

Safety and performance in electric vehicle charging

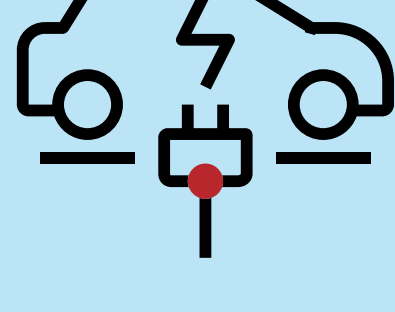


The importance of testing, inspection and certification for the safety and reliability of electric vehicle charging systems

As the global adoption of electric vehicles (EVs) ramps up, the demand for safer, reliable charging infrastructure is also on the rise.

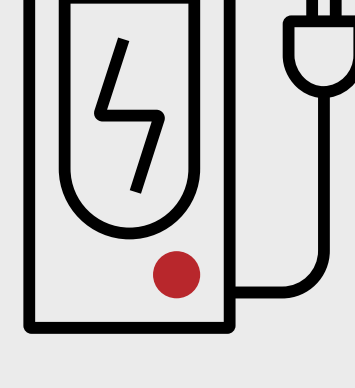
Predicted global EV market in 2033

\$1.58
trillion (USD)¹



Predicted global EV charging infrastructure market in 2033

>\$270.5
billion (USD)²



Critical risks to EV charging infrastructure

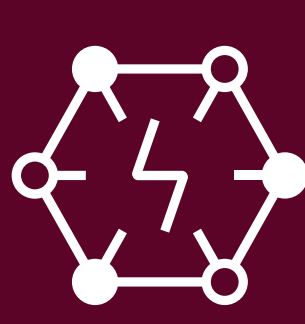
New charging technologies are making EV charging more accessible and attractive but may carry significant safety and security risks.

Safety risks:



- Electrical safety
- Fire hazards
- Cybersecurity threats

Performance risks:



- Charging efficiency reductions
- Equipment reliability

Impact of emerging technologies:

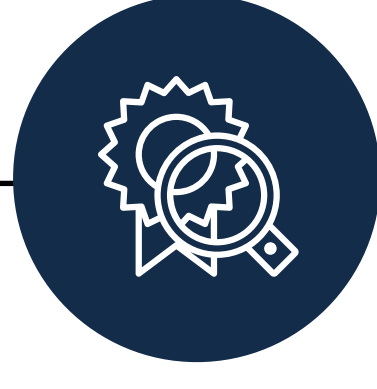


- Integration of wireless charging technology
- Incorporation of energy storage systems
- Automatic connection systems for heavy-duty vehicles

The role of testing, assessment and certification



Successful electrification of transport is based in part on customer and stakeholder trust that the charging infrastructure has been tested for safety, performance and interoperability with grid-connected applications.



