CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Vehicle Interoperability Testing Symposium (VOLTS)

Prepared for: California Energy Commission

Prepared by: innos Incorporation

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Erika Meyers
Primary Author

innos Incorporation
1250 I St NW, Suite 902
Washington, DC 20005
Company Website (https://www.innos.global/en)

Contract Number: 600-21-009

Jeffrey Lu
Commission Agreement Manager

Jaron Weston
Branch Manager
BRANCH NAME GOES HERE

Hannon Rasool
Director
FUELS AND TRANSPORTATION

Drew Bohan
Executive Director

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued the contract solicitation RFP-21-601 *Vehicle Interoperability Testing Symposium (VOLTS)* to select one contractor to conduct a vehicle interoperability testing symposium to support interoperability of electric vehicle (EV) charging. In response to RFP-21-601, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on January 6, 2022, and the agreement was executed as Contract 600-21-009 on September 22, 2022.

ABSTRACT

The Vehicle Interoperability Testing Symposium (VOLTS) and Conference took place on May 8-12, 2023, in Long Beach, California. The objective of VOLTS was to convene key electric vehicle (EV) stakeholders to conduct collaborative, low-risk interoperability tests, develop and finalize products, conduct implementation testing and test tool development for charging standards and protocols, and discuss means to overcome common technology barriers facing the industry. These stakeholders included but were not limited to electric vehicle supply equipment (EVSE) manufacturers, automotive original equipment manufacturers (OEMs), and EV software and network providers. By gathering all these stakeholders together, VOLTS supported rapid protocol testing and validation of many combinations of products and provided an invaluable resource for product development and standards implementation.

More than 350 attendees joined the VOLTS Conference, which featured 34 top experts on a wide range of interoperability and reliability topics focused on International Organization for Standardization (ISO) 15118. On Wednesday, the testing symposium was open to the registered public and on Thursday the testing symposium was only for registered equipment testers. Over the two days, the Testing Symposium hosted over 400 attendees from 38 different e-Mobility companies, which supplied four school buses, four trucks, 13 electric cars, 21 charging stations, and seven test systems for testing, making it the largest CharIN testing event ever organized globally.

Keywords: California Energy Commission, Zero Emission Vehicle, ZEV, Vehicle to Grid, V2G, Vehicle, Interoperability, Testing, Symposium, VOLTS, innos, 600-21-009

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TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

EXECUTIVE SUMMARY

The Vehicle Interoperability Testing Symposium (VOLTS) was a key event designed to advance interoperability in Electric Vehicle (EV) charging. VOLTS brought together EV stakeholders including electric vehicle supply equipment (EVSE) manufacturers, original equipment manufacturers (OEMs), and software providers to conduct testing and refining industry standards in a low-risk, collaborative environment. The primary focus was on validating International Organization for Standardization (ISO) 15118, which facilitates Plug and Charge (PnC), smart charging, and cybersecurity improvements.

Some key findings from VOLTS testing are that 21 EVSE models were tested, including 15 for direct current (DC) charging and six for alternating current (AC) charging. Most of these supported ISO 15118-2, with some extending to ISO 15118-20. Twenty-one EVs participated, with 20 supporting Deutsches Institut für Normung (DIN) 70121 and 17 supporting ISO 15118-2. A total of 174 EV-EVSE pairings took place over two days, with over 1,000 individual tests conducted. More than 80% of charging sessions were successful, showing strong protocol implementation. The PnC success rates were modest, indicating room for improvement in standard adoption and vehicle preparation.

Technical and industry implications were discovered demonstrating that secure interoperable public key infrastructure is crucial for widespread adoption of ISO 15118. The event identified gaps in PnC readiness and the need for better implementation of smart charging capabilities, emphasizing the importance and certification to ensure compatibility and reliability in real world scenarios.

Next steps for industry include enhancing conformance testing and certification by expanding standardized testing to ensure EV-EVSE compatibility, leveraging smart charging capabilities utilizing real-time tariff data for optimizing charging, and improving future testing events by increasing test duration, refining certification processes, and addressing interoperability gaps.

VOLTS provided invaluable data and insights, positioning the industry for improved EV-EVSE charging reliability and seamless interoperability.

