38th International Electric Vehicle Symposium and Exhibition (EVS38) Göteborg, Sweden, June 15-18, 2025

Towards higher charging reliability: implications from CHAdeMO Association's Interoperability Test Centre project

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Executive Summary

As the electrification of vehicles accelerates around the world, 'charging reliability' is recognised as a problem. CHAdeMO charging maintains a relatively high success rate thanks to its certification system and backward compatibility, but as more manufacturers and models of both EVs and chargers enter the market, it is becoming increasingly difficult to warrant high-quality user experience.

In response, CHAdeMO Association launched an interoperability test centre in Japan. Since its full implementation this year, a variety of EVs from cars, buses, to construction machinery have been tested and the EV 'whitelist' is published. Errors are reviewed by experts, which leads to the revision of the specifications as necessary.

This article presents a case study of a not-for-profit standards organisation operating a test centre - its structure, operations, results, and the expected effects - and discusses its advantages and challenges, with the aim to showcase one solution for industry stakeholders.

Keywords: Electric Vehicles; Standardization; AC & DC Charging technology; Fast and Megawatt charging infrastructure

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1 Current charging reliability and trends

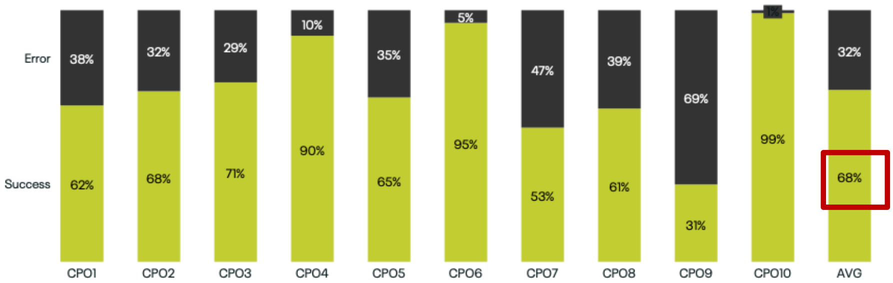
In the current challenging economic and geopolitical climate, the EV industry is at a critical juncture as to whether it can be an effective option for climate change in the future. To encourage hesitant internal combustion engine vehicle drivers to switch to electric vehicles, the general opinion of stakeholders is that today's charging is not reliable enough.

1.1 EU/US markets

According to a study by German consultancy P3 and evercharge, the success rate of fast charging (the rate at which the desired charge was achieved on the first try) in Europe between 2022-2024 was **73%** [1]. According to Hubject, a German e-roaming network service provider, the average charging (authentication) success rate for the 10 CPOs on its network was **68%** as shown in Table 1[2].

In the US, an analysis report analysis of over 13,000 public charging stations and 1 million user reviews by Harvard University found that the charger reliability was **78%** [3]. Although these figures cannot be directly compared due to the variety of charger types and survey methods, overall, it can be said that one in three to five of today's charging events ends in failure.

Table 1: EMP authorization remote start process of ten EU CPOs (Hubject)



1.2 CHAdeMO

CHAdeMO debuted in 2009 as the world's first DC fast charging standard for commercial EVs; CHAdeMO Association defined the certification tests for chargers (2013) and established a third-party certification system (2014). Successful charger certification (conducted by eight homologation bodies in eight countries) results are listed on the CHAdeMO website [4].

When errors have been identified and reported during actual charger operation, the Association has collaborated with charger operators and relevant Working Groups to determine the causes and reflect them in the specification, ensuring backwards compatibility with each version change. As a result, the success rate of CHAdeMO charging has been relatively high [5].

1.3 Definition of charging errors

The above-mentioned statement about not being able to directly compare the figures published by the different agencies because of the different ways in which the statistics are compiled in itself raises questions. There is a growing debate about the reliability of chargers, but how should charger reliability be defined and measured in the first place? The definition is not the same within industry or in legislation that requires a certain reliability rate.

As an example of national legislation, the National Electric Vehicle Infrastructure (NEVI) programme introduced by the Biden administration in the USA required all chargers to have an 'uptime' greater than 97%. This was defined as 'the period during which a charger's hardware and software are both online, available for use, or actively in use, and the charging port successfully dispenses electricity as expected' and 'excludes cases beyond the control of the CPO (e.g. power outages, malfunctioning internet or cellular services)[6].

In the UK, the Public Charge Point Regulations 2023 mandate that public EV charge point operators must ensure their rapid (50 kW or more) stations achieve 'a minimum reliability standard of 99%.' This means that each charging point should be operational and available for use at least 99% of the time over a given year, allowing for approximately 87.6 hours of downtime annually per charger for maintenance or repairs [7].

