



E-Mobility: Navigate Safety, Interoperability, and Conformance

Navigating a key growth phase for the e-mobility market

As governments and industry unite in a bid to achieve a net-zero world, manufacturers of electric vehicles (EVs) and electric vehicle supply equipment (EVSE) are moving to meet rapidly increasing demand for electrified transportation across all major economies.

The market forecast between 2019 and 2025 projects the global electric mobility market will reach \$478.9 billion by 2025, increasing at a rate of 24.7% CAGR during the forecast period.¹

The e-mobility market is entering a critical growth phase driven largely by tightening legislation and ambitious net-zero carbon emissions targets. Forecasts project seismic shifts in the market from 2021-2024 which will ultimately determine who succeeds in the global EV and EV charging market.²

There is a push to completely abolish internal combustion engines and the reliance on conventional fossil fuels. Policymakers are looking to take bold steps to meet consumers' growing preference for environmentally-friendly vehicles.

To maintain momentum and realize the full potential of e-mobility, manufacturers and standardization, regulation, and certification bodies must now work toward harmonizing standards, conformance of operational and safety parameters, and equipment interoperability.

In this whitepaper, we discuss these challenges in more detail and ask: How can EV and EVSE manufacturers navigate a complex regulatory landscape and deliver a quality product without compromising time-to-market projections?

How can EV and EVSE manufacturers adjust to a complex regulatory landscape and deliver quality product without compromising time-to-market projections?

¹ <https://www.kbvresearch.com/electric-mobility-market>

² <https://emobility.has-to-be.com/en/white-paper-ev-charging-forecast>

Challenges Facing the EV/EVSE Market

Although the concept of electric vehicles is not a new one, the market remains in its infancy and is not well-regulated or fully operational. This presents a number of challenges for manufacturers throughout the EV and EVSE ecosystem.

Harmonizing global standards

Currently, there is no single harmonized standard for EV charging, nor are there harmonized standards that ensure conformability and interoperability for new charging products entering the market. Industry goals of conformance and interoperability are challenging to achieve given the number of different standards various geographies adhere to.

Without harmonized standards, manufacturers will continue to incur significant costs associated with adapting and re-certifying their technologies to align with various regional protocols. But these protocols are important because they enable manufacturers to meet demand and penetrate new geographic markets.

By harmonizing standards across borders, manufacturers can deploy their technologies faster, build the infrastructure to service the growing number of EVs sold each year, meet net-zero targets sooner, and thereby lower the purchase price of EVs and EVSE for end users.

Standardization will not change regulation

Harmonizing global regulations will standardize e-mobility technologies at an operational level and help speed the rollout when demand is high. Thus, harmonizing global regulations is a critical step in making the rollout of EVs economically viable. That said, even if the industry achieves standardization for EV technology, different geographic regions will continue to have their own regulatory procedures for all goods entering their markets and this is unlikely to change.

One example of this issue is the European CE mark, a self-certification process that would remain in place even if the e-mobility market harmonizes its standards.

Therefore, industry leaders hope that while a variety of regulatory procedures will remain in place, governments will adopt functional aspects of the main industry standards (CCS, CHAdeMO, GB/T, and ChaoJi), to enable harmonization at a practical level.

Improve quality standards for EVSE

The EV charging market is highly diverse and awash with manufacturing newcomers that have little or no experience designing or producing charging equipment. Encouraged by the EVSE's market growth and profit potential, many electronics companies are trying to produce EV charging technologies with varying degrees of success.

Currently, the e-mobility industry lacks formal standards for performance that are adequate enough to prevent low quality charging equipment from entering the market. Instead, newcomers meet a set of baseline standards for the geographic region they want to sell to; these standards are not comprehensive enough to ensure a quality product.

Regulatory bodies are keen to tackle the issue with improved mandatory quality standards. However, legislative changes take time, and changes of this magnitude do not happen overnight. In the meantime, work is underway to ensure that manufacturers of charging equipment interpret and implement the existing standards correctly, in order to make charging infrastructure as a whole, more user-friendly.

Improved certification processes

Regulatory associations such as the Charging Interface Initiative e.V. (CharIN e.V.), work with their members to identify holes in the certification process and develop suitable testing standards that will promote conformance, interoperability, and improvements in product quality. While these efforts are part of an ongoing process, once enforced, manufacturers will incur fines if they go to market with charging equipment that does not meet the specified testing standards.

Stricter certification requirements will force improvements in product quality and represent a significant step towards harmonizing the technological standards that shape the e-mobility ecosystem.