CHAPTER 1:
VOLTS Testing

Approach and Results

The Vehicle Interoperability Testing Symposium (VOLTS) was designed to support product development and standards implementation in a collaborative, low-risk environment to move toward an interoperable charging ecosystem. VOLTS convened EV stakeholders to conduct interoperability tests, develop and finalize products, conduct implementation testing and test tool development for charging standards and protocols, and discuss means to overcome common technology barriers facing the industry. As mentioned above, these stakeholders included but were not limited to EVSE manufacturers, OEMs, and EV software and network providers. By gathering all these stakeholders together, VOLTS supported rapid protocol testing and validation of many combinations of products, and provided an invaluable resource for product development and standards implementation.[1] VOLTS was designed to troubleshoot products at any stage of development, and help determine if the equipment is ready to move on to conformance testing and commercialization. The tables below show details on the participating companies and equipment, and Figure 1 below shows the high-level multi-day agenda for the event.

Table 1: AC EVSE Technical Registrations

Company
IoTecha
Switch Energy
Switch EV Ltd
Tesla
Zerova Technologies USA

Source: innos, Inc.

Table 2: DC EVSE Technical Registrations

Company	Type
ABB	**ABB Equipment 1**
ABB	**ABB Equipment 2**
Autel Energy	
Borg Warner Inc	
BTC Power Inc	
dSPACE GmbH	
EcoG GmbH	

1 The Request for Proposal - Vehicle Interoperability Testing Symposium (VOLTS), https://www.energy.ca.gov/sites/default/files/2021-10/00_RFP-21-601_VOLTS_Solicitation_Manual_Addendum_01_ada_0.docx

EVgo	
Freewire Technologies	
ideanomics	
InCharge Energy	
Keysight Technologies	
Rectifier Technologies Ltd	
Rivian	
SparkCharge	
TeraWatt Infrastructure	
Vector Informatik GmbH	**Vector Equipment 1**
Vector Informatik GmbH	**Vector Equipment 2**
Zerova Technologies USA	

Source: innos, Inc.

Table 3: EV Technical Registrations

Company	Type
AMP	
Blue Bird Corporation	
BMW of North America	**BMW Equipment 1**
BMW of North America	**BMW Equipment 2**
Canoo Technologies Inc	
Ford Motor Company	**Ford Equipment 1**
Ford Motor Company	**Ford Equipment 2**
Green Power Motor Company	**Green Power Motor Company Equipment 1**
Green Power Motor Company	**Green Power Motor Company Equipment 2**
Hyundai Kia America Technical Center Inc (HATCI)	**Hyundai Kia Equipment 1**
Hyundai Kia America Technical Center Inc (HATCI)	**Hyundai Kia Equipment 2**
Lightning eMotors	
Mercedes Benz R&D North America	**Mercedes Benz Equipment 1**
Mercedes Benz R&D North America	**Mercedes Benz Equipment 2**
Navistar	**Navistar Equipment 1**
Navistar	**Navistar Equipment 2**
PACCAR	**PACCAR Equipment 1**
PACCAR	**PACCAR Equipment 2**
Rivian Automotive	**Rivian Equipment 1**
Rivian Automotive	**Rivian Equipment 2**
Volkswagen Group of America	
Volvo Cars Corporation	