However, the state of being operational and available (or online) as defined in the US and UK should be considered separately from the success of the charging session as shown in the Hubject example: the charging success rate of available chargers was less than 70%.

Charger manufacturer Kempower (Finland) published its own statistics in its white paper in November 2024. In their analysis of 13 million charging sessions using their chargers from December 2018 to July 2024, their 'uptime' was **99%.** Their overall average charging success rate was **a little below 75%** as well, confirming that high charger uptime does not necessarily mean successful charging, although the best operators 'could go as high as close to 85% success rate.' The company went further to identify two failure types: technical ones and the usability ones. The former refers to the error rate in charging caused by EVs or chargers, and the latter, four times more frequent, due to user-related issues, the majority of which involve user authentication failures [8].

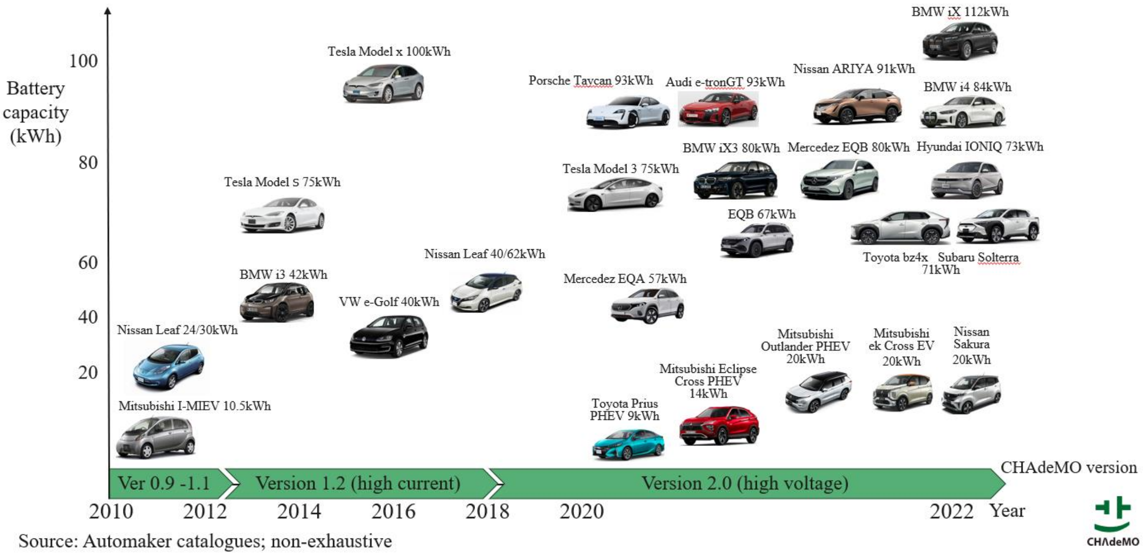
CHAdeMO Association does not have data specifically on CHAdeMO chargers in use in Europe and the USA (40,798[9] and 11,145[10]charging points respectively), but according to e-Mobility Power Co., Inc (eMP), the largest Japanese CPO managing 9,635 CHAdeMO chargers in the Japanese market [11], their public charging stations has a 'reliability' of **99.47%** in FY2024 [12]. This is not the rate of successful charging based on the number of charge sessions, but based on the available time of operation, or 'uptime.' eMP defines a charging error as 'an inability to start charging, aborting in the middle of charging, a failure in the charger or vehicle after charging is completed.' This definition is broad, as it includes 'post-charge failure' on top of both of Kempower's failure types, but eMP also explains that it is difficult to calculate charging success rates, because many of charging failure sessions do not leave logs [13].

There are a number of definitions for charger reliability, charging success rate, and errors. For CHAdeMO Association that provides the CHAdeMO protocol, what is beyond the communication between EVs, and chargers is out of scope. Therefore, this paper will look at the efforts of reducing errors related to the CHAdeMO protocol (or EV-EVSE communication), unless specified otherwise to include other error types such as authentication failures. In other words, this paper talks about the enhancement of 'interoperability.'

1.4 Increasing charging errors

Due to the global trend towards electrification and the rapid evolution of protocol upgrades, charging errors became more noticeable in Japan, where the CHAdeMO headquarters are.