Customer education

There is a distinct lack of customer education when it comes to the difficulties in using charging equipment. EVs and EVSE are new technologies, so there will be a period of adjustment in order for customers to fully understand how the systems work.

Simply put, in some instances, the problem of a car not charging at a specific station is an interoperability/data communication issue. In other instances, the problem might be a charger connection issue that the customer struggles to understand. Implementation guides may support EV owners and users in their self-education process and help avoid charging failures.

Education will play a key role in the specification of charging infrastructures for large-scale projects, such as the installation of city-wide infrastructure, or the transition from internal combustion engines to EVs by public transport providers. Cost is often the deciding factor in these instances and it frequently overrides the importance of choosing a quality charger that is compatible with the vehicles it is installed to charge.

An Overview of Key Standards by Geography

There are a handful of regulatory standards bodies that dominate the economies of North America, Europe, China, and Japan. Most smaller economies are slowly adopting one of the major standards, providing harmonization to some extent. That said, there are anomalies. For example, India is largely self-sufficient in that it produces its own vehicles, but uses a combination of the two most popular standards, CHAdeMO and Combined Charging System (CCS) for its charging infrastructure.

Japan and China took a major step in the right direction with their approach to EV interoperability to ensure the compatibility of the EVs, charging stations, and the grid along with the software applications to allow all components to work seamlessly and effectively. Their commitment is bound to help make the Japanese and Chinese markets more accessible to manufacturers deploying vehicles and charging equipment. The growing popularity of the combined charging system (CCS) protocol in Europe is having a similar effect.

Each of these charging protocols regulates in accordance with International Organization for Standardization (ISO), and International Electrotechnical Commission, (IEC) standards, but promotes different tactics for charging at a functional level. The protocols establish hard boundaries that manufacturers must overcome in order to penetrate markets more broadly.

Combined Charging System (CCS)

Driven primarily by the Society of Automotive Engineers and car manufacturers from Europe and North America, CCS is a standard for charging electric vehicles using Combo 1 or Combo 2 connectors to provide power up to 350 kilowatts. The Combo 1 and Combo 2 connectors are extensions of the IEC 62196 Type 1 and Type 2 connectors, with two additional direct current (DC) contacts to allow high-power DC fast charging.

CCS allows AC charging using the Type 1 and Type 2 connector, depending on the geographic region. EVs and EVSE are CCS compatible if they support either AC or DC charging, in accordance with the standards listed by the CCS.

CharIN e.V., a worldwide association comprised of manufacturers, component suppliers, energy providers, grid operators, test houses, and testing specialists like Keysight, promotes interoperability based on CCS as the global standard for charging vehicles of all kinds.

ChaoJi

ChaoJi is an ultrafast charging protocol for EVs that was codeveloped between Japan's CHAdeMO association and the China Electricity Council, which is responsible for the GB/T EV charging standards in China. Together, both groups represent more than 90 percent of the installed EV fast charger market in the world, DC charging stations up to 120 kilowatts that connect directly to the battery.

Working under the supervision of their respective governments, ChaoJi offers backwards compatibility with both CHAdeMo and GB/T standards which share many common features.

Maximum power for the new ChaoJi standard is tentatively set at 900 kW to meet the needs of high-powered batteries of the future, such as those that will power large vehicles and earth-moving equipment.

In a bid to bring harmonization to the EV market, Japan's CHAdeMo and the China Electricity Council seek partnerships from countries that are interested in helping to develop and roll out the ChaoJi standard.

CharIN Festival and industry collaboration

As we noted earlier, the harmonizing of standards is only one issue at play when it comes to promoting interoperability, safety, and conformance. Within each region where manufacturers are working under the same protocol, there are variables that make implementing harmonization a challenge. The goal of promoting interoperability and improving quality standards among new manufacturers entering the marketplace is a critical step to achieving user acceptance and economies of scale.

The industry is already deploying creative tactics to promote wider interoperability and improved quality standards within each protocol. Tactics like these CharIN Festival will help facilitate opportunities for manufacturers and innovators to share expertise and test the interoperability of existing prototypes.

CharIN's Global Festival

CharIN e.V. is the leading global association dedicated to promoting interoperability based on CCS standards. With more than 200 active members, CharIN is a catalyst for change and advocates for fast charging EVs, as well as smart grid integration in the future.

CharIN understands that interoperability is a major technical challenge because of the large number of different implementations, individual use cases, and requirements in a diverse global market. In order to overcome the challenges, CharIN holds a number of Festivals each year that bring together technology experts from companies within the smart charging community. Experts conduct conformance and interoperability tests on EVs and charging infrastructures, as well as on electronic control units (ECUs) and communication controllers (CCs). The hands-on Festivals enable the industry to tackle the interoperability challenge.