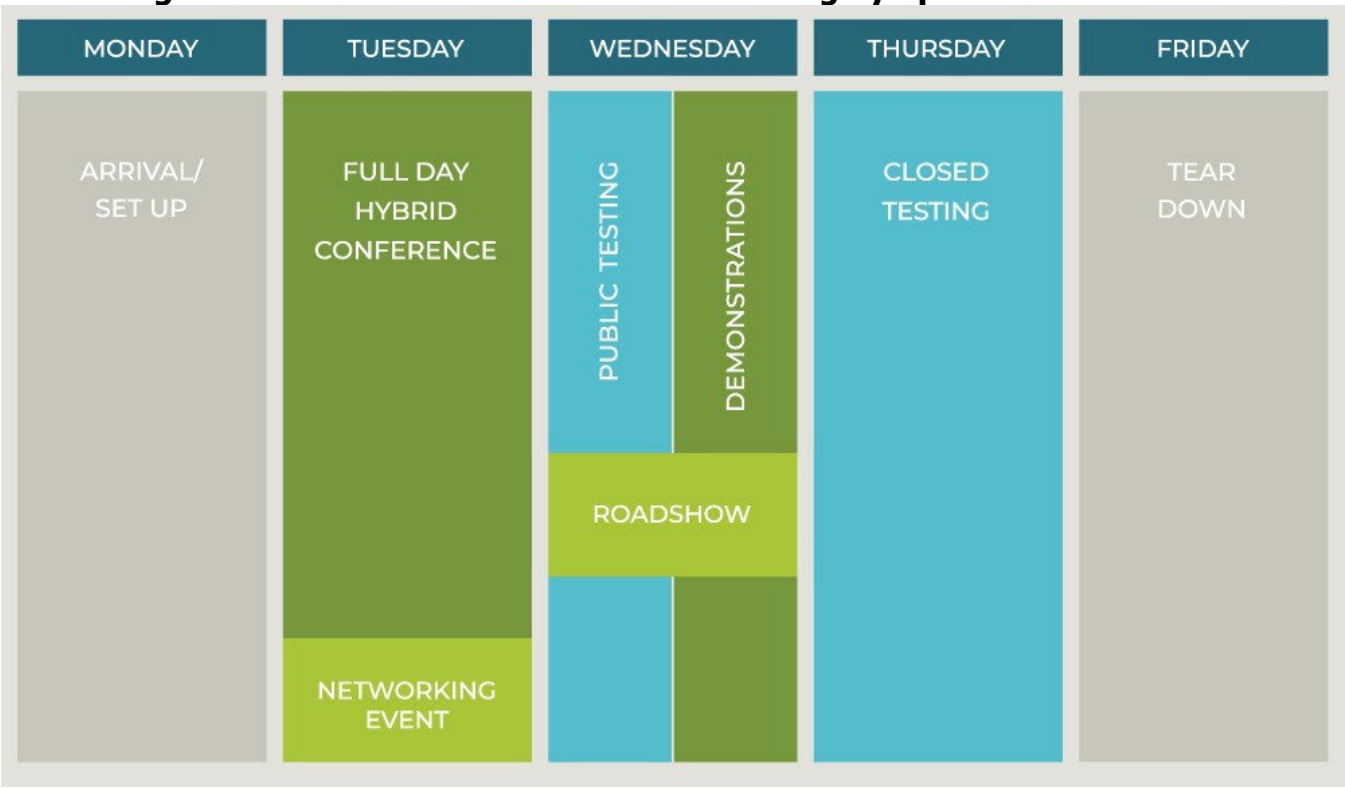
Source: innos, Inc.

Table 4: Test System Technical Registrations

Company
AIO Electric
DEKRA SE
Keysight
Rivian
ROCSYS
Vector Informatik

Source: innos, Inc.

Figure 1: The VOLTS Conference and Testing Symposium Week Flow



Source: innos, Inc.

Technical Capabilities of Participating EVSE

A total of 21 EVSE participated in the testing event. Of these, six supported AC charging and 15 supported DC charging. All 21 registered EVSE supported external identification means, 18 supported ISO 15118-2, and 11 supported ISO 15118-2 with Plug and Charge (PnC). In addition, four test systems participated acting as EVSE. All test systems supported AC and DC charging, ISO 15118-2/3, DIN 70121, external identification means, and PnC. Two test systems additionally supported ISO 15118-20.

15 DC EVSE models participated at VOLTS. Of these:

- Three supported only DIN 70121.
- 12 supported ISO 15118-2 and DIN 70121.
- Nine featured PnC implementation using ISO 15118-2.
- Four supported ISO 15118-20. This does not imply bidirectional charging capability.

Six AC EVSE models participated at VOLTS. Of these:

- All supported ISO 15118-2.
- Five supported both external identification means and PnC.
- One supported only external identification means.

Technical Capabilities of Participating EVs

A total of 21 EVs participated in VOLTS. Of these:

- 20 supported DIN 70121 for DC charging.
- 17 supported ISO 15118-2.
- One supported only ISO 15118-2.
- Nine supported PnC for DC charging.
- Six supported PnC for AC charging.
- Eight were medium- heavy-duty vehicles (that is, not passenger cars)

It was observed that among participating EVs, school buses and other medium- and heavy-duty vehicles were more likely to have supported only DIN 70121. AC testing with ISO 15118-2 had 10 participating EVs. All EVs participating in AC ISO 15118 testing supported external identification means authentication, and five EVs supported PnC for AC charging. Two EVs registered support for ISO 15118-20. An additional two test systems participated in AC testing acting as the EV.

