# ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment

## Eligibility Criteria
## Version 1.1
## Draft 1

Following is the Draft 1 Version 1.1 ENERGY STAR product specification for Electric Vehicle Supply Equipment. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

## 1 DEFINITIONS

A) Electric Vehicle Supply Equipment (EVSE): The conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy from the premises wiring (if available) to the electric vehicle. Charging cords with NEMA 5-15P and NEMA 5-20P attachment plugs are considered EVSEs. Excludes conductors, connectors, and fittings that are part of the vehicle.[1]

1) Level 1: A galvanically-connected EVSE with a single-phase input voltage nominally 120 volts ac and maximum output current less than or equal to 16 amperes ac.[2]

2) Level 2: A galvanically-connected EVSE with a single-phase input voltage range from 208 to 240 volts ac and maximum output current less than or equal to 80 amperes ac.[2]

3) DC-output: A method that uses dedicated direct current (DC) electric vehicle/plug-in hybrid electric vehicle (EV/PHEV) supply equipment to provide energy from an appropriate off-board charger to the EV/PHEV in either private or public locations.[3]

4) Wireless / Inductive: A non-galvanically-connected EVSE.

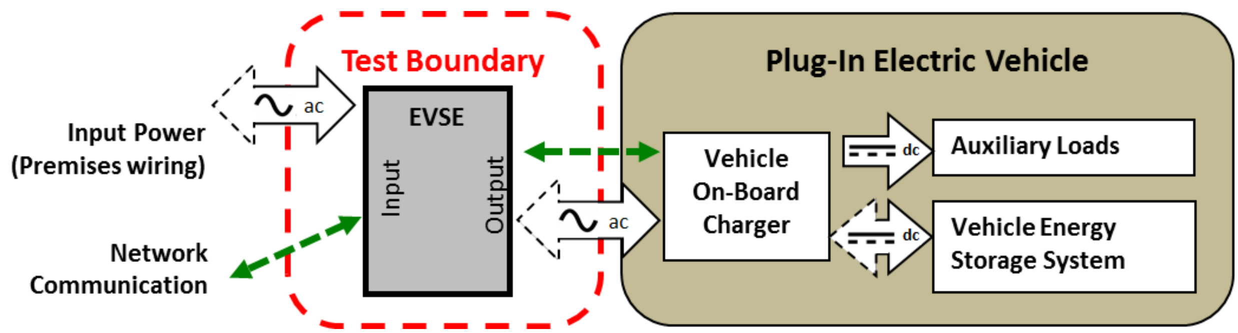



**Figure 1: Schematic of Overall Plug-In Vehicle Charging System Detailing EVSE Test Boundary**

[1] SAE J2894-1 Section 3.10.
[2] This definition is intended to be consistent with the requirements in SAE J1772, with some additional clarifications.
[3] SAE International, Surface Vehicle Standard J1772, “SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler”, Oct. 2017, Section 3.10.

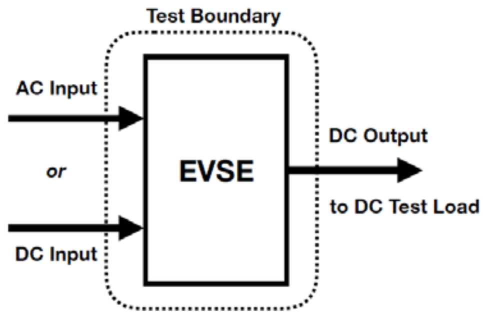



**Figure 2: Schematic of DC-Output EVSE Test Boundary**

B) EVSE Functions:

1) Primary Function: Providing current to a connected load.

2) Secondary Function: Function that enables, supplements or enhances a primary function. For EVSE, examples of Secondary Functions are:

a) Automatic Brightness Control (ABC): The self-acting mechanism that controls the brightness of a display or lamp as a function of ambient light.

b) Full Network Connectivity: The ability of the EVSE to maintain network presence while in Partial On Mode.

Note: Presence of the EVSE's network services, its applications, and possibly its display is maintained even if some components of the EVSE are powered down. The EVSE can elect to change power states based on receipt of network data from remote network devices but should otherwise stay in a low power mode absent a demand for services from a remote network device.

c) Occupancy Sensing: detection of human or object presence in front of or in the area surrounding an EVSE.

d) Communicating with the vehicle;

e) Illumination of display, indicator lights, or ambient lighting;

f) Public access control (RFID card, authorization, etc.);

g) Control Pilot Signal; and

h) Wake-up function.

3) Tertiary Function: Function other than a primary or a secondary function.

Example: An EMC filter and status indication provides their function in No Vehicle Mode, Partial On Mode, and On Mode.

C) DC-output EVSE Product Configurations:

1) Cabinet/Dispenser Product Configuration: A DC-output EVSE that has its components in separate enclosures - one (or more) including power conversion equipment (i.e., cabinet) and one (or more) enclosure that connects to the vehicle and has the user interface (i.e., dispenser).

a) Minimum Dispenser Configuration: The configuration of a DC-output EVSE in which the minimum recommended number of dispensers are connected to a single cabinet.

**Note:** EPA has included a new definition for Minimum Dispenser Configuration. Stakeholder comments regarding the clarity of this definition are welcome.

2) <u>All-in-One Product Configuration</u>: A DC-output EVSE that has all of its components in one enclosure.

D) EVSE Operational Modes and Power States:

Note: The transition period to a different mode; whether automatically initiated, or via user action; does not constitute a mode.

1) Disconnected: Condition of the equipment during which all connections to power sources supplying the equipment are removed or galvanically isolated and no functions depending on those power sources are provided. The term power source includes power sources external and internal to the equipment.

2) No Vehicle Mode: Condition during which the equipment is connected to external power and the product is physically disconnected from vehicle (mode can only be entered or exited through manual intervention). No Vehicle Mode is intended to be the lowest-power mode of the EVSE.

   Note: The vehicle-EVSE interface is in State A of SAE J1772, where the vehicle is not connected.[4]

3) On Mode: Condition during which the equipment provides the primary function or can promptly provide the primary function.

   a) Operation Mode: Condition during which the equipment is performing the primary function.

      Note: The vehicle-EVSE interface is in State C, where the vehicle is connected and accepting energy.[4]

   b) Idle Mode: Condition during which the equipment can promptly provide the primary function but is not doing so.

      Note: Idle Mode is the condition within On Mode where the EVSE is connected to the vehicle or vehicle simulator but is not actively providing current. The vehicle-EVSE interface is in State C, where the vehicle is connected and ready to accept energy.[4]

4) Partial On Mode: Condition during which the equipment provides at least one secondary function but no primary function.

   Note: The vehicle-EVSE interface is in State B1 or B2, where the vehicle is connected but not ready to accept energy and the EVSE is or is not ready to supply energy.[4]

**Table 1: Operational Modes and Power States**

| Operational Modes | Most closely related Interface State as Defined in SAE J1772 | Further Description |
|---|---|---|
| No Vehicle Mode | State A | No Vehicle Mode is associated with State A, or where the EVSE is not connected to the EV. The EVSE is connected to external power. |
| Partial On Mode | State B1 or State B2 | Partial On Mode is associated with State B1 or State B2 where the vehicle is connected but is not ready to accept energy. Sub-state B1 is where the EVSE **is not** ready to supply energy and sub-state B2 **is** where the EVSE is ready to supply energy. |

[4] This mode is intended to be associated with a vehicle/EVSE interface state (e.g., A, B, or C) as defined in SAE J1772.

| | | |
|---|---|---|
| On Mode | | |
| Idle Mode | State C | Idle Mode is associated with State C, where the vehicle is connected and ready to accept energy and the EVSE is capable of promptly providing current to the EV but is not doing so. |
| Operation Mode | State C | Operation Mode is associated with State C, where the EVSE is providing the primary function, or providing current to a connected load (i.e., the relay is closed, and the vehicle is drawing current). |

5) Power Management: Automatic control mechanism that achieves the lowest power consistent with a pre-determined level of functionality.

