



# SURFACE VEHICLE RECOMMENDED PRACTICE

J2847™-1

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Communication for Smart Charging of Plug-in Electric Vehicles  
Using Smart Energy Profile 2.0

## RATIONALE

This document is being updated to add lessons learned from SEP2.0 communication and add additional aspects to indirect and provider communication that are also currently being updated in SAE J2836-1.

SAE J2847-1 has been reaffirmed to comply with the SAE Five-Year Review policy.

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MAPPING OF SAE J2847-1 MESSAGES TO SEP2.0.....

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## 1. SCOPE

This document describes the details of the Smart Energy Profile 2.0 (SEP2.0) communication used to implement the functionality described in the SAE J2836-1 use cases. Each use case subsection includes a description of the function provided, client device requirements, and sequence diagrams with description of the steps. Implementers are encouraged to consult the SEP2.0 schema and application specification for further details. Where relevant, this document notes, but does not formally specify, interactions between the vehicle and vehicle operator.

### 1.1 Purpose

The primary purpose of SAE J2847-1 is specifying the communications needed for grid-optimized energy transfer for plug-in electric vehicles (PEV); that is, ensuring that vehicle operators have sufficient energy for driving while enabling the delivery of that energy to vehicles in ways that minimize stress upon the grid or reduce customer costs. This can be accomplished, for example, by vehicle owners' voluntary participation in a utility controlled-charging program in return for incentives, and the specification therefore supports information flows that enable such mechanisms.<sup>1</sup>

This specification supports forward power flow (FPF) energy transfer from the grid to the vehicle to charge the vehicle's rechargeable energy storage system (RESS). Implementation of SAE J2847-1 is encouraged for enabling utility or premises Energy Management System (EMS)-controlled charging load management and demand response incentive programs and vehicle communication with home area network (HAN) SEP2.0 communications-capable electrical devices.

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

Beyond its primary purpose of energy transfer, SAE J2847-1 enables other applications between vehicles and the grid, such as vehicle participation in a utility-controlled charging plan (as noted above), or participation in an HAN of SEP2.0 communications-capable electrical devices.

## 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](http://www.sae.org).

|         |                                                                                                               |
|---------|---------------------------------------------------------------------------------------------------------------|
| J1772   | SAE Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler                            |
| J2836   | Instructions for Using Plug-in Electric Vehicle (PEV) Communications, Interoperability and Security Documents |
| J2836-1 | Use Cases for Communication Between Plug-in Vehicles and the Utility Grid                                     |
| J2836-2 | Use Cases for Communication Between Plug-in Vehicles and Off-Board DC Chargers                                |
| J2836-3 | Use Cases for Plug-in Vehicle Communication as a Distributed Energy Resource                                  |
| J2836-5 | Use Cases for Customer Communication for Plug-in Electric Vehicles                                            |

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

|         |                                                                     |
|---------|---------------------------------------------------------------------|
| J2847-2 | Communication Between Plug-in Vehicles and Off-Board DC Chargers    |
| J2847-3 | Communication for Plug-in Vehicles as a Distributed Energy Resource |
| J2894-1 | Power Quality Requirements for Plug-in Electric Vehicle Chargers    |
| J2894-2 | Power Quality Test Procedures for Plug-in Electric Vehicle Chargers |
| J2931-1 | Digital Communications for Plug-in Electric Vehicles                |
| J2931-4 | Broadband PLC Communication for Plug-in Electric Vehicles           |

#### 2.1.2 IEEE Publications

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

IEEE 2030.5                      Standard for Smart Energy Profile Application Protocol

#### 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 DIN Publications

DIN SPEC 70121:2014        Digital Communication Between a DC EV Charging Station and an Electric Vehicle for Control of DC Charging in the Combined Charging System

##### 2.2.2 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

##### 2.2.3 UCA® International Users Group Publication

Available from UCA® International Users Group, 10604 Candler Falls Court, Raleigh, NC 27614, [www.ucaiug.org](http://www.ucaiug.org).

UCAlug Home Area Network System Requirements Specification

### 3. DEFINITIONS

#### 3.1 ADVANCED METERING INFRASTRUCTURE (AMI)

AMI typically refers to the 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.

