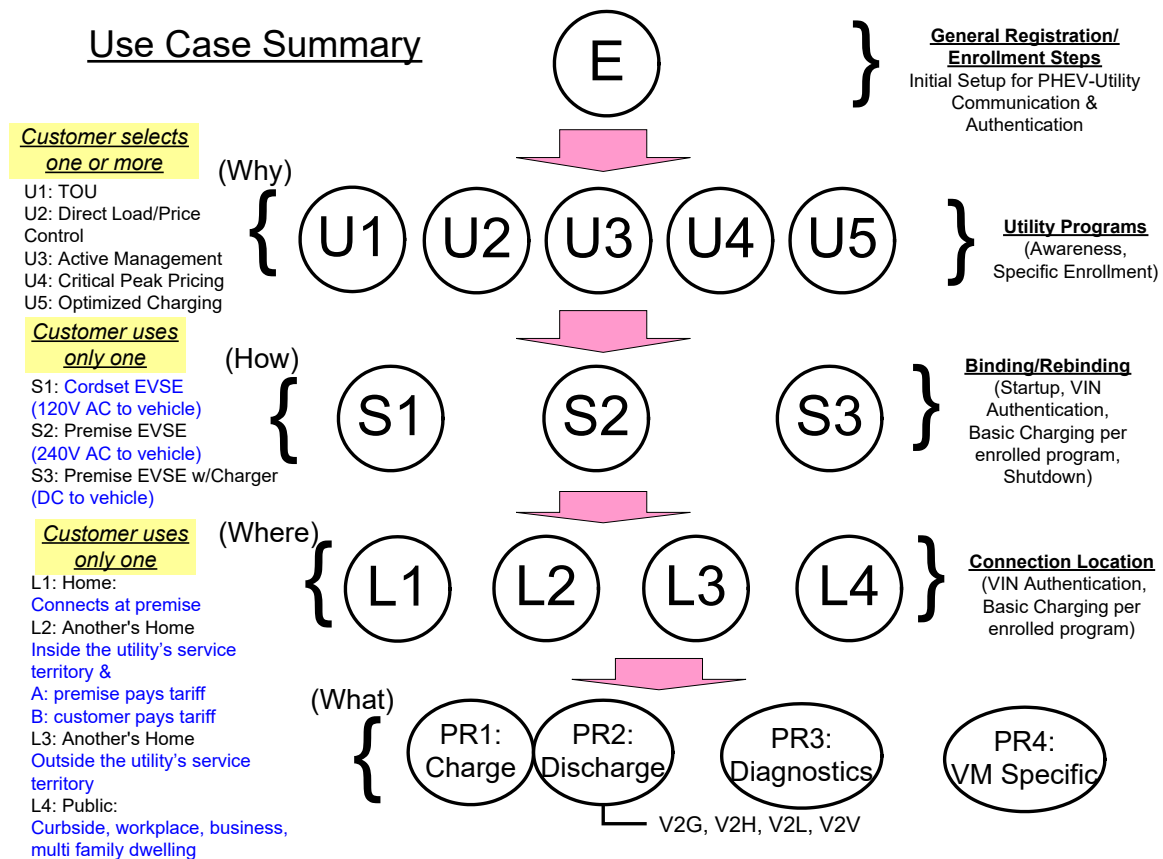
Triggering Event	Primary Actor	Pre-Condition	Post-Condition
The customer wants to download or retrieve information from the PEV.	Customer	Customer has a PEV and has connected to an EVSE.	The customer was able to have the data transmitted by the means selected (vehicle display, AMI, EVSE screen, etc.).

3.5.1 Steps for this Scenario

Step #	Actor	Description of the Step	Additional Notes
1	Customer	Customer selects desired option using desired means (vehicle display, AMI, EVSE screen, etc.).	
2	Utility	Utility provides additional responses resulting from specific programs.	One example would be either the fixed or mobile EUMD reading on energy provided.
3	Customer	Customer receives feedback on billing or payment of these actions as applicable.	EVSE display could offer this.
4	Customer	Customer could receive info regarding amount and times of energy transfer for transaction.	EVSE display could offer this.

4. REQUIREMENTS

This Use Case outlines a series of more detail Use Cases that identify the overall approach and requirements the customer will address to take advantage of various utility programs while fueling their PEV with electrical energy. The general enrollment is intended to cover common attributes, and then the specific utility programs may vary throughout different utility territories. The binding and rebinding identifies the specific attributes of each connection cycle with its varying architectures, and then the location aspects are identifying items that vary with each location category. Finally, the customer attributes are defined as charging, discharging, doing diagnostics, or VM-specific functions.