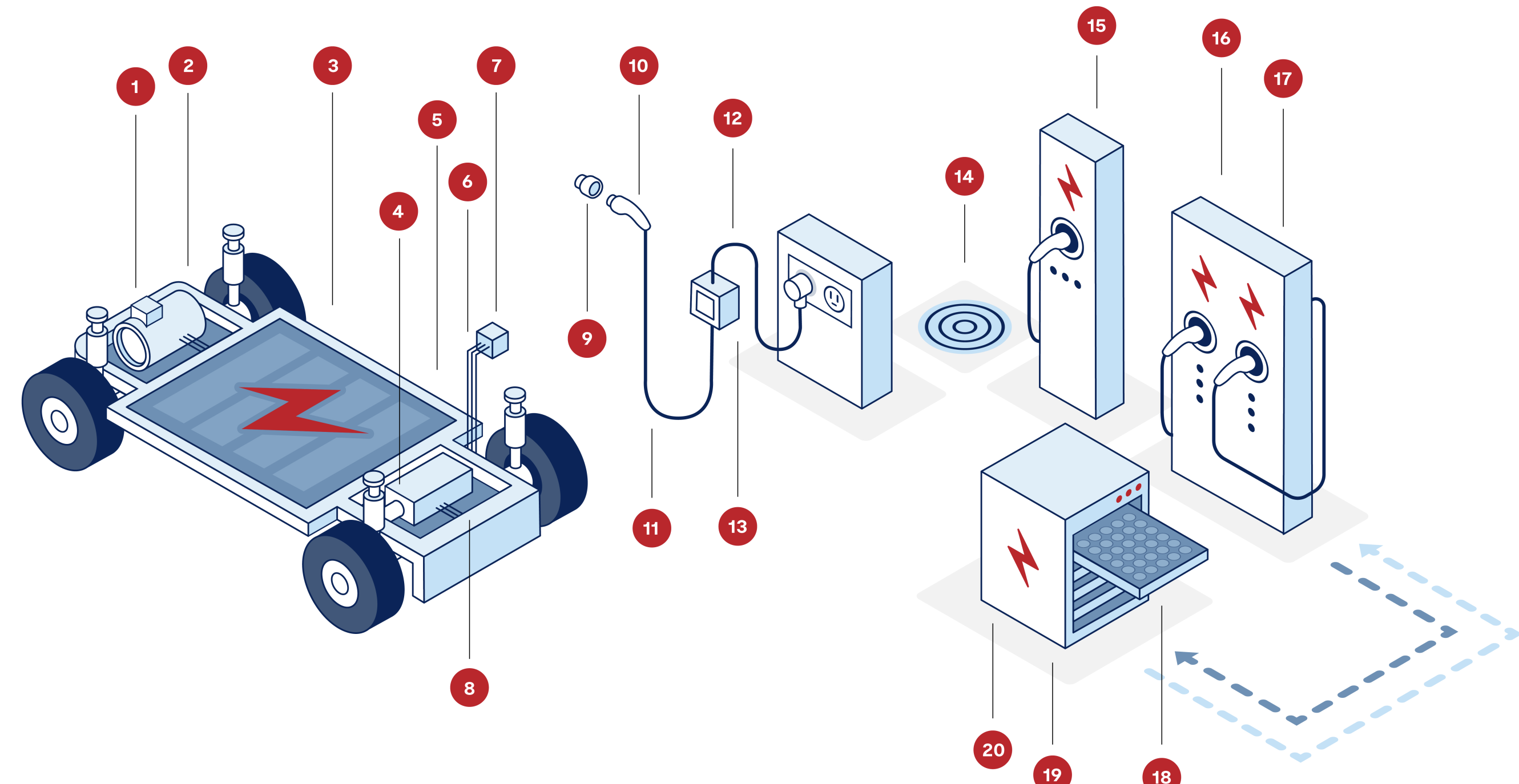
That trust is supported by rigorous tests and certification to determine whether charging equipment meets established safety and performance standards before deployment and by providing regular inspections to routinely evaluate charging infrastructure to maintain compliance.



UL Solutions supports the EV industry with laboratory facilities and capabilities to test and certify EV charging infrastructure.

Supporting safety and reliability throughout the electric vehicle (EV) and electric vehicle supply equipment (EVSE) chain

Applicable standards and certifications for EV and EVSE



EV and battery

1. Onboard inverters

UL 458A
Outline of Investigation for Power Converters/Inverters for Electric Land Vehicles

UL 1741 SC

2. Onboard motors

UL 1004-1

The Standard for Rotating Electrical Machines

3. Onboard batteries

UL 2580

The Standard for Batteries for Use in Electric Vehicles

ISO 26262

ISO/SEA 21434

ECE R100/GB 38031/LV 124/OEM
Design validation (DV) testing product verification (PV) testing

4. Onboard chargers

UL 2202

The Standard for Electric Vehicle (EV) Charging System Equipment

UL 9741

ISO 17409

ISO 26262

ISO/SAE 21434

5. EV relay

UL 61810-20

Outline for Electric Vehicle Electrical Mechanical Relays

6. Onboard wire and tubing

UL 2733

Outline of Investigation for Surface Vehicle On-Board Cable

7. Vehicle inlets

UL 2251

The Standard for Plugs, Receptacles, and Couplers for Electric Vehicles

IEC 62196-1

IEC 62196-2

IEC 62196-3

8. Onboard connectors

UL 2734

Outline of Investigation for Connectors and Service Plugs for Use with On-Board Electric Vehicle (EV) Charging Systems

