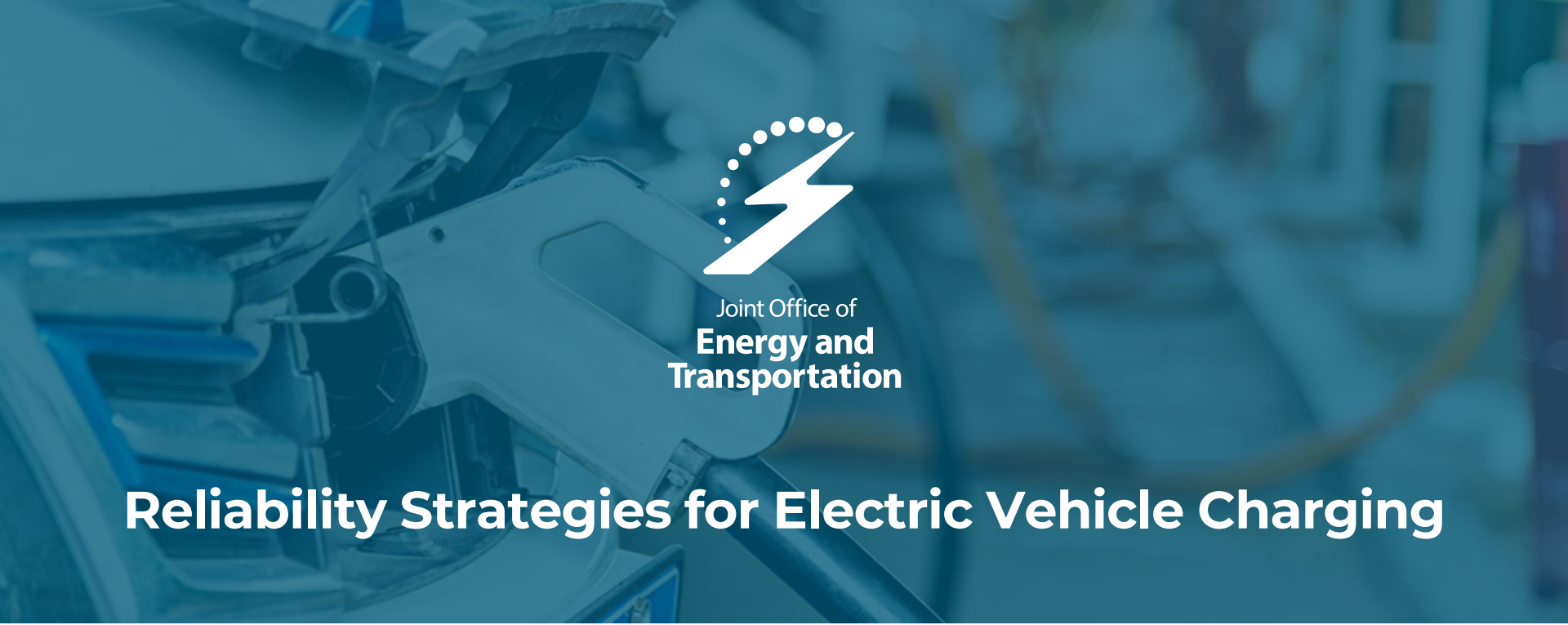


Joint Office of
Energy and
Transportation

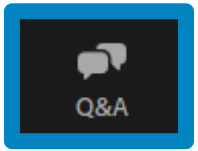
Reliability Strategies for Electric Vehicle Charging

5/23/2024

driveelectric.gov

Zoom Tips and Housekeeping

- Controls are located at the bottom of your screen. If they aren't appearing, move your cursor to the bottom edge.
- Submit questions using the "Q&A" window



Disclaimer

Notice: This webinar is being recorded and may be posted on the Joint Office website or used internally.

If you speak during the webinar or use video, you are presumed to consent to recording and use of your voice or image.