4.1 Functional Requirements

Func. Req ID	Functional Requirement	Associated Scenario # (if applicable)	Associated Step # (if applicable)
1	PEV sends energy request to ESI. This includes amount and charging rate.	Utility uses this to plan grid loading.	
2	ESI sends energy available to PEV. This includes amount and charging rate.		
3	The ESI and PEV shall exchange information, so the PEV can display the cost per distance.		
4	The ESI and PEV shall exchange information such as connection start, desired charge start, desired charge finish, and expected connection end.	Complies with programs.	
5	Fixed or mobile EUMD sends energy used to ESI.		
6	The ESI and PEV shall exchange program information, such as TOU, RTP, and CPP.		
7	An EVSE with multiple ports would require multiple EUMDs to associate and record energy transferred to each PEV for the energy transfer session.		

4.2 Non-Functional Requirements

Non-Func. Req ID	Non-Functional Requirement	Associated Scenario # (if applicable)	Associated Step # (if applicable)

4.3 Business Requirements

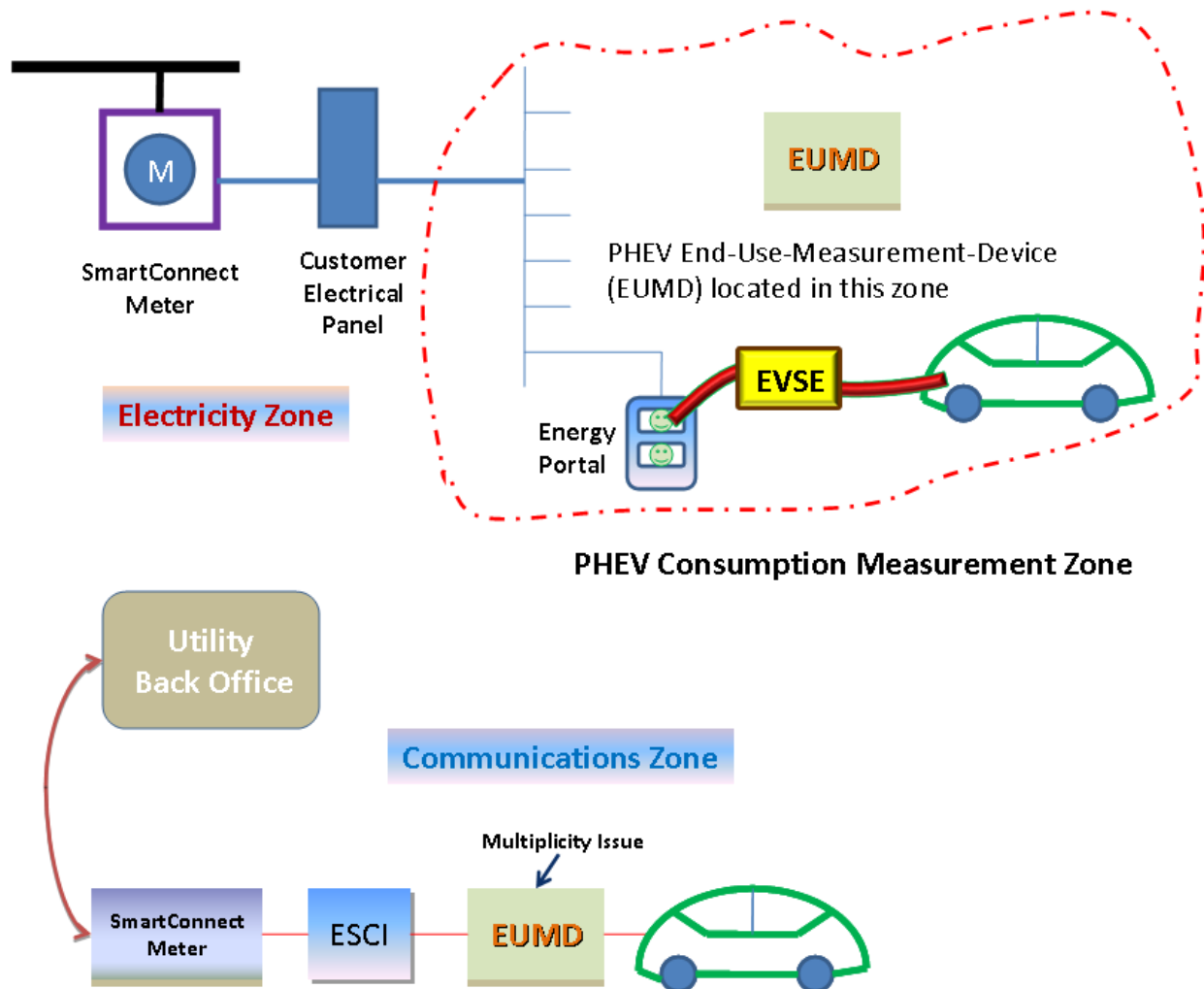
Bus. Req ID	Business Requirement	Associated Scenario # (if applicable)	Associated Step # (if applicable)

5. USE CASE MODELS

The enrollment process will include capturing the following customer, vehicle, and usage information. This is to be used by the utility to predict the energy needs of the customer and plan for optimized charging of the plug-in vehicles.