E) Other:

1) Apparent power (S): The product of RMS voltage and RMS current, which is equal to magnitude of the complex power, and measured in volt-amperes (VA).

2) Average Power (P) (also Real Power): The power in a circuit which is transformed from electric to non-electric energy and is measured in watts (W). For a two-terminal device with instantaneous current and voltage waveforms i(t) and v(t) which are periodic with period T, the real or average power P is[5]:

$$P = \frac{1}{T}\int_{0}^{T} v(t)i(t)dt$$

3) Duty Cycle: The ratio or a given time interval of the uninterrupted duration at the high logic state to the total time.

Note: This duty cycle, lying between 0 and 1, may be expressed as a percentage.

4) Power Factor (PF): The ratio of the average power (P) in watts to the apparent power (S) in volt-amperes.

$$PF = \frac{P}{S}$$

5) Unit Under Test (UUT): The specific sample of a representative model undergoing measurement which includes the base product and any accessories packaged with it.

6) Illuminance: The luminous flux per unit area of light illuminating a given surface, expressed in units of lux (lx).

7) Luminance: The photometric measure of the luminous intensity per unit area of light travelling in a given direction, expressed in candelas per square meter (cd/m$^2$).

8) High Resolution Display: A screen device that converts a video signal into a visual output and is capable of displaying a minimum of 480x234 native resolution and has a backlight (e.g., LCD panel, OLED panel).

[5] Average power is intended to align with the definition of real power in SAE J2894.

F) Product Family: A group of product models that are (1) made by the same manufacturer, (2) subject to the same ENERGY STAR certification criteria, and (3) of a common basic design. Product models within a family differ from each other according to one or more characteristics or features that either (1) have no impact on product performance with regard to ENERGY STAR certification criteria, or (2) are specified herein as acceptable variations within a Product Family. For EVSE, including both cabinet and dispenser for cabinet/dispenser configuration DC-output EVSE, acceptable variations within a Product Family include:

1) Color,
2) Output cable, and
3) Housing.

**Note:** EPA has made a minor edit to the definition of Product Family to clarify that the acceptable variations within a Product Family apply to both the cabinet and dispenser for cabinet/dispenser configuration DC-output EVSE.

G) Connected Functionality Definitions

1) Communication Link: The mechanism for bi-directional data transfers between the EVSE and one or more external applications, devices or systems.

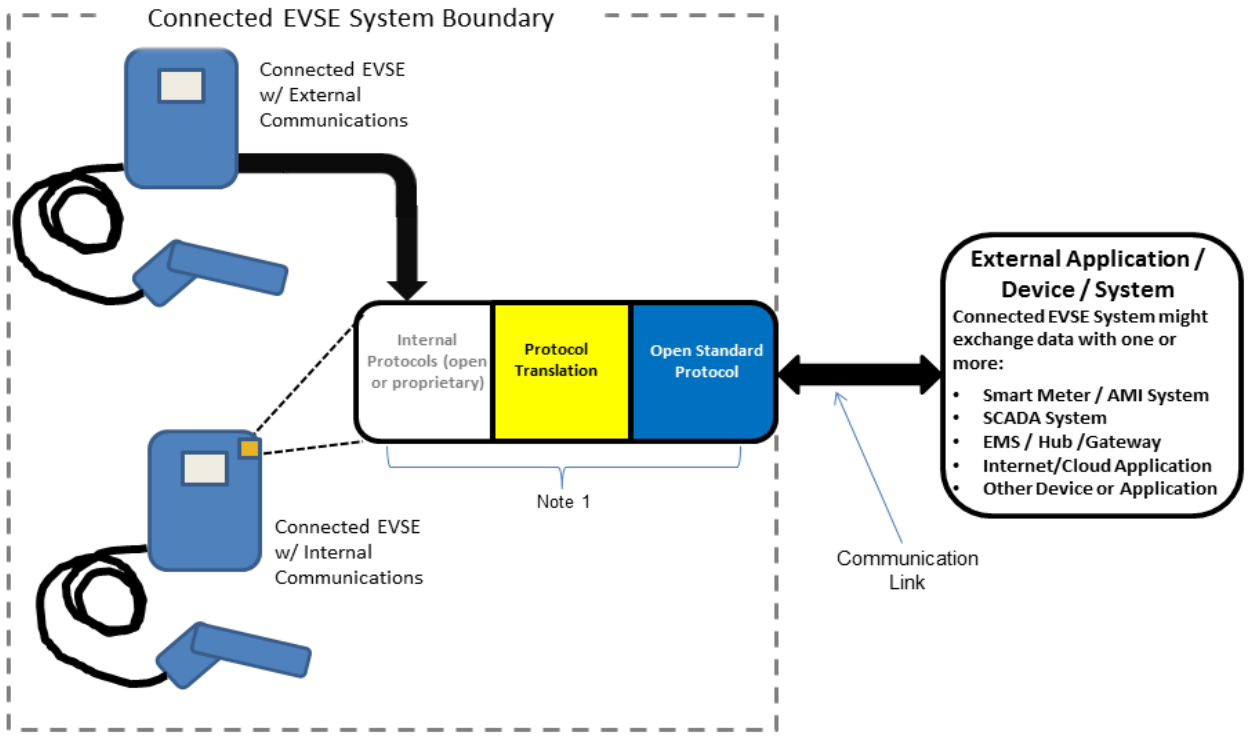
2) Demand Response (DR): Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized[6].

3) Demand Response Management System (DRMS): The system operated by a program administrator, such as the utility or third party, which dispatches signals with DR instructions and/or price signals to the ENERGY STAR EVSE and receives messages from the EVSE.

4) EVSE System: As shown in Figure 3, it includes the ENERGY STAR certified EVSE, integrated or separate communications hardware, and additional hardware and software required to enable connected functionality.

5) Load Management Entity: DRMS, home energy management system, etc.

[6] Federal Energy Regulatory Commission, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp




Note: Communication device(s), link(s) and/or processing that enables Open Standards-based communication between the EVSE and external application / device / system(s). These elements, either individually or together, could be within the EVSE, and/or an external communication module, a hub/gateway, or in the Internet/cloud.

**Figure 3: Connected EVSE System**

H) Open Standards: Standards that are:

1) Included in the Smart Grid Interoperability Panel (SGIP) Catalog of Standards,[7] and/or
2) Included in the National Institute of Standards and Technology (NIST) Smart Grid framework Tables 4.1 and 4.2,[8] and/or
3) Adopted by the American National Standards Institute (ANSI) or another well-established international standards organization such as the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), International Telecommunication Union (ITU), Institute of Electrical and Electronics Engineers (IEEE), or Internet Engineering Task Force (IETF).

I) **Acronyms:**

1) A: Ampere
2) ABC: Automatic Brightness Control
3) ac: Alternating Current
4) dc: Direct Current
5) DOE: U.S. Department of Energy

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[7] http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PMO#Catalog_of_Standards_Processes

[8] http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf

6) DR: Demand Response
7) EPA: Environmental Protection Agency
8) EVSE: Electric Vehicle Supply Equipment
9) IEC: International Electrotechnical Commission
10) IEEE: Institute of Electrical and Electronics Engineers
11) NEMA: National Electrical Manufacturers Association
12) SAE: Society of Automotive Engineers
13) UUT: Unit Under Test
14) V: Volt
15) W: Watt

> **Note:** EPA has added definitions of DC-output EVSE and DC-output EVSE product configurations. These definitions are consistent with the definitions developed in the ENERGY STAR Final Draft Version 1.1 DC-output EVSE Test Method.