CharIN Festivals enable attendees to:

1. Participate as a tester or an observer.
2. Meet international technology experts who specialize in smart charging communication.
3. Network, share, and learn during Festival days and evening events.



Figure 1. Keysight Scienlab Charging Discovery System (top right) and the regenerative power supply (lower right) at the CharIN Festival Europe 2021 event <https://www.charin.global/events/testival-europe/gallery/>

Michael Tybel, head of the Scienlab Solution Center for Keysight's Automotive & Energy Solutions (AES) division, comments on the benefits of the CharIN Festival events:

"CharIN e.V. offers a range of events focused on different areas of the EV/EVSE ecosystem. Some are dedicated to controllers such as EVCC and SECC, while others are for EV/EVSE system level testing.

"Keysight has participated in the system-level testing events since 2017 with our CDS, combined with a high voltage power source and load that provides a full charging interface emulation of an EV or EVSE. This equipment means we can benefit from advanced testing capabilities during each charging session, enabling us to identify and investigate even minor implementation flaws.

"Testing aside, the CharIN Festival is an excellent opportunity to meet and exchange ideas with some of the industry's leading experts, which could be either product developers or highly experienced test engineers. These events provide extraordinary opportunities to learn and to teach. For us, it is a unique networking opportunity and a practical way to demonstrate the capabilities of our test system, while offering valuable feedback to EV and EVSE manufacturers on the conformance and interoperability of their CCS interface implementation."

Manufacturers need guidance to navigate a complex regulatory landscape

It is clear that the e-mobility ecosystem will need time to mature. Changes to policy, regulation, and standards do not happen overnight. While industry influencers make necessary changes, manufacturers must continue to make progress during this critical growth phase if governments are to meet ambitious net zero targets. For now, manufacturers must navigate a complex regulatory landscape that requires a vast amount of engineering power, multiple design variations, repeat testing, and certification, all of which equates to more investment and a potential loss of efficiency.

Testing is key

Keeping production costs low and time-to-market projections quickly are key priorities as EV demand grows. Employing the services of a leading testing partner early in the R&D process is critical. In doing so, manufacturers will receive full insight into the performance and successes of their designs in the earliest stages. The insight helps to keep prototyping minimal and progress on track.

Performance testing needs to be front and center early on in the development and production processes. Early testing enables manufacturers to prioritize conformance and product quality standards that will ensure long-term viability of their products, while keeping costs low and time frames tight.

The benefit of independent test houses

Test houses play a critical role in supporting original equipment manufacturers (OEMs) and EVSE network providers and helping them to achieve the required certification and accreditation standards across both automotive and electrification protocols. With a broad spectrum of technology and testing knowledge at their disposal, test house experts use test equipment aligned with the latest test requirements to ensure that your equipment meets evolving standards.

When purchasing state-of-the-art test equipment is not financially feasible for a manufacturer, independent test houses can offer a full range of services at a much more affordable OPEX cost. Further, a test house can stress test conditions to the limits, using highly automated technology without damaging the vehicle or charging equipment under test.

When partnering with an independent testing specialist, the onus is on the test house to ensure thorough, repeatable, and reliable tests, in addition to the safety of the device under test, and all engineers involved in the process.

Case Study – DEKRA and Keysight Support Manufacturer Testing Requirements

When DEKRA, the world leader in testing and certification of products and systems needed to upgrade its test equipment to meet the evolving testing standards for EV and EVSE charging technology, it selected Keysight as its new partner.

A member of CharIN, Keysight has the ability to test conformance against all leading global standards with its CDS. The CDS solution is capable of testing and certifying products quickly, accurately, and in accordance with the highest recognized standards.

Commenting on the partnership, Beat Kreuter, vice president of business line product safety testing at DEKRA said:

“Partnering with Keysight enables DEKRA to better serve an automotive industry with solutions in an area where the energy grid meets the automotive world. Keysight solutions enable us to improve safety on the road through the use of highly automated testing technology.”

Thorough testing for optimum performance

Whether you test in-house or use an independent testing body, it is important to test thoroughly. Testing to optimize performance and interoperability is a very complex process.

