33rd Electric Vehicle Symposium (EVS33)
Portland, Oregon, June 14 - 17, 2020

Plugging Energy Efficiency into North American EV Charging Infrastructure

Peter Banwell[1], Stacy Noblet[2]

[1] *United States Environmental Protection Agency, 1201 Constitution Ave, Washington, D.C. 20004. banwell.peter@epa.gov*

[2] *ICF. 1725 Eye (I) Street NW, Suite 1000, Washington, DC 20006. stacy.noblet@icf.com*

Summary

The U.S. Environmental Protection Agency (EPA) ENERGY STAR® program has advanced energy efficiency since 1992 by making it easy to identify and purchase certified products. Beginning in 2015, the program developed an alternating current electric vehicle supply equipment (EVSE) specification with the goals of reducing electricity waste, increasing the use of open communication protocols, and ensuring the use of safety-certified equipment. In 2018, EPA began to revise the specification to include direct current EVSE.

This paper explores the process leading up to and following the launch of the ENERGY STAR EVSE specification. It explores lessons learned in early partnerships with stakeholders to incorporate the specification into policies and planning, while maximizing energy efficiency.

Keywords: efficiency, electric vehicle supply equipment (EVSE), DC Fast Charging, Level 1, Level 2

1 The Need for Energy Efficiency and Safety Requirements in EVSE

Electric vehicles (EVs) present an opportunity to substantially reduce transportation costs and related air emissions, but this transition from liquid fuels to electrons will come with an increase in electricity use. According to the National Renewable Energy Laboratory, future growth in annual electricity consumption will be driven primarily by increased transportation electrification [1]. Beginning in 2015, the U.S. Environmental Protection Agency's (EPA) ENERGY STAR program researched and then developed a specification for electric vehicle supply equipment (EVSE), motivated by its mission to promote energy efficiency, an understanding that the rise in EV use would mean a growing electrical load, and its recognition of the power of the ENERGY STAR label in consumer purchasing decisions. The specification for alternating current (AC) power EVSE included criteria to limit power consumption during standby (i.e., when the EVSE is not actively charging). The ENERGY STAR program also heard from the transportation electrification industry about concerns for safety and the move towards Demand Response capability. Thus, the current specification incorporates safety certification and the promotion of Demand Response capable products using open communications protocols.

In conjunction with the specification launch in late 2016, EPA began to implement a marketing and outreach plan that targeted EVSE manufacturers and network providers, state agencies, electric utilities, non-profits, automobile manufacturers, and major EVSE purchasers. The goal of the outreach was to increase awareness and understanding of the existing ENERGY STAR EVSE specification and gather feedback on program improvements to inform future versions of the specification. Some stakeholders indicated that a broader product mix would better serve the industry's needs. In response, EPA began to develop a revised ENERGY STAR specification that is inclusive of direct current (DC) output EVSE, including DC fast chargers.

1.1 The ENERGY STAR Program

ENERGY STAR® is the government-backed symbol for energy efficiency. It is recognized by over 90 percent of Americans nationwide [2]. Products that earn the ENERGY STAR prevent greenhouse gas emissions by meeting strict energy efficiency guidelines. Approximately 15,000 private and public sector organizations voluntarily partner with ENERGY STAR, and more than 2,000 manufacturers currently participate in the program qualifying over 60,000 product models across more than 75 product categories. Since its inception in 1992, 6 billion ENERGY STAR certified products have been sold. Moreover, nearly 700 utilities and other energy efficiency program sponsors, servicing over 95 percent of U.S. households in 50 states, leverage ENERGY STAR to deliver greater energy efficiency.

