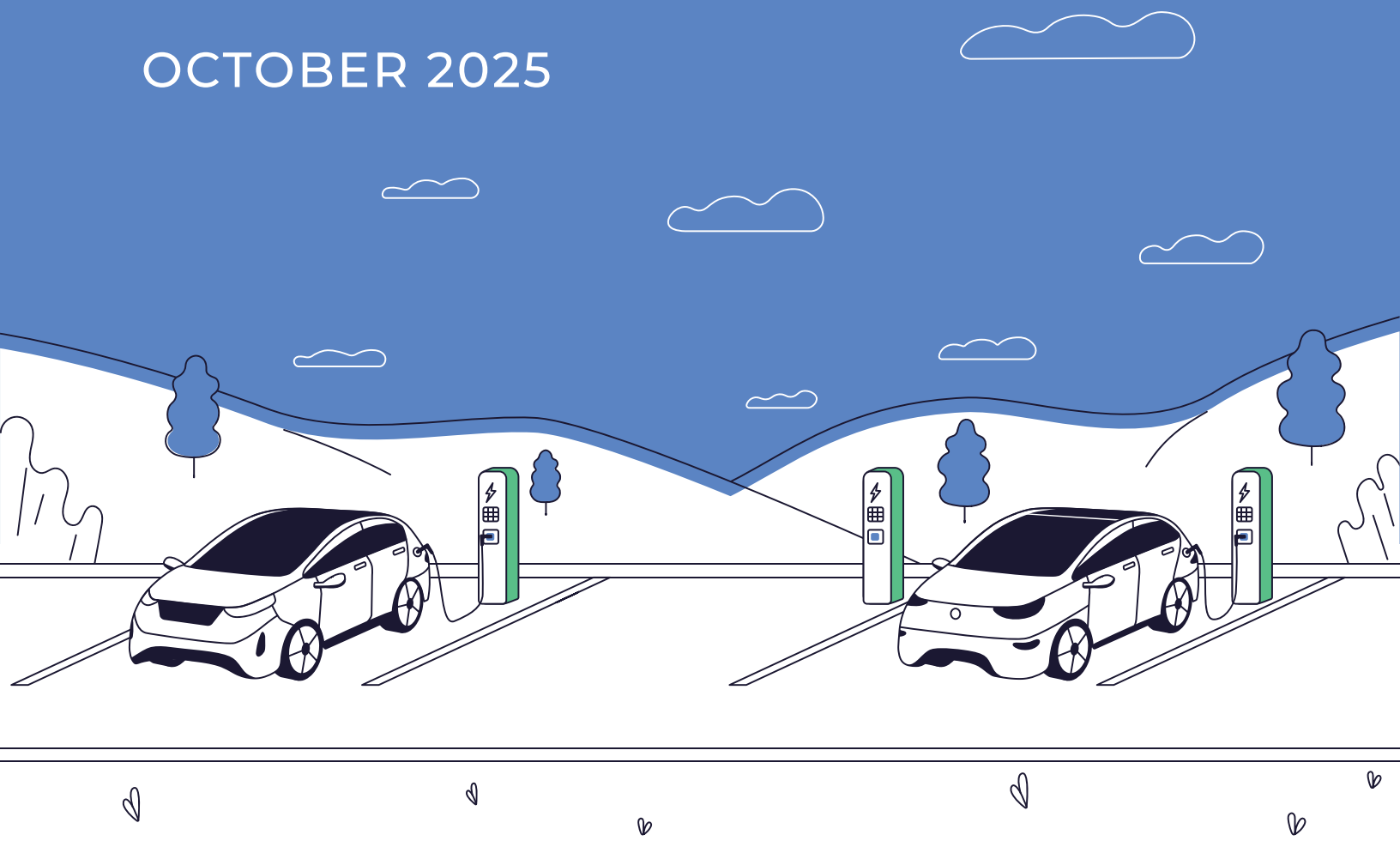
GAPS PROGRESS REPORT

of Standards and Codes for Electric Vehicles at Scale

OCTOBER 2025



Prepared by the

ANSI Electric Vehicles Standards Panel (EVSP)

GAPS PROGRESS REPORTS VERSION HISTORY

The Electric Vehicle Standards Panel (EVSP) published the *Roadmap of Standards and Codes for Electric Vehicles at Scale* (June 2023). The most current information reported on standards activities in the gaps progress reports is retained from version to version. The most current version is retained on the ANSI website at www.ansi.org/evsp. The roadmap and gaps progress reports can be downloaded for free. See the report overview for more information.

S.N.	*Version*	*Publication Date*	*Version Note*
1	May 2025	5 May 2025	1st gaps progress report against 2023 Roadmap
2	Oct 2025	30 October 2025	2nd gaps progress report against 2023 Roadmap; 21 new gaps proposed

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GAPS PROGRESS REPORT OVERVIEW

The Electric Vehicle Standards Panel (EVSP) is tracking progress by standards developing organizations (SDOs) and others to address the gaps identified in the *Roadmap of Standards and Codes for Electric Vehicles at Scale* (June 2023). The updates provided in this progress report were derived from various sources: direct inputs from SDO staff and subject matter experts (with attribution), SDO alert mechanisms, and independent research by ANSI staff based on publicly available SDO work programmes and other information. As such, this report should not be viewed as a consensus document and it does not necessarily reflect the views of the individuals or organizations named. It is intended to be a "living document" that will be maintained and periodically re-published as standards development work continues or until such time as the EVSP undertakes to develop a next version of its standardization roadmap. Comments and suggested edits to the gaps are to be addressed at a later date.

Click on any of the roadmap gap titles below for the most recent updates (highlighted and dated) since the deadline for input **(10/3/2025) on the October 2025 progress report which was published 10/30/2025**. You will see fields for updates since roadmap was published, new published standards, and new in-development standards. In some cases, staff has determined that a published standard or in-development standard may be responsive to an identified v3 gap(s) or topical area based on the standard's title/abstract. In other cases, staff was unable to make such a determination and, in such cases, the standard is listed at the end of a chapter.

Updates, corrections, and suggested edits should be sent to evsp@ansi.org.

SUMMARY TABLE OF GAPS AND RECOMMENDATIONS

Accompanying the roadmap is a ***Summary Table of Gaps and Recommendations*** identified in the roadmap. This spreadsheet allows users to sort and filter the 37 gaps based on the categories such as topic, R&D needs, recommendation, or organizations. Below is a listing of the gaps organized by current priority. The prioritize identified at the time of the roadmap's publication is also shown.

HIGH PRIORITY

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
2.2	Gap V1: Battery Safety	High	High
2.2.2	Gap V2: Delayed Battery Thermal Events	High	High
2.4	Gap V3: Safe Storage of Lithium-ion Batteries	High	High
2.5	Gap V4: Packaging and Transport of Lithium-ion Batteries	High	High
2.6	Gap V5: Design for Battery Recyclability/Materials Reclamation	High	High
3.1.2	Gap C1: Megawatt Charging Systems (MCS)	High	High
3.1.3.1	Gap C2: Static Wireless Charging	High	High
4.1.1	Gap G1: Standardization of Error Codes and Reporting	High	High
4.1.3	Gap G3: Communication of standardized EV sub-metering data	High	High
4.1.3	Gap G5: Standardization of EV sub-meters	High	High
4.2.1	Gap G6: Dynamic Capacity Management (DCM)	**High**	Medium
4.3	Gap G15: Assess Interoperability Between Communication Protocols and Standards	**High**	Low
5	Gap S1: Comprehensive review of cybersecurity codes and standards for applicability to the EV charging ecosystem	High	High
5	Gap S2: The lack of an end-to-end secure trust chain and encryption system for the EV charging ecosystem	High	High
5	Gap S3: Cybersecurity and Data Privacy	High	High
5	Gap S4: Robust "Security-by-Design"	**High**	Medium
5	Gap S7: Cybersecure Firmware and Software Updates	High	High
5	Gap S8: EVSE Cyber-physical Vulnerabilities	**High**	Medium

MEDIUM PRIORITY

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
2.7	Gap V6: Battery Secondary Uses	Medium	Medium
3.1.3.2	Gap C4: EMC and EMF Measurements of Dynamic Wireless Power Transfer (WPT)	Medium	Medium
3.2.1.2	Gap C6: Power Export	Medium	Medium
3.2.1.6	Gap C7: Cable Management	Medium	Medium
3.2.2.1	Gap C8: Fire protection in relation to EV parking/charging in/near older buildings	Medium	Medium
4.1.2	Gap G2: Locating and Reserving a Public Charging Station, Obtaining Pricing and Availability Information	Medium	Medium

4.1.3	Gap G4: Metrological Traceability for Quantitative Measurement of DC Power Delivery	Medium	Medium
4.2.1	Gap G7: Safety and Protection of DC architectures are not standardized	Medium	Medium
4.2.1	Gap G8: Fault Current Signatures for AC and DC Architectures under Islanding Conditions	Medium	Medium
4.2.1	Gap G9: "Ride Through" Requirements for EVSE under Grid Service Conditions	Medium	Medium
4.2.1	Gap G10: DC-as-a-Service (DCaaS)	Medium	Medium
4.2.2	Gap G11: Structured Information and Energy Services Exchange with Utilities	Medium	Medium
4.3	Gap G12: Assess UL 1741 V2G Integration Requirements	Medium	Medium
4.3	Gap G13: Maintain Alignment between UL 9741 and UL 1741	Medium	Medium
4.3	Gap G14: Revise SAE J3072 to harmonize with UL 1741 SB	Medium	Medium
5	Gap S5: Digital Cybersecurity as Part of Interconnection Standards	Medium	Medium
5	Gap S6: Cybersecurity of Power Management under DER Aggregation Scenarios	Medium	Medium

LOW PRIORITY

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
3.1.3.2	Gap C3: Dynamic Wireless Charging Interoperability	Low	Low
3.1.3.3	Gap C5: Communications in Support of Wireless Power Transfer	Low	Low

SECTION 2: VEHICLE SYSTEMS

The topical area of Vehicle Systems primarily relates to battery energy storage and related subsystems but may also include other energy storage systems, including fuel cells and mechanical energy storage. The most common types of batteries being developed for electric transportation are lithium-ion-based. Topics addressed in this section include: power rating methods; battery safety; battery testing – performance and durability; battery storage; battery packaging, transport and handling; battery recycling; battery secondary uses; and crash tests/safety.

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
2.2	Gap V1: Battery Safety *(last updated 10/7/2025)*	High	High
2.2.2	Gap V2: Delayed Battery Thermal Events *(last updated 10/7/2025)*	High	High
2.4	Gap V3: Safe Storage of Lithium-ion Batteries *(last updated 10/7/2025)*	High	High
2.5	Gap V4: Packaging and Transport of Lithium-ion Batteries *(last updated 10/7/2025)*	High	High
2.6	Gap V5: Design for Battery Recyclability/Materials Reclamation	High	High
2.7	Gap V6: Battery Secondary Uses	Medium	Medium
Section 2 Vehicle Systems Recommendations ***(last updated 9/19/2025)***			

Gap V1: Battery Safety

There is an ongoing need to address safety issues related to battery thermal runaway, potential immersion scenarios, and vibration resistance.

R&D Needed: Yes. Further investigation regarding safety issues (e.g., hazmat) for water and sand immersion should be conducted prior to addressing in standards.

Recommendation: Continue to advance battery safety through NHTSA's participation in the development of Phase 2 of Global Technical Regulation No. 20 for Electric Vehicle Safety and the SAE Battery Field Discharge Committee.

Priority: High

Organization(s): NHTSA, WP.29, SAE, USFA (United States Fire Administration)

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, D.Anand, INL:** Federal Motor Vehicle Safety Standards; FMVSS No. 305a Electric-powered vehicles: Electrolyte spillage and electrical shock protection was updated.
- **9/19/2025, R.Kaiser:** New York State Battery Energy Storage System Guidebook. Related to commercial grade battery energy services.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, D.Anand, INL:** Design standards related to safety-stranded energy management and battery diagnostic ports so recyclers can quickly diagnose battery status.

New Published Standards & Codes	New In-Development Standards & Codes
9/19/2025, T.Bohn, ANL: SAE J3356 Battery Management System: Surface Vehicle Battery Diagnostic Technical Information Report	**9/19/2025, T.Bohn, ANL:** SAE J3356/1 Battery Management System: Surface Vehicle Battery SOH Technical Information Report **9/19/2025, T.Bohn, ANL:** SAE J3356/2 Battery Management System: Surface Vehicle Battery SOC Technical Information Report

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Gap V2: Delayed Battery Thermal Events

The issue of delayed battery thermal events needs to be addressed.

R&D Needed: Yes

Recommendation: Address the issue of delayed battery thermal events in future rulemaking and/or revisions of SAE J2929 and J2990 and with the SAE Battery Field Discharge Committee.