On the vehicle side, the introduction of EVs/PHEVs to the Japanese market accelerated in the 2020s, compared to only a few models each year in the 2010s. As seen on Figure 1, the market has witnessed an overall increase in battery capacity and the variety of CHAdeMO charging protocol versions since the early 2020s. As of April 2025, the number of BEVs eligible for Japanese government subsidies has swelled to 63 models from 24 companies and 47 models from 18 companies for PHEVs [14].

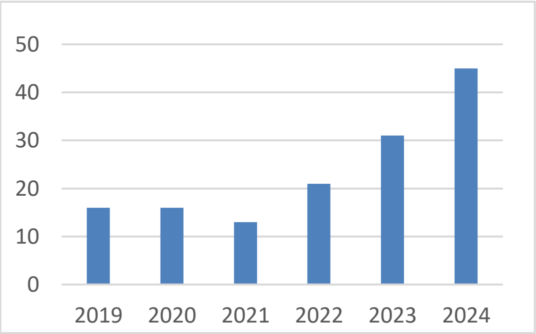


Source: Automaker catalogues; non-exhaustive

Figure 1: CHAdeMO EV/PHEV launch in the Japanese market (Battery capacity/CHAdeMO version/year)

On the charger side, there has also been an increase in market introductions. Although CHAdeMO Association does not have information on the market introduction of all chargers, as of April 2025, 259 models from 34 EVSE companies were on the list of chargers eligible for subsidies published by the Next Generation Vehicle Promotion Centre (NEV) [15]. Because the CHAdeMO certification is a pre-requisite for the NEV subsidy, the number of CHAdeMO certifications issued for chargers by the accredited certification bodies has been on the rise, reaching 45 in FY24, despite a temporary drop around the Covid-19 pandemic (Table 2).

Table 2: CHAdeMO EVSE certifications (number of chargers certified/year)



Data on the number of charging errors was not available, but according to eMP, the following types of errors have increased in the early 2020s.

- Error between the older version of the charger and the newer version of the vehicle due to lack of description in the Specification.
  - Circuit equipment damage due to inrush current during charging
  - Ground fault detection activated when unnecessary
- Errors caused by vehicles not following the CHAdeMO protocol
  - Ver 1.2 vehicles could not support information on Ver 2.0 chargers
- Errors caused by chargers not following the CHAdeMO protocol
  - Operates below the minimum current value of the control signal line
  - Isolation diagnostic timeout activated

Vehicle OEMs generally take their vehicles to charger manufacturers for testing, but testing with all charger manufacturers is difficult. In some cases, charging tests were performed on market chargers, which led to events where the chargers were faulty.

When problems occurred in the market, complaints were raised with CPOs and vehicle manufacturers, which were then discussed among CPOs, vehicle manufacturers, and charger manufacturers individually, information on problems related to the CHAdeMO protocols was not shared with CHAdeMO Association. In order to improve this situation, the Association set up a system for collecting and sharing error information in autumn 2022. More concretely, it was decided to collate and compile a database of fault information reported by vehicle manufacturers, charger manufacturers, CPOs and others, and then, depending on the content, request a study by the WG or revise the specifications to eliminate faults in the market, one by one. This information collection & sharing is still being conducted on an ongoing basis.

In November 2022, a connection test event was organised to evaluate connections between EVs/PHEVs and multiple chargers to improve vehicle/charger interoperability. Nevertheless, challenges remained as one-off test events are not sustainable and conventional individual testing model by each vehicle model is inefficient, imposing a heavy time and cost burden on the parties involved.

Connection test event; photo courtesy of CHAdeMO Association

In 2023, CHAdeMO board members agreed to establish the CHAdeMO Interoperability Test Centre (CITC) to establish a more permanent system to ensure the interoperable connection of vehicles and chargers and to prevent problems in the market. Full-scale operation began in April 2024.

2 CHAdeMO Interoperability Test Centre (CITC)

While the setting up of a connection test centre itself is not unusual [16], the CITC initiative has some unique features. These features are described in this section.

- The CHAdeMO vehicle quality checklist for the vehicle side is used as an evaluation criterion.
- There are two types of test centres with EVSEs: a test centre that simulates the majority of the current Japanese market environment, and a centre that tests with high-power, next-generation chargers, which can be considered the future market environment.
- Vehicle-charger combinations that pass the test will be published on the Association’s 'whitelist' on its website [17]. This will provide transparency for CPOs, general installers (charger buyers) and users.

- In addition to the EVSE-equipped test centres, an interoperability ecosystem can be found with a lab where protocol testing can be performed.
- CHAdeMO Association has agreed to invest on behalf of EV charging-related industry stakeholders and also takes on the administrative and coordination role of the test centres, thereby reducing the cost of tests. This could be the catalyst for a positive spiral effect: cost reductions lower the hurdles to using the test centres → increase in the number of companies taking the tests → improved interoperability and reduced charging failures → improved user satisfaction.