Technical Capabilities of Participating Test Systems

Six test systems participated in the testing event simulating either an EV or EVSE. Two were registered as EV simulation (to serve as a test system for EVSE) and four were registered as EVSE simulation (to serve as a test system for EVs). All test systems supported DIN 70121 and ISO 15118-2, including smart charging and PnC. Three test systems supported ISO 15118-20.

Summary of Test Scenarios

VOLTS participants were paired up to conduct pre-defined interoperability test scenarios. For every test session, participants submitted the outcome of the test scenario using a survey form. For every test session, the partners agreed on which party would be responsible for submitting the test survey. All data were anonymized and processed for this report. Because the process to protect the anonymity of testing results required validation to be completed by the paired testing submitter, quality assurance of post-submission aggregate testing data was limited.

Each test slot lasted for two hours. During each test slot, about 90 minutes was dedicated to mandatory and pre-selected baseline test scenarios, as well as conditional test scenarios. If the conditional test scenarios were feasible based on the capabilities of the products comprising the test couple, the test couple was directed to execute the conditional test scenarios during the test session. For the last 30 minutes of the test slot, free interoperability testing was allowed.

Unlike at prior CharIN testing events, participants at VOLTS submitted data from test sessions to help identify and publicize potential interoperability challenges. At prior CharIN testing events, issues discovered might be debugged on the spot, but such spot fixes do not typically

facilitate in-depth analysis and debugging to thoroughly resolve interoperability issues. A key goal for VOLTS was to leverage the collected data to better identify and address root causes of interoperability challenges.

As mentioned above, testing scenarios were split into two main parts identified as baseline tests and conditional tests. Baseline tests included scenarios simulating "normal" charging sessions as any driver might experience during charging.

These baseline tests included:

1. The EV is connected with the EVSE, the EV initiates a charging session by establishing a communication link, including either a transmission control protocol or transport layer security connection, followed by selection of the communication protocol (DIN 70121, ISO 15118-2, and so on), selection of the payment method (external identification means or PnC), and charging for one minute.
2. The EV shift position is manipulated while the connector is plugged in and charging.
3. The connector is inserted to produce a lock fault.
4. The connector latch is pressed while charging.
5. Emergency stop at the EVSE.

In addition to baseline tests, conditional tests validated scenarios involving ISO 15118-2 external identification means and PnC, smart charging, and ISO 15118-20. Not all products or test pairs could execute conditional tests. The full test scenario script can be viewed at https://drive.google.com/file/d/1JmoOiKN1VQLZUlNxRq-zpuMOLO7jfjt5/view.

Summary of Test Results

All EVs and EVSE supported the Combined Charging System Type 1 connector for DC charging, the SAE J1772 connector for AC charging, or both. By design, VOLTS was scoped to focus on ISO 15118 intra-protocol testing to ensure interoperable implementations of ISO 15118 communication between EVSEs and EVs. This includes secure communication, such as certificate handling, to ensure secure and interoperable public key infrastructure. A few key statistics and takeaways from VOLTS include:

- Over the course of two days, across seven test slots, 174 EV-EVSE pairings occurred, with each pairing lasting for two hours.
- Collectively, over 1,000 individual tests were performed and more than 50% of all tests used ISO 15118 communication.
- More than 80% of the attempted charging sessions resulted in successful charging. This is notable as the event included production as well as prototype/pre-production systems for vehicles and charging systems.
- A relatively modest number of successful PnC tests were reported due to time constraints or because the equipment was not prepared for the test scenario.
- To date, ISO 15118-2 smart charging capabilities are not yet widely implemented or used in EVs and EVSEs. This could be due to several factors including the lack of market signals or the use of alternate data routes beyond ISO 15118, such as telematics.

The complete report results of the public interoperability test data are available at https://www.charin.global/news/first-of-its-kind-public-ev-interoperability-testing-data/.