Agenda

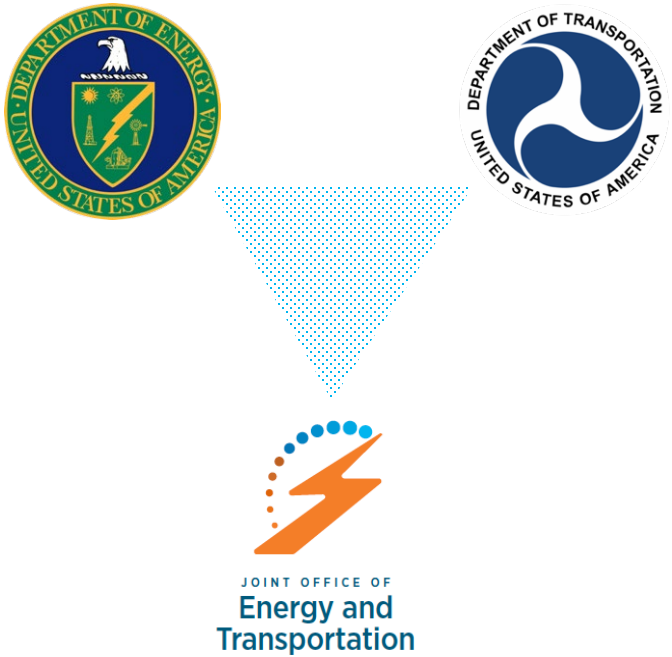
Introduction from the Joint Office

Presentations from panelists

Panel Discussion

Audience Q&A

Mission and Vision



Mission

To accelerate an electrified transportation system that is affordable, convenient, equitable, reliable, and safe.

Vision

A future where everyone can ride and drive electric.

BIL Programs Supported by the Joint Office

The Joint Office will provide unifying guidance, technical assistance, and analysis to support the following programs:

National Electric Vehicle Infrastructure (NEVI) Formula Program (U.S. DOT)
$5 billion for states to build a national electric vehicle (EV) charging network along corridors

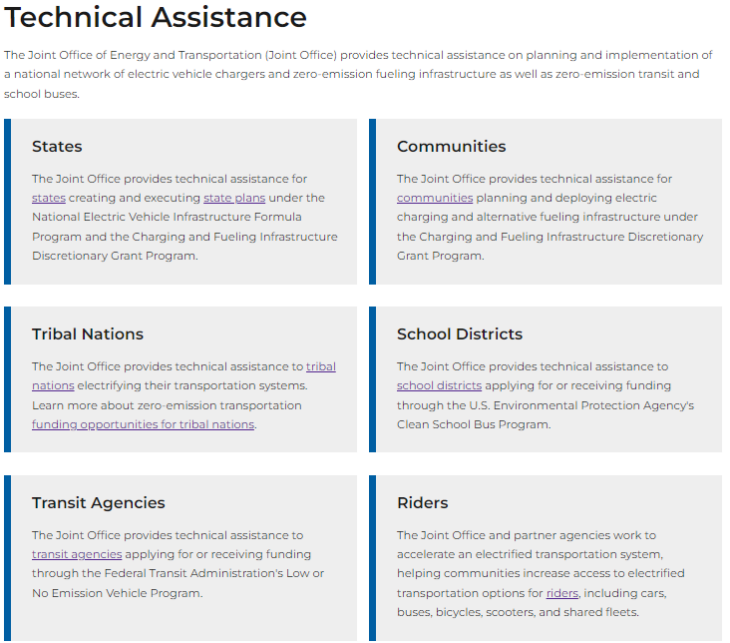
Charging & Fueling Infrastructure (CFI) Discretionary Grant Program (U.S. DOT)
$2.5 billion in community and corridor grants for EV charging, as well as hydrogen, natural gas, and propane fueling infrastructure

Low-No Emissions Grants Program for Transit (U.S. DOT)
$5.6 billion in support of low- and no-emission transit bus deployments

Clean School Bus Program (U.S. EPA)
$5 billion in support of electric school bus deployments

Technical Assistance Strategies

- Specialized assistance for **states, communities, Tribal Nations**, **transit agencies**, and **school districts.**
- **One-on-one meetings** with states.
- **Concierge service** (phone, email, web form) to efficiently route technical assistance requests.
- Technical assistance support team has **50 staff members across 10 organizations**.