# 2 SCOPE

## 2.1 Included Products

2.1.1 Products that meet the definition for EVSE as specified herein are eligible for ENERGY STAR certification, with the exception of products listed in Section 2.2. In addition, eligible EVSE shall fall into one of the following categories:

i. Level 1 EVSE.

ii. Level 2 EVSE.

iii. Dual Input Level 1 and Level 2 EVSE.

iv. DC-output EVSE with output power less than or equal to 350 kW.

## 2.2 Excluded Products

2.2.1 Products that are covered under other ENERGY STAR product specifications are not eligible for certification under this specification. The list of specifications currently in effect can be found at www.energystar.gov/specifications.

2.2.2 The following products are not eligible for certification under this specification:

i. DC-output EVSE with power greater than 350 kW.

ii. Pantograph EVSE (chargers with an automated connection system, or ACS).

iii. Wireless/Inductive EVSE.

iv. Medium voltage AC input supply EVSE (13.2 kV).

v. Power electronic components inside the vehicle.

**Note:** EPA has updated the scope to include DC-output EVSE with power less than or equal to 350 kW and exclude DC-output EVSE with power greater than 350 kW, pantograph EVSE, and Medium voltage AC input supply EVSE (13.2 kV). The updated scope is consistent with the scope proposed in the Final Draft DC-output EVSE Test Method, with the exception of the exclusion of medium voltage products. A stakeholder asked if products intended to connect directly to a medium voltage supply (e.g., 13.2 kV) would be eligible for ENERGY STAR certification since only low voltage options are considered in the test method's Table 1: AC-input Supply Requirements. Since these products are much different than low voltage input products and would thus have differing test considerations and require alternate laboratory equipment, EPA is excluding them from scope.

# 3 CERTIFICATION CRITERIA

## 3.1 Significant Digits and Rounding

3.1.1 All calculations shall be carried out with actual measured (unrounded) values. Only the final result of a calculation shall be rounded.

3.1.2 Unless otherwise specified within this specification, compliance with specification limits shall be evaluated using exact values without any benefit from rounding.

3.1.3 Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the nearest significant digit as expressed in the corresponding specification limit.

## 3.2 General Requirements

3.2.1 Each EVSE submitted for ENERGY STAR certification shall be Listed by a Nationally Recognized Testing Laboratory (NRTL) for safety.

3.2.2 Dual Input Level 1 and Level 2 EVSE shall meet all requirements and report information in both configurations.

## 3.3 No Vehicle Mode Requirements for Level 1 and Level 2 EVSE

Note: These requirements refer to the SAE J1772 State A.

3.3.1 Measured No Vehicle Mode power ($P_{NO\_VEHICLE}$) for Level 1 and Level 2 EVSE shall be less than or equal to the Maximum No Vehicle Mode Power Requirement ($P_{NO\_VEHICLE\_MAX}$), as calculated per Equation 1, subject to the following requirements.

i. For products with ABC enabled by default, the average No Vehicle Mode power in high and low illuminance conditions shall be used in place of $P_{NO\_VEHICLE}$, above.

ii. For products capable of network connection with multiple protocols (e.g., Wi-Fi and Cellular), only the allowance for the protocol enabled during testing shall be claimed.

**Equation 1: Calculation of Maximum No Vehicle Mode Power Requirement**

$$P_{NO\_VEHICLE\_MAX} = 2.6 + P_{WAKE} + P_{DISPLAY}$$

*Where*:

- $P_{NO\_VEHICLE\_MAX}$ *is the Maximum No Vehicle Mode Power Requirement;*
- $P_{WAKE}$ *is the No Vehicle Mode power allowance for the network connection with wake capability enabled during testing listed in Table 2; and*

- *$P_{DISPLAY}$ is the No Vehicle Mode power allowance for a High-Resolution Display enabled during testing listed in Table 2.*

**Table 2: No Vehicle Mode Power Allowances**

| Product Function | No Vehicle Mode Power Allowance<br>(watts, rounded to the nearest 0.1 W for reporting) |
|---|---|
| In-use Wi-Fi or Ethernet Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$,<br>*Where:*<br>• *n* is the number of outputs. |
| In-use Cellular with Wake Capability *($P_{WAKE}$)* | $\frac{2.0}{n}$,<br>*Where:*<br>• *n* is the number of outputs. |
| Other In-use LAN (Local Area Network) Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$,<br>*Where:*<br>• *n* is the number of outputs. |
| In-use High Resolution Display ($P_{DISPLAY}$) | $[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]/_{n}$<br>*Where:*<br>• *A* is the Screen Area in square inches;<br>• *ℓ* is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 4) C) of the ENERGY STAR Test Method for Determining Electric Vehicle Supply Equipment Energy;<br>• *tanh* is the hyperbolic tangent function; and<br>• *n* is the number of outputs.<br><br>**Example**: For a single-output EVSE with a maximum measured luminance of 300 candelas/m$^2$ and a 5×5-inch screen, the allowance for the in-use display would be 2.7 watts. |

## 3.4 Partial On Mode Requirements for Level 1 and Level 2 EVSE

Note: These requirements refer to the SAE J1772 State B1 or State B2.

3.4.1 Measured Partial On Mode power ($P_{PARTIAL\_ON}$) for Level 1 and Level 2 EVSE shall be less than or equal to the Maximum Partial On Mode Power Requirement ($P_{PARTIAL\_ON\_MAX}$), as calculated per Equation 2, subject to the following requirements.

i. For products with ABC enabled by default, the average Partial On Mode power in high and low illuminance conditions shall be used in place of $P_{PARTIAL\_ON}$, above.

ii. For products capable of network connection with multiple protocols (e.g., Wi-Fi and Cellular), only the allowance for the protocol enabled during testing shall be claimed.

**Equation 2: Calculation of Maximum Partial On Mode Power Requirement**

$$P_{PARTIAL\_ON\_MAX} = 2.6 + P_{WAKE} + P_{DISPLAY}$$

*Where*:

- $P_{PARTIAL\_ON\_MAX}$ *is the Maximum Partial On Mode Power Requirement;*
- $P_{WAKE}$ *is the Partial On Mode power allowance for the network connection with wake capability enabled during testing listed in Table 3; and*
- $P_{DISPLAY}$ *is the Partial On Mode power allowance for a High-Resolution Display enabled during testing listed in Table 3.*

**Table 3: Partial On Mode Power Allowances**

| Product Function | Partial On Mode Power Allowance (watts, rounded to the nearest 0.1 W for reporting) |
|---|---|
| In-use Wi-Fi or Ethernet Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$, *Where:* • *n* is the number of outputs. |
| In-use Cellular with Wake Capability *($P_{WAKE}$)* | $\frac{2.0}{n}$, *Where:* • *n* is the number of outputs. |
| Other In-use LAN (Local Area Network) Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$, *Where:* • *n* is the number of outputs. |
| In-use High Resolution Display ($P_{DISPLAY}$) | $[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]/_{n}$ *Where:* • *A* is the Screen Area in square inches; • *ℓ* is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 4) C) of the ENERGY STAR Test Method for Determining Electric Vehicle Supply Equipment Energy; • *tanh* is the hyperbolic tangent function; and • *n* is the number of outputs. **Example**: For a single-output EVSE with a maximum measured luminance of 300 candelas/m$^2$ and a 5×5-inch screen, the allowance for the in-use display would be 2.7 watts. |

## 3.5 Idle Mode Requirements for Level 1 and Level 2 EVSE

Note: These requirements refer to the SAE J1772 State C.

3.5.1 Measured Idle Mode power ($P_{IDLE}$) for Level 1 and Level 2 EVSE shall be less than or equal to the Maximum Idle Mode Power Requirement ($P_{IDLE\_MAX}$), as calculated per Equation 3, subject to the following requirements.

i. For products with ABC enabled by default, the average Idle Mode power in high and low illuminance conditions shall be used in place of $P_{IDLE}$, above.

ii. For products capable of network connection with multiple protocols (e.g., Wi-Fi and Cellular), only the allowance for the protocol enabled during testing shall be claimed.