CHAPTER 2:
VOLTS Public Conference

More than 354 global attendees joined the VOLTS Conference, which was hosted at the Hotel Maya in Long Beach, California. The full-day event featured 34 top experts on a wide range of interoperability and reliability topics focused on ISO 15118, including features like PnC, bidirectional charging, cybersecurity, and other features enabled by the ISO communication standard. Discussions on key challenges to public charging were also discussed, such as workforce development, electric utility interconnection, and success metrics for public charging infrastructure investments. The recordings from each of the conference sessions, opening remarks, keynote, and closing session are available on a dedicated VOLTS YouTube Channel at https://www.youtube.com/@VOLTS_Interoperability.

VOLTS Conference Welcome Remarks

- Welcome by Host, CharIN (Erika Myers, Executive Director)
- Welcome by Testing Symposium Host Sponsor, WattEV (Emil Youssefzadeh, Chairman of the Board)
- Welcome by Main Sponsor, CEC (Hannon Rasool, Director of Fuels and Transportation Division)
- Welcome by CharIN e.V. (Michael Keller, Executive Board)

VOLTS Conference Keynote

- Oleg Logvinov, Chair of CharIN North America, CEO and President of IoTecha

This keynote presentation, titled *The Importance of Global EV Standards*, highlighted the importance of global standards for market scalability and the need for an ecosystem-wide approach to implementation of EV and charging infrastructure technologies and grid interoperability. It outlined how the universal adoption of ISO 15118 and Open Charge Point Protocol will enhance the user experience, reliability, operations, and grid services, such as vehicle-grid integration, which will unlock value for everyone that is a part of this ecosystem, including the end users. CharIN has been a convener of the EV charging ecosystem and has created a platform for interoperability-related activities, but can only be successful if all stakeholders, including industry and government, are engaged.

VOLTS PANEL 1: Scaling EV Charging Networks That Are Robust and Reliable

The panel focused on scaling up charging networks that are robust and reliable. What can the industry do to ensure future charging infrastructure has at least 95-98% uptime? The session included discussions on interoperability and maintenance, the need for metrics beyond uptime, and the need for more interoperability testing. Moderator and speakers included:

- John Smart (Moderator, Group Lead, Energy Storage & Electric Transportation Idaho National Laboratory)
- Bryce Wynter (Systems Engineer, EVgo)
- Lars Peter Bech (R&D Interoperability Manager, ABB E-mobility)
- Jasmeen Bal (Manager, Charging Validation, Lucid Motors)
- Lonneke Driessen (Director, Open Charge Alliance)

VOLTS FIRESIDE CHAT: A Deep Dive on New Federal Highway Administration EVSE Technical Requirements

This fireside chat focused on Federal Highway Administration's recently published minimum standards and requirements for chargers funded through the federal National Electric Vehicle Infrastructure Program. Moderator and speakers included:

- Erika Myers (Moderator, Executive Director, CharIN North America)
- Alex Schroeder (Chief Technology Officer, Joint Office of Energy and Transportation)
- John Smart (Group Lead, Energy Storage & Electric Transportation, Idaho National Laboratory)

VOLTS PANEL 2: Accelerate Industry Acceptance and Implementation of ISO 15118-20, Including PnC

This session focused on accelerated industry acceptance and implementation of ISO 15118-20 and answered questions such as: What resources are needed? What areas need more focus and effort? How have the use cases evolved? What's emerging and changing? The focus of the session included PnC and the interoperability of transport layer security. The moderator and speakers included:

- Noel Crisostomo (Moderator, Physical Scientist, Office of Policy, U.S. Department of Energy)
- Dr. Mohamad Abdul-Hak (Senior Manager e-Drive, Mercedes-Benz Research & Development N.A)
- Max Zettl (Sr. Manager Engineering and Chief Engineer, Acting Director, Electrify America)
- Dr. Marc Mültin (Founder & CEO, Switch)
- Michael Macaluso (EVP Engineering, IoTecha).
- Panel Sponsor: Brian Romansky (GM Connected Vehicle Solutions, Integrity Security Services)

VOLTS PANEL 3: Public Key Infrastructure Lessons Learned from Industry: Ensuring Interoperability

What technical solutions can enable interoperability between public key infrastructure roots, such as certificate trust lists, cross certification, and others? This session described best practices from mature industries like cable, 911 services, and the internet. Moderator and speakers included:

- Jacob Mathews (Moderator, Principal, EV Consulting)
- Sarah Hipel (Program Manager, Standards and Reliability, Joint Office of Energy and Transportation)
- Michael Keller (Executive Board member, CharIN e.V.)
- Jeremy Whaling (Senior EVSE Engineer, EVgo)
- Steffen Rhinow (Director Plug&Charge, Hubject)
- Felix Schmidt (Senior Engineer Connected eMobility, BMW).