Consistent with the commitment to help consumers save money and reduce their environmental impact, EPA seeks to expand the ENERGY STAR program as new opportunities arise. In assessing the suitability of new products for inclusion in the ENERGY STAR program and establishing ENERGY STAR product performance specifications, EPA considers a set of well-tested program principles. In consideration of these principles, EPA ensures that product categories proposed for inclusion in the ENERGY STAR portfolio will yield significant energy savings on a national basis. EPA pursues products where product energy consumption and performance can be measured and verified with testing, and when establishing eligibility criteria, EPA proposes levels that maintain product performance such that performance is not traded for efficiency. Additionally, EPA sets specifications so that if there is a cost differential for the consumer at time of purchase, that cost is recovered through utility bill savings, within the life of the product. EPA invites stakeholders to comment on the feasibility and benefit of including these features in ENERGY STAR product specifications.

1.1.1 Process for Developing an EVSE Specification and Test Method

Prior to developing the EVSE specification, to ensure that products could be tested uniformly, EPA investigated whether a test method to measure energy efficiency related to EV charging existed. For both AC and DC charging stations, there was no existing industry test method to measure energy efficiency of the EVSE alone. As a result, EPA needed to develop an appropriate, repeatable, and accurate method of measuring energy efficiency for products prior to developing the rest of the program requirements. Establishing a test method enables purchasers to more easily compare products and can lead to the design of future generations of efficient products.

EPA drafted a test method for Level 1 (120 volt) and Level 2 (208-240 volt) AC EVSE in collaboration with the Department of Energy's Idaho National Laboratory, Argonne National Laboratory, and Lawrence Berkeley National Laboratory beginning in 2015. These partners brought expertise in developing standards related to EVSE and in improving the efficiency of devices in a low-power, network-connected state. EPA began development of the test method for DC charging stations in May 2018 and has collaborated closely with industry to develop a fair, accurate, and repeatable test procedure.

During the development of these test methods, EPA frequently sought feedback from stakeholders and, to the extent possible, harmonized requirements with existing internationally accepted standards pertaining to EVSE. The test method includes detailed information about confirming the availability of potential energy savings features, such as automatic dimming of a high-resolution display incorporated into the product. Once a test method is close to finalization, EPA begins to work with stakeholders to assemble test data for the commercially available products. Those data are the basis for proposing energy efficiency criteria during the specification development process.

During the development of the AC EVSE specification, stakeholders commented that products with no safety certifications were (and are still) being sold through major retailers [3]. As a result, EPA required that all products that seek ENERGY STAR certified be listed for safety by a Nationally Recognized Testing Laboratory (NRTL). Other issues, such as power consumption adjustments for network connectivity, were also addressed and accounted for in the final specification. For energy efficiency levels, EPA relied on a data set of existing products on the market and found that there was a 10x difference in energy losses during standby and no vehicle modes. At the time, since there was no focus in this area, manufacturers reported that they had not been concerned with energy efficiency during the product design process. After consideration, EPA chose to set the specification requirements at the efficient end of the spectrum, based on the logic that most products could meet a low standby power requirement over time, if the products were well designed. This decision delayed program growth, since there were very limited efficient models on the market at the program launch, but has proven to be an achievable specification and performance level for manufacturers over time.

The Version 1.0 AC EVSE specification took effect in December 2016. The Final Version 1.0 specification establishes power consumption requirements for Level 1, Level 2, and dual Level 1/Level 2 EVSE in No Vehicle, Partial On, and Idle Modes. It provides allowances for network connectivity and high-resolution displays to capture top performing EVSE with added features and functionality that may be preferred by some consumers. The specification also establishes basic criteria for certified EV chargers capable of supporting Demand Response that are seeking to be listed as ‘connected’ on the ENERGY STAR product finder. EPA plans to consider criteria for standby modes, as well as efficiency during charging for DC EVSE in the forthcoming Version 1.1 specification.