**Equation 3: Calculation of Maximum Idle Mode Power Requirement**

$$P_{IDLE\_MAX} = (0.4 \times Max\ Current) + 2.6 + P_{WAKE} + P_{DISPLAY}$$

*Where:*

- $P_{IDLE\_MAX}$ *is the Maximum Idle Mode Power Requirement, in watts;*
- *Max Current is the Nameplate Maximum Output Current, in amperes;*
- $P_{WAKE}$ *is the Idle Mode power allowance for the network connection with wake capability enabled during testing listed in Table 4; and*
- $P_{DISPLAY}$ *is the Idle Mode power allowance for a High-Resolution Display enabled during testing listed in Table 4.*

**Table 4: Idle Mode Power Allowances**

| Product Function | Idle Mode Power Allowance (watts, rounded to the nearest 0.1 W for reporting) |
|---|---|
| In-use Wi-Fi or Ethernet Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$, <br>*Where:*<br>• *n* is the number of outputs. |
| In-use Cellular with Wake Capability *($P_{WAKE}$)* | $\frac{2.0}{n}$, <br>*Where:*<br>• *n* is the number of outputs. |
| Other In-use LAN (Local Area Network) Interface with Wake Capability *($P_{WAKE}$)* | $\frac{1.0}{n}$, <br>*Where:*<br>• *n* is the number of outputs. |
| In-use High Resolution Display *($P_{DISPLAY}$)* | $[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]/_{n}$<br>*Where:*<br>• *A* is the Screen Area in square inches;<br>• *ℓ* is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 4) C) of the ENERGY STAR Test Method for Determining Electric Vehicle Supply Equipment Energy;<br>• *tanh* is the hyperbolic tangent function; and<br>• *n* is the number of outputs.<br><br>**Example**: For a single-output EVSE with a maximum measured luminance of 300 candelas/m$^2$ and a 5×5-inch screen, the allowance for the in-use display would be 2.7 watts. |

**Note:** EPA has made minor edits in sections 3.3, 3.4, and 3.5 to clarify that the requirements listed in these sections are specific to Level 1 and Level 2 EVSE. No changes have been made to the No Vehicle, Partial On, or Idle Mode requirements for Level 1 and Level 2 EVSE.

## 3.6 No Vehicle Mode Requirements for DC-output EVSE

Note: These requirements refer to SAE J1772 State A (No Vehicle Mode).

3.6.1 Measured No Vehicle Mode Power ($P_{NO\_VEHICLE}$) shall be less than or equal to the Maximum No Vehicle Mode Power ($P_{NO\_VEHICLE\_MAX}$) as calculated per Equation 4, subject to the following requirements.

i. For products with ABC enabled by default, the average No Vehicle Mode power in high and low illuminance conditions shall be used in place of $P_{NO\_VEHICLE}$, above.

ii. For Cabinet/Dispenser Configuration DC-output EVSE, No Vehicle Mode Power shall be tested and reported for the Minimum Dispenser Configuration.

**Equation 4: Calculation of Maximum No Vehicle Mode Requirement for DC-output EVSE**

$$P_{NO\_VEHICLE\_MAX} = (35.6 \times \ln(Max\ Power)) - 54.3 + P_{DISPLAY}$$

*Where*:

- $P_{NO\_VEHICLE\_MAX}$ *is the Maximum No Vehicle Mode Power Requirement, in watts;*
- *Max Power is the Nameplate Maximum Output Power, in kilowatts; and*
- $P_{DISPLAY}$ *is the No Vehicle Mode power allowance for a High-Resolution Display enabled during testing listed in Table 5.*

**Table 5: No Vehicle Mode Power Allowances for DC-output EVSE**

| Product Function | No Vehicle Mode Power Allowance (watts, rounded to the nearest 0.1 W for reporting) |
|---|---|
| In-use High Resolution Display (*$P_{DISPLAY}$*) | $[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]/n$<br>*Where:*<br>• *A* is the Screen Area in square inches;<br>• *ℓ* is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 4) C) of the ENERGY STAR Test Method for DC-output EVSE<br>• *tanh* is the hyperbolic tangent function; and<br>• *n* is the number of outputs.<br><br>**Example**: For a single-output EVSE with a maximum measured luminance of 300 candelas/m$^2$ and a 5×5-inch screen, the allowance for the in-use display would be 2.7 watts. |

**Note:** Based on preliminary data, EPA is proposing that the Maximum No Vehicle Mode Power Requirement be a logarithmic function of the nameplate maximum output current. EPA would appreciate stakeholder comments and the submission of additional data to support further refinement of this proposal as needed.

EPA currently only has sufficient data to justify a DC-output EVSE No Vehicle Mode power allowance for in-use High Resolution Displays. The allowance proposed is consistent with the criteria for Level 1 and Level 2 EVSE and based on the ENERGY STAR Displays requirements for Signage Displays. Stakeholders may notify EPA and provide relevant supporting data to request allowances for widely used product features that consume additional power in No Vehicle Mode.

EPA is proposing requiring that cabinet/dispenser DC-output EVSE meet the No Vehicle Mode requirements above when tested in the Minimum Dispenser Configuration. Testing in the minimum configuration is intended to minimize testing burden for cabinet/dispenser products to the extent possible. EPA expects that No Vehicle Mode power will, at most, scale linearly with the number of dispensers for these products, and thus testing the minimum configuration is expected to provide sufficient differentiation. Stakeholders are encouraged to provide feedback as to whether the proposed No Vehicle Mode requirements are appropriate for cabinet/dispenser products tested in the Minimum Dispenser Configuration. Comments are also welcome regarding the extent to which testing the minimum configuration is expected to be representative of configurations that are typically installed.

## 3.7 Partial On Mode Requirements for DC-output EVSE

Note: These requirements refer to SAE J1772 State B1 or B2 (Partial On Mode).

3.7.1 Partial On Mode Power ($P_{PARTIAL\_ON}$) for DC-output EVSE shall be less than or equal to the Maximum Partial On Mode Power ($P_{PARTIAL\_ON\_MAX}$) as calculated per Equation 5, subject to the following requirements.

i. For products with ABC enabled by default, the average Partial On Mode power in high and low illuminance conditions shall be used in place of $P_{PARTIAL\_ON}$, above.

ii. For Cabinet/Dispenser Configuration DC-output EVSE, Partial On Mode Power shall be tested and reported for the Minimum Dispenser Configuration.

**Equation 5: Calculation of Maximum Partial On Mode Requirement for DC-output EVSE**

$$P_{PARTIAL\_ON\_MAX} = (35.6 \times \ln(Max\ Power)) - 54.3 + P_{DISPLAY}$$

*Where*:

- $P_{PARTIAL\_ON\_MAX}$ *is the Maximum Partial On Mode Power Requirement, in watts;*
- *Max Current is the Nameplate Maximum Output Power, in kilowatts; and*
- $P_{DISPLAY}$ *is the Partial On Mode power allowance for a High-Resolution Display enabled during testing listed in Table 6.*

**Table 6: Partial On Mode Power Allowances for DC-output EVSE**

| Product Function | Partial On Mode Power Allowance<br>(watts, rounded to the nearest 0.1 W for reporting) |
|---|---|
| In-use High Resolution Display (*$P_{DISPLAY}$*) | $[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]/n$<br>*Where:*<br>• *A* is the Screen Area in square inches;<br>• *ℓ* is the Maximum Measured Luminance of the Display in candelas per square meter, as measured in Section 4) C) of the ENERGY STAR Test Method for DC-output EVSE;<br>• *tanh* is the hyperbolic tangent function; and<br>• *n* is the number of outputs.<br><br>**Example**: For a single-output EVSE with a maximum measured luminance of 300 candelas/m$^2$ and a 5×5-inch screen, the allowance for the in-use display would be 2.7 watts. |

**Note:** The proposed Partial On Mode requirements above are identical to the No Vehicle Mode requirements in Section 3.6. As noted regarding the proposed No Vehicle Mode requirements, stakeholders are encouraged to submit feedback on the maximum Partial On Mode requirement, allowances needed for additional product features in high demand, and whether the requirements are appropriate for cabinet/dispenser products tested in the Minimum Dispenser Configuration.