#### 3.2 BATTERY ELECTRIC VEHICLE (BEV)

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

#### 3.3 CUSTOMER INFORMATION SYSTEM (CIS)

Items included in this system could be what information the utility desires to meet the needs of the customer such as type of PEV (PHEV or BEV), battery capacity, expected energy amounts, power level, frequency of charge events, connecting method (AC L1 or L2), etc.

#### 3.4 DEMAND RESPONSE LOAD CONTROL (DRLC)

Client devices include thermostats and devices that support load control. Server devices include ESIs, premises EMSs that may be acting as a proxy for upstream demand response/load control management systems, and subsequent data stores.

#### 3.5 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).

#### 3.6 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.

#### 3.7 ELECTRIC VEHICLE STORAGE BATTERY (BATTERY)

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

#### 3.8 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

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

#### 3.9 END-USE-MEASUREMENT-DEVICE (EUMD)

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

#### 3.10 ENERGY MANAGEMENT SYSTEM (EMS)

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

### 3.11 ENERGY TRANSFER

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

### 3.12 ESI

A device, with multiple network interfaces, which is a member of both the home smart 846 energy network and a service provider's private network. This is the primary mechanism for 847 the service provider to contribute data and directives into the smart energy network and to 848 receive responses from smart energy devices (see 3.19).

### 3.13 HOME AREA NETWORK (HAN)

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

### 3.14 IN-HOME DISPLAY

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

### 3.15 RECHARGEABLE ENERGY STORAGE SYSTEM (RESS)

An energy storage system for delivery of electric energy and which is rechargeable. The terms battery, ESS, and RESS are often used interchangeably.

### 3.16 REVERSE POWER FLOW (RPF)

Reverse power flow means the direction of energy is flowing from the vehicle back to the grid.

### 3.17 SIGNAL LEVEL ATTENUATION CHARACTERIZATION (SLAC)

Protocol to measure the attenuation of a signal between green PHY stations acting as PEVs and EVSEs. It is used for matching.

### 3.18 SMART CHARGING

Smart charging is a communication system in which PEVs optimize the combination of charging schedule, customer preferences, and grid capacity. Smart charging can include participation in utility programs that include time of use rates, demand response, or regulation services.

### 3.19 UTILITY

Utility provides electrical energy and typically refers to a collection of systems that include the CIS, the AML, rates, and revenue. The utility makes available to PEV through the ESI pricing tables, DRLC, or discrete events. The utility also supplies information such as tariff rate, interval for metered kW·h consumption, and validation of PEV program for PEV ID, etc.

## 4. TECHNICAL REQUIREMENTS

When connecting the EVSE to the vehicle and using PLC communication, SLAC and the Service Discovery Process identified in SAE J2931-4 and SAE J2931-1 respectively apply. DIN 70121 and ISO 15118-3 also include information on SLAC and SDP.

As the association is complete per SLAC and the communication link is established per SDP, then the SEP2.0 messages can be transmitted per this document and IEEE 2030.5.

### 4.1 System Definition

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

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

U2: Direct Load Control Programs (Demand Response)

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

U4: Critical Peak Pricing (CPP/Load Shifting)

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

SEP2.0 offers a host of different communications structures and resources, and is meant to be applicable to a wide spectrum of devices throughout the HAN environment. This document refers to and makes use of only the portions of SEP2.0 relevant to the application of the five use cases described above. For full and complete information regarding SEP2.0 implementation, including requirements, schemas, and certification, please refer to the source SEP2.0 documents (see Section 2).

It should be noted that multiple use cases may be implemented at once. For example, it is possible to have a customer enrolled in both U1 and U2 programs. In this case, all messaging and requirements defined in this section for each of those use cases must be supported simultaneously by the PEV. The messages within this document are also applicable when a PEV is not directly enrolled in a utility program (e.g., for customer charging management or facility demand management).

#### 4.1.1.1 End Device Control

Implementations of electric charging with SAE J2847-1 messages support the control of the charging session (determination of charge times, user's preferences, etc.). This control may reside either in the EVSE or the PEV. In the case where both devices support SAE J2847-1 messages, and are capable of managing the session, it has been assumed that the PEV will be the default controlling device. There are various ways for this to be accomplished, all of which are determined by the functionality of the EVSE or preferences of the EVSE owner.