Priority: High

Organization(s): NHTSA, SAE

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, D.Anand, INL:** A standards committee is needed around continuous battery monitoring for potential partial or delayed thermal events.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap V3: Safe Storage of Lithium-ion Batteries

No standards or guides have been identified that address the safe storage of damaged (i.e., unknown condition) lithium-ion batteries, whether at warehouses, repair garages, recovered vehicle storage lots, or auto salvage yards.

R&D Needed: Yes. Assess various known failure modes and appropriate battery storage procedures. modes. Resulting consequences from failures should be determined and associated mitigating measures such as explosion control should be explored. Research should consider gas and fire detection and suppression technologies / systems.

Recommendation: A standard or guide for the safe storage practices for EV batteries must be developed, addressing damaged batteries and the wide range of storage situations that may exist, including when the batteries have been separated from their host vehicle.

Priority: High

Organization(s): SAE, NFPA, ICC, IEC, UNECE, UL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
9/29,2025, A.Sinnott, ULSE: *UL 1487 Battery Containment Enclosures, Edition 1* revision was published in February 2025. This standard addresses battery containment enclosures intended to mitigate the heat, fire, and deflagration hazards that can result from lithium-ion battery thermal runaway. **3/19/2025 D.Trayers, UL:** *EN 14470-1:2023, (DIN) Fire safety storage cabinets - Part 1: Safety storage cabinets for flammable liquids* Applicable to cabinets intended for storage of lithium-ion batteries. (Note: not new but wasn't referenced in roadmap) **3/19/2025 D.Trayers, UL:** *EN 14470-2:2006, (DIN) Fire safety storage cabinets - Part 2: Safety cabinets for Pressurised Gas Cylinders* Applicable to cabinets intended for storage of lithium-ion	**10/7/2025, D.Anand, INL:** NFPA 855 Standard for the Installation of Stationary Energy Storage Systems including warehouses. This standard provides the minimum requirements for mitigating the hazards associated with ESS. Comment closing date was 10/17/2025.

batteries. (Note: not new but wasn't referenced in roadmap) **3/19/2025 D.Trayers, UL:** *ANSI/CAN/UL 5800:2020, Battery Fire Containment Products* Applies to battery fire containment products, including enclosures/cabinets. Not specific to damaged batteries but can be expanded/adapted during revision cycles. (Note: not new but wasn't referenced in roadmap) **3/19/2025 D.Trayers, UL:** *UL 9540A (Mar2025) Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway.	

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Gap V4: Packaging and Transport of Lithium-ion Batteries	
Standards are being developed on battery package testing and performance-based packaging for lithium batteries as cargo on aircraft. **R&D Needed**: No **Recommendation**: Complete work on SAE standards in development on battery package testing and performance-based packaging for lithium batteries as cargo on aircraft. **Priority:** High **Organization(s):** SAE, DOT/FAA, United Nations	
Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*: **10/7/2025, F.Wagner:** UN 38.3 (Global regulation for battery transport on ships and aircraft **Other Committees / Organizations with Relevant Work:** • No updates as of publication of this report. **Comments Received on Gap for Future Consideration:** • No comments as of publication of this report.	
New Published Standards & Codes	**New In-Development Standards & Codes**

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Gap V5: Design for Battery Recyclability/Materials Reclamation

Standards for battery construction design with the intention of recycling/materials reclamation are needed. The ability to disassemble batteries after use in order for parts and materials to be reclaimed or recycled to manufacture new batteries should be considered during the design phase.

R&D Needed: Yes, there is a need for additional R&D on design for recyclability, as batteries are getting less conducive to recycling. Additional R&D is needed by the national labs on design for recyclability of EV (li-on) batteries. This could include addressing the calculation method toward recycling efficiency and recovery rates based on an agreed unit (possibly weight) and/or life-cycle assessment tools, including energy recovery. Recycling is important to reduce the amount of materials to be mined, because the processing of lithium ion produces toxic biproducts.

Recommendation: Develop standards for battery construction design with the intention of recycling/materials reclamation.

Priority: High

Organization(s): ANL, SAE, ISO, NEMA

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
3/17/2025, A.Krabbe, ULSE: UL 3601 Standard for Measuring and Reporting Circularity of Li-ion and Other Secondary Batteries (Edition 1, Dec 2024), may support this gap.	**3/18/2025, D.Karner, EAI:** SAE *WIP J2997 Standards for Battery Secondary Use.* To develop standards for a testing and identity regimen to define batteries for variable safe reuse. The potential for the state of health standards to help maintain the batteries in their best reusable and compatible condition should provide for the best way to lower the overall lifetime cost of the batteries. Transportation standards will be necessary anyway to provide for multiple location resources to repackage and have storage logistics. Labelling will be necessary to authenticate the State of health and compatibility with traceability.

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Gap V6: Battery Secondary Uses

There is a need for standards addressing methods to capture and track battery health for second life applications for grid storage and other uses. The principal objective is to decide whether a battery should be reused, repurposed, or recycled.

R&D Needed: Yes, to provide an indicator of residual value. The obstacles for generating a ledger or lifetime tracking register, in the cloud or on the device, that shows the history of the battery needs further study.

Recommendation: Explore the development of standards for battery secondary uses, addressing such issues as safety and performance testing for intended applications, grid connection/communication interfaces, identification of parts/components, and telematics (for cloud-based tracking) that can be removed from the pack without destroying or damaging it.

Priority: Medium

Organization(s): NEMA, SAE, UL, NAATBATT

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **9/29/2025, A. Sinnott, ULSE:** End product standards that may allow the use of repurposed/remanufactured batteries (e.g. UL 1973 Batteries for Use in Stationary and Motive Auxiliary Power Applications and UL 9540 Energy Storage Systems and Equipment) will reference UL 1974 with additional requirements.
- **3/24/2025 R.Patel:** Performance testing should include testing for the remaining life span and capacity of the battery in a standard way. This would help indicate what the battery could be repurposed for.

New Published Standards & Codes	New In-Development Standards & Codes
9/29/2025, A. Sinnott, ULSE: *UL 1974 Evaluation for Repurposing or Remanufacturing Batteries,* Edition 2 provides the base requirements for repurposing and remanufacturing batteries. **3/17/2025, A.Krabbe, ULSE:** UL 3601 Standard for Measuring and Reporting Circularity of Li-ion and Other Secondary Batteries (Edition 1, Dec 2024) Section 19 Extension of Useful Life, may support this gap.	**3/18/2025, D.Karner, EAI:** SAE *WIP J2997 Standards for Battery Secondary Use.* To develop standards for a testing and identity regimen to define batteries for variable safe reuse. The potential for the state of health standards to help maintain the batteries in their best reusable and compatible condition should provide for the best way to lower the overall lifetime cost of the batteries. Transportation standards will be necessary anyway to provide for multiple location resources to repackage and have storage logistics. Labelling will be necessary to authenticate the State of health and compatibility with traceability.

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Section 2 Vehicle Systems Recommendations / Comments Since Publication of Roadmap

*Additional general comments, standards activities, and recommendations for gaps in standards and codes related to the **Section 2: Vehicle Systems**.*

New Gap Suggestions

The following gap(s) was suggested during comments against the gaps progress report. This language did not go through EVSP working group or public review. It is for information only and has not been assigned an EVSP gap number but may be considered by the EV standardization community.

9/19/2025, B.Engle, Amphenol: New Gap Suggestion: Low Conductivity Thermal Management

Standardization, including harmonization with existing related standards, or the type of liquid coolants, related systems, and maintenance are needed for low conductivity thermal events.

Most on-vehicles are liquid cooled are already. A dual path exists – direct and indirect:

- Low conductivity is normally in a sealed system separate from the battery, motor, and inverter. The motor and the coolant are segregated. A breach of the high-voltage coolants system or could result in a short circuit in a damage event. Conductivity is low enough not to cause an immediate short circuit, overcurrent, or failure.
- Very low conductivity (or dielectric coolants) is typically used in immersion cooling where fast charging is targeted. Solid state systems will need this.

SAE WIP J3359 for EV Low Conductivity Thermal Management Fluids describes this issue further.

Organizations: SAE

New Published Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional newly published standards or codes provided as of publication of this report.

New In-Development Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional in-development standards or codes provided as of publication of this report.

General Comments

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional in-development comments were provided as of publication of this report.

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SECTION 3: CHARGING INFRASTRUCTURE

In order to promote the development, acceptance and deployment of EVs, and to discourage the imposition of market barriers, it is imperative that plugs, chargers and EVs be interoperable. EV owners must be able to easily recharge their vehicle at their home or office and when traveling long distances within their own state and across state lines. Harmonized standards that assure the interoperability of EVs with the charging infrastructure will do much to help grow the market for EVs, and thus will be in the best interest of EV and EVSE manufacturers, as well as EV users.

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
3.1.2	Gap C1: Megawatt Charging Systems (MCS) *(last updated 9/19/2025)*	High	High
3.1.3.1	Gap C2: Static Wireless Charging *(last updated 10/3/2025)*	High	High
3.1.3.2	Gap C3: Dynamic Wireless Charging Interoperability *(last updated 9/19/2025)*	Low	Low
3.1.3.2	Gap C4: EMC and EMF Measurements of Dynamic Wireless Power Transfer (WPT)	Medium	Medium
3.1.3.3	Gap C5: Communications in Support of Wireless Power Transfer	Low	Low
3.2.1.2	Gap C6: Power Export *(last updated 10/27/2025)*	Medium	Medium
3.2.1.6	Gap C7: Cable Management	Medium	Medium
3.2.2.1	Gap C8: Fire protection in relation to EV parking/charging in/near older buildings	Medium	Medium
Section 3 Charging Infrastructure Recommendations ***(last updated 9/19/2025)***			

Gap C1: Megawatt Charging Systems (MCS)

Standards are needed for MCS to support for heavy-duty EVs such as box trucks, semi-trucks, aircraft, ~~trucks~~ and buses.

R&D Needed: Yes. Interoperability testing and data collection.

Recommendation: Complete work on SAE J3271 (2025 edition published). Complete update work on UL 2251 (couplers) and UL 2202 (chargers) to address MCS, specifically liquid cooled cables. Expand the use case area (e.g., marine, aviation).

Priority: High

Organization(s): SAE, DOE, NEMA, UL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **3/20/2025, S.Park, ULSE**: UL 2202 added cable management in Certification Requirement Decision dated Jul 6, 2023.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **3/24/2025, R.Patel**: Suggested revisions to gap description shown with track changes above.

New Published Standards & Codes	New In-Development Standards & Codes
9/19/2025, T.Bohn, ANL: *ISO 15118-10:2025 Road vehicles — Vehicle to grid communication interface. Part 10: Physical layer and data link layer requirements for single-pair Ethernet* **9/19/2025, J.Leber, CSA:** *CSA/ANSI C22.2 NO. 343:25, Electric vehicle energy management systems* **9/19/2025, EVSP AG:** *SAE J3271 SAE Megawatt Charging System for Electric Vehicles* (published 3/5/2025) This document includes: • Electromechanical Coupler Specifications • Communication and Controls • Cables/Cable Handling, Cooling, and Automated Connection Systems • Use Cases Including Grid Interconnection, Black Start, and Bidirectional Power Transfer • Interoperability Testing Requirements and Test Procedures **3/17/2025, A.Krabbe/J.Bablo, ULSE:** UL 2278 Megawatt Charging Configured Electric Vehicle Couplers was developed to address MCS and covers EV couplers of the megawatt configuration (Edition 1, Feb 2025)	**9/19/2025, T.Bohn, ANL:** *ISO 15118-11 Road vehicles — Vehicle to grid communication interface Part 11: Physical layer and data link layer for single-pair conformance test plan* **9/19/2025, T.Bohn, ANL:** *UL 3141 UL LLC Outline of Investigation for Power Control Systems*, outline published 10/9/2024 and WG is actively meeting. Technical lead: Scott Picco, UL. **3/20/2025, S.Park, ULSE**: UL 2251 Plugs, Receptacles, and Couplers for Electric Vehicles (Edition 4, Dec 2022) is currently undergoing an update to add liquid cooling. **2/18/2025, J.Bablo, UL:** Updates to UL 2202 DC Charging Equipment for Electric Vehicles (Edition 3, Dec 2022) are currently in process that will increase the output parameters for tests up to 3000 A to align with megawatt charging. **2/18/2025, J.Bablo, UL:** IEC TC69 PT61851-23-3 DC electric vehicle supply equipment for Megawatt charging systems is currently developing requirements for megawatt chargers. The IEC document will be design based with only specific systems allowed as was the case with IEC 61851-23. **2/18/2025, J.Bablo, UL:** IEC TC23/SC23H/PT63379 Vehicle connector, vehicle inlet and cable assembly for Megawatt DC charging is currently developing requirements for megawatt couplers.

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Gap C2: Static Wireless Charging

Standards for heavy-duty/high power static wireless charging are still in development.