2.1 Vehicle quality checklist

As mentioned above, CHAdeMO Association established a third-party certification system and entrusted the operation of charger certification to third-party homologation bodies, but in order to operate the CITC and conduct connection tests, vehicle-side test specifications were required. For this, in December 2023, the Specification WG of the Association prepared and published a Vehicle Quality Checklist, which specifies the vehicle-side test items. Such a vehicle-side checklist by a charging standard developing organisation may be the first of its kind.

This list consists of two main parts: 'items to be desk-checked or with a simulator' and 'vehicle tests to be conducted at CITC'. The items to be checked on the simulator are assumed to have been cleared before the actual vehicle tests at CITC. The items to be checked with a simulator include basic requirements such as output range, detection of connector connection and disconnection, power supply interruption during connection, and prevention of vehicle mis-start. On the other hand, for the tests to be conducted by the CITC, issues that are only likely to become apparent in combination with the charger were defined, as well as items and test methods that vehicle manufacturers should pay special attention to. For example, the tracking of the charging current to the current command value, false diagnosis of ground faults, etc. In formulating the vehicle quality checklist, the Association paid particular attention to the management of information related to individual companies and products, minimising the amount of information to be made public.

2.2 CHAdeMO Interoperable Testing Centre (CITC) setup

The main part of the CITC is interoperability testing using actual products conducted at UL Solutions in Ise and TÜV Rheinland Japan in Nakano (operational from March 2025). For the part of the simulator verification items that are carried out as part of the vehicle development phase, protocol tests can be carried out at Toyo Technica Corporation in Tokyo.
Interoperability testing is accepted by the CHAdeMO Secretariat as a contact point ([Apply] in Figure 2), and CHAdeMO Association is responsible for the administration as part of its member services. The data

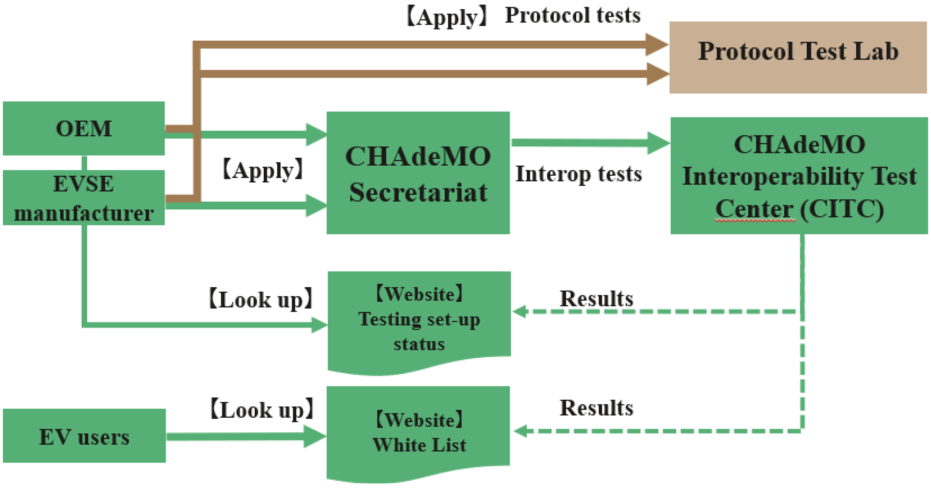


Figure 2: CHAdeMO interoperability test centre (CITC) set-up

to be measured and collected in the tests are limited to those related to the interfaces defined in the CHAdeMO standards. Basically the test requests accepted on a first-come, first-served basis, but in order to prevent continuous use or long-term reservations that may risk monopolising the facility, the Secretariat may adjust the reservations to ensure fairness. Bookings for protocol tests are not under the control of the Secretariat. When an enquiry is made to the Secretariat, the Secretariat will ask what type of test the applicant wants to perform and then recommend the use of a test facility that meets their needs.

The use of the test centre is paid for by the member who wishes to use it (a vehicle manufacturer). The Association sets the prices for the part related to the CHAdeMO connection tests. The common goal of 'improving reliability' is understood by members in different roles, and each member shares the costs, thereby minimising the overall costs of the test centre project. Vehicle-charger combinations judged to be 'compliant' are published on the Association’s website as a ‘white list’ ([Results] in Figure 2) and made widely available not only to stakeholders in the e-mobility industry such as CPOs and charger installers, but also to general users ([Look up] in Figure 2). Details of the whitelist are discussed below.