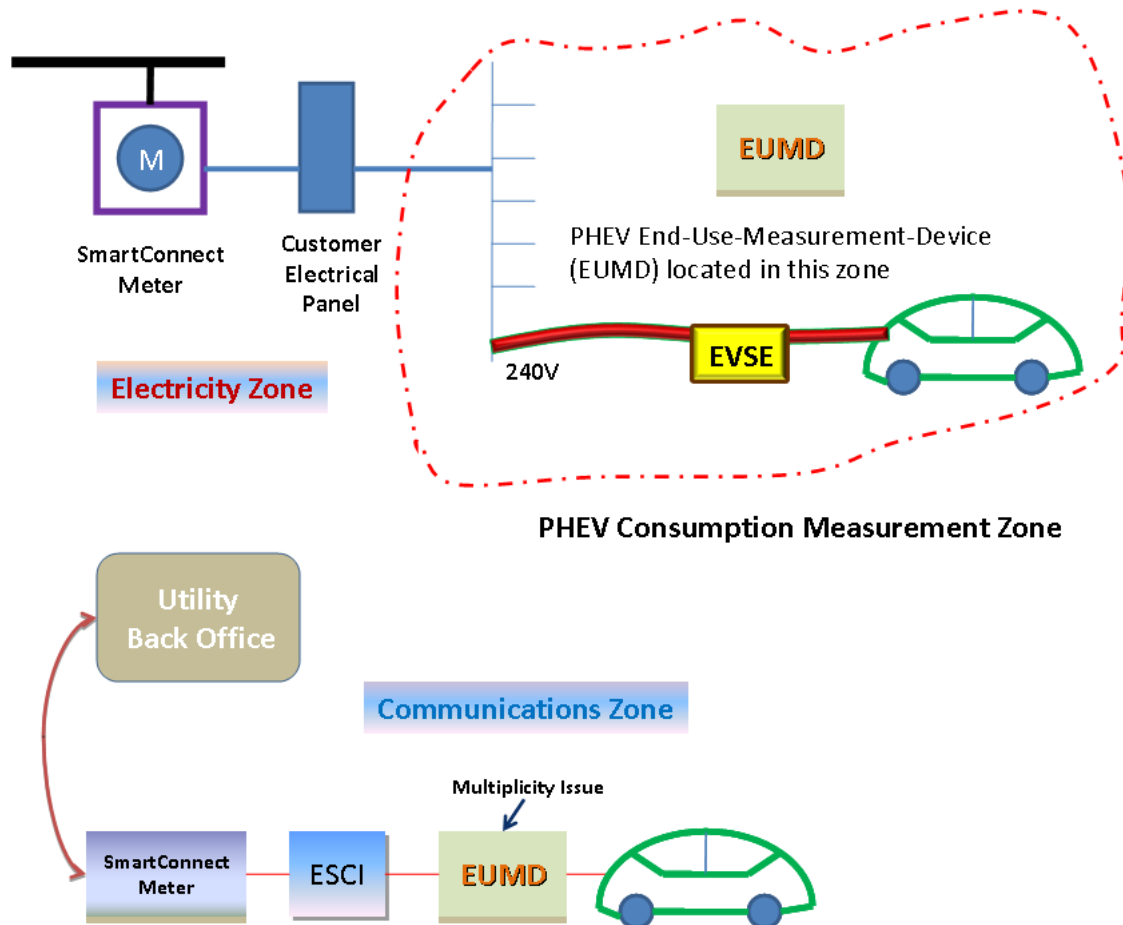
5.1 System Diagram

Using EVSE cordset - see Use Case S1.