R&D Needed: ~~No~~ Yes

Recommendation: Complete work on SAE J2954/2 and other in-development standards to deal with heavy-duty/high power static wireless charging.

Priority: High

Organization(s): SAE, UL, IEC/TC 69, ISO TC22/SC37

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **9/19/2025, T.Bohn, ANL:** Cooperative research program (CFP) between wireless charging manufacturers and SAE for validation testing that will lead to publication of SAE J2954/2.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
3/19/2025 D.Trayers, UL: *ANSI/UL 2750 (Nov 2023) Wireless Power Transfer Equipment for Electric Vehicles* covers wireless power transfer (WPT) equipment for transferring power to a stationary electric vehicle. Since output ratings are determined by the manufacturer, UL 2750 can be used for heavy duty applications. Noting that SAE J2954 covers light duty EV's. **3/17/2025, A.Krabbe, ULSE:** UL 2750 Wireless Power Transfer Equipment for Electric Vehicles (Edition 1, Nov 2023) covers WPT to stationary EVs	**10/3/2025 A. Sinnott, ULSE:** Revisions for UL 2750 Wireless Power Transfer Equipment for Electric Vehicles have been submitted to reference the updated version of SAE J2954. **9/19/2025, T.Bohn, ANL:** SAE WIP: J2954/2 Wireless Power Transfer for Heavy-Duty Electric Vehicles Cooperative research program (CFP) between wireless charging manufacturers and SAE for validation testing that will lead to publication of SAE J2954/2.

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Gap C3: Dynamic Wireless Charging Interoperability

Standards for dynamic wireless charging interoperability are still needed. Both light-duty and heavy-duty EVs should be able to use the same ground-based transmitter system.

R&D Needed: Yes. Testing, data collection.

Recommendation: Develop standards to address dynamic wireless charging interoperability.

Priority: Low

Organization(s): SAE, IEC/TC 69, ISO TC22/SC37

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.
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New Published Standards & Codes	New In-Development Standards & Codes
	9/19/2025, T.Bohn, ANL: SAE WIP: J2954/3 Dynamic Wireless Power Transfer for both Light and Heavy-Duty Electric Vehicles (SAE RP J2954/3).

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Gap C4: EMC and EMF Measurements of Dynamic Wireless Power Transfer (WPT)

There are paths for obtaining the necessary EMC approvals before systems can be deployed for static WPT. Methods and procedures for conductive charging are needed for dynamic WPT. R&D investigations have to be undertaken to determine practical methods and procedures for determining reproduceable EMC and EMF measurements so that documents can be developed and accepted by the relevant regulatory agencies. This will have to be needed before development and demonstration installations of dynamic WPT will be allowed.

R&D Needed: Yes. Additional data collection and experimentation of the methods will need to happen before a documented procedure will be generated and accepted by industry and regulatory agencies.

Recommendation: Develop standards to address dynamic wireless power transfer, similar to parts of ANSI C63.30 which includes this topic for static WPT.

Priority: Medium

Organization(s): SAE, IEC/TC 69, ISO TC22/SC37

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap C5: Communications in Support of Wireless Power Transfer

The following issues need to be addressed:

- ISO 15118-series – resolution of conflicting requirements in ISO 15118-2 and/or ISO 15118-20 and publication in order to include static WPT
- SAE J2847/6 needs to be updated and harmonized with ISO 15118-2 and/or ISO 15118-20 so that there are uniform communication requirements for WPT

R&D Needed: TBD

Recommendation: Complete work on communication standards in development for static and dynamic wireless charging.

Priority: Low

Organization(s): SAE, ISO, IEC

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap C6: Power Export

While permitting for EVSE installation is covered by codes, permitting for the actual delivery of power from the vehicle (i.e., power export) is not specified in codes. Conformance with stationary energy storage systems and V2G standards, such as NFPA 855, may be required. SAE J3072 specifies the need for a permit but does not describe how to comply. There are terms and conditions for interconnections related to power export. Addressing this gap requires coordination between utilities, authorities having jurisdiction (AHJs), and code organizations.

R&D Needed: Only vehicles meeting building code requirements for stationary storage should be able to provide V2G services. Appropriate identification and hand shaking with V2G capcble EVSE must be developed.~~No~~

Recommendation: Address power export in relevant codes in cases where the NEC does not apply (e.g., interconnection agreements). Identify and facilitate integration of energy services to vehicle power export capabilities.

Coordinate NFPA 855 requirements with SAE standards for vehicle batteries that will be operated in V2G service. Educate building code inspectors on V2G service and code requirements.

Priority: Medium

Organization(s): NEMA, IEEE, Code organizations, utilities, AHJs, NFPA

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **5/1/2025, D.Karner, EAI:** See track changes on R&D and the gap recommendation.
- **9/26/2025, J.Smith, SCE:** It is inappropriate to align EV V2G under stationary battery standards (NFPA 855, etc.). The most prominent reason for this is that EVs do not present as a battery attached to a structural premise. In addition, EV batteries are components of a transportation device. See SCE safety recommendations.

New Published Standards & Codes	New In-Development Standards & Codes
10/27/2025, J.Bablo, UL: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* revision was published as Edition 3 in April 2025. **10/27/2025, J.Bablo, UL:** *UL 9741 Electric Vehicle Power Export Equipment (EVPE)* Edition 1 was published September 2023.	**3/13/2025 B.Doherty NEMA:** NEMA is working on a technical NEMA Revision to EVSE 40011-2024: EVSE Power Export Standard, and then will be moving towards ANSI Accreditation for the standard.

3/13/2025 B.Doherty NEMA: EVSE 40011-2024: EVSE Power Export Standard. This standard defines characteristics in key domains, electrical, communications, and cybersecurity, for permitting of power export between Electric Vehicle Supply Equipment (EVSE) and an electric power system (EPS).	

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Gap C7: Cable management

Functional management of EV cables in public parking spaces is not specifically addressed by codes or standards.

R&D Needed: No

Recommendation: Guidelines or standards relating to EVSE cable management in public parking spaces and how it is documented should be developed.

Priority: Medium

Organization(s): UL, NEMA, NFPA, NIST, DOJ

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)***:**

- **3/20/2025, S.Park, ULSE**: UL 2594 Certification Requirement Decision includes cable management systems and endurance test, dated Jun 22, 2023.

Other Committees / Organizations with Relevant Work:

- **3/13/2025 B.Doherty NEMA:** NEMA formed a technical committee to develop a guideline.

Comments Received on Gap for Future Consideration:

- **3/24/2025, R.Patel**: Cable reach should also be considered. Depending on the site and vehicle type, a different cable length or management system to charge the EV may be needed
- **2/18/2025, J.Bablo, UL:** Both UL 2594, Electric Vehicle Supply Equipment, and UL 2202, DC charging Equipment, have been updated to include requirements around cable management. Overall, these standards cannot dictate design so as such they are addressing damage to the cable and means of providing cable management on a case by case basis dependent on actual design. Both standards are processing these changes through the SDO revision cycle.

New Published Standards & Codes	New In-Development Standards & Codes
3/17/2025, A.Krabbe, ULSE: UL 2594 Electric Vehicle Supply Equipment (Edition 3, Dec 2022) provides requirements for cable management but does not contain extensive guidelines for implementation.	**3/13/2025 B.Doherty NEMA:** NEMA filed an ANSI PINS for *BSR/NEMA EVSE 40007-202X, Electric Vehicle Cable Management in Public Charging and Parking Spaces (new standard) PINS: Mar 1, 2024* to develop a standard that defines best practices for functional management of EV cables in public charging/parking spaces. Standard will align with existing UL safety standards.

	2/18/2025, J.Bablo, UL: Updates to UL 2202 DC Charging Equipment for Electric Vehicles (Edition 3, Dec 2022) are underway.

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Gap C8: Fire protection in relation to EV parking/charging in/near older buildings	
Fire propagation of electric vehicles differs from conventional vehicles. There is potential for explosive gas build up which can result in an explosion. As mentioned above, there are many conversations around parking and charging EVs in or near older structures, such as multi-family residences with an indoor or underground parking lot. If a fire incident was to occur where many EVs are in the same parking area, issues arise such as whether the building can withstand the intensity of a lithium-ion battery fire and, what that means for any fire protection equipment that should be installed. Note: This is also a concern for parking/charging in or near older commercial buildings as well. **R&D Needed:** Potentially, yes. Research into building materials that can or cannot withstand a lithium-ion fire. Fire protection equipment that should be installed and other fire prevention means may also require research. Note: The 2023 edition of NFPA 88A requires the installation of automatic sprinkler systems in all parking structures in accordance with NFPA 13 and NFPA 13R as applicable. It also requires that automatic sprinkler systems be inspected, tested, and maintained in accordance with NFPA 25. **Recommendation:** Develop standards or codes to address the issue of fire protection where EVs are parked/charging in/near older buildings. **Priority:** Medium **Organization(s):** International Code Council (ICC), NECA, NEMA, NFPA, and the International Association of Electrical Inspectors (IAEI) to address code related issues	
Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*: • No updates as of publication of this report. **Other Committees / Organizations with Relevant Work:** • No updates as of publication of this report. **Comments Received on Gap for Future Consideration:** • No comments as of publication of this report.	
New Published Standards & Codes	**New In-Development Standards & Codes**

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Section 3 Charging Infrastructure Recommendations / Comments Since Roadmap Publication

*Additional general comments, standards activities, and recommendations for gaps in standards and codes related to the **Section 3: Charging Infrastructure**.*

New Gap Suggestions

The following gap(s) was suggested during comments against the gaps progress report. This language did not go through EVSP working group or public review. It is for information only and has not been assigned an EVSP gap number but may be considered by the EV standardization community.

9/19/2025, B.Engle, Amphenol: New Gap Suggestion: Battery Decommissioning Procedures

Standards are needed to address safety and second handling of DDR/end of life battery systems when on a vehicle after a damage event. A standard to outline the initial triage of battery system involved in an event and consider scenarios to evaluate or discharge a battery because it has risks. Stakeholders need guidance about how to manage that process and determine what the format for decommissioning.

EPRI put together a format decommissioning a BESS system but other sized systems where infrastructure and contractors are not engaged. The individually dismantling these other sized systems are going to have very limited information but they need visual guidance. Some considerations are:

- *Emergency response / dismantling guide*
- *Readying for safe transport (Load shifting, clipping 10%, stabilize)*
- *Discharge considerations (Hazard level / DMS / impact on recoverability of the chemistries)*

Battery Decommissioning Committee started in 2025 to establish recommended practices to enable safe field procedures for safety and handling of on- vehicle battery systems. See also, SAE J3009: Stranded Energy – Reporting and Extraction from Vehicle Electrochemical Storage Systems.

Organization(s): SAE, NEMA, UL

2/25/2025, F.Reyes, UL: New Gap Suggestion: Bidirectional – Personnel Protection Requirements while exporting to grid.

Application of ground fault and isolation monitoring requirements for the protection of personnel during bidirectional export to grid. Determine appropriate location of protection to provide an acceptable minimum level protection.

R&D Needed: Yes.

1- Gap analysis to determine the hazards during bidirectional export and minimum level of protection unique to this type of supply source.
2- If protection is determined to be required per item 1, where should the protection be located during export?
3- During a ground fault event at the EV cable, the fault may be sourced from either or both the utility grid and EV or separately derived source, requiring considerations to mitigate two interdependent current sources. Project scheme shall consider this potential occurrence.

Recommendation: Coordination of technical committees' members of SAE J3072, UL 9741, & UL 2251.

Priority: Medium

Organization(s): SAE, NEMA, UL

New Published Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- **8/10/2025, T.Bohn, ANL:** *SAE J3253, Electric Power Take-Off Interface for Commercial Vehicles* (published Aug 2025) covers the general guidelines for conductive power transfer of high voltage Direct Current (DC) between OEM commercial truck chassis electrical systems and electrically powered body accessory equipment.
- **3/19/2025 D.Trayers, UL:** Consider adding "Adapters" as a topic. *ANSI/CAN/UL 2252, Adapters for Use with Electric Vehicle Couplers* was published on 3/19/2025 and *SAE WIP J3400-1 Electric Vehicle Charging Adapter Safety and OEM Qualified Device Designation* is in development.

New In-Development Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- **3/20/2025, S.Park, ULSE**: Concerns over long-term reliability of EVSEs especially those installed outdoors have been expressed. UL 2594 Electric Vehicle Supply Equipment (Edition 3, Dec 2022) references UL 50E Enclosures for Electrical Equipment, Environmental Considerations (pressure washer test) which had ballot & comments due 12/9/24.

General Comments

Additional comments related to charging infrastructure that are not already included in the chapter above.