2.3 CITC testing at UL Solutions

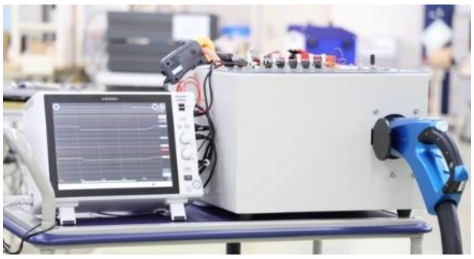
The CITC test centre at the UL Solutions Ise headquarters is equipped with 13 chargers widely used on the market at various power levels (25-180 kW) and CHAdeMO versions (see Table 3), where OEMs can test CHAdeMO connections using actual equipment, along with any other tests they wish.

One of the selection criteria for the chargers was ‘at least 700 units installed in Japan', so that the 13 chargers installed represent approximately 70% of the chargers installed in the market.

CITC testing site in Ise
(photo courtesy of UL Solutions)

Table 3: Charger set-up at CITC UL Solutions Ise site (as of 2024-09-25)

	Charger manufacturer	**Model**	**kW**	**CHAdeMO version**
1	NEC Corporation	NQVC500	50	0.9
2	Nissan Motor Co., Ltd.	NSQC443BB	44	0.9
3	Takaoka Toko Co., Ltd.	HFR1-40B4-A3	40	0.9
4	Hasetec Corporation	LJ03-2P2W-UN	25	0.9
5	Nichicon Corporation	NQC-TC503N	50	1.0
6	Takaoka Toko Co., Ltd.	HFR1-50B8	50	1.1
7	ABB Ltd.	Terra 184 JJ-X	180	1.2
8	Delta Electronics	EVHJ104J2CB30	100	1.2
9	Shindengen Electric Manufacturing Co., Ltd.	SDQC2F90EXT4415- MBMS	90	1.2
10	Takaoka Toko Co., Ltd.	HFR1-120B10-A7	120	2.0
11	Nichicon Corporation	NQD-UCX04P	100	2.0
12	Daihen Corporation	DQC050LS-DA	50	2.0
13	Takaoka Toko Co., Ltd.	HFR1-50B9	50	2.0



CITC testing site in Ise
(photo courtesy of UL Solutions)

In the tests, an analyser is connected between the vehicle and the charger to monitor the charging status, and the data specified in the checklist is acquired and diagnosed. Normal charging, ‘refill charging’ that starts again after stopping, as well as simulated ground faults are some of the important points to be evaluated. The results of these tests, carried out by UL Solutions engineers, confirm that the criteria are met, i.e. that there are no errors on either the charger or vehicle side, that charging stops after a ground fault, etc.

2.4 CITC testing (TÜV Rheinland Japan)

In March 2025, a new test centre became operational at TÜV Rheinland Japan (Nakano). This centre, which targets high-power and next-generation chargers, differentiates itself from the UL Solutions test centre by installing 500 A power cubicles, high-voltage, and high-output chargers, as well as new or less common chargers on the market. They are also able to conduct V2H testing and charger-side testing. In March 2025, a major Japanese charger manufacturer's 400 kW-class ultra high-power charger was already tested and received CHAdeMO certification.

2.5 Simulator testing (Toyo Corporation)

Companies wishing to develop EVs and chargers compatible with CHAdeMO charging can use the facilities of measurement technology specialist Toyo Corporation for product development and protocol testing. The company's EV Charging Test Lab is equipped with facilities specialising in simulation of both EVs and chargers, including dynamic control, high voltage control (1,000 V) and bi-directional charging (using grid-simulated power supplies and various V2H devices). For CHAdeMO, protocol versions from 0.9 to 2.0 can be tested and evaluated.

Currently, the laboratory can test all the items to be checked with a simulator out of the 'items to be desk-checked or with a simulator' section of the Vehicle Quality Checklist by CHAdeMO Association.

According to Yoshiyuki Tanaka of the Toyo Corporation’s e-Mobility Measurement Division, the lab is used by companies that do not have their own development tools such as analysers as part of their development process, by EVSE importers as a go-to place for product checks, or by vehicle OEMs for final checks on vehicles prior to introduction to the Japanese market.