EV supply equipment

9. EV charging adapter

UL 2252

The Standard for Adapters for Use with Electric Vehicle Couplers

10. Vehicle connector

UL 2251

The Standard for Plugs, Receptacles and Couplers for Electric Vehicles

UL 2278

The Standard for Megawatt Charging Configured Electric Vehicle Couplers

11. Offboard cable

UL 2263

The Standard for Electric Vehicle Cable

IEC 62893-1

IEC 62893-2

IEC 62893-4-1

IEC 62893-4-2

DIN EN 50620

12. Cordset

UL 2594

The Standard for Electric Vehicle Supply Equipment

ISA/IEC 62443

IEC 62752

IEC 61851-1

13. Personal protection equipment

UL 2231-1 and UL 2231-2

The Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits

IEC 61008-1

IEC 61009-1

IEC 62955

IEC 62423

14. Wireless charging

UL 2750

Standard for Wireless Power Transfer Equipment for Electrical Vehicles

ISA/IEC 62443

Energy storage

15. AC charging station

UL 2594

The Standard for Electric Vehicle Supply Equipment

IEC 61851-1

IEC 61851-1-21-2

IEC 61439-7

IEC 62752

ISA/IEC 62443

IEC 61508

16. DC charging station

UL 2202

The Standard for Electric Vehicle (EV) Charging System Equipment

IEC 61851-1

IEC 61851-23

IEC 61851-21-2

IEC 61851-24

IEC 61439-7

ISA/IEC 62443

IEC 61508

17. Bidirectional charging station

UL 9741

Standard for Electric Vehicle Power Export Equipment (EVPE)

ISA/IEC 62443

Energy storage

18. Energy storage battery

UL 1973

The Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications

IEC 62619

IEC 62485-5

ISA/IEC 62443

IEC 61508

19. Power conversion equipment

UL 2251

The Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

IEC 62109

ISA/IEC 62443

IEC 61508

20. Energy storage systems

UL 9540

The Standard for Energy Storage Systems and Equipment

UL 9540A

The Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

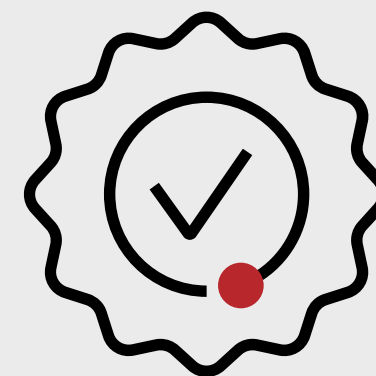
IEC 62933

ISA/IEC 62443

IEC 61508

Comprehensive testing and certification services to EV charging standards

- ANSI/UL 2202, the Standard for DC Charging Equipment for Electric Vehicles
- ANSI/UL 2594, the Standard for Electric Vehicle Supply Equipment (AC output)
- ANSI/UL 2750, the Standard for Wireless Power Transfer Equipment for Electric Vehicles
- ANSI/UL 9741, the Standard for Electric Vehicle Power Export Equipment (EVPE)
- ANSI/UL 2231-1, the Standard for Personnel Protection Systems for Electric Vehicle Supply Circuits; Part 1: General Requirements (referred to in UL 2202/UL 2594/UL 9741)
- ANSI/UL 2231-2, the Standard for Personnel Protection Systems for Electric Vehicle Supply Circuits: Protective Requirements for Protection Devices for Use in Charging Systems (referred to in UL 2202/UL 2594/UL 9741)
- ANSI/UL 2251, the Standard for Plugs, Receptacles and Couplers for Electric Vehicles
- UL 2252, the Standard for Adapters for Use with Electric Vehicle Couplers
- UL 2278, the Standard for Megawatt Charging Configured Electric Vehicle Couplers



National Certification Body (CB) scheme evaluations and certificates services through UL International Demko A/S, a UL Solutions certification body

- IEC 61851-24, Electric Vehicle Conductive Charging Systems – Digital Communication Between a DC EV Supply Equipment and an Electric Vehicle for Control for DC Charging
- IEC 62752, In-Cable Control and Protection Device for Mode 2 Charging of Electric Road Vehicles
- IEC 62196 series (-1, -2 and -3), Plugs, Socket-Outlets, Vehicle Connectors and Vehicle Inlets – Conductive Charging of Electric Vehicles

Additional offerings for original equipment manufacturers

- ENERGY STAR® program requirements for electric vehicle supply equipment eligibility criteria version 1.1
- Electromagnetic compatibility (EMC), safety, emissions and immunity testing for wireless devices
- Testing for compliance with U.S. Federal Communications Committee (FCC) regulations
- Cybersecurity testing
- Functional safety testing, certification, advisory and training services

¹ Electric vehicle market by product, range, vehicle type, vehicle class, region and company analysis 2025-2033, Research and Markets, January 2025, <https://www.researchandmarkets.com>.

² Electric vehicle infrastructures market to reach \$270.5 billion, globally, by 2033 at 27.6% CAGR, Allied Market Research, September 11, 2024, <https://www.prnewswire.com/news-releases>.