- **9/1/2025, MBayings, EVRoaming:** There are no standards for charging infrastructure for disabled persons. AC/DC/HPC hardware standards are needed. For communication about usability, EVRoaming Foundation is working on OCPI addition to support this, but there is a gap for standards for the chargers Describing it all via OCPI is not the solution.
- **3/14/2025, AAmin, CSA Group:** CSA is currently working on EVEMS standard CSA C22.2 NO. 343. It is ANSI approved to use for product certification in USA and SCC approved for use in Canada.
    - EVEMS- a means used to control EVSE loads through the process of connecting, disconnecting, increasing, or reducing electric power to the loads and consisting of any of the following: a monitor(s), communications equipment, a controller(s), a timer(s), and other applicable device(s). additional recommendations or comments provided as of publication of this report.
    - **3/24/2025 BNordman, LBL:** The US National Electrical Code also has a term for something like this (e.g., Power System Controller) that keeps loads below a panel or service connection limit. That is not EV-specific but can include EVSEs.

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SECTION 4: GRID INTEGRATION

The charging of EVs creates both risks and opportunities for service providers and consumers. At a minimum, consumers want access to a ubiquitous charging infrastructure that enables them to charge their EVs safely and quickly at the cheapest possible rate and to know what that rate will be, in advance. Energy Service Providers want to be able to incentivize charging to off-peak hours to improve grid efficiency and potentially to protect grid assets.

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
4.1.1	Gap G1: Standardization of Error Codes and Reporting (last updated 10/7/2025)	High	High
4.1.2	Gap G2: Locating and Reserving a Public Charging Station, Obtaining Pricing and Availability Information (last updated 10/7/2025)	Medium	Medium
4.1.3	Gap G3: Communication of standardized EV sub-metering data (last updated 10/7/2025)	High	High
4.1.3	Gap G4: Metrological Traceability for Quantitative Measurement of DC Power Delivery (last updated 10/27/2025)	Medium	Medium
4.1.3	Gap G5: Standardization of EV sub-meters (last updated 10/7/2025)	High	High
4.2.1	Gap G6: Dynamic Capacity Management (DCM) (last updated 10/27/2025)	High	Medium
4.2.1	Gap G7: Safety and Protection of DC architectures are not standardized (last updated 9/16/2025)	Medium	Medium
4.2.1	Gap G8: Fault Current Signatures for AC and DC Architectures under Islanding Conditions (last updated 9/29/2025)	Medium	Medium
4.2.1	Gap G9: "Ride Through" Requirements for EVSE under Grid Service Conditions (last updated 9/29/2025)	Medium	Medium
4.2.1	Gap G10: DC-as-a-Service (DCaaS) (last updated 10/7/2025)	Medium	Medium
4.2.2	Gap G11: Structured Information and Energy Services Exchange with Utilities (last updated 9/29/2025)	Medium	Medium
4.3	Gap G12: Assess UL 1741 V2G Integration Requirements (last updated 9/29/2025)	Medium	Medium
4.3	Gap G13: Maintain Alignment between UL 9741 and UL 1741	Medium	Medium
4.3	Gap G14: Revise SAE J3072 to harmonize with UL 1741 SB (last updated 9/29/2025)	Medium	Medium
4.3	Gap G15: Assess Interoperability Between Communication Protocols and Standards (last updated 9/29/2025)	High	Low
Section 4 Grid Integration Recommendations **(last updated 10/7/2025)**			

Gap G1: Standardization of Error Codes and Reporting

To develop best practices and guidance for diagnostics including standardized error codes across the EV charging ecosystem, such as for no charge events. Considerations include what should be reported, specific formats, associated language, and appearance (e.g., symbols, color) for display. Reporting may be done to various actors (i.e., person charging, building owner, charge point operator, grid, or a third-party) and privacy restrictions may apply.

R&D Needed: Yes.

Recommendation: Conduct a review of applicable standards (e.g., OCPP, IEC 15118, IEEE 1621) particularly error tables and gather inputs on common errors from relevant stakeholders. Determine which errors should be reported and develop language for displaying the error.

Priority: High

Organization(s): OCA, CharIN, SAE, manufacturers, operators

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, D.Anand, INL:** Through the DOE/DOT Joint Office of Energy and Transportation, minimum required error codes for EV-EVSE communications have been completed, published, and adopted by some entities within the EV charging ecosystem. Activities to identify Minimum Required Diagnostic Information (MRDI) for charging infrastructure is ongoing.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, D.Anand, INL:** This gap may fit better under Section 3 Charging Infrastructure. If it remains here, utilities should be added to the list of organizations.
- **3/24/2025, R.Patel**: Suggested revisions to gap description shown with track changes above.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap G2: Locating and Reserving a Public Charging Station, Obtaining Pricing and Availability Information

There is a need for standard(s)/implementation guides to permit EV drivers to locate a public charging spot, reserve its use in advance, and obtain pricing information and near real-time availability.

See also new gaps in Section 4 Grid Integration Recommendations from April 2025

R&D Needed: No

Recommendation: Develop a standard(s) / implementation guides to permit EV drivers to universally locate and reserve a public charging spot, and to obtain pricing information and near real-time availability.

Priority: Medium

Organization(s): SAE, OCA, EVRoaming Foundation, ~~eMI³,~~ ETSI ITS

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, D.Anand, INL:** The National Electric Vehicle Infrastructure (NEVI) Formula Program requires participants to report information including charging locations and charger availability information through the Electric Vehicle Charging Analytics and Reporting Tool (EVChart).
- **9/1/2025, MBayings, EVRoaming:** OCPI 2.3.0 booking module with all this functionality in it is freely available for download. This version is compliant with EU NAP (AFIR) regulations, contains vehicle types for locations, is extendable, and contains optional Payment terminal and Booking module. (Version 2.1.1 is not supported anymore). OCPI 3.0 is available in draft version – target release date is mid-2025. It is the aim that modules from 3.0 can also work together with v.2.30.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **4/8/2025, B.Nordman, LBL:** *Comment on gap description:* It is unclear if this is M2M communication, how the information is conveyed to humans, or both. Also need to consider both ordinary commercial chargers, and individual chargers (usually residences) that make theirs available to others. *Comment on gap recommendation:* Need to support dynamic pricing, and forecasts of prices in addition to guaranteed prices.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap G3: Communication of standardized EV sub-metering data

Standards are needed for communication of EV sub-metering data between third parties and service providers.

R&D Needed: No

Recommendation: Develop a standard to communicate EV sub-metering data between a third party and a billing agent (e.g., utility).

Priority: High

Organization(s): ~~OpenADE~~OpenADR, ~~/~~NAESB, IEEE, MESA, SunSpec Alliance, OpenFMB, NIST USNWG EVF&S, ANSI C12

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, J.Smith, SCE:** The MDMA (Meter Data Management Agent) data transfer requirements have been established and are in use at SCE.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, J.Smith, SCE:** The MDMA (Meter Data Management Agent) data transfer requirements have been established and are in use at SCE.
- **10/7/2025, F.Wagner**: OCPP 2.1 includes support for submetering, including meter values, transaction data, and calibration. It likely superseding other resources and addresses everything needed for metering.
- **9/19/2025, R.Kaiser, Evoke:** OCPI+ extensions can deliver standardized session telemetry, interval metering, uptime, and utilization data. These extensions are being submitted to the EVRoaming Foundation for review and adoption.
- **4/8/2025, B.Nordman, LBL:** Comment on gap description: How about between a customer device and a service provider, e.g., for a tariff for charging separate from the primary customer tariff?

New Published Standards & Codes	New In-Development Standards & Codes

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Gap G4: Metrological Traceability for Quantitative Measurement of DC Power Delivery

At present, the U.S. does not maintain System Internationale (SI) traceability for DC measurement in ensuring metrological soundness of DC EVSEs. Further, there is no current specification for transfer standards or processes for establishing traceability of EVSE measurement of DC power by testing authorities.

R&D Needed: Yes. Develop specifications for transfer standards and processes to ensure metrological traceability and accuracy for DC power measurement for DC EVSEs. (This work is in process.)

Recommendation: Develop standard to address the transfer and traceability of meters for the testing of DC EVSE.

Priority: Medium

Organization(s): NIST

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)***:**

- **10/27/2025, D.Anand, INL:** NIST published a report titled *Power and Energy Generation and Measurement System to Support DC Charging of Electric Vehicles* in May 2024. R&D work should be continued to address the balance of the traceability infrastructure needs to be built out and the National Conference of Weights and Measures should create a process for DC EVSEs to compare their measurements to the NIST system.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap G5: Standardization of EV sub-meters

Standards for EV sub-meters, including embedded sub-meters, are needed to address performance, security/privacy, access, and data aspects. Standardization of commercial transactions EV sub-meters is complete.

Utility tariffs involving sub-metering is a complicated process at present with much state-to-state and utility-to-utility differences (what is allowed, how it is interpreted). Policy development is needed to assist utilities in applying EV charging tariffs to the facility, and not the customer charging their vehicle.

R&D Needed: No

Recommendation: Develop standards or guidelines related to the functionality and measurement characteristics of sub-meters for EVs, including embedded sub-meters in the EVSE or EV. Such standards should address different form factors, capabilities, installation, and certification. Organizations developing standards, guidelines or use cases related to EV sub-metering should coordinate their activities in order to avoid duplication of effort, assure alignment, and maximize efficiency.

Priority: High

Organization(s): NEMA, USNWG EVF&S, SEPA, EPRI, ANSI

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **4/8/2025, B.Nordman, LBL:** *Comment on gap description:* Is this backwards? Is it to charge it to the customer and not to the facility? Isn't this between the facility and the vehicle owner – why is the grid involved?

New Published Standards & Codes	New In-Development Standards & Codes

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Gap G6: Dynamic Capacity Management (DCM) | Load Management

DCM relates to managing local distribution capacity constraints and balancing supply and demand on the grid with the requirements of ~~the~~ EV charging ~~station~~ and other loads on the grid. Open Automated Demand Response (OpenADR 2.0) is one way of managing capacity for DCM focusing on energy and demand response, as well as pricing communications. Newer iterations of OpenADR are expected to improve grid coordination.

Presently, program/user guides on OpenADR and IEEE 2030.5 exist. There have been a large number of pilots carried out to address this topic. Questions remain though as to clarification of further grid coordination mechanisms to be supported, as well as consumer information to enhance understanding of these standards. (see also G11)

R&D Needed: Yes, to determine ways to do DCM

Recommendation: Continue to pursue various ways to do DCM (e.g., within the context of OpenADR) to identify and incorporate advanced grid coordination mechanisms. Determine if existing program/user guides on OpenADR and IEEE 2030.5 are sufficient or if additional consumer information is needed.

Priority: ~~Medium~~High

Organization(s): IEEE, NEMA, OpenADR Alliance, and others as appropriate

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, D.Anand, INL:** Revise title to Load Management. OCPP, IEC 61850, and UL 3141 (Power Conversion System) should also be considered. OpenADR should not be the sole focus.
- **9/19/2025, R.Kaiser, Evoke:** The EPRI FlexLoad Guide describes how the DER Capacity Exchange and Dispatch Exchange enable location-aware dispatch across feeders, substations, and load zones. OpenADR 3 can enable VEN registration, dynamic VEN assignment, and constraint-based targeting, establishing dynamic operating envelopes and real-time capacity management. A DOE-funded proof-of-concept validated this approach in Con Edison's service territory.
- **4/8/2025, B.Nordman, LBL:** The OpenADR 3 defines two ways to manage capacity (one limit-based (DOE) and a second one that is limit-based (and more appropriate for EV charging). Many utilities are testing flexible load connections for EV charging stations, though generally much less dynamic than is supported by OpenADR 3.
- **4/8/2025, B.Nordman, LBL:** IEEE 2030.5 supports Dynamic Operating Envelopes (DOE).

New Published Standards & Codes	New In-Development Standards & Codes
10/27/2025, B.Nordman, LBL: The *OpenADR 3.1.0 Standard* was published. **4/8/2025, B.Nordman, LBL:** The *OpenADR 3.0 Standard* was published in September 2023. It is not intended to replace the OpenADR 2.0a/b Profile Specifications. Rather, it provides an additional, simplified way to add OpenADR functionalities in current, as well as different and new scenarios.	

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Gap G7: Safety and Protection of DC architectures are not standardized

Technology is not well established nor is it currently known how to do a thorough DC protection system design (especially with regard to islanding). Short circuit protection for complex energy sources (e.g., multiple energy sources and bidirectional power flow) is the primary gap. IEEE P2030.12 is a draft guide for microgrid protection systems. The National Electrical Code® (NEC®) does address DC microgrids, principally driven by photovoltaics and energy storage. There is considerable cross-over with the solar industry within SunSpec and for microgrids within the Emerge Alliance. In Europe, the Open Society (OS) Foundation is working to develop guidelines and transfer them to the International Electrotechnical Commission (IEC) for formal standardization.

R&D Needed: Yes

Recommendation: Continue to pursue standardization of safety and protection for DC architectures, especially within the IEEE P2030 suite of standardization activities.