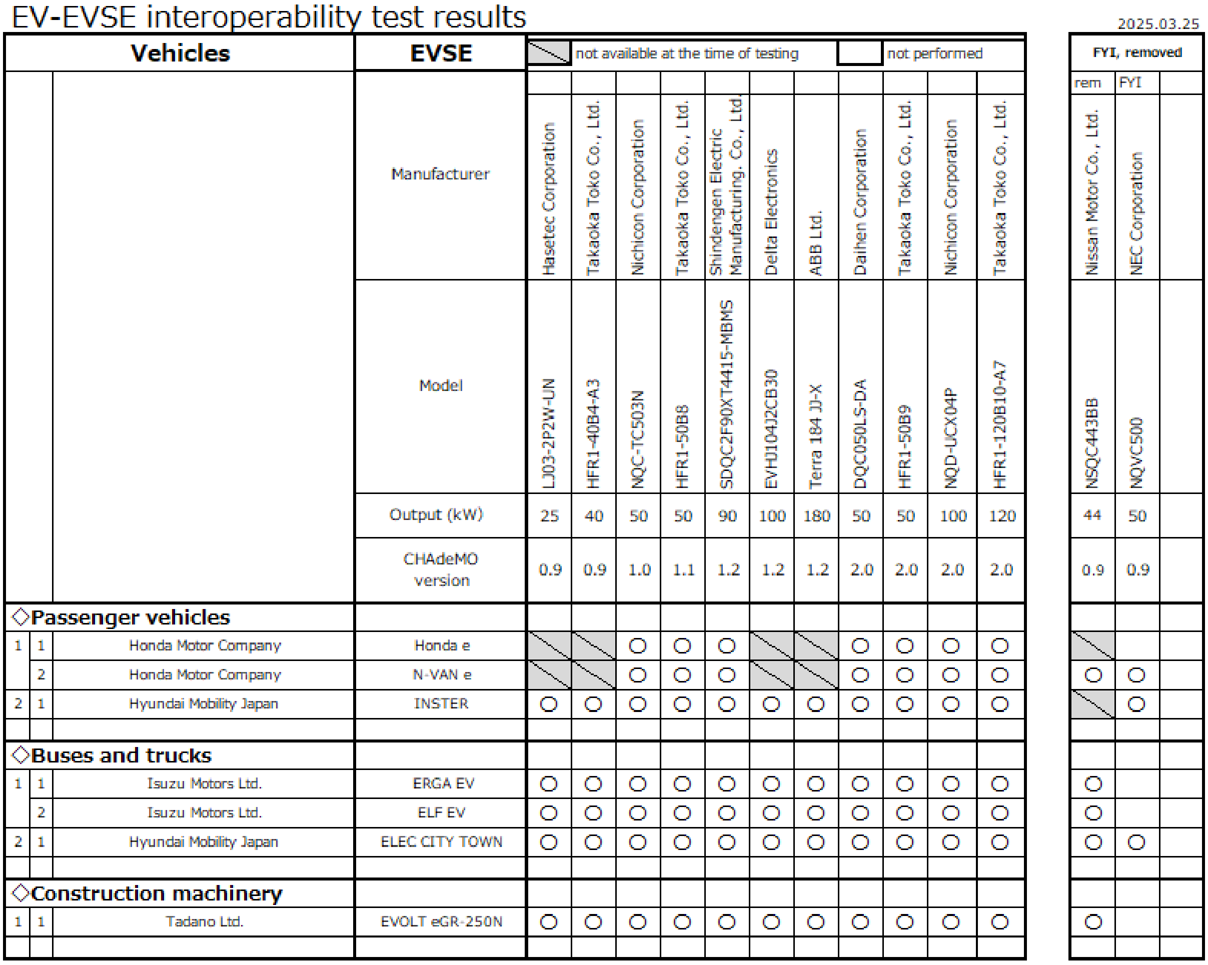
In the period from the start of the pilot operation in autumn 2023 to March 2025, 17 days of testing for CHAdeMO member OEMs and 19 days for CHAdeMO member charger manufacturers were performed, accounting for two-thirds of the company's total EV charging lab usage. M. Tanaka explains that ‘Taking into account the public nature of improving interoperability for public EV chargers, we offer our services for CHAdeMO protocol testing at a lower cost than normal operations,’ emphasizing the importance of their lab operating not only as a private lab but also as part of the CHAdeMO Association's CITC scheme.

Toyo Corporation lab
(photo Tomoko Blech)

3 CITC achievements

According to CHAdeMO Association, from November 2023, when the first pilot operation at UL Solutions started as the test centre, until March 2025, a total of 11 companies (seven vehicle manufacturers of passenger cars, buses and trucks, three EVSE and other suppliers, and one construction machinery vehicle manufacturer) applied to use the centres. Of these, a total of seven vehicle models passed the test: three passenger cars, two buses and trucks, and one construction machinery vehicle [18]. The test results are published on the CHAdeMO website as a ‘white list’ as shown below, so that it can be seen at a glance which vehicles that have been tested have confirmed compatible with which charger models of which charger manufacturers[17].