Under the current ENERGY STAR efficiency requirements for Level 1 and Level 2 EVSE, savings from ENERGY STAR certified stations will grow to more than $17 million or 62 gigawatt-hours, with the potential to prevent more than 280 million pounds of greenhouse gas emissions, equivalent to the emissions from more than 26,000 gas powered vehicles. EPA also expects significant savings to result from the Version 1.1 DC EVSE specification; a 50-kilowatt (kW) DC fast charging station with a 10 percent utilization and 92 percent active charging efficiency would have an estimated 3.8 megawatt-hours per year of operation mode losses alone. By comparison, a typical full-size ENERGY STAR refrigerator uses about 425 kilowatt-hours (kWh) per year. [4]

2 ENERGY STAR Program Requirements for Electric Vehicle Supply Equipment

In the process of developing test methods and specifications, EPA relies on existing data and industry practices whenever possible. The Level 1 and Level 2 definitions were harmonized with the Society for Automotive Engineers (SAE) J1772 standard definitions as seen in Figure 1.

Electric Vehicle Supply Equipment (EVSE): The conductors, including the undergrounded, 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 to the electric vehicle. Charging cords with NEMA 5-15P and NEMA 5-20P attachment plugs are considered EVSE. Excludes conductors, connectors, and fittings that are part of the vehicle.

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. 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.

Figure 1: Level 1 and Level 2 EVSE Definitions

EPA defined the boundary condition for testing to include the EVSE only and exclude the vehicle as shown in Figure 2. EPA's Green Vehicle Guide and the corresponding Fuel Economy label already measure and include information on miles per gallon equivalent to allow for comparison to vehicles using different fuels and to account for losses in the in-vehicle battery rectifier and charger [5].

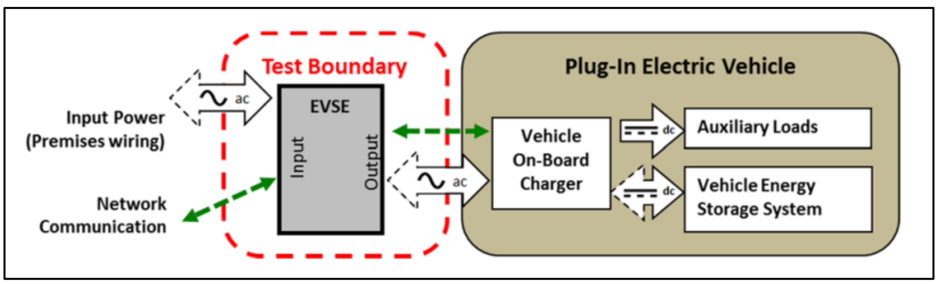

Figure 2: Schematic of Plug-In Vehicle Charging System and EVSE Test Boundary

The modes of operation and associated power states for an EVSE were defined and related to the interface states in SAE J1772. EPA defined these modes in order to set efficiency criteria for the three standby modes – No Vehicle Mode, Partial On Mode, and Idle Mode – defined in Table 1.

Table 1: Modes of Operation Definitions

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 connect 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.
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).

The maximum power requirement for these standby modes are identical in the following aspects:

- There is a base allowance of 2.6 watts applied to all models,
- If a product has network connection enabled upon shipment, it is enabled during testing and the allowances described in Table 2 are added to the base allowance, and
- If a product has a high-resolution display, it is enabled during testing and the allowances described in Table 2 are added to the base allowance. This equation is adapted from the ENERGY STAR Displays specification requirements, which are intended for outdoor use.

Table 2: Power Allowances for Product Features

Product Function	**No Vehicle 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 ($P_{DISPLAY}$)	$\frac{[(4.0 \times 10^{-5} \times \ell \times A) + 119 \times \tanh(0.0008 \times [A - 200.0] + 0.11) + 6.0]}{n}$ 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 5x5 inch screen, the allowance for the in-use display would be 2.7 watts.

Idle Mode has one additional component to add to the maximum power requirement calculation, that is intended to account for power required to close a relay/contactor. This allowance is equal to the maximum output current multiplied by 0.4.