Priority: Medium

Organization(s): IEEE, UL (several safety standards related to safety), NFPA

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
09/16/2025 D.Trayers (UL Solutions): ANSI/UL 3001:2025 Standard Distributed Energy Resource Systems, covering requirements for large microgrids (US and Canada) was published on April 21, 2025.	**09/16/2025 D.Trayers (UL Solutions):** UL 3010 Single Site Energy Storage Systems (small microgrids) outline of investigation is under development. **09/16/2025 D.Trayers (UL Solutions):** UL 3001D – DC Distributed Energy Storage Systems (DC microgrids) outline of investigation is under development.

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Gap G8: Fault Current Signatures for AC and DC Architectures under Islanding Conditions

Identifiable fault currents can be an issue for AC and DC architectures. Specifically, the magnitude and signature of fault currents within AC and DC architectures can be too low to trip protection and provide safety. The issue of fault currents is largely covered in UL 1741 and UL 9741 for AC and DC systems. UL 1741 Supplement SC includes a safety overvoltage protection function in the event the EV exceeds 120 percent of

nominal unit voltage. The V2G interconnection criteria will follow national grid interconnection standards. However, coordination in front of and behind the meter is needed when systems are islanding, especially within the context of hybrid (AC/DC intertwined) and DC architectures, and non-linear loads.

R&D Needed: Yes

Recommendation: Explore fault currents under islanding conditions and, as appropriate, implement codes and standards development to address safety and grid interconnection performance aspects for EVSE.

Priority: Medium

Organization(s): UL, FERC, NEMA, NERC, Vehicle OEMs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, D.Anand, INL:** Significant issues exist between auto OEMs and infrastructure providers.

New Published Standards & Codes	New In-Development Standards & Codes
10/15/2025, C.Bernat: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* revision was published as Edition 3 in April 2025.	**9/29/2025 A. Sinnott, ULSE**: UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources is preparing to go to ballot. Estimated publication is early 1st quarter 2026. **3/17/2025 A.Krabbe, ULSE**: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* Supplement SC (Interconnection systems equipment "ISE") is currently under development.

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Gap G9: "Ride Through" Requirements for EVSE under Grid Service Conditions

"Ride Through" requirements encompass how systems/devices will behave when conditions on either side of the point of interconnection (EV Station or grid) are not normal. There is a dichotomy: first, for the distribution network within the EV station itself especially under islanding (i.e., not connected to the grid) conditions, and, second, on the grid side specifically at the systems level with regard to voltage and frequency. When EVSE are supplying power to the grid, "Ride Through" requirements need to be defined under specific conditions. "Ride Through" is not applicable in this context for DC systems.

R&D Needed: Yes

Recommendation: Explore "Ride Through" requirements for EVSE under grid service conditions. "Ride Through" requirements are covered under IEEE 1547, with V2G specifically covered under IEEE 1547.1. UL 9741 covers AC coupled output and interconnection, with the latest version addressing vehicle-to-everything (V2X). UL 1741 Supplement SC will address situations where vehicles have onboard AC inverters. As appropriate, implement codes and standards development.

Priority: Medium

Organization(s): IEEE, UL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **2/25/2025 F.Cleveland, Xanthus**: Suggested revisions to gap recommendation to " Ensure "Ride Through" requirements for EVSE under grid service conditions are captured correctly in UL 1741-SC and in the communication protocols used to the EVSE and between the EVSE and the EV."

New Published Standards & Codes	New In-Development Standards & Codes
10/15/2025, C.Bernat: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* revision was published as Edition 3 in April 2025. **6/27/2025 T.Bohn, ANL**: OCPP 2.0 adopted by reference OCPP 2.0.2 as *IEC 63584:2024 Open Charge Point Protocol (OCPP)* in October 2024. **2/25/2025 F.Cleveland, Xanthus**: *IEC 62460:2025, Temperature - Electromotive force (EMF) tables for pure-element thermocouple combinations*	**9/29/2025 A. Sinnott, ULSE**: UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources is preparing to go to ballot. Estimated publication is early 1st quarter 2026. **2/25/2025 F.Cleveland, Xanthus**: *ISO 15118-20:2022/DAmd1, Road vehicles — Vehicle to grid communication interface, Part 20: 2nd generation network layer and application layer requirements Amendment 1: AC DER service, MCS service, and improved security concept.* **2/25/2025 F.Cleveland, Xanthus**: IEEE 1815.2 (joint with MESA) will define the communication requirements for distributed energy resources (DER), with a special focus on utility-scale energy storage systems (ESS). See more.

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Gap G10: DC-as-a-Service (DCaaS)

A thorough review of standards is needed for applicability. This includes electrical power standards and any other standards for DC distribution, as well as for fast charging stations and DC microgrids. DCaaS is a business proposition and involves standards, codes, policy development, and coordination to ultimately be successful. Monetization of the business proposition requires an approved DC tariff which does not exist.

R&D Needed: No

Recommendation: Pursue a comprehensive review of codes and standards for applicability to DCaaS. Determine which existing codes and standards apply in specific situations and identify any existing gaps. Work with public utility regulators to establish DC tariffs.

Priority: Medium

Organization(s): Current/OS, IEEE, NFPA, SunSpec, Emerge Alliance, public utility regulators

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- **10/7/2025, D.Anand, INL:** National Grid is trying to implement DCaaS.

Comments Received on Gap for Future Consideration:

- **4/8/2025, B.Nordman, LBL:** This gap should cover both DC provided by the utility as well as that provided by the customer internal to the customer site.

New Published Standards & Codes	New In-Development Standards & Codes
9/29/2025 A. Sinnott, ULSE: *UL 3202 Mobile Electric Vehicle Charging Systems Integrated with Energy Storage Systems, Edition 1* which addresses DC charging was published June 2025.	

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Gap G11: Structured Information and Energy Services Exchange with Utilities

There is a need for structured information and energy services exchange to enable utilities to balance utility-side availability of renewables with site requirements, including EVs, stationary storage, and/or any flexible load to provide grid services**.** This gap specifically encompasses the need for structured information exchange to enable balance and negotiation, not command and control. This includes how to measure, communicate, and confirm transfer of information. In short, it is an energy services exchange and value proposition gap and incorporates information transfer at the distribution level. (see also G6)

R&D Needed: Yes, further development and demonstration

Recommendation: Continue to pursue improved mechanisms for structured information and energy services exchange within the context of IEEE P2030.5, ~~and~~ IEEE P2030.13, and IEC 61850. Additionally, the North American Energy Standards Board (NAESB) is working on the transmission side, while the US DOE Grid Modernization Laboratory Consortium (GMLC) has looked at this extensively over the last five years.

Priority: Medium

Organization(s): IEEE, OpenADR, NAESB, and GMLC

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **9/19/2025, R.Kaiser, Evoke:** The EPRI FlexLoad Reference Guide provides standardized OpenADR3 JSON schemas for Energy Services Exchanges: Real-Time Demand, Forecasting, DER Capacity, Dispatch, and Performance. This framework provides a single, interoperable pathway for utilities, aggregators, and CSOs, eliminating reliance on proprietary integrations. Additionally, the DER Capacity Exchange enables standardized capacity declarations to EVSEs, EVs, and aggregators. By directly communicating available charging or curtailment capacity, it ensures that grid-constrained information is reflected and acted upon in real time.
- **4/8/2025, B.Nordman, LBL:** *Comment on gap description:* This puts the utility as the balancer. The customer is much better suited to do this – in coordination with the utility. Also need to clarify which, or all of, the EV, EVSE, and other customer devices are involved.

New Published Standards & Codes	New In-Development Standards & Codes
09/16/2025, D.Trayers (UL Solutions): UL 3141 Power Control Systems - Outline of Investigation, published on October 2024, addresses the use of PCS (Power Control Systems) in distributed energy resource (DER) systems including primary power sources (utility grid).	

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Gap G12: Assess UL 1741 V2G Integration Requirements

Assess and potentially revise UL 1741 and Supplements to ensure it properly accounts for V2G integration. Currently, most requirements cannot be used for automotive electronics and an automotive version would be needed (SAE J3072 was created for this purpose).

R&D Needed: Yes

Recommendation: Assess and revise, if necessary, UL 1741. The UL 1741 Supplement SC task group should continue to support SAE J3072 and J3068/2 for V2G-AC.

Priority: Medium

Organization(s): UL, SAE, IEEE

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
10/15/2025, C.Bernat: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* revision was published as Edition 3 in April 2025.	**9/29/2025 A. Sinnott, ULSE**: UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources is preparing to go to ballot. Estimated publication is early 1st quarter 2026.

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Gap G13: Maintain alignment between UL 9741 and UL 1741

With regard to V2G, these two standards complement each other and it is important to maintain alignment as they are revised. For UL 9741 to apply to V2G-AC, the standard needs to align with UL 1741 Supplement SC which calls out conformance to SAE J3072.

R&D Needed: Yes

Recommendation: Continue to update UL 9741 to achieve alignment with evolving UL 1741

Priority: Medium

Organization(s): UL, SAE, IEEE

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes
10/15/2025, C.Bernat: *UL 1741 Inverters, Converters, Controllers and Interconnection*	**3/19/2025 D.Trayers, UL:** UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for

System Equipment for Use With Distributed Energy Resources revision was published as Edition 3 in April 2025.	Use With Distributed Energy Resources Supplement SC (Interconnection systems equipment "ISE") is currently under development **3/17/2025 A.Krabbe, ULSE**: *UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources* Supplement SC (Interconnection systems equipment "ISE") is currently under development.

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Gap G14: Revise SAE J3072 to harmonize with UL 1741 SB

SAE J3072 currently references IEEE 1547 (2018) and IEEE 1547.1 (2020); however, it does not currently reference UL 1741 Supplement SB. UL 1741 Supplement SB contains approximately 30 pages of additions and corrections that need to be used in conjunction with the IEEE 1547 standard suite. IEEE 1547 is the test standard where UL 1741 is the certification standard. They need to be used together. There are plans to amend J3072 to reference UL 1741 Supplement SB due to this situation. Note: J3072 inverters are intended to be used in conjunction with UL 1741 Supplement SC bidirectional EVSE (BEVSE).

R&D Needed: Yes

Recommendation: Amend J3072 to reference and align with UL 1741 Supplement SB.

Priority: Medium

Organization(s): SAE, IEEE, UL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **9/29/2025 A.Sinnott, ULSE:** SAE should reference UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources. No new updates from ULSE.
- **2/25/2025 F.Cleveland, Xanthus**: Revise gap description to "SAE J3072 currently references IEEE 1547 (2018) and IEEE 1547.1 (2020) and was updated to reflect issues as found during development of UL 1741 Supplement SC bidirectional EVSE (BEVSE). As that supplement becomes finalized, consistency with SAE 3072 needs to be ensured" with a recommendation to "continue work on UL 1741 SC and ensure consistency with SAE 3072"

New Published Standards & Codes	New In-Development Standards & Codes
10/15/2025, C.Bernat: *UL 1741 Inverters, Converters, Controllers and Interconnection*	

System Equipment for Use With Distributed Energy Resources revision was published as Edition 3 in April 2025.	

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Gap G15: Assess Interoperability Between Communication Protocols and Standards

Interoperability incorporates seamless implementation of communication protocols and standards, including coordinated testing procedures to verify end to end performance for grid interaction and support. The ability to assess interoperability between the utility and the downstream DER via allowed protocols per IEEE 1547 (IEEE 2030.5, SunSpec Modbus, and DNP3) is required to ensure utility / DER compatibility. UL 1741 Supplement SB (through reference to IEEE 1547) requires testing with the implemented protocol(s).

R&D Needs: No

Recommendation: Assess interoperability between communication protocols and standards

Priority: ~~Low~~High

Organization(s): UL, IEEE, ISO, OpenADR, SunSpec, DNP3, OCPP

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)***:**

- **2/25/2025 F.Cleveland, Xanthus**: Significant work has been undertaken to use the IEC 61850-7-420 data object names across many of these protocols, including IEEE 1815.2 (DER Profile for DNP3), OCPP 2.0.1, ISO 15118-20 amendment x, SunSpec Modbus for DER. That work is not yet complete but is close.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **2/25/2025 F.Cleveland, Xanthus**: Work needs to continue on communications interoperability as V2G becomes more defined, and as other technologies and requirements increase their capabilities.
- **4/8/2025, B.Nordman, LBL:** *Comment on Gap Description:* IEEE1547, This effectively only covers coordination with inverters, for inverter functions. It does not cover coordination for energy or capacity. Those are proposed as new gaps. The content is quite distinct for each so three separate gaps are appropriate, not one unwieldly one.