## 3.8 Operation Mode Requirements for DC-output EVSE

3.8.1 Average loading-adjusted efficiency ($Eff_{AVG}$) for DC-output EVSE with output power less than or equal to 65 kW, as calculated per Equation 7, shall be greater than or equal to the Minimum Average Efficiency ($Eff_{AVG\_MIN}$) in Table 7. The average loading-adjusted efficiency for DC-output EVSE with output power greater than 65 kW shall be reported.

i. For cabinet/dispenser configuration DC-output EVSE, average loading-adjusted efficiency shall be tested and reported for the Minimum Dispenser Configuration.

3.8.2 The efficiency at each loading condition ($Eff_i$) shall be calculated per Equation 6.

**Equation 6: Calculation of Efficiency at Loading Condition *i***

$$Eff_i = 0.15 \times Eff_{i,20F} + 0.75 \times Eff_{i,68F} + 0.10 \times Eff_{i,104F}$$

*Where:*

- *$Eff_{i,20F}$ is the recorded efficiency at loading condition i at the 20°F ambient test temperature.*
- *$Eff_{i,68F}$ is the recorded efficiency at loading condition i at the 68°F ambient test temperature.*
- *$Eff_{i,104F}$ is the recorded efficiency at loading condition I at the 104°F ambient test temperature.*

**Note:** To develop the weighting factors above, EPA analyzed typical meteorological year weather data (TMY3) for a total of six cities comprising one city in each Building America climate zone. EPA would welcome suggestions as to alternate approaches to develop appropriate weighting factors based on representative temperature conditions across the U.S.

3.8.3 The average loading-adjusted efficiency ($Eff_{AVG}$) shall be calculated per Equation 7.

**Equation 7: Calculation of Average Loading-Adjusted Efficiency**

$$Eff_{AVG} = 0.02 \times Eff_{25\%} + 0.11 \times Eff_{50\%} + 0.09 \times Eff_{75\%} + 0.78 \times Eff_{100\%}$$

*Where:*

- *$Eff_{25\%}$ is the efficiency at the 25% loading condition (Loading Condition 1 per Table 3 of the ENERGY STAR Test Method), expressed as an integer from 0 to 1, calculated per Equation 6;*
- *$Eff_{50\%}$ is the efficiency at the 50% loading condition (Loading Condition 2 per Table 3 of the ENERGY STAR Test Method), expressed as an integer from 0 to 1, calculated per Equation 6;*
- *$Eff_{75\%}$ is the efficiency at the 75% loading condition (Loading Condition 3 per Table 3 of the ENERGY STAR Test Method), expressed as an integer from 0 to 1, calculated per Equation 6; and*
- *$Eff_{100\%}$ is the efficiency at the 100% loading condition (Loading Condition 6 per Table 3 of the ENERGY STAR Test Method), expressed as an integer from 0 to 1, calculated per Equation 6.*

**Table 7: Minimum Average Loading-Adjusted Efficiency requirement for DC-output EVSE with**

**output power ≤ 65 kW**

| Minimum Average Efficiency ($Eff_{AVG\_MIN}$) |
|---|
| 0.93 |

**Note:** EPA analyzed charging profiles of multiple popular electric vehicle models to develop the loading condition weighting factors in Equation 7. EPA seeks comment on this proposal and stakeholders are encouraged to provide additional data regarding typical duty cycles of DC-output EVSE with output power below 65 kW.

EPA is proposing a minimum Average Loading-Adjusted Efficiency requirement of 0.93 for DC-output EVSE with output power at or below 65 kW. Based on data EPA has received from stakeholders and per a review of product specification sheets, this corresponds with a market pass rate of approximately 80%. EPA understands that the market for DC-output EVSE is growing rapidly and believes that this requirement will balance the need to set achievable goals for nascent products while guaranteeing significant energy savings and encouraging efficient product design in current and future DC-output EVSE.

## 3.9 Additional Reporting Requirements

3.9.1 Report the measured Idle Mode Power for DC-output EVSE per the ENERGY STAR DC-output EVSE Test Method.

**Note:** EPA currently does not have sufficient data to set Idle Mode requirements for DC-output EVSE and is accordingly proposing requiring that this information be reported.

## 3.10 Connected Functionality

This section includes connected criteria for ENERGY STAR certified EVSE. Compliance with this section is optional. EVSE that comply with all connected criteria will be identified on the ENERGY STAR website as having 'Connected' functionality. EPA does not have a test method for compliance to this section. At this time, EPA intends compliance with this criterion be confirmed through documentation with the certification body.

**Note**: At this time, EPA intends compliance with this criterion to be confirmed through documentation with a certification body, rather than with a test procedure. For instance, this might include annotated product manuals, a record of product examination, etc. However, EPA is interested in stakeholder comments regarding whether having testing would make the criteria significantly more useful, i.e. would programs be able to rely on it in the absence of a test? Furthermore, EPA would like to know if having a test procedure to validate these criteria would make the criteria prohibitive for manufacturers to pursue (in terms of testing burden).

Note: EPA recommends that, once DR capability is added, the EVSE be capable of directly or indirectly supporting both signals-based DR, as well as price response. As appropriate, EPA further encourages connected functionality that enables direct control by the Load Management Authority as well as integration with commercial EVSE management applications and/or energy management systems. Brand owners are encouraged to engage with utilities to ensure DR capabilities align with utility needs and DR program designs.

**Note**: The connected criteria proposed in this section are designed with long dwell time applications in mind, as EPA's understanding is that these provide the most load flexible resource. EPA considered limiting connected recognition to lower-power EVSE which are more likely to be used in long dwell time applications, but ultimately decided not to limit them. Stakeholder feedback is welcome.

A. <u>Communications</u>:

3.10.1 Grid Communications: The product shall include a communication link that is capable of bi-directional data transfer between the EVSE and one or more external applications, devices or systems. This link shall use open standards, as defined in this specification, for all communication layers.

Note: The communication device(s), link(s) and/or processing that enables Open Standards-based communication between the EVSE and external application / device / system(s) either individually or together, could be within the EVSE, and/or an external communication module, a hub/gateway, or in the Internet/cloud.

i. Products that include a communication link that uses Open Charge Point Protocol (OCPP) also comply with this criterion.

Note: Effective November 24, 2015 OCPP is being developed by Open Charge Alliance as the Standard Development Organization with a goal of integrating OCPP with the International Electrotechnical Commission (IEC) framework[9]. EPA is proposing to include OCPP since it is widely used and is in the process of being established as an open standard.

ii. In the absence of OCPP, the EVSE shall meet the communication and equipment performance standards for SEP 2.0, CTA-2045A, and/or OpenADR 2.0.

iii. It is mandatory to report whether the EVSE complies with ISO 15118.

3.10.2 Open Access: To enable interconnection with the product over the communication link, an interface specification, application programming interface (API) or similar documentation that is intended to enable DR functionality shall be made readily available.

Note: Products that enable direct, on-premises, open-standards based interconnection are preferred, but alternative approaches, where open-standards connectivity is enabled only with use of off-premise services, are also acceptable.

B. Connected EVSE Product Requirements:

The following capabilities shall be enabled through the EVSE. The EVSE product shall maintain these capabilities through subsequent software and firmware changes.

3.10.3 Scheduling: The EVSE must provide ability for consumers to set and modify a schedule.

3.10.4 Remote Management: The product shall be capable of receiving and responding to consumer authorized remote requests (not including third-party remote management which may be made available solely at the discretion of the manufacturer), via a communication link, similar to consumer controllable functions on the product.