Technical Assistance

The Joint Office of Energy and Transportation (Joint Office) provides technical assistance on planning and implementation of a national network of electric vehicle chargers and zero-emission fueling infrastructure as well as zero-emission transit and school buses.

States

The Joint Office provides technical assistance for states creating and executing state plans under the National Electric Vehicle Infrastructure Formula Program and the Charging and Fueling Infrastructure Discretionary Grant Program.

Communities

The Joint Office provides technical assistance for communities planning and deploying electric charging and alternative fueling infrastructure under the Charging and Fueling Infrastructure Discretionary Grant Program.

Tribal Nations

The Joint Office provides technical assistance to tribal nations electrifying their transportation systems. Learn more about zero-emission transportation funding opportunities for tribal nations.

School Districts

The Joint Office provides technical assistance to school districts applying for or receiving funding through the U.S. Environmental Protection Agency's Clean School Bus Program.

Transit Agencies

The Joint Office provides technical assistance to transit agencies applying for or receiving funding through the Federal Transit Administration's Low or No Emission Vehicle Program.

Riders

The Joint Office and partner agencies work to accelerate an electrified transportation system, helping communities increase access to electrified transportation options for riders, including cars, buses, bicycles, scooters, and shared fleets.

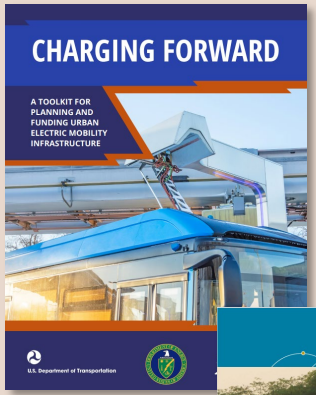
driveelectric.gov/technical-assistance

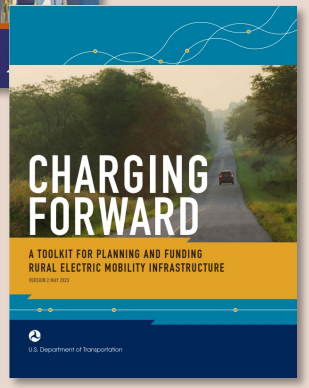
Concierge Service Contact Methods: 833-600-2751 | doe-dot.jo.ta@nrel.gov | driveelectric.gov/contact/