When an SEP2.0-enabled PEV wishes to connect to an SEP2.0 network, it must follow the same sequence to access SEP2.0 resources that other devices do. This involves an out-of-band enrollment, certificate exchange, and device registration process (see 4.3). This process is how SEP2.0 devices join and "advertise" their capabilities on an SEP2.0 network (similar to exchanging a message saying "Smart PEV Present" or "SEP2.0 Device Present"). However, where control of a session ultimately resides depends on the functionality of the EVSE and the preference of the EV owner, whether the EVSE bridges SEP2.0 messages from the PEV to the ESI/EMS, acts as the SEP2.0 server or gateway (e.g., mirrors messages from the ESI/EMS), or retains control depends on the EVSE being used in the charging session. No matter how it is accomplished, when an EVSE and a PEV SEP are both SEP2.0 devices, an EVSE shall allow the PEV to manage the charging session.

Table 1 indicates the expected outcomes for the various scenarios. It is advisable for vehicle manufacturers to include an easily accessible option (smart charging OVERRIDE or CHARGE NOW function) for selecting immediate charging. The maximum PEV charging rate is limited by either the SAE J1772 control pilot pulse width, or internal controls (i.e., battery management system), whichever is lower.

**Table 1 - Smart PEV and EVSE combinations**

| Case | PEV Supports<br>SAE J2847-1<br>Messaging | EVSE<br>Supports<br>SAE J2847-1<br>Messaging | Result                                                                                                                                                                             |
|------|------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | NO                                       | NO                                           | No “smart charging” support.                                                                                                                                                       |
| 2    | NO                                       | YES                                          | EVSE is “smart charging” enabled, and computes charge schedule. EVSE manipulates charging by controlling SAE J1772 pilot.                                                          |
| 3    | YES                                      | NO                                           | PEV is “smart charging” enabled, and computes charge schedule.                                                                                                                     |
| 4    | YES                                      | YES                                          | Both devices are “smart charging” capable. Upon completion of application access processes (see 4.3), EVSE shall be able to relinquish control of the charging session to the PEV. |

#### 4.1.2 Mapping of SEP2.0 Function Sets to SAE Use Cases

Table 2 describes which SEP2.0 function sets are required to achieve the functionality as described in the SAE J2836-1 use cases. The fields marked in the table represent only the bare minimum function sets required to implement the functionality described in the use cases. It should be remembered that it is possible for multiple use cases to be implemented in parallel, or for additional functionality not discussed within this document to be applied in parallel to any use case functions described, which could result in additional function sets being employed. A simple example of this could be the messaging function set - while not required to implement the functionality described in any of the use cases, it could be used in addition to the required function sets to provide messaging to the consumer.

**Table 2 - SEP2.0 function sets by use case**

| Function<br>Sets/Resources      | Registration/<br>Enrollment | SAE J2836-1 |    |    |    |    | Comments                                                                                                                                                                                                  |
|---------------------------------|-----------------------------|-------------|----|----|----|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                 |                             | U1          | U2 | U3 | U4 | U5 |                                                                                                                                                                                                           |
| 1. Billing                      |                             |             |    |    |    |    | Not addressed in the current revision of SAE J2847-1                                                                                                                                                      |
| 2. Demand Response/Load Control |                             |             | X  |    |    |    |                                                                                                                                                                                                           |
| 3. Support and Common Resources | X                           | X           | X  | X  | X  | X  | Includes self device/end device (used for registration and enrollment), time, device information, power status, function set assignments, subscription/notification, response, network status, log events |
| 4. Distributed Energy Resource  |                             |             |    |    |    | X  | This function set is employed in SAE J2847-3 (RPF)                                                                                                                                                        |
| 5. Software Download            |                             |             |    |    |    |    |                                                                                                                                                                                                           |
| 6. Messaging                    |                             |             |    |    |    |    |                                                                                                                                                                                                           |
| 7. Metering/Meter Mirroring     |                             | X           |    |    |    |    | The metering function set may be employed in any of the use cases if the EUMD is within the PEV but is required for specific EV TOU programs                                                              |
| 8. Prepayment                   |                             |             |    |    |    |    |                                                                                                                                                                                                           |
| 9. Pricing                      |                             | X           |    | X  | X  |    |                                                                                                                                                                                                           |
| 10. Flow Reservation            |                             |             |    |    |    | X  |                                                                                                                                                                                                           |
| 11. Response                    |                             | X           | X  | X  | X  | X  |                                                                                                                                                                                                           |

## 4.2 Important Notes About Figures and Physical and Logical Devices

The following sections of this document contain several figures which illustrate example message flows between devices. In most of these figures, the devices are defined by their logical function, with their most likely physical form listed in brackets. For example, “DRLC client (PEV)” means that the logical function of the device or that is being performed is a DRLC client, while the most likely physical form or location of this function is within the PEV. The references to physical devices are meant to illustrate only the simplest or most common application and are meant to improve the reader’s understanding.