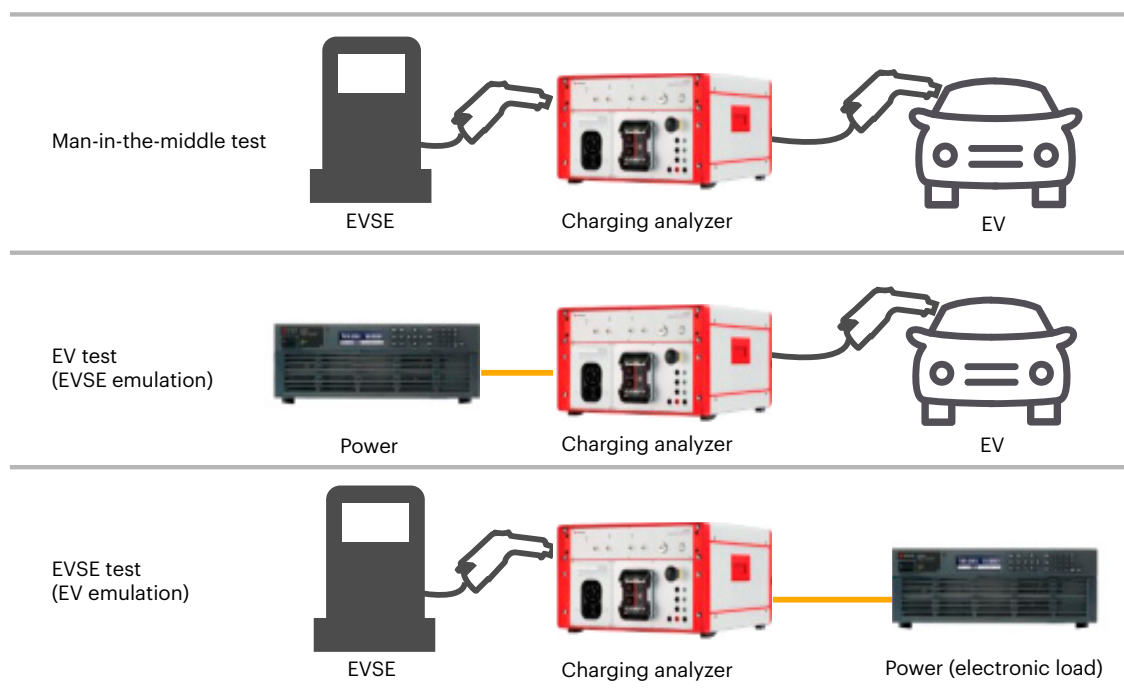
To illustrate the level of detail required, here is an example of one commonly used test scope for EVSE that uses the CDS in combination with a bidirectional power source to emulate the configurable charging interface of an EV. This makes it possible to test EVSE under real conditions.

Introducing Keysight's SL1040A Series Scienlab CDS

Keysight's SL1040A Scienlab CDS Series is a state-of-the-art holistic test solution for all AC and DC charging interfaces of EVs and EVSE. The solution verifies product performance and prototypes, including fault conditions up to future testing standards of 400 kW, long before a market release. The CDS - EMC Series features an innovative modular design- for use in anechoic test chambers and enables conducted and radiated testing of emissions and immunity during AC or DC charging.

Use the CDS in three ways:

1. **Man-in-the-middle test:** The CDS decodes and measures communication and power signals between the charging station and the electric vehicle.
2. **EV test:** To enable EV testing, use the CDS in combination with the same bidirectional power source to emulate any type of charging station.
3. **EVSE test:** Use the CDS in combination with a bidirectional power source to emulate any type of EV and test charging stations under real conditions.



Keysight's SL1047A Scienlab CDS – High-Power Series:

Future charging standards demand more charging current, such as the 600 A, and liquid-cooled charging adapter. In response to this demand, Keysight introduced the CDS High-Power Series (CDS HP Series), in which the cooling unit accommodates the use of interchangeable liquid-cooled charging adapters.

Therefore, the CDS HP Series enables testing of high-power DC charging interfaces of EVs and EVSE up to 600 A and 1500 V (up to 900 kW). The CDS HP Series also corresponds with the requirements of ChaoJi, a newly proposed charging standard under development since 2018.

Customers may order the CDS HP Series with the maximum voltage of 1000 or 1500 V DC, or an upgrade from 1000 V DC to 1500 V DC.

Discover more

[Keysight's test solutions for EV/EVSE charging interfaces](#)

[SL1040A Scienlab CDS Portable Series data sheet](#)

[SL1040A Scienlab CDS EMC Series for EV Test data sheet](#)

[SL1040A Scienlab CDS EMC Series for EVSE Test data sheet](#)

[SL1047A CDS High-Power Series data sheet](#)