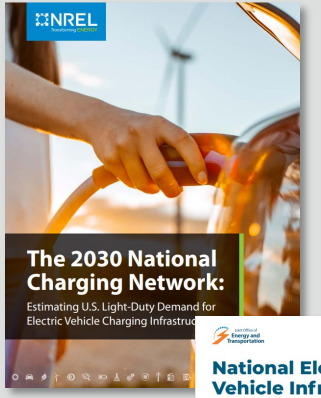
Rural and Urban EV Toolkits

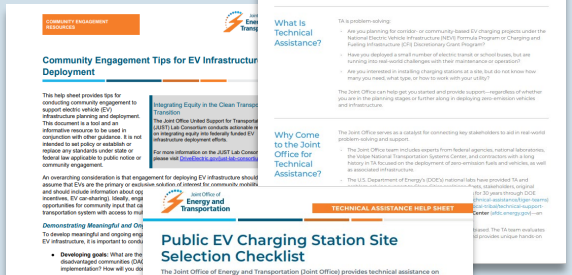
Forecasts and Reports

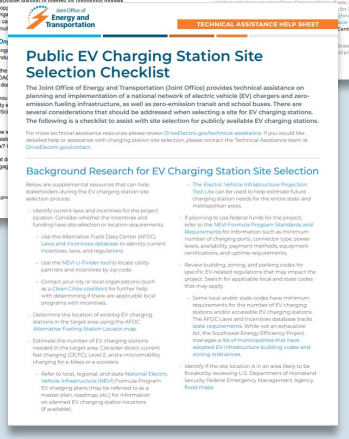
Help Sheets and Checklists





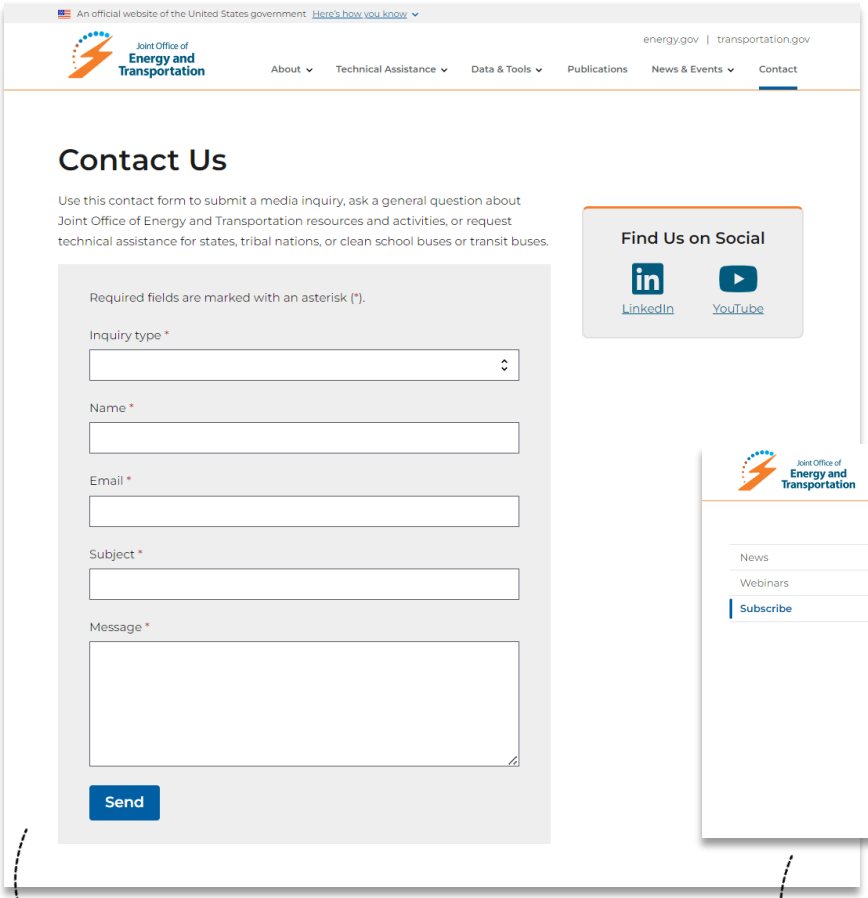


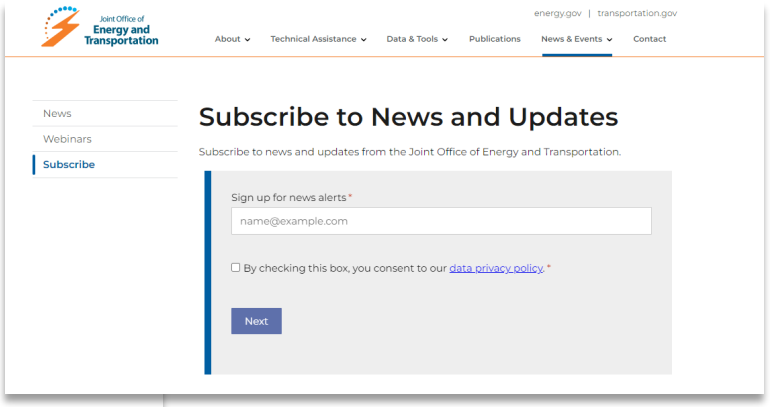




driveelectric.gov/resources

- Request assistance via online form
- Initial response within 48 hours
- General questions and feedback welcome!