EPA included optional connected functionality criteria in the specification to recognize products that are capable of supporting Demand Response programs from utilities and aggregators. These connected criteria require that any product listed as ‘connected capable’ on the ENERGY STAR website be able to support open standards communication and allow consumers to override a Demand Response event. The schematic in Figure 3 demonstrates how a connected EVSE system should operate with open standards. (Note: These requirements are currently under revision as of March 2020.)

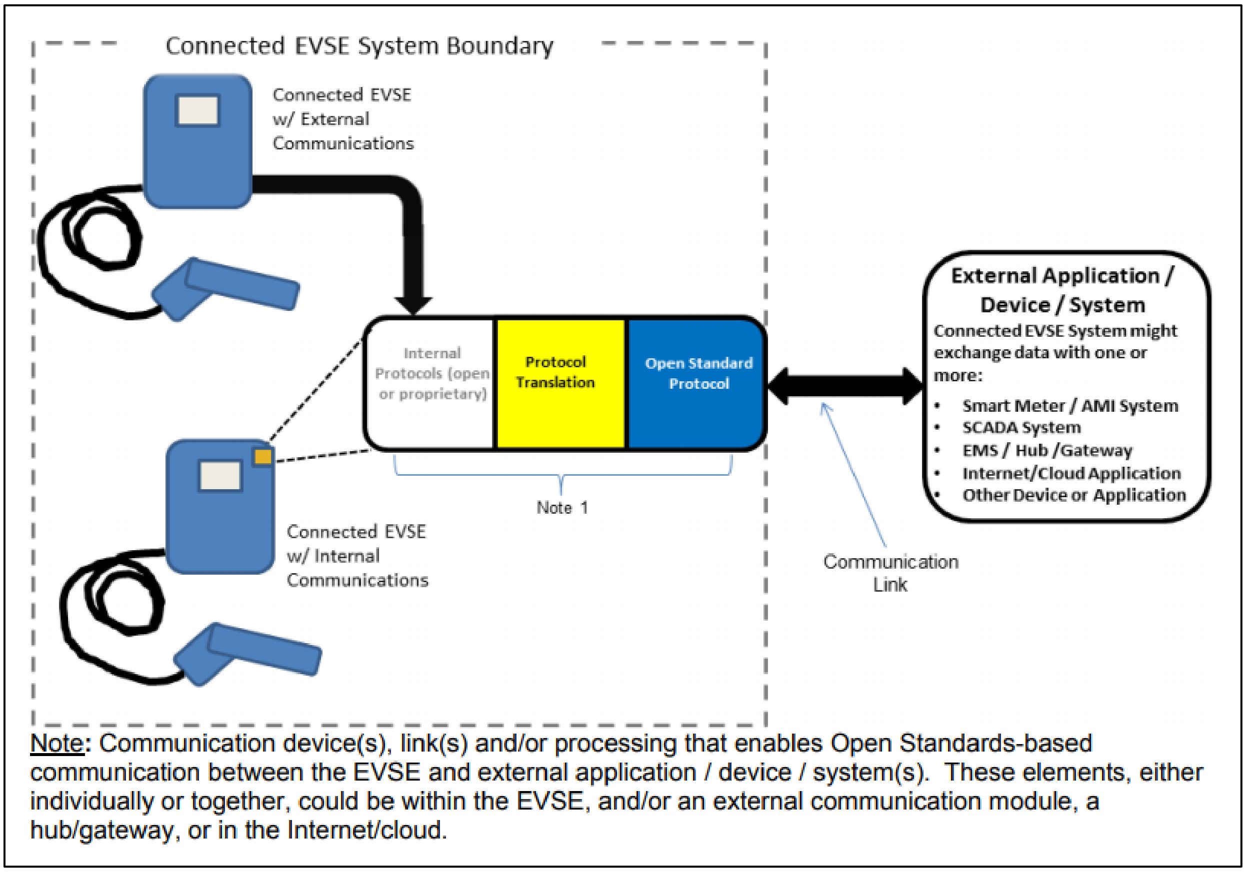

Figure 3: Connected EVSE System

The final criteria were developed with extensive input from industry and government, including: Idaho National Laboratory, Argonne National Laboratory, Lawrence Berkeley National Laboratory, AeroVironment (now Webasto), the California Investor Owned Utilities (IOUs), ChargePoint, ClipperCreek, Edison Electric Institute, General Motors, Greenlots, Leviton, and the National Electrical Manufacturers Association.