New Published Standards & Codes	New In-Development Standards & Codes
9/29/2025 A. Sinnott, ULSE: References for Cybersecurity were added to UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources and published April 2025.	**2/25/2025 F.Cleveland, Xanthus**: OCPP 2.0 as revisions to *IEC 63584:2024 Open Charge Point Protocol (OCPP).* **2/25/2025 F.Cleveland, Xanthus**: *ISO 15118-20:2022/DAmd1, Road vehicles — Vehicle to grid communication interface, Part 20: 2nd generation network*

2/25/2025 F.Cleveland, Xanthus: *IEC 63584:2024 Open Charge Point Protocol (OCPP).* (OCPP 2.0.1)	*layer and application layer requirements Amendment 1: AC DER service, MCS service, and improved security concept.* **2/25/2025 F.Cleveland, Xanthus**: IEEE 1815.2 (joint with MESA) will define the communication requirements for distributed energy resources (DER), with a special focus on utility-scale energy storage systems (ESS). See more.

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Section 4 Grid Integration Recommendations/Comments Since Publication of Roadmap

*Additional general comments, standards activities, and recommendations for gaps in standards and codes related to the **Section 4: Grid Integration**.*

New Gap Suggestions

The following gap(s) was suggested during comments against the gaps progress report. This language did not go through EVSP working group or public review. It is for information only and has not been assigned an EVSP gap number but may be considered by the EV standardization community.

10/7/2025, D.Anand, INL: New Gap Suggestion: Interoperability between Utility Operated ADMS and DERMS systems
Utilities do not have visibility of charging loads to be able to monitor and control the grid. There is no way to know which parts of the grid are impacted. More visibility on EV loads is needed.

10/7/2025, D.Anand, INL: New Gap Suggestion: Utility Procurement of Aggregator Services
Standards are needed on communications pathways and how aggregator requirements are enforced. There is a gap with regards to utility procurement of services from aggregators, especially given the proliferation of third-party aggregators. Aggregators tend to over promise and under deliver.

10/7/2025, D.Anand, INL: New Gap Suggestion: Microgrid/Building Management Systems
There is a lack of standards to actively coordinate building management systems and microgrids. To avoid demand charges, it is critical to have standards.

10/7/2025, D.Anand, INL: New Gap Suggestion: Permitting/Load Approval Processes for Large Charging Sites
There is a lack of processes, procedures, and standards to guide the approval, development, and implementation of large charging sites.

9/19/2025, B.Engle, Amphenol: New Gap Suggestion: Micro-grid operations
Standards for charging at micro-grids (or “mostly off-grid”) are needed. A micro-grid has a separate domain of power managed independently. The controller is the connected to the grid but not the charger. The majority of off-grid charging is DER storage and can help with energy storage. Most of the time the loads are low but they

vary. Some facilities may have too much generate to off load or store but could export this power for off-grid charging. It would be helpful to users to know the demand cycle so they can determine what is needed to charge off-grid.

This is related to gap G6.

4/8/2025, B.Nordman, LBL: New Gap Suggestion: Communicating Electricity Price Information to EVSE and EV

To minimize customer costs, time-varying electricity prices need to be communicated to the EVSE and/or EV, to cover the time period when charging may occur. This may be a retail price, or a "local price" that reflects the true value of electricity at the point inside the customer site where the electricity is delivered to the EVSE. This also applies to EV export. (see also Gap G2)

R&D Needed: Yes.

Recommendation: Review the various pathways that retail electricity prices (import and export) can pass through from the Energy Service Provider to the EVSE and EV. Identify suitable and recommended communication protocols, describe how complete their content is, and if any updates are needed.

Priority: High

Organization(s): OpenADR, IEEE, OCA, Connectivity Standards Alliance (CSA), SAE

Comments on Draft New Gap:

- **9/19/2025, R.Kaiser, Evoke**: EPRI FlexLoad Guide – The DER Capacity Exchange (OpenADR 3) provides standardized capacity declarations to EVSEs, EVs, and aggregators. These allow direct communication of available charging/curtailment capacity, ensuring grid-constrained information is acted upon in real time

4/8/2025, B.Nordman, LBL: New Gap Suggestion: Communicating Electricity Capacity Information to EVSE and EV

To minimize customer costs, electricity capacity information needs to be communicated to the EVSE and/or EV, to cover the time period when charging may occur. This will typically be the capacity (import and export) limits at the customer meter, along with estimates of the future consumption of the rest of the customer site. The EVSE or EV may also be able to negotiate changes to capacity limits with the operator of the local distribution grid. See also Gap G11.

R&D Needed: Yes.

Recommendation: Review existing mechanisms in standards for coordinating customer capacity needs and limits between the grid and the customer site. Consider if any additional mechanisms should be developed. Determine the communication needs for this data. Identify suitable and recommended communication protocols, describe how complete their content is, and if any updates are needed.

Priority: High

Organization(s): OpenADR, IEEE, OCA, Connectivity Standards Alliance (CSA), SAE

4/8/2025, B.Nordman, LBL: New Gap Suggestion: User Interface Standards

SAE J2402_201001 defines standard symbols and colors for use on vehicle dashboards, so that users of vehicles will reliably understand how to safely operate it. It covers both passenger vehicles as well as medium and heavy duty trucks. Use of this standard is widespread and very successful. Charging user interfaces lack such a standard. There are generic UI standards (mainly ISO and IEC) to build on, and that the SAE standard references, but new content is needed. The UI elements may appear on vehicle dashboards, at the cable connection point, on charger hardware, and on display screens in the vehicle, charger, phone apps, or elsewhere. See also Gap G1.

R&D Needed: Yes.

Recommendation: Review the various relevant existing standards. Survey UI elements used on existing products, to understand the information elements that need to be conveyed, and what is used on existing products. The survey should cover as many geographies as is feasible. Elements may include symbols, colors, physical mappings, audio, tactile/haptic, and dynamic operation. Evaluate potential bodies to host the standard (e.g. SAE, ISO, or IEC).

Priority: High

Organization(s): IEEE, SAE, ISO, IEC

New Published Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional newly published standards or codes provided as of publication of this report.

New In-Development Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional in-development standards or codes provided as of publication of this report.

General Comments

Additional comments related to grid integration that are not already included in the chapter above.

- **9/19/2025, B.Nordman, LBL:** The Mercury Consortium was formed in 2025 bring together manufacturers, utilities, regulators, and tech providers. They develop and promote guidelines for consumer devices—such as EVs, heat pumps, residential batteries, and smart thermostats—to integrate into energy systems and participate in demand-response programs and markets. They are working on EV charging standards so coordination would be beneficial.
- **4/8/2025, B.Nordman, LBL:** Check all uses of the term “rate” and where what is really meant is “price” (as in this case), use “price” instead. Rate is inherently ambiguous – sometimes price, sometimes tariff, and sometimes bill.

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SECTION 5: CYBERSECURITY

A lack of cybersecurity has the potential to be a major impediment to the large-scale adoption and integration of EVs with the grid. The vast cross-sectoral nature of the EV ecosystem, combined with the complexity of systems and technologies required to integrate EVs onto the grid, exposes a multitude of cybersecurity risks. Apart from AC Level 1 chargers, EVSE has evolved rapidly to be networked and maintain a wide variety of communication functions. As communication networks for EVs, EVSE, and external systems increase, the attack surface also increases, leaving the charging infrastructure and wider EV ecosystem more open to exploitation of cybersecurity vulnerabilities. Cybersecurity breaches can affect the ability of charging equipment to function, expose personally identifiable and financial information, and more ominously affect safe operations of the charging equipment and the vehicles themselves, both during the charging processes and vehicle utilization.

SECTION	GAP #, TITLE AND DESCRIPTION	CURRENT PRIORITY	PRIORITY IN 2023 ROADMAP
5	Gap S1: Comprehensive review of cybersecurity codes and standards for applicability to the EV charging ecosystem (last updated 10/7/2025)	High	High
5	Gap S2: The lack of an end-to-end secure trust chain and encryption system for the EV charging ecosystem (last updated 10/7/2025)	High	High
5	Gap S3: Cybersecurity and Data Privacy (last updated 10/27/2025)	High	High
5	Gap S4: Robust "Security-by-Design" (last updated 10/7/2025)	High	Medium
5	Gap S5: Digital Cybersecurity as Part of Interconnection Standards (last updated 10/7/2025)	Medium	Medium
5	Gap S6: Cybersecurity of Power Management under DER Aggregation Scenarios (last updated 10/7/2025)	Medium	Medium
5	Gap S7: Cybersecure Firmware and Software Updates (last updated 10/7/2025)	High	High
5	Gap S8: EVSE Cyber-physical Vulnerabilities (last updated 10/27/2025)	High	Medium
Section 5 Cybersecurity Recommendations **(last updated 10/7/2025)**			

Gap S1: Comprehensive review of cybersecurity codes and standards for applicability to the EV charging ecosystem

Gaps should be identified and prioritized.

R&D Needed: No

Recommendation: Conduct a comprehensive inventory and review of standards with regard to cybersecurity applicability across the EV charging ecosystem. Ascertain potential gaps with regard to cybersecurity. In Winter 2023, Southern California Edison proceeded on a project for the California Energy Commission to explore cybersecurity codes and standards gaps with stage 1 focusing on identifying gaps and stage 2 to initiate addressing them.

Priority: High

Organization(s): Industry, Government, SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, J.Smith, SCE:** SCE is in the final review stage of the SCE EV Charging Cybersecurity Gap Analysis which SCE performed on behalf of California IOUs under direction from the CPUC. Consultations are ongoing on how public versions will be released and communication of results. After the SCE cybersecurity gap report is released, cross reference to identify consistencies/inconsistencies with the ANSI roadmap/gaps progress report should be done. Resolve and implement modifications as appropriate. Continue to engage with the CPUC.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/07/2025, R. Varriale, ANL:** The U.S. DOE National Nuclear Security Administration (NNSA) has funded two studies led by Sandia National Laboratories (SNL).
    1. The *Assessment and Coordination of EVSE Cybersecurity Standards* (report published August 2024) found that cybersecurity certification programs for EVSE are fragmented due to no single certification covering all aspect of the device and the existence of multiple programs under different levels of regulation. No cybersecurity programs are directly for EVSE. ISA/IEC 62443 was found to be significantly in line with EVSE security needs and will be used in future testing to certify EVSE, identify where gaps exist, and standards can be improved to lead certification efforts in harmonizing EVSE cybersecurity standards.
    2. The *Standardization and Recommendations for EVSE Cybersecurity Standards* (report published January 2025) aims to find appropriate strategies for closing cybersecurity gaps identified in the aforementioned report and work towards a comprehensive cybersecurity certification program for EVSE. Future testing will leverage ISA/IEC 62443 to assess EVSE security gaps and strengths to provide insights to support certification development and harmonization of cybersecurity standards.

  RECOMMENDATION: Cross-reference and reconcile the ANSI Roadmap of Codes and Standards for EVs@Scale, NNSA assessments, SCE EV Charging Cybersecurity Assessment, the Grid Modernization 2.1 cybersecurity findings to develop a unified perspective of cybersecurity gaps across the EV charging ecosystem.

New Published Standards & Codes	New In-Development Standards & Codes
9/26/2025 G. Fernandes, ULSE: *UL 2900-1, ANSI/CAN/UL Software Cybersecurity for Network-Connectable Products, Edition 2*. Many EV charging stations are networked to allow remote monitoring, usage tracking, etc. **3/19/2025 D.Trayers, UL:** *ANSI/UL 5500 (July 2023) Remote Software Updates*, is limited to software influencing safety of particular end products, which can include EVSE/EVCE.	**9/19/2025, T.Bohn, ANL: SAE** *J2931/7 Security for Plug-In Electric Vehicle Communications* is being revised, work underway in 2025. Cross functional mapping effort included. **9/1/2025, MBayings, EVRoaming:** VDE Guide *VDE-AR-E 2532-100 Requirements for an authentication for the use of electric mobility supply systems* contains minimum requirements for environments in order to introduce a trustworthy charge authorization code into an electric mobility supply system. It aims to prevent unauthorized charging and fraud in the ecosystem by upgrading to asymmetric cryptography. It relies on

2/25/2025 F.Cleveland, Xanthus: Updates to *IEC 62351:2025 SER, Power systems management and associated information exchange - Data and communications security - ALL PARTS* and specifically IEC 62351-9:2023 *Cyber security key management for power system equipment* **2/25/2025 F.Cleveland, Xanthus**: *IEC TS 62443-1-5:2023, Security for industrial automation and control systems - Part 1-5: Scheme for IEC 62443 security profiles* **2/25/2025 F.Cleveland, Xanthus**: *IEC PAS 62443-2-2:2025, Security for industrial automation and control systems – Part 2-2: IACS security protection scheme* **2/25/2025 F.Cleveland, Xanthus**: *IEC 62443-2-4:2023, Security for industrial automation and control systems - Part 2-4: Security program requirements for IACS service providers* **2/25/2025 F.Cleveland, Xanthus**: *IEEE 1547.3-2023, Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems* Guidelines for cybersecurity of distributed energy resources (DER) interconnection with electric power systems (EPS) are provided in this guide.	additional asymmetric card authentication assuring the cards originality and authenticity.