Table 4: EV-EVSE interoperability test results (‘whitelist’) on the CHAdeMO website



EV-EVSE interoperability test results

2025.03.25

▨ not available at the time of testing ☐ not performed

Vehicles			EVSE												FYI, removed		
															rem	FYI	
			Manufacturer	Hasetec Corporation	Takaoka Toko Co., Ltd.	Nichicon Corporation	Takaoka Toko Co., Ltd.	Shindengen Electric Manufacturing. Co., Ltd.	Delta Electronics	ABB Ltd.	Daihen Corporation	Takaoka Toko Co., Ltd.	Nichicon Corporation	Takaoka Toko Co., Ltd.	Nissan Motor Co., Ltd.	NEC Corporation	
			Model	LJ03-2P2W-UN	HFR1-40B4-A3	NQC-TC503N	HFR1-50B8	SDQC2F90XT4415-MBMS	EVHJ104J2CB30	Terra 184 JJ-X	DQC050LS-DA	HFR1-50B9	NQD-UCX04P	HFR1-120B10-A7	NSQC443BB	NQVC500	
			Output (kW)	25	40	50	50	90	100	180	50	50	100	120	44	50	
			CHAdeMO version	0.9	0.9	1.0	1.1	1.2	1.2	1.2	2.0	2.0	2.0	2.0	0.9	0.9	
◇Passenger vehicles																	
1	1	Honda Motor Company	Honda e	▨	▨	○	○	○	▨	▨	○	○	○	○	▨		
	2	Honda Motor Company	N-VAN e	▨	▨	○	○	○	▨	▨	○	○	○	○	○	○	
2	1	Hyundai Mobility Japan	INSTER	○	○	○	○	○	○	○	○	○	○	○	▨	○	
◇Buses and trucks																	
1	1	Isuzu Motors Ltd.	ERGA EV	○	○	○	○	○	○	○	○	○	○	○	○		
	2	Isuzu Motors Ltd.	ELF EV	○	○	○	○	○	○	○	○	○	○	○	○		
2	1	Hyundai Mobility Japan	ELEC CITY TOWN	○	○	○	○	○	○	○	○	○	○	○	○	○	
◇Construction machinery																	
1	1	Tadano Ltd.	EVOLT eGR-250N	○	○	○	○	○	○	○	○	○	○	○	○		

Last year, a large electric crane was tested. As the first construction machinery in Japan to pass CHAdeMO interoperability tests, the case symbolised the era of electrification[19].

Electric construction machinery testing (photo courtesy of Tadano Ltd.)

Dr. Noboru Kawaguchi, Business Development Manager, UL Solutions, explains the significance of this project. ‘At UL Solutions, we believe we can contribute to improving the charging quality as a CHAdeMO verification body. However, rather than a single company undertaking such a project, collaboration amongst CPOs, EVSE manufacturers, and certification bodies through the establishment of the CTIC scheme under the initiative of CHAdeMO Association will better ensure the improvement of overall charging quality.’ He also said that 'the involvement of an industry-unifying organisation such as CHAdeMO is important for this type of quality improvement projects,' emphasising the benefits of the CITC setup for a project that benefits not only the industry players but also the general EV users.

Has the operation of the centres reduced the number of charging errors? According to e-Mobility Power Co., Inc., it ‘has experienced a decrease in charging errors over the past few years,’ but it explains that ‘it is difficult to know what elements have caused the reduction of the number of defects, partly because test centre testing is not mandatory.’

While e-Mobility Power Co., Inc. appreciates the CHAdeMO Association's efforts to establish test centres, it explains, this is not the only factor contributing to the company's high reliability rate, either. For example, the company has in place,

- A 24-hour charge monitoring and control system to remotely re-start the system,
- Tracking of individual charging sessions so that they get detailed error information,
- Discussions with relevant stakeholders after receiving error information to immediately apply countermeasures to the same models of chargers to prevent recurrence and deter failures,
- Systematic replacement of aged chargers (e.g. installed circa 2010-2016),

to name a few [20]. Their system is designed to achieve a high reliability from all aspects. It can be said that CHAdeMO's CITC activities only contribute to small part of the above, i.e. ‘avoiding errors in the charging sequence’ step.