VOLTS PANEL 4: Managing EVSE Network Payments

This session covered how ISO 15118 can help to fix payment issues and what we can learn from the credit card industry. Moderator and speakers included:

- Cliff Fietzek (Moderator, Chief Technology Officer, InCharge)
- Steve Carrillo (Senior Director of Product Management, VISA)
- Carly Furman (CEO, Nayax LLC)
- Dirk Großmann (Senior Manager Development, Vector)

- Matthieu Loos (Senior Technical Advisor, FLO EV Charging)

VOLTS PANEL 5: **Accelerating Charger Deployment, Energization, and Workforce Development**

This session focused on how the industry can scale EV charging given electric utility interconnection constraints and workforce considerations. Moderator and speakers included:

- Jackie Piero (Moderator, Head of Policy & Regulation, Mobility House)
- John Halliwell (Senior Technical Executive, EPRI)
- Heidi Sickler (Senior Director of Policy and Market Development, West, BP Pulse fleet)
- David Schlosberg (VP of Energy & Utilities, TeraWatt Infrastructure)
- Larry Rillera (ZEV Workforce and Equity, CEC)
- Panel Sponsor: Leslie Graham (Director of Development, IREC)

VOLTS Concluding Remarks

Jeffrey Lu, the Commission Agreement Manager for the VOLTS project, gave an update and request for feedback on a recently shared funding concept, the Charging Interoperability and Collaboration Yard ("Charge Yard") which has the goal of improving charging interoperability and fostering industry collaboration to ultimately realize a better and smarter experience.

Concluding remarks by:

- Jeffrey Lu (Air Pollution Specialist, CEC)
- André Kaufung (Managing Director, CharIN e.V.)
- Erika Myers (Executive Director, CharIN North America)

CHAPTER 3:
VOLTS Participants

After the VOLTS conference and testing event, the organizers sent a post-event survey where 91 individuals completed some portion (19% response rate). The purpose of VOLTS post-event survey was to understand more about event attendees, why they attended, if they would attend in the future, what was most useful, and how events like VOLTS can improve. Survey results include quantitative and qualitative feedback, summarized below.

Quantitative feedback included the following. VOLTS was able to attract a lot of new attendees and possibly these attendees will attend similar future events, as 52% were new to a CharIN event and 81% said they would attend again. An impressive 90% of attendees had an excellent, very good, or good experience at VOLTS. (Hereafter, "excellent, very good, or good" will be represented by E/VG/G.) Participants attended VOLTS for a variety of reasons with EV/EVSE testing activities leading slightly over content/education and networking, which were nearly tied for importance. Seventy percent of survey respondents attended both the conference and testing symposium.

For the VOLTS conference, 86% thought conference material was useful for their line of work and 94% of respondents rated speakers E/VG/G. For testing symposium survey respondents, 46% were observers and 53% were testers, and 92% rated the testing symposium as E/VG/G and 94% rated usefulness for their line of work as E/VG/G. As for the test pairing program, 90% rated E/VG/G for the time of each test pairing and 40% said they would recommend using a prescribed test plan (35% said maybe). Sixty three percent thought future events should include similar data collection and dissemination activities. Finally, 85% rated demonstrations as E/VG/G, and the roadshow was rated 100% E/VG/G.