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Gap S2: The lack of a~~n end-to-end~~ secure trust chain and encryption system for the EV charging ecosystem
This results from the use of different protocols and data transfer mechanisms between EV charging related systems. An entity trust chain is needed across all elements of the EV charging ecosystem incorporating a comprehensive public key infrastructure (PKI). **R&D Needed:** Yes **Recommendation:** Industry consensus and implementation is needed for a comprehensive end-to-end trust chain incorporating a PKI system for the EV charging ecosystem. Consideration could be given to the Cab Authority Browser (CAB) forum as a model to reach consensus. While it appears that in some cases EV-EVSE communications may be fully encrypted, it not clear that other communication channels within the EV ecosystem (e.g., from the charging stations to the EVSPs, and between CNOs) are fully secure. ISO 15118 provides guidance on secure communications, but gaps remain. IEEE P2030.5 indicates there must be end-to-end security but does not provide the means to achieve this. Close coordination should be established with the

SAE EV PKI Consortium [previously the EV Collaborative Research Project (CRP)] which has developed a PKI system and is now shifting to implementation. Standards that support a V2G communications interface include: IEC 62351 and IEC 62443 (both of which reference ISO 15118-2 and 15118-20) to ensure system security, including cybersecurity protection of digital keys. ISO 15118-2 and ISO 15118-20 work together to support the EV to grid interface. As appropriate, implement codes and standards development to reflect implementation of an industry agreed upon PKI.

Priority: High

Organization(s): Industry including equipment and system manufacturers, CNOs, aggregators, PKI infrastructure developers, Government, Associations, and SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, T.Carroll, PNNL:** Terms like end-to-end trust or end-to-end security carry specific meanings in other domains, implying guaranteed confidentiality and integrity from one endpoint to another. The current EV charging ecosystem does not meet those standards, so using this terminology overstates the actual protections. The most realistic goal today is strong security implemented segment by segment.

New Published Standards & Codes	New In-Development Standards & Codes
2/25/2025 F.Cleveland, Xanthus: *IEC 63584:2024 Open Charge Point Protocol (OCPP).* (OCPP 2.0.1)	**2/25/2025 F.Cleveland, Xanthus**: OCPP 2.0 as revisions to *IEC 63584:2024 Open Charge Point Protocol (OCPP).*
2/25/2025 F.Cleveland, Xanthus: Updates to *IEC 62351:2025 SER, Power systems management and associated information exchange - Data and communications security - ALL PARTS* and specifically IEC 62351-9:2023 *Cyber security key management for power system equipment*	**2/25/2025 F.Cleveland, Xanthus**: *ISO 15118-20:2022/DAmd1, Road vehicles — Vehicle to grid communication interface, Part 20: 2nd generation network layer and application layer requirements Amendment 1: AC DER service, MCS service, and improved security concept.*
2/25/2025 F.Cleveland, Xanthus: *IEC TS 62443-1-5:2023, Security for industrial automation and control systems - Part 1-5: Scheme for IEC 62443 security profiles*	**2/25/2025 F.Cleveland, Xanthus**: IEEE 1815.2 (joint with MESA) will define the communication requirements for distributed energy resources (DER), with a special focus on utility-scale energy storage systems (ESS). See more.
2/25/2025 F.Cleveland, Xanthus: *IEC PAS 62443-2-2:2025, Security for industrial automation and control systems – Part 2-2: IACS security protection scheme*	
2/25/2025 F.Cleveland, Xanthus: *IEC 62443-2-4:2023, Security for industrial automation and*	

control systems - Part 2-4: Security program requirements for IACS service providers **2/25/2025 F.Cleveland, Xanthus**: *IEEE 1547.3-2023, Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems* Guidelines for cybersecurity of distributed energy resources (DER) interconnection with electric power systems (EPS) are provided in this guide.	

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Gap S3: Cybersecurity and Data Privacy

Due to the nature of cybersecurity, the interactions of systems, and the emerging threats environment, there is an ongoing need for guidelines and standards to address cybersecurity and data privacy concerns specific to EVs and smart grid communications. There are tradeoffs between cybersecurity and privacy which have not yet been fully evaluated. There are means to strengthen cybersecurity, while maintaining data privacy, such as MAC address randomization, short life certificates, and certificate pooling. Architectures should be designed with cybersecurity and privacy in mind.

R&D Needed: No

Recommendation: Develop guidelines and standards to address cybersecurity and data privacy concerns specific to EVs and smart grid communications.

Priority: High

Organization(s): IEC, IEEE, ISO, NIST, SAE, UL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- **10/07/2025, R. Varriale, ANL:** The CharIN *Threat Model* white paper looks at use case, threat scenarios, risk at and adjacent to the charger, payment/finance, and the grid. It may provide useful insights and guidance related to this gap.

Comments Received on Gap for Future Consideration:

- No comments as of publication of this report.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap S4: Robust "Security-by-Design"

Security-by-Design is needed for equipment and systems throughout the EV charging ecosystem.

R&D Needed: Yes

Recommendation: Assess cybersecurity requirements in the initial design phases of equipment and systems throughout the EV charging ecosystem. This should be a broad-based assessment examining cybersecurity risks across the EV ecosystem including such areas as mobile apps and platforms. Identify common methods including required and optional features and functions. Establish robust metrics identifying security-by-design; for example, passing vulnerabilities testing. Consider exploration of other industries with similar challenges. Identify gaps and provide recommendations to serve as a model and establish a framework for future codes and standards development. Implement codes and standards, as appropriate, to advance "Security-by-Design" practices.

Consideration could be given for a process similar to the "Threat and Risk Analysis" that is part of ISO 21434 and UNECE R155, and that can apply to EVSEs (and is already done on EVs today for models that are sold in the UNECE countries). Consideration should be given to existing "security by design" requirements already in place in the automotive industry.

Priority: ~~Medium~~High

Organization(s): Auto OEMs, EVSE manufacturers, CNOs, EVSPs, utilities, Government, and SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025 R. Varriale, ANL:** DOE VTO has supported R&D examining EVSE-to-backend networking and tools for cyber hygiene involving robust cybersecurity practices and consistent application of security measures to protect networks and sensitive data from threats. The report "Addressing Cybersecurity Risk between EVSE and Charge Point Management Systems" highlights weaknesses found, cybers hygiene best practices, and differences between global and U.S. based industrial leaders. A second project focused on securing EV charging ecosystem mobile apps. Here, an inventory has been developed of mobile apps, vulnerabilities, and potential risks identified using the Mobile Application Vetting (MAV) tools developed by the DHS CISA and assessed the risks and impacts to the EV charging ecosystem.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **9/19/2025, B.Harris, DOE/VOLPE:** Change priority level to high because other industry sectors (e.g., solar) have seen inverters imported from overseas have imbedded radios inside.

New Published Standards & Codes	New In-Development Standards & Codes

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Gap S5: Digital Cybersecurity as Part of Interconnection Standards

Cybersecurity threats exist at the power system point of interconnection. The digital interconnection could be compromised which may affect the electrical interconnection. Presently, there appears to be no standards requirements nor other guidance for utilities to address digital cybersecurity challenges.

R&D Needed: Yes

Recommendation: Assess the need and requirements for cybersecurity as part of power system interconnection standards. Determine cybersecurity challenges facing the digital interface (such as digital entry points) and the hosting capability of existing systems. As part of interconnection agreements, electricity providers should query downstream entities on factors potentially affecting digital cybersecurity such as the number of inverters envisioned to be operating. As appropriate, undertake cybersecurity codes and standards development for power system interconnection.

Priority: Medium

Organization(s): Electric utility industry, Government, Aggregators, and SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, F.Salcedo, DOE VTO:** DOE VTO and other offices are exploring/addressing various issues related to interconnection of large load EV charging stations to the electrical grid. However, to date, no specific efforts have focused on the digital cybersecurity of interconnection.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **2/25/2025 F.Cleveland, Xanthus**: IEEE 1547.3 and IEC 62443 series are being used by utilities, but with no overall set of requirements. DOE/NARUC has published a high-level set of DER cybersecurity recommendations, but with few details specific to EVs. The California Public Utilities Commission (CPUC)'s High DER OIR has published a Cybersecurity Working Group report on cybersecurity requirements for DER, but that effort is waiting for further clarifications on CPUC actions.

New Published Standards & Codes	New In-Development Standards & Codes
2/25/2025 F.Cleveland, Xanthus: *IEEE 1547.3-2023, Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems* Guidelines for cybersecurity of distributed energy resources (DER) interconnection with electric power systems (EPS) are provided in this guide.	**2/25/2025 F.Cleveland, Xanthus**: Revision of IEEE 1815-2012 Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3) to include cybersecurity provisions Secure Authentication (SAv6) to use Advanced Malware Protection (AMP)

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Gap S6: Cybersecurity of Power Management under DER Aggregation Scenarios

Cybersecurity gaps exist with regard to aggregation of DERs for Grid Services and subsequent power management.

R&D Needed: Yes

Recommendation: Assess cybersecurity threats resulting from the aggregation of DERs and subsequent power management within the context of grid services. Identify requirements under multiple use case scenarios, considering broad elements such as the use of telemetry and ability of aggregators to ensure security. Consider IEEE P2030.5 and FERC 2222 as a starting place for guidance. As appropriate, implement codes and standards development to mitigate risks.

Priority: Medium

Organization(s): Industry, Government, equipment and system developers, and SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, R. Varriale, ANL:** Argonne National Lab and Sandia National Laboratories have developed a report for the Defense Innovations Unit (DNI)/ DOE CESER looking at cybersecurity (including communications protocols) under DER aggregation scenarios in the context of smart grids.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **9/19/2025, R.Kaiser, Evoke:** EPRI FlexLoad Guide – The DER Capacity Exchange (OpenADR 3) provides standardized capacity declarations to EVSEs, EVs, and aggregators. These allow direct communication of available charging/curtailment capacity, ensuring grid-constrained information is acted upon in real time

New Published Standards & Codes	New In-Development Standards & Codes

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Gap S7: Cybersecure Firmware and Software Updates

Cybersecurity posture, unlike safety, diminishes over time as the threat landscape evolves and new vulnerabilities are uncovered. Therefore, updating/patching of software is absolutely paramount to maintain good cybersecurity for the life time of vehicles.

There is a need for secure firmware and software updates for equipment and systems within the EV charging ecosystem. Signed, authenticated updates are required from trusted sources with the need to ensure systems are resilient to corrupted updates. Although some OEMs also have developed their own algorithms to protect firmware/software updates, open-sourced the algorithms, and shown they are compatible with the majority of automotive processors on the market today, the approaches are fragmented and may need standardization. Likewise, EVSE manufacturers, charge point operators, and charge network operators require processes and

procedures for secure firmware and software updates and which may require standardization. Concerns surround smaller entities' ability to establish and robustly implement secure, remote firmware and software updates.

R&D Needed: Maybe. It would be helpful to obtain data which would provide vehicle and EVSE OEMs and back-end systems operators a mechanism to ensure trust in and provide authorization, certification, and dissemination of firmware and software updates.

Recommendation: Determine needs and requirements, and as appropriate, implement codes and standards development. Explore industry best practices.

Priority: High

Organization(s): OEMs, EVSE manufacturers, EVSPs, and SDOs

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- No updates as of publication of this report.

Other Committees / Organizations with Relevant Work:

- No updates as of publication of this report.

Comments Received on Gap for Future Consideration:

- **10/7/2025, B.Carlson/K.Rohde, INL:** Concerns surround smaller entities (e.g., EVSE manufacturers) ability to establish and robustly implement secure, remote firmware and software updates.

New Published Standards & Codes	New In-Development Standards & Codes
3/17/2025 A.Krabbe, ULSE: *UL 5500 Remote Software Updates* (Edition 1, July 2023) support this gap.	**10/01/2025 S MIX, PNNL:** IEEE Standard *C37.231-2006 Recommended Practice for Microprocessor-Based Protection Equipment Firmware Control* specifies how manufacturers communicate firmware changes to end users. It is under revision to address changes since the last update, including specifying a secure method of firmware transport. Although it is designed primarily for electric power protection devices, it should be able to be extended at least to charging infrastructure, if not to EV's themselves.

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Gap S8: EVSE Cyber-physical Vulnerabilities

EVSE have physical vulnerabilities that can serve as threat vectors and cascade to cybersecurity high consequence events. It is relatively simple to physically penetrate an EVSE and concerns surround the ensuing ability to move upstream and further compromise the EV charging ecosystem.

R&D Needed: Yes

Recommendation: Compile a thorough assessment of EVSE physical vulnerabilities and ascertain the principal threat vectors within the overarching physical design. Examples may include such items as debug ports (JTAGs), lockable cabinets, and physical issues of the cable such as broken wire and the potential to wrap and extract information. Prepare recommendations for mitigation. Conduct standards development culminating in a recommended practice addressing EVSE cyber-physical vulnerabilities.