3.10.5 Consumer Feedback: The EVSE shall be capable of providing at least two types of messages relevant to optimizing its energy consumption, either:

[9] http://www.openchargealliance.org/news/announcement/

i. In the car, on the product (e.g. EVSE display), control application (e.g., app on smartphone), and/or

ii. Transmitted to consumers and consumer authorized third parties via a communication link. This link can include open standards protocols used for Demand Response or could use a secondary communication link.

3.10.6 Consumer Override: The vehicle, EVSE, or consumer may override the EVSE’s response to a DR request or override any current or scheduled events to preserve safety or user experience. The consumer shall be able to override the EVSE’s response to a DR request via the EVSE, its control application (e.g., app on smartphone), or via the vehicle user interface. If an override occurs, the EVSE shall send a message to the load management entity via the open standards protocols used for Demand Response.

3.10.7 Loss of Connectivity: A ‘loss of connectivity’ event is defined as 5 consecutive polling events from the DRMS not responded to by the EVSE, or vice versa.

Note**:** DR program implementation may set the polling time interval, so the elapsed time for a ‘loss of connectivity’ event may vary.

i. If a ‘loss of connectivity’ event occurs while processing a DR event with a set duration or end time, product may complete the DR event as planned, returning to normal operation as set by the customer afterwards, or if over-ridden.

ii. If a ‘loss of connectivity’ event occurs while processing a DR event without a set duration or end time, product will resume normal operation within 30 minutes.

**Note:** EPA proposes defining loss of connectivity in terms of missed polling events, providing clarity for design and testing. In addition, EPA proposes that when disconnected, EVSE may complete DR events that have planned end times and allows them to delay stopping events without end times. EPA seeks feedback from stakeholders on this proposal.

C. DR Requests and Responses:

The EVSE shall support the following open standard defined DR signals.

3.10.8 Operational Mode Functionality:

- **Charge now (Load Up):** If a vehicle is plugged in and it is not fully charged, EVSE will begin charging the vehicle, continuing as normal until the vehicle is fully charged. For use in a case where the scheduling of charging occurs outside of the product, the EVSE service provider has no control over the charging schedule. Both immediate events and events scheduled in advance will be supported.
- **Curtail Charge:** The EVSE will not begin or continue charging at greater than 50% of its maximum rated output power. Both immediate events and events scheduled in advance will be supported.
- **Delay Charge:** The EVSE will not begin or continue charging. Both immediate events and events scheduled in advance will be supported.
- **Return to Normal Operation:** The EVSE will return to default standby mode.

**Note:** EPA would like to request feedback from stakeholders if these DR signals are appropriate for the long dwell time use cases, as previously mentioned. In addition to this, EPA would also like to continue discussion with stakeholders to determine the appropriate percentage level of the maximum rated output power to restrict curtailed charge signal. EPA understands that EVSE may also schedule charge based on grid signals, such as a time of use pricing plan. EPA believes that the commands above make sense in cases where it isn't the EV service provider manages responses. EPA proposes requiring these capabilities for use cases where they will be needed. These correspond to commands usually characterized as "load up", "general curtailment", and "critical curtailment", respectively. The connected criteria for many ENERGY STAR product types include specifications of the expected duration that events may last, and the number of events per day the product shall provide. If stakeholders think such definition would be useful, please let EPA know.

# 4 TESTING

## 4.1 Test Methods

4.1.1 Test methods identified in Table 8 shall be used to determine certification for ENERGY STAR.

**Table 8: Test Methods for ENERGY STAR Certification**

| Product Type | Test Method |
|---|---|
| Level 1 and Level 2 Electric Vehicle Supply Equipment | ENERGY STAR Level 1 and Level 2 Electric Vehicle Supply Equipment Test Method (Rev. Apr-2017) |
| DC-output Electric Vehicle Supply Equipment | ENERGY STAR DC-output Electric Vehicle Supply Equipment Test Method |
| Electric Vehicle Supply Equipment with Display | ENERGY STAR Displays Test Method (Rev. Sep-2015) |
| Electric Vehicle Supply Equipment with Full Network Connectivity | Section 6.7.5.2 of Consumer Electronics Association (CEA) 2037-A, Determination of Television Set Power Consumption |

**Note:** EPA has added the DC-output EVSE Test Method to the table above and updated the title of the Level 1 and Level 2 EVSE Test Method to reflect that it applies only to Level 1 and Level 2 equipment. When the Version 1.1 specification is finalized, EPA anticipates making minor updates to the Level 1 and Level 2 EVSE Test Method to clarify that it is applicable only to a subset of the equipment types which are eligible to be certified to ENERGY STAR.

## 4.2 Number of Units Required for Testing

4.2.1 Representative Models shall be selected for testing per the following requirements:

i. For certification of an individual product model, the Representative Model shall be equivalent to that which is intended to be marketed and labeled as ENERGY STAR.

ii. For certification of a Product Family, the highest energy using model within that Product Family can be tested and serve as the Representative Model. Any subsequent testing failures (e.g., as part of verification testing) of any model in the family will have implications for all models in the family.

4.2.2 A single unit of each Representative Model shall be selected for testing.

4.2.3 All units/configurations for which a Partner is seeking ENERGY STAR certification, must meet the ENERGY STAR requirements. However, for DC-output EVSE only, if a Partner wishes to certify configurations of a model for which non-ENERGY STAR certified alternative configurations exist, the Partner must assign the certified configurations an identifier in the model name/number that is unique to ENERGY STAR certified configurations. This identifier must be used consistently in association with the certified configurations in marketing/sales materials and on the ENERGY STAR list of certified products (e.g. model A1234 for baseline configurations and A1234-ES for ENERGY STAR certified configurations).

Note: There may be cases—as described in the paragraph above—where not all units/configurations will meet ENERGY STAR requirements. If so, the worst-case configuration for test will be the worst-case certified configuration, and not one of the presumably even higher-energy consuming non-certified configurations.

**Note:** EPA is aware that EVSE manufacturers may offer a variety of configurations within a manufacturer model family and that, in certain cases, some of these configurations may not meet the ENERGY STAR criteria. EPA is adding the model number identification requirement above to assist consumers and utilities in identifying configurations that are ENERGY STAR certified. EPA would appreciate feedback as to whether this proposal will be sufficient to identify ENERGY STAR models, whether any modifications are necessary, and the feasibility of implementing unique model number identifiers for ENERGY STAR certified configurations.

### 4.3 International Market Certification

4.3.1 Products shall be tested for certification at the relevant input voltage/frequency combination for each market in which they will be sold and promoted as ENERGY STAR.

## 5 EFFECTIVE DATE

5.1.1 Effective Date: The ENERGY STAR Electric Vehicle Supply Equipment specification shall take effect December 27, 2016. To certify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on the model's date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.

**Note:** This Version 1.1 specification will be effective upon finalization. This amendment does not affect the certification of current ENERGY STAR products.

5.1.2 <u>Future Specification Revisions</u>: EPA reserves the right to change this specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through stakeholder discussions. In the event of a specification revision, please note that the ENERGY STAR certification is not automatically granted for the life of a product model. Considerations for future revisions include:

i. EPA will continue to monitor the market for wireless EVSE and evaluate the opportunity to differentiate such products based on energy performance. Should the potential for significant energy savings exist among these products, EPA will consider expanding the scope of this EVSE specification to include them in a future revision.

ii. EPA will consider including operation mode criteria for DC-output EVSE with a rated output greater than 65 kW in the future when data is more readily available.

iii. EPA will assess the power draw associated with different network protocols to determine if it may be necessary to test all connections in the future. In addition, EPA will consider how to appropriately encourage the powering down of certain features (e.g., network connectivity, in-use display) to a lower power state when there is no user activity. For DC-output EVSE, this includes the amount of time spent in Idle Mode before and after a charging session.