However, it is important to note that the physical device shown in brackets in which the logical function resides may be something other than what is described in each figure. For example, while in the simplest and most likely arrangement, most of the server/ESI functions described are likely to reside in a “smart meter” in a home, they may also reside in another device in other applications, such as an EMS in a public or commercial parking structure. Similarly, while the PEV is envisioned as the simplest and most likely physical form of the SEP2.0 device or client, these functions could also be implemented into an “intelligent” EVSE or other device.

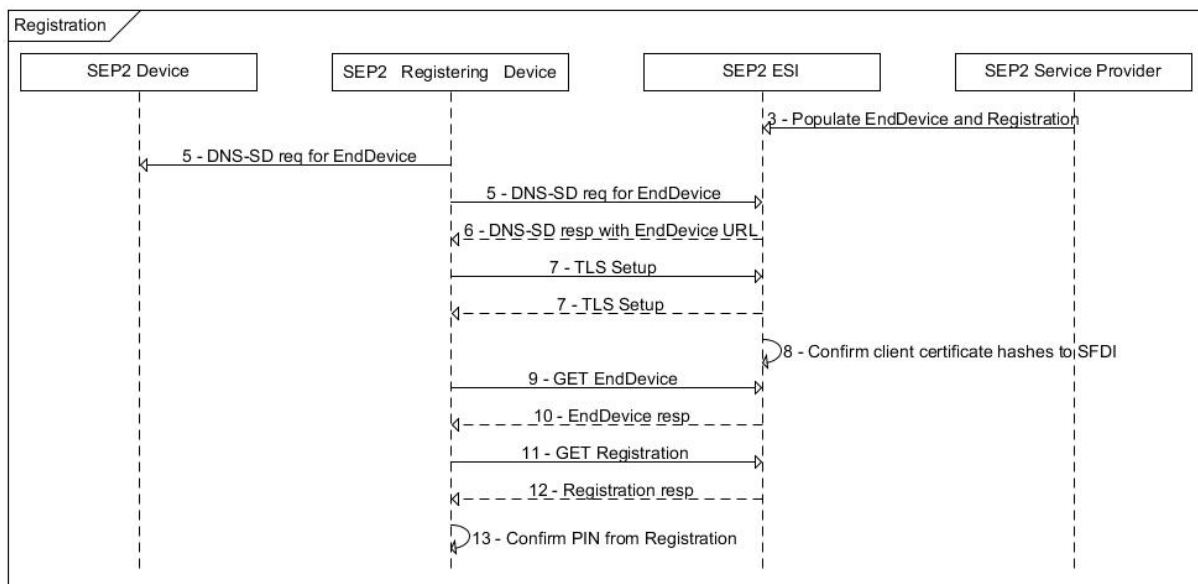
## 4.3 Application Access

Once authenticated and authorized through network access, a node can freely communicate in the network at the network layer. However, authentication and authorization at the application layer normally needs to occur to allow the access of resources as a client host. Registration with a utility or third party service provider may also be needed to provide explicit device and user authorization at the application layer. Further information related to application authentication and authorization can be found in the SEP2.0 application specification.

### 4.3.1 Operation Sequences

This flow describes client device registration to the customer HAN and is assumed a prerequisite to implement each use case.

Sequence diagram:



NOTE: The registering device can either be remote or local, could be located in the same physical device as the ESI, and is logically represented separately in this diagram. The sequence diagram shows the local registration example.