Priority: ~~Medium - Low~~High

Organization(s): EVSE manufacturers, national laboratories, and SDOs, INL

Updates Since v3 was Published *(Research, Regulation/Policy, Conformity Assessment, etc.)*:

- **10/7/2025, B.Carlson/K.Rohde, INL:** INL has a good grasp on cyber-physical vulnerabilities, but with technology quickly evolving, new vulnerabilities emerge. Programs are needed to roll out procedures and teach industry how to secure cyber-physical vulnerabilities.
    1. See also, INL *EV SALaD 2023 Demonstration - Best Practices and Mitigations for Protecting EVSE Infrastructure* (August 2024). A revision is in development.

Other Committees / Organizations with Relevant Work:

- **3/13/2025 B.Doherty NEMA:** NEMA formed a technical committee to develop a guideline.

Comments Received on Gap for Future Consideration:

- **10/27/2025, B.Carlson/K.Rohde INL:** Significant progress has been achieved assessing EVSE physical vulnerabilities and ascertaining the principal threat vectors within the overarching physical design and recommendations have been developed for mitigation.
- **10/7/2025, R.Cryar, NREL:** A further concern surrounds defining, monitoring, and detecting anomalous behavior. An adversary will utilize persistence to continue a cyber-physical attack. A baseline of normal, consistent operations should be understood and established as a starting point for assessing anomalous behavior.

New Published Standards & Codes	New In-Development Standards & Codes
	3/13/2025 B.Doherty NEMA: NEMA filed an ANSI PINS for *BSR/NEMA EVSE 40006-202X, Cyber and Physical Security of Electrical Vehicle Supply Equipment (new standard) PINS: Mar 1, 2024* to develop a standard to define best practices that mitigate cyber/physical vulnerabilities of Electric Vehicle Supply Equipment.

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Section 5 Cybersecurity Recommendations/Comments Roadmap Publication

*Additional general comments, standards activities, and recommendations for gaps in standards and codes related to the **Section 5: Cybersecurity**.*

New Gap Suggestions

The following gap(s) was suggested during comments against the gaps progress report. This language did not go through EVSP working group or public review. It is for information only and has not been assigned an EVSP gap number but may be considered by the EV standardization community.

10/7/2025, T.Carroll, PNNL & B.Harris, DOT Volpe: New Gap Suggestion: Cryptography
Cybersecurity systems need the ability to adjust/switch to address new cyber challenges (e.g., quantum computing) without having to replace existing hardware. Potentially, codes and standards should be considered to guide and enable this flexibility. Also, ISO 15118-2 mandates a TLS cipher suite that has been formally discouraged since 2016. Implementers are left with two insufficient options: 1- ignore the standard and risk interoperability issues, or 2- comply and rely on libraries that are obsolete, rarely updated, and potentially harbor known, actor-exploitable vulnerabilities. Also the requirements regarding certificate practices are dated. ISO 15118-20 selects elliptic-curve P-521 for key exchange and signatures—a choice inconsistent with most other industries, which are holding off for guidance on preferred post-quantum–capable certificates. We should follow through to post quantum computing; not stop at P-521. Given the long lifespan of these standards and the rapid pace of cybersecurity change, security provisions should be decoupled from the core standard, and alternative mechanisms for maintaining and updating cybersecurity requirements beyond the ISO process should be considered.

10/7/2025, T.Carroll, PNNL: New Gap Suggestion: Weak Transaction Integrity and Non-Repudiation
Mechanisms for proving that a charging transaction occurred exactly as recorded are limited. Plug-and-Charge adds convenience but does not strengthen non-repudiation, and OCPI introduces additional complexity without addressing this weakness. The SAE public-key infrastructure (PKI) offers little improvement. **Recommendation**: Cryptograms that bind time, location, and session details are needed; similar to those used in EMV credit-card transactions—to provide strong evidence that a specific charging event took place as recorded. Lessons learned from the credit card industry should be used to strengthen/update integrity of ISO 15118 and OCPP, while revisiting Plug and Charge.

10/7/2025, T.Carroll, PNNL: New Gap Suggestion: Organizational Cybersecurity Attestation
There is a need for organizational attestation to ensure secure development and lifecycle management. Vendors and operators will likely need to adopt formal organizational attestation, demonstrating that their processes, practices, and deployed equipment adhere toa secure lifecycle for both device and software management.

10/7/2025, T.Carroll, PNNL / B.Harris, DOT Volpe / R.Varriale, ANL: New Gap Suggestion: Cybersecurity Overlay Standard(s)

A high-level standard(s) which provides a baseline, universal, and holistic cybersecurity approach is needed. This should permit newer companies and accommodate newer functionalities.

1- It should encompass communications, interoperability, and enforcement – basically how things are going to work together.
2- The overlay standard should incorporate the charger and back-end should include OCPI and OCPP.
3- Cybersecurity elements of standards should be de-coupled from the functional (e.g., communications, safety, etc.) aspects of standards.
4- A singular approach is needed for cybersecurity, not each standard invoking their own cybersecurity elements system-to-system (i.e., EV-EVSE, EVSE-charging station, charging station-to-cloud, etc.).

Outdated security provisions and slow standards revisioning processes (e.g., ISO 115118 and OCPP) demonstrate this need. It is too slow and difficult to update cybersecurity standards and not in tune with the dynamic nature of evolving cybersecurity threats. Possibly, a bundle of cybersecurity standards -1, -2 may be needed for the EV charging ecosystem which would be easily updated.

10/7/2025, R.Cryar/D.Saleem, NREL: New Gap Suggestion: Cybersecurity Certification Standard for EVs/EVSE/Charging Stations

Currently, there are no specific cybersecurity standards to certify key elements of the EV charging station ecosystem, including EVs/EVSE/charging stations.

10/7/2025, B.Carlson/K.Rohde, INL: New Gap Suggestion: Supply Chain Cybersecurity Vulnerabilities

There is concern surrounding the propagation of attacks via the supply chain. Specifically, entry points that can lead to broader, more serious upstream attacks and exploitation.

10/7/2025, B.Carlson/K.Rohde, INL T.Carroll, PNNL: New Gap Suggestion: Cybersecurity Governance

Guidelines and/or standards are needed to frame the governance of cybersecurity systems, protocols, and practices. For example:

1- Establishment of specific procedures with regards to identification of holders of private keys and certificate revocation, as well as system restoration post exploitation.
2- Roles and responsibilities need to be clearly defined and how they will engage with the ecosystem when there is a vulnerability or cybersecurity event.

10/7/2025, B.Carlson/K.Rohde, INL / R.Varriale ANL: New Gap Suggestion: Cybersecurity Posture & Maturity

Guidelines and/or standards are needed to assess an entity's cybersecurity posture and enable rationalization of risk tolerance. Identification of specific targets is needed and metrics to achieve them.

Metrics are needed to assess the cybersecurity posture and maturity of key entities across the EV charging ecosystem. This includes metrics to gauge the cybersecurity progress/status of an organization. The DOE Cybersecurity Capability Maturity Model (C2M2) is a tool to help organizations evaluate their cybersecurity capabilities and optimize investments. The tool (model) can be used to evaluate, prioritize, and improve their

cybersecurity capabilities. The DOE Vehicle Technologies Office is sponsoring the CyberMESA project to develop a series of metrics across segments of the EV charging ecosystem including targets to assess cyber posture from end-to-end as all system are interdependent.

10/7/2025, B.Carlson/K.Rohde, INL: New Gap Suggestion: Cybersecurity Certification of EV Charging Equipment
Cybersecurity certification of EV charging equipment (and supporting standards) are needed to increase the confidence for buyers that any EV charging equipment had gone through cybersecurity testing and require that patching will be provided to maintain security moving forward. This would provide private companies leverage to ensure vendors secure the cybersecurity of their products.

10/7/2025, B.Harris, DOT Volpe: New Gap Suggestion: Objective definition of conformance to standards
Define what conformance actually means and what level of cybersecurity is actually achieved in the field.

New Published Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- **3/17/20252025 A.Krabbe, ULSE:** UL 2900 Series are General Cybersecurity Standards, including
  - UL 2900-1 Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements (Edition 2, April 2023) This standard applies to network-connectable products that shall be evaluated and tested for vulnerabilities, software weaknesses and malware.
  - UL 2900-2-2 Outline of Investigation for Software Cybersecurity for Network-Connectable Products, Part 2-2: Particular Requirements for Industrial Control Systems (Edition 1, 2016)

New In-Development Standards

Additional newly published standards or codes related to vehicle safety that are not already included in the chapter above.

- No additional in-development standards or codes provided as of publication of this report.

General Comments

Additional comments related to grid integration that are not already included in the chapter above.

- **10/7/2025, R.Varriale, ANL:** Workforce development should be considered. Acceleration of cybersecurity workforce training is need to upscale cybersecurity testing. Examples include EVCAT (Cybersecurity Automated Test Kit) and the NIST NICE KSAs (knowledge, skills, abilities) education for assessing EV charging.
- **10/7/2025, R.Varriale, ANL:** MW level charging raises concerns about potential cybersecurity risks and impact upon the grid.

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GENERAL COMMENTS & UPDATES RELATED TO THE EVSP ROADMAP

Additional general recommendations for gaps in standards and codes related to Electric Vehicles.

10/01/2025, S.MIX, PNNL General comments and additional gaps

- There's also not a lot on digital certification management and payment card security. For certificate management, the existing RFCs and "good practices" are probably OK, as well as work produced by the SAE EVPKI and CA Browser Forum, and there could be some work in PCI DSS (Payment Card Industry Data Security Standard) that may address security for payment systems, but they're not "standards" from an accredited standards Development Organization (SDO) like ISO, or a Standards Setting Organization (SSO) like NIST.
- One area that could be addressed by further SDO/SSO activity is covered by NIST IR 8320 "Hardware-Enabled Security: Enabling a Layered Approach to Platform Security for Cloud and Edge Computing Use Cases", where the charger would be considered an "edge device".

4/8/2025, B.Nordman, LBL: Comments on the June 2023 original Roadmap

- The concept of V2G should be disaggregated into inverter functionality, discharge to the customer site that doesn't result in customer export to the grid, and discharge that does result in export. Vehicles are NOT connected to the grid. They are connected (by the EVSE) to the customer site.
- The discussion treats the customer as a mostly passive actor. The customer should be understood to be an active agent in their own affairs, with their preferences acted on by devices they own. Coordination with the grid is essential, but more on a peer basis than a central control paradigm.
- Charging in multi-family residential sites should be added as an additional application context.
- Curbside charging needs more attention, both chargers operated publicly, and those operated by adjacent property owners.
- It is unclear why microgrids are referenced. Microgrids only come into play when the grid is down, in which case no coordination with the grid is needed. Any customer might have sophisticated functionality internally, but not have microgrid capability.
- It would be good to more clearly differentiate the three domains of grid coordination: inverter management, energy management, and capacity management.
- Residential applications are described as different from others. We should seek to have customer type have as little to do with the technology as possible. Charging stations are special – no other customer type is.
- Some of the discussion about coordination for EVs is really coordination with customers in general – and should not be seen as, or implemented as, being EV-specific.
- The Matter protocol is now very relevant and should be incorporated.

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EVSP Overview

Formally launched in March 2011, the ANSI Electric Vehicles Standards Panel (EVSP) is a cross-sector coordinating body whose objective is to foster coordination and collaboration on standardization matters among public- and private-sector stakeholders to enable the safe, mass deployment of electric vehicles (EVs) and associated infrastructure in the United States with international coordination, adaptability, and engagement. The ANSI EVSP does not develop standards; rather, it serves as a forum for facilitating coordination among standards developing organizations (SDOs) and others.

EVSP Standardization Roadmap

On June 15, 2023, ANSI announced the publication of the ***Roadmap of Standards and Codes for Electric Vehicles at Scale*** developed by the EVSP. The roadmap's primary focus is on light-duty, on-road plug-in EVs that are recharged via a connection to the electrical grid, as well as the supporting charging infrastructure needed to power them. Medium and heavy-duty EVs are also covered, as is wireless charging. A total of 37 standardization gaps are identified with corresponding recommendations across the topical areas of vehicle systems, charging infrastructure, grid integration, and cybersecurity. Of the 37 gaps, 14 gaps/recommendations are identified as high priority, 20 as medium priority, and 3 as low priority. In 23 cases, additional pre-standardization research and development (R&D) is needed.

Some 80 individuals from 130 public- and private-sector organizations supported the roadmap's development, including U.S. federal government agencies and national laboratories, standards developing organizations (SDOs), industry, academia, and others. The document represents the culmination of the EVSP's work to identify key safety, performance, and interoperability issues for EVs and charging infrastructure, relevant published standards and standards in development, and to assess gaps.

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