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driveelectric.gov/subscribe

Polling Questions

Panelists

Jacob Matthews
Joint Office

John Smart
Idaho National Laboratory

Frank Marotta
General Motors

Kenneth Tennyson
Electrify America

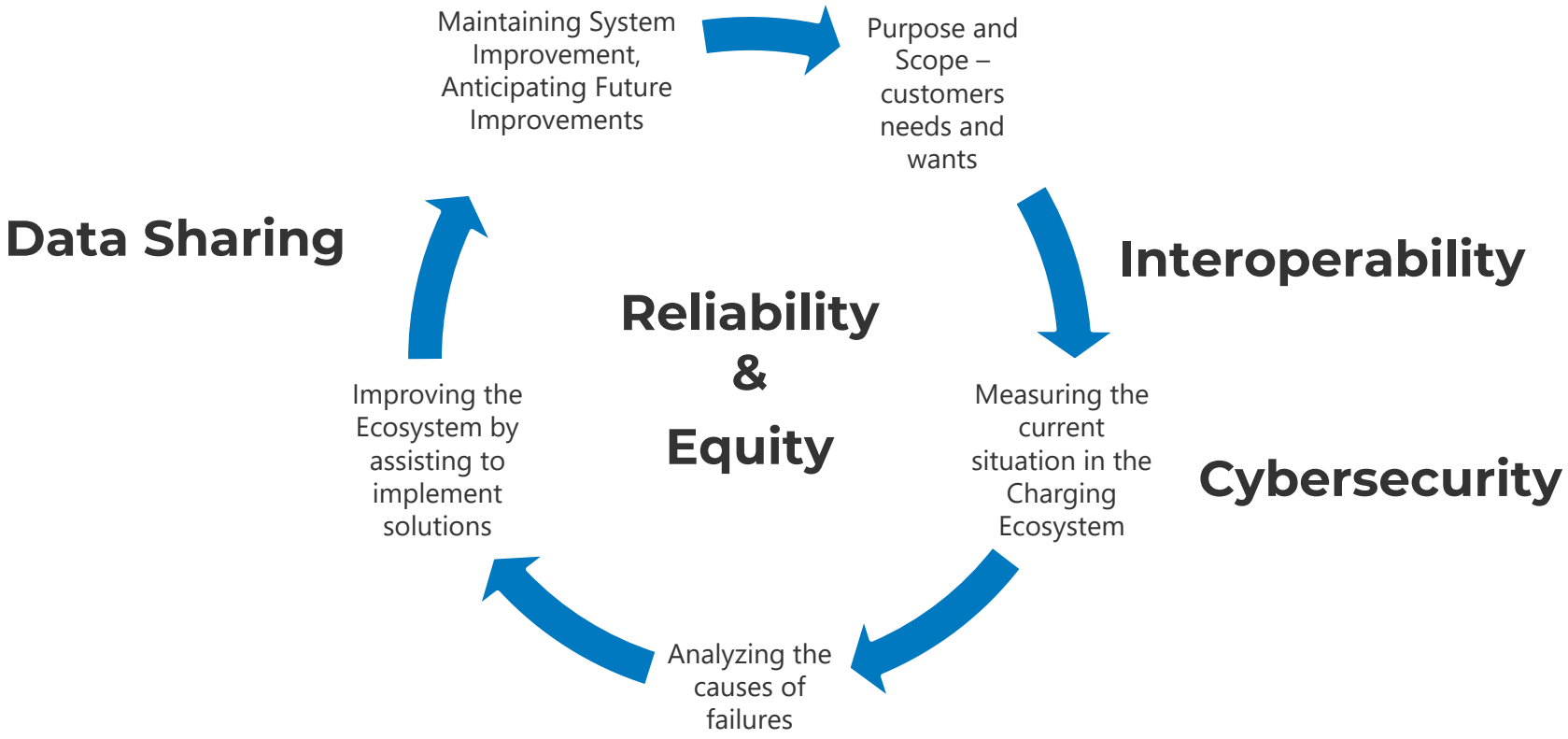
Cuong Nguyen