Step descriptions:

| Step | Description                                                                                                                                                                                                                         |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | At time of device manufacture/packaging, short form device identification (SFDI) and/or QR-code of the client device certificate is printed on client device packaging. Registration PIN is printed on the client device packaging. |
| 2    | (Out of band) User establishes secured and authenticated session with desired service provider. This may be a password protected IVR system, web site, etc. SFDI and/or QR-code is delivered to the service provider.               |
| 3    | (Out of band) Service provider populates client device's EndDevice (containing SFDI) and registration (containing PIN) resources to appropriate HAN registration server (typically the ESI).                                        |
|      | <i>Begin client boot into HAN.</i>                                                                                                                                                                                                  |
| 4    | Client device joins the HAN (layer 2).                                                                                                                                                                                              |
| 5    | Client issues DNS-SD request to locate its EndDevice (keyed by its SFDI).                                                                                                                                                           |
| 6    | ESI provides DNS-SD response with URL to client's EndDevice.                                                                                                                                                                        |
| 7    | Clients connects to ESI, performing TLS and client authentication. Note that client certificate is sent in the clear and thus SFDI can be determined.                                                                               |
|      | <i>Client and server now have an encrypted connection. Each has determined it is talking to an authenticated SEP2.0 device, but have not confirmed they are talking to the correct specific SEP2.0 device.</i>                      |
| 8    | ESI verifies client certificate hashes to the client SFDI.                                                                                                                                                                          |
|      | <i>ESI has determined it is talking to the correct client.</i>                                                                                                                                                                      |
| 9    | Client GET's its EndDevice from ESI.<br><br>Client sends the following request:<br><br><full HTTP request example here>                                                                                                             |
| 10   | ESI responds with the EndDevice resource.<br><br>Server sends the following response:<br><br><full HTTP response example here>                                                                                                      |
| 11   | Client GET's its Registration (containing its PIN) from the ESI.<br><br>Client sends the following request:<br><br><full HTTP request example here>                                                                                 |
| 12   | ESI responds with the registration resource. Note: the PIN is thus transmitted over a secure channel.<br><br>Server sends the following response:<br><br><full HTTP response example here>                                          |
| 13   | Client verifies its PIN versus that provided by the ESI.                                                                                                                                                                            |
|      | <i>Client has verified it is connected to the correct HAN.</i>                                                                                                                                                                      |

#### 4.4 Application of Messaging

This section describes the details of the messages required to implement the functionality described in the SAE J2836-1 use cases using SEP2.0.

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

#### 4.4.1 Loss of Communications or Power

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

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

#### 4.4.2 Pricing: Rates/Tariffs/Programs

The set of pricing messages are intended to allow the customer to send a request to a utility or ESI for current and future electricity pricing information, upon which the customer or vehicle may make a decision about when to charge the vehicle. Some utilities or energy providers may wish to offer different unit costs for energy at different times during the day, and this set of messages is used to communicate those periods and rates. It is understood that the customer shall be permitted the option to charge at any time irrespective of pricing, but that doing so may result in a higher electricity cost to the customer, and/or non-compliance with a utility rate program (if the customer is registered in one) that may result in an increased cost to the customer.

The following device requirements and operational sequences are derived from the SEP2.0 application specification. The device requirements section captures normative description of pricing client device behavior; this is simply a summary, additional detail and application guidelines can be found within the application specification. The operational sequence section will cover three basic operations of pricing functionality.

##### 4.4.2.1 U1 (Time-of-Use), U3 (Real Time Pricing), U4 (Critical Peak Pricing)

These three SAE pricing use cases can be achieved using the SEP2.0 pricing function set, though only U1 is represented here. Access to certain prices/tariffs might be dependent on program enrollment. Pricing implementation guidelines can be found in 12.4 and Section 17 of the SEP2.0 application specification.

NOTE: Objects will vary for different pricing programs; only an example of one will be shown below.

##### 4.4.2.1.1 Client Device Requirements

The following requirements are derived from the pricing function set (see 12.4) of the SEP2.0 specification. These requirements capture the baseline functionality required for pricing client devices as defined by SEP2.0; however, they can be modified as seen fit by the SAE community.

A SHALL below defines required functionality, while a SHOULD defines optional functionality.

Client devices of the pricing function set SHALL:

- Implement and support the time function set as a client.
- Implement and support the response function set as a client.
- Be able to internally store and support at least two unique pricing events per RateComponent.
- Poll the pricing event list (TimeTariffIntervalList) when not subscribed, in order to stay updated on new or cancelled events. It is recommended that polling pricing client devices request updated information for pending TimeTariffInterval instances just prior to those TimeTariffInterval instances becoming active.
- Provide response acknowledgments to the pricing server for events requiring a response.
- Read the status of a pricing event (TimeTariffInterval) before execution of the event, if the event was scheduled in the past and the client is not subscribed to the event.