3 Early Results and Partnerships

As a marker of energy efficiency, the ENERGY STAR label has become a key product differentiation factor that influences consumer purchasing behavior. EPA relies on voluntary partnerships with industry stakeholders to certify products to a specification (e.g., manufacturers) and to raise awareness of the certification and qualified products (e.g., utilities, state agencies). Following the launch of Version 1.0 of the EVSE specification, EVSE manufacturers, charging network providers, utilities, state agencies, and other industry organizations formed partnerships with ENERGY STAR to increase the market penetration of certified EVSE. As of March 2020, 14 EVSE manufacturers have certified over 80 product models, accounting for multiple product families. [6]

Understanding the benefits of the program, new manufacturer partners continue to certify their products. State incentive programs are one driver; EPA has partnered with state agencies to promote ENERGY STAR EVSE through incentive program requirements. The California Energy Commission requires ENERGY STAR EVSE as part of its California Electric Vehicle Infrastructure Project (CALeVIP) incentive program [7]. The New York State Energy Research & Development Authority also requires current or pending ENERGY STAR certification for all chargers in the Charge Ready NY Level 2 program [8].

4 Barriers

An increasing number of EVSE manufacturers are considering and incorporating the ENERGY STAR specification into their product design processes. EPA recognizes, however, that there are some industry barriers in the adoption of the specification as well as the uptake of EVs in general. First, since EVs are just getting started in the United States, the public attention is focused mainly on the vehicles and not the chargers. Second, while consumers are accustomed to looking for ENERGY STAR certified refrigerators, that recognition took decades to establish, and EV chargers are a new product category. Third, there is a general lack of awareness of the ENERGY STAR certification for EVSE among policymakers, utilities, and others in a position to educate consumers on the benefits. EVSE manufacturers report that they are operating on thin margins and that only the highest priority product engineering changes are acted on immediately. Finally, while ENERGY STAR has hundreds of ongoing partnerships with utility programs for product categories like water heating and lighting, there is a lengthy and unpredictable regulatory process of utility program approval for programs that could promote and incentivize EVSE.

To overcome these barriers, EPA is meeting the industry where they are, including at industry events and through direct outreach. EPA is also continuing to build and strengthen relationships with like-minded membership and advocacy organizations. These efforts are in addition to a continued focus on partnerships with state agencies and utilities to ensure the ENERGY STAR specification is incorporated into programs and education.

5 The Expansion of Scope to include DC Fast Charging

In order to keep abreast of the rapidly changing technology, in May 2018, EPA proposed to expand the scope of the ENERGY STAR EVSE specification to include DC output charging products. EPA has harmonized the definition of DC charging with the SAE J1772 standard, as a method that uses dedicated DC EVSE to provide energy from an appropriate off-board charger to the vehicle in either private or public locations.

DC charging technology has evolved significantly in recent years to provide shorter charge times with the long-term goal of becoming comparable to a stop at a gas station. Today the fastest charging units are capable of 800V and can add 60 miles to an electric Porsche's range in 4 minutes, though this technology is far from widespread [9]. Due to the potential for DC fast chargers to increase the range of EVs and the efforts to establish EV charging corridors for cross-country EV transportation, there has been an increase in demand for this product type. Adding DC charging stations to the ENERGY STAR scope will bring new energy savings opportunities and value to stakeholders. In contrast to the Level 2 specification (Version 1.0), which relies heavily on minimizing standby losses, there is potential to differentiate between these products based on energy efficiency. Currently, claimed efficiency ranges for DC EVSE on the market appear to be between 92 and 97 percent when the EVSE is actively charging at full output. INL tested one DC EVSE during active charging and found efficiency at 30 to 50 kW to range from 91 to 93 percent, and lower efficiencies at lower power levels [10]. For another EVSE, the efficiency was 86 to 89 percent, including the transformer losses [11].