ABB E-Mobility

Jacob Matthews

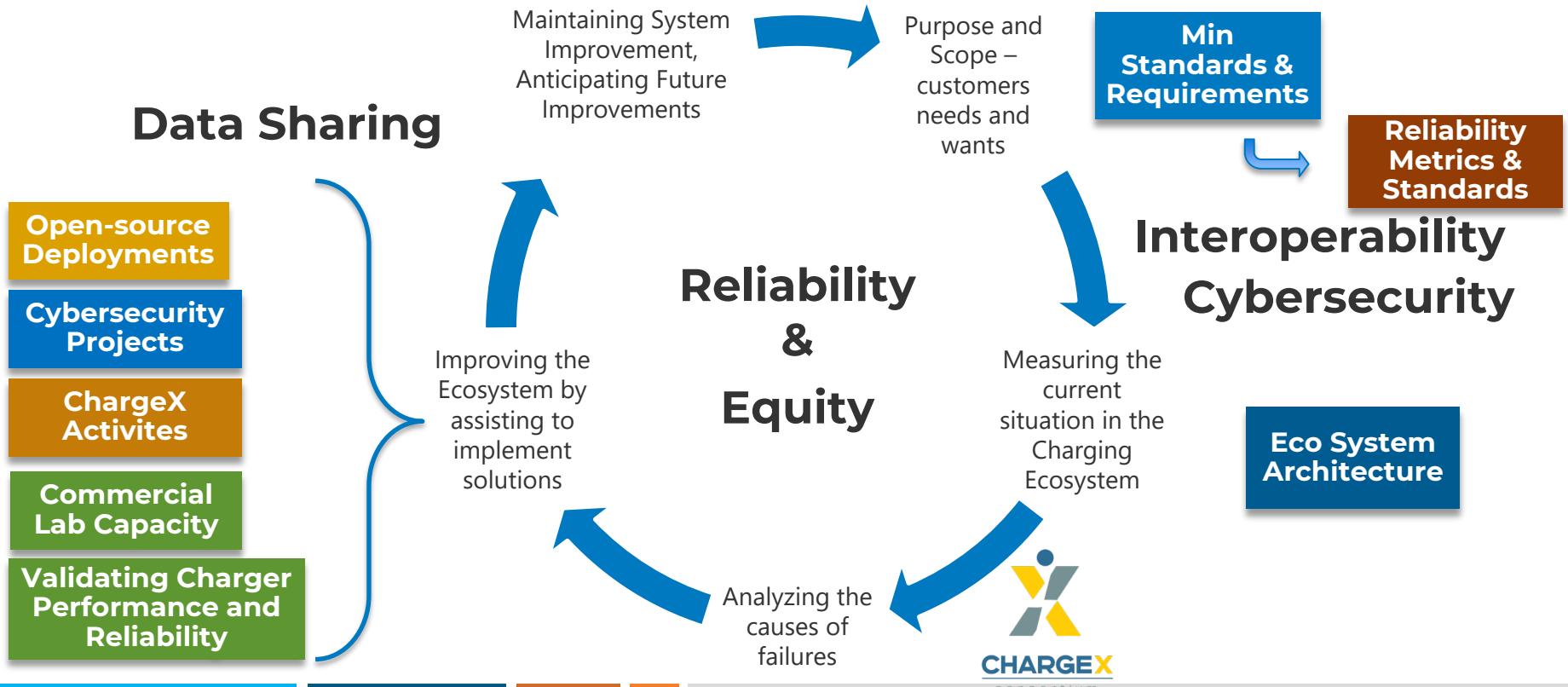
Joint Office

Approach to Improve EV Charging Interoperability & Reliability

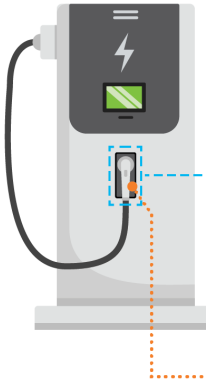
We are tackling the overarching challenges to build a reliable, convenient national charging network