As for whether the continued operation of the test centres has triggered a positive spiral effect, such as increased user satisfaction and higher EV adoption in the Japanese market, no particular data showing a correlation could be found, partly because it is still early days. A careful analysis will be necessary after keeping a close eye on the trends of various indicators.

4 Challenges and considerations for CITC operations

In the nascent EV and charging infrastructure development phase, it is not enough to increase and accelerate EV sales simply by introducing more vehicles and installing more charging infrastructure; the overall experience of customers using EVs must be positive, including successful and seamless charging. As a necessary minimum condition for this, the CHAdeMO Association was established in 2010 with the aim of harmonising charging standards and guaranteeing interoperability, and a transparent third-party certification system was introduced quite early. However, more than a decade on, errors were increasing as the number of vehicle and charger types increased. The CITC project was launched when the Association went back to basics and identified the need for more permanent interoperability testing facility.

While recognising the importance of interoperability testing, some stakeholders say that it should essentially be the responsibility of the OEMs that make EVs and the EVSE manufacturers that make chargers, while some OEMs believe that the infrastructure is not their responsibility. Especially at a stage like the Japanese market, where there is little scale, it is cost-prohibitive for individual companies (including OEMs, EVSE manufacturers, CPOs who operate chargers, and general installers) to operate and maintain such test centres. That is how CHAdeMO Association, a not-for-profit organisation formed by EV charging industry stakeholders and an organisation with a high degree of public interest, has taken on this task.

Is this a sustainable operation? If the market growth accelerates and reaches a stage where a certain scale can be expected, further players may join the test centre business, creating a situation where the business is based on healthy competition. Perhaps. Or, due to the nature of this business, there could also be a scenario in which, when the higher stage of interoperability improvement is reached, the Specifications will be close to perfection, as the know-how of the ecosystem in general will improve, making the test centres no longer necessary. In this latter case, the centres could be expected to end their role.

In terms of operational challenges for the centres, given the framing of the test centre as 'testing with most chargers installed in the market (high market coverage)', chargers with a high market share based on the number of eMP network, the largest CPO, were selected for the main test centre (UL Solutions Ise). However, as the number of chargers by other installers increases, flexible replacement of test chargers may be necessary to avoid causing market fixation. To this end, CHAdeMO Association needs to keep track of market trends, such as increasingly more popular (or unpopular) charger makers and models. eMP suggests that it would be a good idea to survey charger manufacturers at the same time each year, for example, asking them about the number of delivery (by model) in the previous year [21].'

Another issue is that the use of the test centres is voluntary. Some fear that this will result in a certain number of companies with many defects remaining, because ‘companies that care about quality will use the CITC more and companies that do not care about quality will not use it unless obligatory.’ In a scenario where latecomer charger manufacturers and EV OEMs of inferior quality are in proliferation, how and to what extent the use of the CITC can be made binding may be key.

Furthermore, it will be important to consider how to improve interoperability in an ‘extended e-mobility ecosystem’ beyond the EV-EVSE communication, such as user authentication and communication beyond the charger, which is currently outside the scope of the CITC. As an example, the establishment of a third-party certification system in the Korean market by OCA, the developer of OCPP, may be a best practice to watch. OCA has recently started discussions with stakeholders in Japan for OCPP certification. There may be synergies in creating a more seamless testing environment through collaboration with these adjacent groups.

5 Conclusion

To encourage hesitant internal combustion engine vehicle drivers to switch to electric vehicles, it is more important than ever that industry players work together effectively to increase charging success rates and improve the overall customer experience.

This case study shows that CHAdeMO Association and industry stakeholders are aiming for a higher level of reliability in the market as a whole through a wide range of steady measures such as third-party certification system, ensuring backwards compatibility, collecting and responding to error information in the market, connection testing, setting up test centres, creating a unique vehicle-side checklist for this purpose, etc. This was likely made possible because many Association members have been cooperating with each other for more than a decade in developing, using, and revising the CHAdeMO charging standard.

While it is difficult to apply the same model to various markets of different sizes and structures, we are convinced that each of these diligent efforts by CHAdeMO, a neutral, stakeholder-bridging entity, in order to increase consumer confidence will be helpful in other markets. We hope that we can contribute as an example of the industry's efforts for higher charging reliability.

Acknowledgments

I wish to express my sincere gratitude to Kazumasa Arai, Take Suzuki, and Tom Hakomori of CHAdeMO Association Tokyo Secretariat, as well as to Hiroaki Endo and Masayuki Fukuhara, e-Mobility Power Co., Inc., Dr. Noboru Kawaguchi of UL Solutions, and Yoshiyuki Tanaka of Toyo Corporation for providing valuable data and support.

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