While Level 2 AC chargers are relatively straightforward, DC EVSE units are more complex than their AC cousins since they have more functions and features. DC EVSE are much larger, industrial style chargers that require heating and cooling the unit depending on external temperature, liquid cooling of the charging cable, network connectivity, networked payment systems, and large display screens. EPA plans to account for these functions the in the Version 1.1 specification that will establish efficiency criteria to recognize the top-performing products.

EPA has proposed a scope for the Version 1.1 EVSE specification based on two main performance criteria: DC EVSE output power and charging interface. To distinguish by charging interface, two product categories, wireless charging products, and pantograph bus chargers (those with an automated connection system), are excluded from the scope at this time. In terms of power levels, the scope includes all DC output products including and below 350 kW and excludes all models that are above 350 kW.

This scope is based on stakeholder feedback and DC EVSE products available on the market currently. EPA reviewed available DC EVSE products and compiled the information shown in Figure 4, which is based on rated power output. EPA observed that a significant number of products available today are rated at 50 kW output. There are three products available that are between 60 – 65 kW, which EPA believes would be similar in nature (technologically and in electrical design) to the 50 kW products. As such, EPA proposed bins, shown in Table 3, to require all products below and including those rated at 65 kW to meet forthcoming efficiency criteria in both standby mode and during active charging (operation mode). EPA chose to group these products into distinct categories with fewer requirements for high power EVSE in response to stakeholder feedback that larger DC-output EVSE are newer to market, not as commoditized and more customizable, and there is a lack of data on efficiency for these products. EPA agrees that operating efficiency is a key metric for consumers and hopes to include operation mode criteria for the products with output power greater than 65 kW in a future revision of the specification, once data is available. At this time, EPA is still requiring that operation mode test results be reported on the Certified Product List in order to provide consumers with this information.