For qualitative feedback, survey participants provided numerous thoughtful constructive feedback and suggestions for improvement. Below is a summary this feedback:

- Respondents indicated the importance of CEC funding in having more OEMs attend and send multiple vehicles. If the CEC was able to fund similar events in the future, it could play a big role in expanding the reach of an event like VOLTS. Participants also appreciated the proximity of the event to an event like ACT Expo, which also helped increase participation from OEMs.
- Conference feedback was generally positive but requested more audience engagement, better use of the app to support engagement, more technical topics focused on solving issues and moving the industry forward, and a more intuitive virtual experience.
- Testing event feedback was also positive, but with many requesting a more comfortable testing site, more power, and pairings made with more consideration for compatibility, protocol, capabilities, and what is being tested. Finally, some feedback included recommended items to drop from or add to the testing plan.

CHAPTER 4:
Next Steps for Industry

Looking Forward

The e-mobility industry is under great pressure to keep pace with the growing demand for EVs and charging infrastructure, while ensuring that EV drivers enjoy a seamless charging experience with any EV at any EVSE. Insights from the VOLTS event contributed to the following recommended next steps for the industry.

1. Consistently Perform Conformance Testing and Certification

EV-EVSE interoperability could be improved by expanding the use of protocol conformance and certification testing, which offer standardized and scalable approaches to ensure that EV and EVSE conform to protocol specifications. Other communication standards and industry associations, such as W-Fi and Bluetooth, have established best practices for conformance testing and certification. In both of those examples, third-party testing and certification schemes are used to qualify products and ensure a high level of interoperability.

2. Make Better Use of Smart Charging Capabilities of ISO 15118

Future testing events could provide an improved platform to support testing of smart charging capabilities including crafted schedules, which may or may not include utility electricity tariff information. These crafted schedules could be provided by a backend that is accessible to participants or are manually coded into EVSEs.

3. Make Improvements to Future Testing Events

Based on feedback from participants and observers, attendees recommended that CharIN:

A. Continue to collect data to recognize the state of ISO 15118 implementation and interoperability gaps.
B. Continue to implement a mandatory test plan or test script, but either reduce the number of testing scenarios or increase the length of the test sessions.
C. Establish dedicated test slots / positions for specific tests, such as manipulation of the EVs shift position, smart charging, PnC, etc.
D. Improve the technical capability registration process to confirm that equipment can in fact support certain technical capabilities.
E. Build out additional backend infrastructure for things like smart charge testing and PnC testing.
F. Expand permanent testing facilities to overcome the challenges of temporary testing facilities.

GLOSSARY

ALTERNATING CURRENT (AC)—Flow of electricity that constantly changes direction between positive and negative sides. Almost all power produced by electric utilities in the United States moves in current that shifts direction at a rate of 60 times per second.

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

1. Forecasting future statewide energy needs
2. Licensing power plants sufficient to meet those needs
3. Promoting energy conservation and efficiency measures
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
5. Planning for and directing state response to energy emergencies.

DEUTSCHES INSTITUT FÜR NORMUNG (DIN)—The German Institute for Standardization, is the independent platform for standardization in Germany and worldwide.[2]

DIRECT CURRENT (DC)—A charge of electricity that flows in one direction and is the type of power that comes from a battery.

ELECTRIC VEHICLE (EV)—A broad category that includes all vehicles that are fully powered by Electricity or an Electric Motor.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)—Infrastructure designed to supply power to EVs. EVSE can charge a wide variety of EVs including BEVs and PHEVs.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATON (ISO)—The International Organization for Standardization, brings global experts together to agree on the best way of doing things – for anything from making a product to managing a process.[3]

ORIGINAL EQUIPMENT MANUFACTURER (OEM)—Refers to the manufacturers of complete vehicles or heavy-duty engines, as contrasted with remanufacturers, converters, retrofitters, up-fitters, and re-powering or rebuilding contractors who are overhauling engines, adapting or converting vehicles or engines obtained from the OEMs, or exchanging or rebuilding engines in existing vehicles.

PLUG AND CHARGE (PnC)—Framework to enable secure automatic authentication as soon as drivers plug in, a capability.[4]

VEHICLE INTEROPERABILITY TESTING SYMPOSIUM (VOLTS)—To conduct an electric vehicle charging interoperability testing event in California.

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2 The Deutsches Institut Für Normung source, https://www.din.de/en/about-standards/a-brief-introduction-to-standards.

3 The International Organization For Standardization source, https://www.iso.org/about.

4 The Plug And Charge source, https://driveelectric.gov/news/universal-plug-and-charge.