**Note:** EPA is considering either setting a requirement for or requiring reporting of the amount of time a unit spends in Idle Mode in a typical charge cycle in future versions. EPA would appreciate stakeholder feedback on this topic.

iv. EPA will consider amending the test method for Level 1 and Level 2 models with ABC enabled by default to require illuminance conditions greater than 300 lux that would better represent typical outdoor conditions.

# APPENDIX A: DEMAND RESPONSE MESSAGE MAPPING

This Appendix is informational only. It provides a useful framework for aligning the requirements in section 3.10 B and the signals identified in section 3.10.8 with the CTA 2045-A, OpenADR 2.0b, and OCPP operational states. Not every response listed below may be required.

**Note:** EPA has added Appendix A and the additional table below to provide stakeholders with additional guidance and clarity regarding the connected signals and device properties.

| Category | Sub-type | Demand Response Messaging | Response Result | ANSI/CTA (2045-A) | OpenADR (2.0b) | OCPP |
|---|---|---|---|---|---|---|
| Signals | Curtail Charge | **General Curtailment** | Don't begin or continue charging above 50% rated output power | Shed [10] | oadrDistributeEvent: CHARGE_STATE.[11] | SetChargingProfile[12] |
| | Charge Now | **Load Up** | Begin charging immediately (if possible) | End device should run and continue as possible without wasting energy. Opposite of Shed [10] | oadrDistributeEvent: LOAD_DISPATCH. | ReserveNow [12] |
| | Run Normal | **Return to Normal Operation** | Return to Standby mode | End Shed / Run Normal [10] | oadrDistributeEvent: CANCELLED. | Reset[12] |
| | Delay Charge | **Delay Charge** | Delay charging | Pending Event Time | oadrDistributeEvent: LOAD_CONTROL. | NotifyEventRequest[12] |
| | | **Off Mode** | Turn off (if possible) | Grid Emergency | oadrDistributeEvent: SIMPLE level 3. | CancelReservation[12] |

[10] CTA Reference {CTA 2045-A: Table 8-2}
[11] ADR Reference {Section 8.1, OpenADR 2.0b EiEvent Service; Figures 4 & 5, EiEvent Patterns; Section 8.2.2, OpenADR 2.0b Signal Definitions; Table 1, Signals }
[12] OCPP Reference {Section Messages, OCPP 2.0.1- Open Charge Alliance. 2019; Part 2- Specification}

| | | | | | | |
|---|---|---|---|---|---|---|
| | Real Time / Device Logic | **Real Time System Load** | Use / do not use energy when appropriate (follow programming) | Request for Power Level [8.2.1] | | GetChargingProfiles [12] |
| | | **Utility Peak Load Price Signal** | | Present Relative Price, 9.1.3 | oadrDistributeEvent: ELECTRICITY_PRICE. | CostUpdated [12] |
| | | **Excess Capacity (DER)** | | Grid Guidance | | |
| **Device Properties & Enrollment** | Opt Out | **Consumer Override** | End user device follows user inputs when overridden | Part of Operational State Query/ Response when overridden or in receipt of load reduction message [10] | oadrCreateOpt: device sends upstream opt message.[13] | ChangeAvailability [12] |
| | Dev. Info | **Device Information** | Indicates all mandatory information in Get Info payload | Device Information Request | Ei:eiTargetType (endDeviceAsset) | GetLog |
| | Status | **State Reporting Requirements** | Provide state information to requestor | Operational State Query (8.2.4) | EiReport. oadrPayloadResourceStatus | GetMonitoringReport |
| **Device Energy** | Energy | **Power (Instantaneous)** | Demand of product (W) | GetCommodity Read, code 0 | oadrPayloadResourceStatus: energyReal | MeterValues |
| | | **Energy (Cumulative)** | Energy used by product (kWh) | GetCommodity Read, code 0 | oadrPayloadResourceStatus: energyReal | |

[13] ADR Reference {Section 8.5, OpenADR 2.0b EiOpt Service; Figure 17, Interaction Diagram: Create Opt}

# Informational Appendix – EVSE Communication

Managed charging has many benefits if used in the right way. These benefits include increased savings, improved efficiency, and renewable integration. There are different entities involved in the managed charging infrastructure. These include the following:

1. Utility
2. Smart Meter
3. Network Service Provider/ Aggregators
4. Electric Vehicle Supply Equipment
5. Electric Vehicle

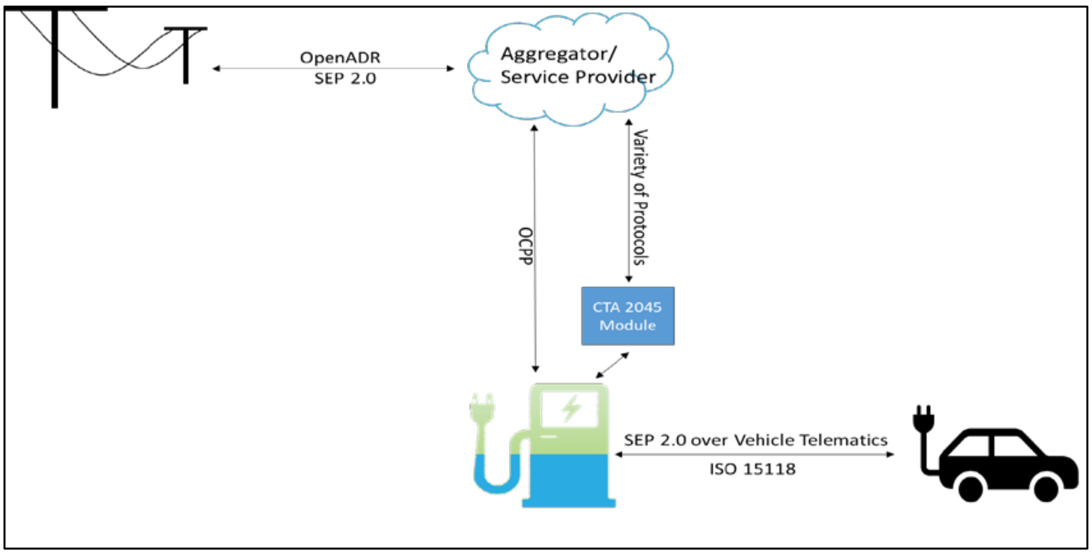



**Figure 1: Open Protocols based EV Charging Example Architecture**

The managed charging infrastructure involves communication between different entities and requires the use of a combination communication protocols. These include both application layer protocols (also referred to as the messaging protocols) and transport layer protocols. The main function of messaging protocols is to carry specific instructions to the individual entities but are independent of how they're carried. An example of a messaging protocol is: 'Charge only if the battery State of Charge (SOC) drops below 50%'. On the contrary, transport layer protocols ensure the delivery of a message from one point to another over a specific medium such as cellular or internet. Some standards include both application as well as transport layer protocols.