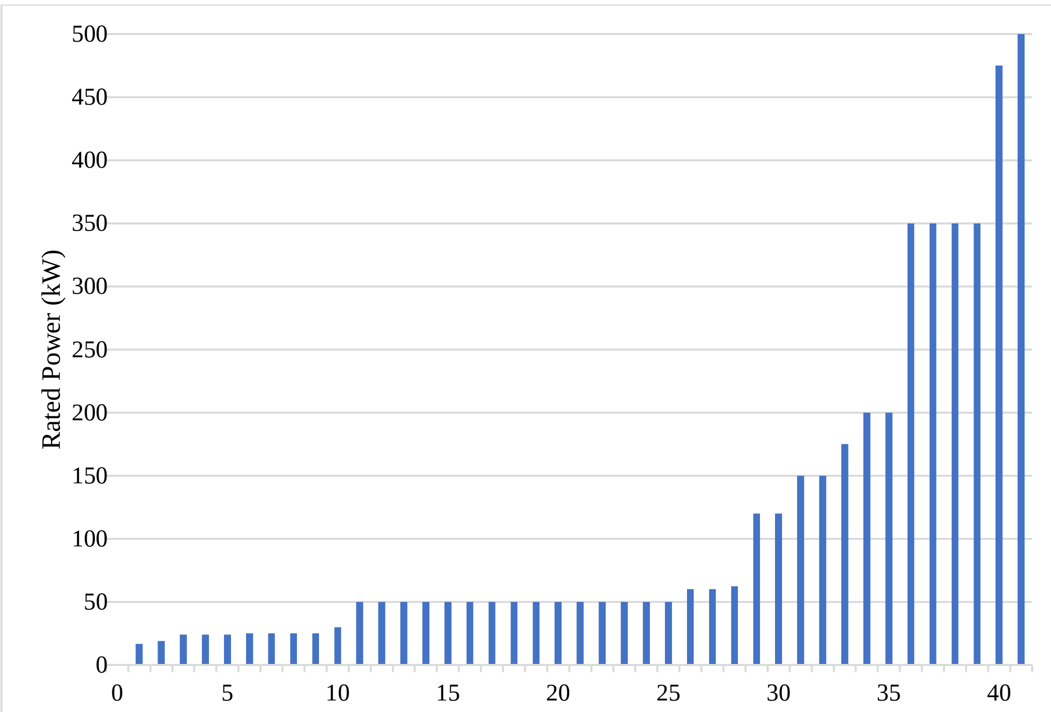

Figure 4: DC EVSE Models Available on Market (as of mid-July 2019) [12]

Table 3: Proposed Scope for Version 1.1. DC EVSE Specification

DC EVSE Output Power	≤65 kW	65 kW < Output Power ≤ 350 kW	> 350 kW
Standby Mode Criteria	✓	✓	
Operation Mode Criteria	✓	Report efficiency, but no criteria	Out of scope, no criteria
Network Connection Required	✓	✓	

While only products at 65 kW output power, or below, will have to meet the forthcoming operation mode criteria, all products will need to be tested at the proposed loading conditions in Table 4 to determine their efficiency while charging. EPA developed these loading conditions with extensive input from stakeholders. Specifically, stakeholders recommended testing at specified percentages of full load conditions and EPA incorporated loading conditions at 25, 50, 75, and 100 percent of maximum output power in order to ensure all products will be tested at a minimum of four different loading conditions, resulting in efficiency values across the product's full capability and load profile. EPA retained two fixed measurement conditions of 50 kW and 150 kW after reviewing peak DC charging power for multiple EVs on the market today. A significant number of EVs draw a maximum of 50 kW and a typical maximum power draw for EVs with larger battery packs is approximately 150 kW. There are vehicles available that are capable of drawing a maximum of 200 to 250 kW, but only for relatively short periods of time before the charge rate begins to taper. Maintaining these two exact loading conditions will allow for easy comparison from product to product, while including the loading points at percentages of maximum output power will provide an understanding of how EVSE efficiency varies across load conditions above and below those fixed points of comparison. EPA clarified that the EVSE only needs to be tested once at each loading condition and duplicate loading conditions can be ignored (e.g., for a 150 kW capable EVSE, it would only need to be tested at either loading condition 5 or 6, since both would equal 150 kW).

Table 4: Proposed Operation Mode Loading Conditions for Version 1.1. DC EVSE Specification

	Test Condition	**Example for 150 kW capable UUT**	**Example for 50 kW capable UUT**
Loading Condition 1	25% of Maximum Available Output Power ± 2% and 350 V ± 7 V	37.5 kW	12.5 kW
Loading Condition 2	50% of Maximum Available Output Power ± 2% and 350 V ± 7 V	75 kW	25 kW
Loading Condition 3	75% of Maximum Available Output Power ± 2% and 350 V ± 7 V	112.5 kW	37.5 kW
Loading Condition 4	50 kW ± 1 kW and 350 V ± 7 V	50 kW	N/A
Loading Condition 5	150 kW ± 3 kW and 350 V ± 7 V	N/A	N/A
Loading Condition 6	100% Maximum Available Output Power (determined in Section 7.4.B), above) ± 2% and 400 V ± 7 V **Note:** The test must be conducted at 400V. If a UUT cannot achieve the rated output power at this voltage, the UUT must be tested at the lowest voltage required to achieve the loading condition specified (in terms of rated output power)	150 kW	50 kW

EPA is currently collecting data from manufacturers based on the Final Draft test method to validate the test procedure and to inform the forthcoming Draft 1 Version 1.1 specification. EPA expects to set efficiency criteria based on this data for standby modes and active charging. EPA also plans to use stakeholder data to identify features that may require additional power and provide appropriate allowances for these features. The final specification will be completed late Fall 2020, at which point manufacturers can apply right away for certification. It is important that industry studies the steps necessary to complete testing, including the location of test facilities, in order to prevent a delay in the certification process.