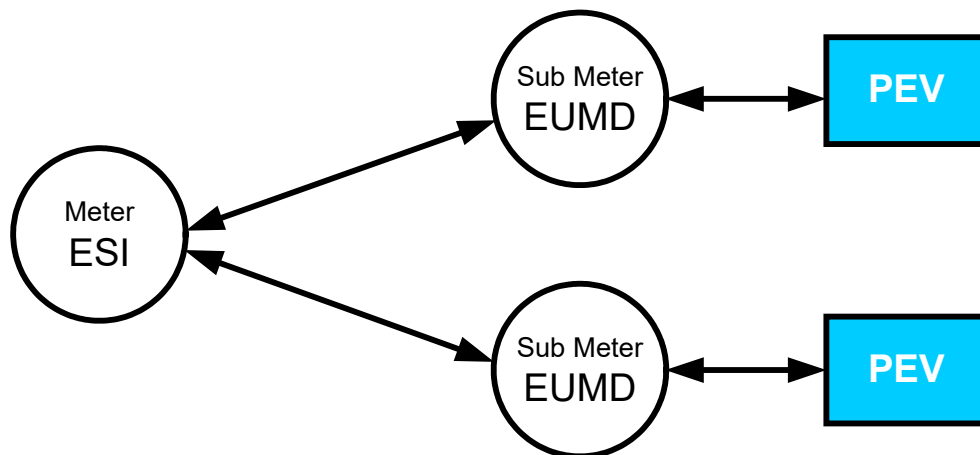
5.2 System Diagram

Using premise-mounted EVSE - see Use Case S2 and S3.



5.3 System Diagram

An EUMD is required for each PEV. An EVSE with multiple ports would require multiple EUMDs to associate and record energy transferred to each PEV for the energy transfer session.



A.2 PEV1 - UTILITY PROVIDES SERVICES TO PEV CUSTOMER

AMI USE CASE:
PEV1 - UTILITY PROVIDES SERVICES TO PLUG-IN ELECTRIC VEHICLE (PEV) CUSTOMER
01/22/09

Document History**Revision History**

Revision Number	Revision Date	Revision/ Reviewed By	Summary of Changes	Changes Marked
(#)	(yymmdd)	(Name)	(Describe change)	(Y/N)
0.1	080627	Jerry Melcher	Initial draft document.	N
0.2	080702	Jerry Melcher	Draft document - JCMb.	Y
0.3	080724	Jerry Melcher	Addition of S2, utility provides billing services scenario.	Y
1.0	080811	Bryan Lambird	Includes modifications required by taking binding and re-binding scenarios out of Use Case P2; S2 and S3 removed at this time for socialization purposes; will be included in v2.0.	Y
2.0	090122	Arindam Maitra	Updates:	Y
3.0	090305	Rich Scholer	Deleted requirement section until we can coordinate with HAN submissions. Updated EUMD definition.	Y
3.1	091230	Rich Scholer	Added Requirements	N

Approvals

This document requires following approvals.

Name	Title

1. USE CASE DESCRIPTION

1.1 Use Case Title

Utility provides services to PEV customer.

1.2 Use Case Summary

Customers are interested in fueling vehicles with electricity. EVs and PEVs are emerging transportation options for consumers. Electric utilities desire to support these emerging loads with electricity at “off peak” times, when energy costs are low and generation and power delivery assets are underutilized. PEV manufacturers are interested in working with utilities to develop customer rates/programs which could provide consumers with an increased incentive to purchase a PEV. To enable utility customer rates/programs specifically to customers with PEVs, the utility must offer special services for these customers. These services include the ability to enroll, register, and initially setup communications between a PEV and the utility (one-time setup), the ability to repeatedly re-establish communications for each PEV charging session (repeat communications/re-binding), the ability to provide PEV charging (and other) status information to customer information channels (e.g., web, display devices), and the ability to correctly bill PEV customers according to their selected rates/programs.

1.3 Use Case Detailed Narrative

Within a utility service territory, the consumer can plug in a PEV to receive a charge of electrical energy at their premise, or plug in at another premise location. The utility may offer the customer a PEV tariff that provides a low rate for off-peak charging and a higher rate for on-peak charging. The utility must provide services to support energy supplied to customer PEV. These services include enrollment into a PEV program, PEV communications session binding, PEV energy billing, and PEV information services. The utility will implement an enrollment system for customers with a PEV including registration and commissioning. The utility's ESCI shall allow for the establishment of a communications session (communications binding), at a premise location each time a PEV plugs in for charging. Energy supplied to the PEV is reported to the utility for billing and presentation to the customer. Information related to utility PEV programs, energy usage, and PEV charging status/information will be made available to the customer for viewing via a website or other customer provided display equipment.

This Use Case covers four scenarios:

1. Customer enrolls in PEV program and completes initial setup for PEV-utilities communications. The following programs are discussed:
 - U1: Enrollment Process to TOU Program.
 - U2: Enrollment Process to Direct Load/DDC Program.
 - U3: Enrollment Process to RTP or Hourly/Periodic Pricing Program.
 - U4: Enrollment Process to CPP or Hourly/Periodic Pricing Program.
 - U5: Enrollment Process to Active Load Management Program.
2. PEV and utility establish/re-establish communications session at the time of charging.
3. Utility provides billing services for PEV charging to customer.
4. Utility provides customer access to PEV charging and status information.