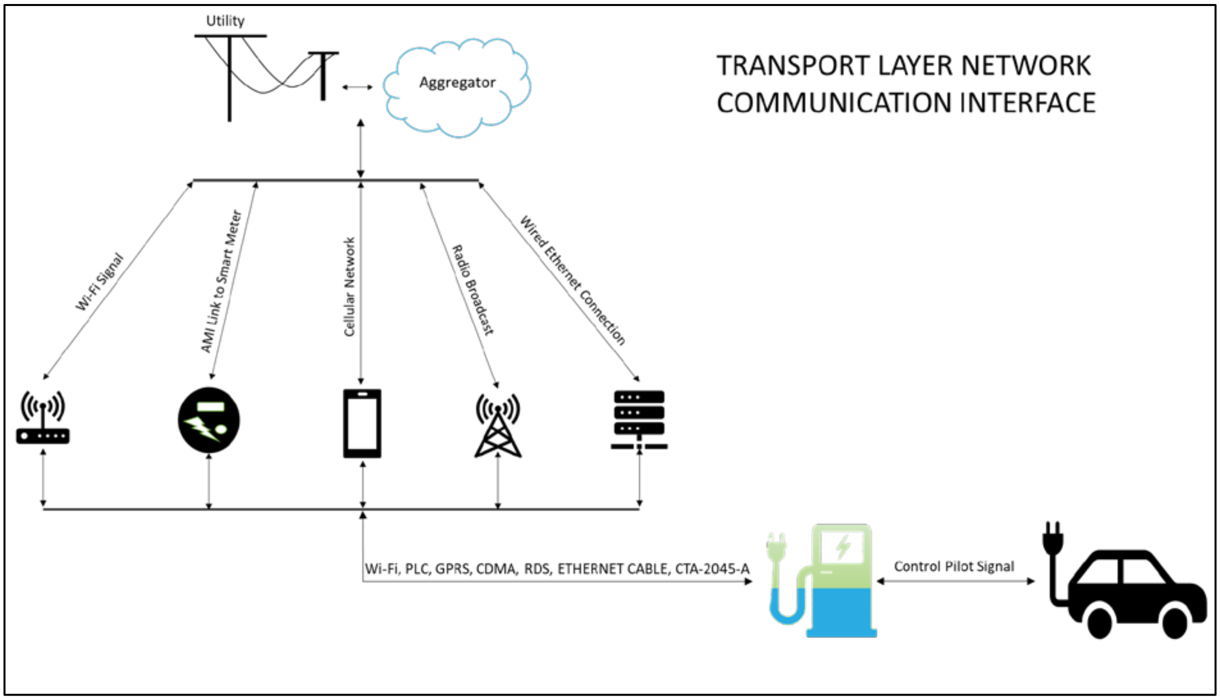



**Figure 2: EV Charging Infrastructure Network Communication Interface Options**

There are multiple options for transport and messaging layers, covering various links in the communication chain. Many options overlap, having both transport and messaging layer standards, and potentially covering more than one link.

Transport layer communication can be conducted via either a wired or wireless medium. The different transport layer protocols in the Managed Charging infrastructure include the following:

1. Ethernet
2. WiFi
3. Power Line Carrier (Zigbee or HomePlug Green PHY)
4. AMI
5. Mobile Communication (GSM, CDMA, GPRS)
6. Radio Data Systems (RDS)

Messaging protocols can be proprietary or open standard based. EPA requires the use of open standards-based communication. However, the messaging protocols are specific to communication between entities and vary depending on the domain. It is possible to pair several communication protocols to achieve desired results.

Note that managed charging is a balance between grid needs and the needs of the vehicle operator. In general, the utility or aggregator will have the best understanding of grid needs, while the vehicle or EVSE service provider will have the best understanding of how much charge the vehicle needs, and how soon. The optimal balance of these needs can be found if there is a single entity with both pieces of information. For this to occur, either the charger and vehicle need to use a rich communication protocol such as ISO 15118, or information will need to be transferred between the utility/aggregator and an EV service provider that has information from the vehicle. The CTA-2045-A module can either contain an OpenADR 2.0 VEN, or not making it possible to use different protocols in parallel to achieve managed charging. Some communications between the EVSE and Utility or the aggregator could include CTA-2045-A for a part of its transport and messaging layers.

**CTA-2045-A:** CTA-2045-A identifies the physical and data-link characteristics of the interface, along with certain higher-layer and application layer elements as needed to assure interoperability over a broad range of device capabilities.[14] Defines the communication between an end use device and a module which plugs into a physical port on the device. The module may support a variety of transport and application layer protocols. This allows EVSE manufacturers to supply a port rather than an end-to-end solution, and utilities to be entirely in control of the infrastructure for communications from the home to their DRMS, using their choice of communications protocol – or several.

The table below shows some of the open standard messaging protocols that can be used between different entities. Please note that this table is for representative purposes only. EPA encourages the use of different architectures for enhanced savings.

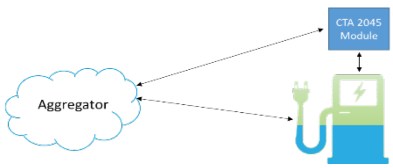
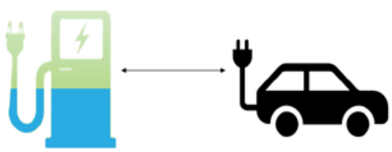
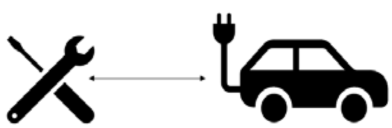
| | |
|---|---|
|   | 1. SEP 2.0 (IEEE 2030.5)<br>2. OCPP 1.6, 2.0<br>3. OpenADR 2.0*<br>4. CTA-2045-A*<br>*Used for Managed Charging Particularly |
|  | 1. ISO/ IEC 15118<br>2. SEP 2.0 (IEEE 2030.5) |
|  | 1. Vehicle Telematics (Proprietary Protocol)<br>2. SEP 2.0 (IEEE 2030.5) |

**Table 1: Open Standards Protocols for Managed EV Charging**

The different open standards protocols are as follows:

1. **OCPP 1.6, 2.0**: The Open Charge Alliance developed the OCPP protocol to foster global development, adoption, and compliance of communication protocols in the EV charging infrastructure. It is used for effective communication between the EVSE and the Aggregator. It includes Smart Charging support for load balancing and use of charging profiles. Compared to the version 1.6 there are significant updates to version 2.0 including Device management, Improved transaction handling, support for ISO 15118 among many others.[15] OCPP is often used for financial transactions involved in charging, and for that reason is already included in many chargers located in public spaces, and some in private homes as well.
2. **OpenADR 2.0**: OpenADR is an open, highly secure and two-way information exchange model and global Smart Grid standard. The OpenADR Alliance manages the Open Automated Demand Response for communication between Virtual top nodes and the Virtual end nodes over the IP network. It helps organizations all over the world standardize DR and DER communications and processes.[16] OpenADR only covers the application layer and therefore does not by itself fully define

[14] Consumer Technology Association, https://standards.cta.tech/apps/group_public/project/details.php?project_id=192
[15] Open Charge Alliance, https://www.openchargealliance.org/
[16] openADR Alliance, https://www.openadr.org/overview

an open protocol-based DR architecture. Virtual top nodes and virtual end nodes can be in the cloud or located in specific devices.

3. **IEEE 2030.5 or SEP 2.0**: Application layer protocol that defines messages between any client/server. Includes support for demand response, distributed energy resource (DER), metering, pricing, client authentication/authorization and other related applications. Default protocol for California Rule 21 DER communications. Protocol utilized for SAE J2847 AC messaging between EVSE and EV.[17]
4. **ISO/ IEC 15118**: ISO 15118 specifies the communication between Electric Vehicles, including Battery Electric Vehicles and Plug-In Hybrid Electric Vehicles, and the Electric Vehicle Supply Equipment. Includes support for EV authentication/authorization (Plug and Charge), metering and pricing messages. Protocol utilized for SAE J2847 DC messaging.**Error! Bookmark not defined.** Widely adopted in Europe, it is not yet commonplace in the US but is included in the future plans of many vehicle and charger manufacturers for the US market.
5. **Vehicle Telematics**: Many vehicles that are available in the market today have onboard diagnostics and telematics systems with connected capabilities allowing managed charging depending on the grid load. Many vehicles have on board battery management systems allowing the vehicle owner to align with time-of-use charging or other EV rates.[18]

[17] CPUC Vehicle Grid Integration Communications Protocol Working Group VGI Glossary of Terms, https://www.cpuc.ca.gov/vgi/

[18] Smart Electric Power Alliance, A Comprehensive Guide to Electric Vehicle Managed Charging, https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/