The ENERGY STAR Program is deeply engaged in the EV charging space and will remain engaged as this technology expands and changes throughout the decade. EPA's role is to provide guidance for purchasers, utilities, states, homeowners and others, who are seeking efficient EV charging products with laboratory verified performance results. In the future, EPA sees a role for emerging technologies like wireless charging, which have several practical advantages, and looks forward to working with industry on the development of performance and safety standards in order to make that potential expansion possible. EPA is also working today to actively expand our partnerships with utilities, states, homeowners, and other parties to increase adoption of all existing categories of ENERGY STAR EV chargers on the market.

References

[1] Mai, Trieu et al. *Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States.* National Renewable Energy Laboratory, 2018.

[2] Consortium for Energy Efficiency, Inc., National Awareness of ENERGY STAR Surveys, www.cee1.org/content/national-awareness-energy-star-surveys, accessed 2020-03-04

[3] Halliwell, John. "Non-Listed Electric Vehicle Supply Equipment: Follow-up from March 2019 IWC." EPRI IWC Minneapolis, MN – Great River Energy. 13 June 2019. assets.ctfassets.net/ucu418cgcnau/18QXaldiMTAxzGaZKsuaN2/7afa3811cf9d7fc42c032f4a19301bc0/D2-2_-_June_2019_EPRI_IWC_-_Non-listed_EVSE_follow_up_Halliwell.pdf

[4] U.S. Environmental Protection Agency, ENERGY STAR Version 5.0 Refrigerator and Freezers Specification Analysis. www.energystar.gov/products/spec/residential_refrigerators_and_freezers_specification_version_5_0_pd

[5] U.S. Environmental Protection Agency, Green Vehicle Guide, www.epa.gov/greenvehicles/learn-about-fuel-economy-label#NewLabel, accessed 2020-03-02

[6] U.S. EPA, ENERGY STAR Certified EVSE, www.energystar.gov/productfinder/product/certified-evse/results, accessed 2020-03-04

[7] California Energy, Commission. "ENERGY STAR® Certification Process." CALeVIP, 2020, calevip.org/energy-star-certification-process.

[8] New York State Energy Research and Development Authority (NYSERDA). "Charge Ready NY Equipment and Network Qualification Process Request for Qualifications (RFQL) 3902." NYSERDA, 2020, portal.nyserda.ny.gov/servlet/servlet.FileDownload?file=00Pt000000Dpgn4EAB.

[9] Hughes, Michael. "Charging Up the Porsche Taycan: Fast Charging and More." ChargePoint, 14 Oct. 2019, www.chargepoint.com/blog/charging-porsche-taycan-fast-charging-and-more/.

[10] Idaho National Laboratory, "DC Fast Charger Fact Sheet: ABB Terra 53 CJ charging a 2015 Nissan Leaf," June 3, 2016, avt.inl.gov/sites/default/files/pdf/evse/ABBDCFCFactSheetJune2016.pdf.

[11] U.S. Department of Energy, "Production EVSE Fact Sheet: DC Fast Charger: Hasetec," https://avt.inl.gov/sites/default/files/pdf/evse/DCFCHasetec.pdf.

[12] U.S. Environmental Protection Agency, DC Fast Charger Market Analysis, 2019.

Presenter Biography

Peter Banwell is the Marketing Director of EPA's ENERGY STAR program, based in Washington D.C. He has over 20 years of experience with energy efficiency and renewable energy including: energy regulatory work at the state level, sales and installation of energy-saving technologies, and management of a renewable energy company in Asia. His current responsibilities include overseeing the development of marketing plans for a wide variety of ENERGY STAR products, co-development of new retailer-utility program models, international lighting work and promotion of emerging technologies.