Activities we are engaged in:



EV Charging Minimum Standards



Charging is a predictable and reliable experience, by ensuring that there are consistent plug types (at least 4 CCS), power levels, and a minimum number of chargers capable of supporting drivers' fast charging needs;

Chargers are working when drivers need them to, by requiring a 97 percent uptime reliability requirement;

Drivers can easily find a charger when they need to, by providing publicly accessible data on locations, price, availability, and accessibility through mapping applications;

Drivers do not have to use multiple apps and accounts to charge, by facilitating several payment types

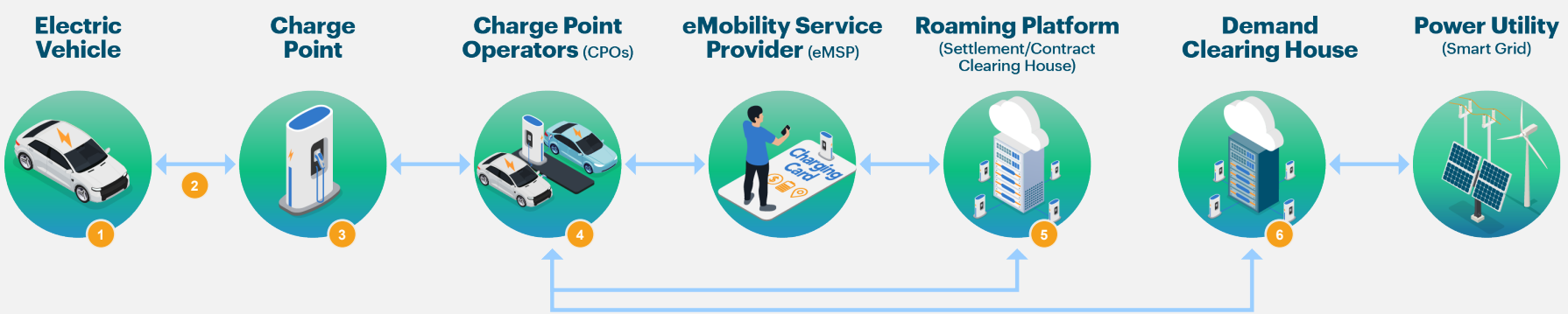
Chargers will support drivers' needs well into the future, by focusing on interoperability and ensuring that chargers and vehicles work seamlessly, similarly, and together

Reliability Standard / Metric

NEVI Uptime Requirement.

- CFR680.116 Minimum uptime. States or other direct recipients must ensure that each charging port has an average annual uptime of greater than 97%. In other words, the charger must be operational and deliver the minimum required power at least 97% of 'Time' in a year.
- A charging port is considered "**up**" when its hardware and software **are both online** and available for use, or in use, and the charging port successfully dispenses electricity in accordance with requirements for **minimum power level** (see § 680.106(d)).

Our Charging Ecosystem



1

Electric Vehicle OEM
- Vendor lock in
- Tier 1 suppliers control code stack in EVCC
- Fragmented implementations 15118-2
- Hardware cable lengths affecting communication (SLAC)
- Testing capabilities: black box source code

2

EV to Charge Point
- Inconsistent reinitialization behavior i.e. re-authentication after session failure is not part of the standard
- Non-happy path testing capabilities
- Non-deterministic testing makes it difficult to debug errors

Opportunities
- Authorization/payment: contract communication

3

Charge Point
- Multiple operating systems
- Inconsistent reinitialization behavior i.e. re-authentication after session failure is not part of the standard
- Hardware cable lengths and noise affecting communication
- Fragmented implementation of 15118-2
- Testing capabilities: black box source code

Opportunities
- Authorization/payment: contract communication

4

Charge Point Operators
- Non-happy path testing capabilities
- OCA OCPP testing is happy path only
- Poor diagnostics capabilities
- Different CSMS/OCPP implementations

Opportunities
- Authorization/payment
  - Remote starts
  - Credit card handling
  - Plug & Charge support

5

Roaming
- Lack of choice between roaming

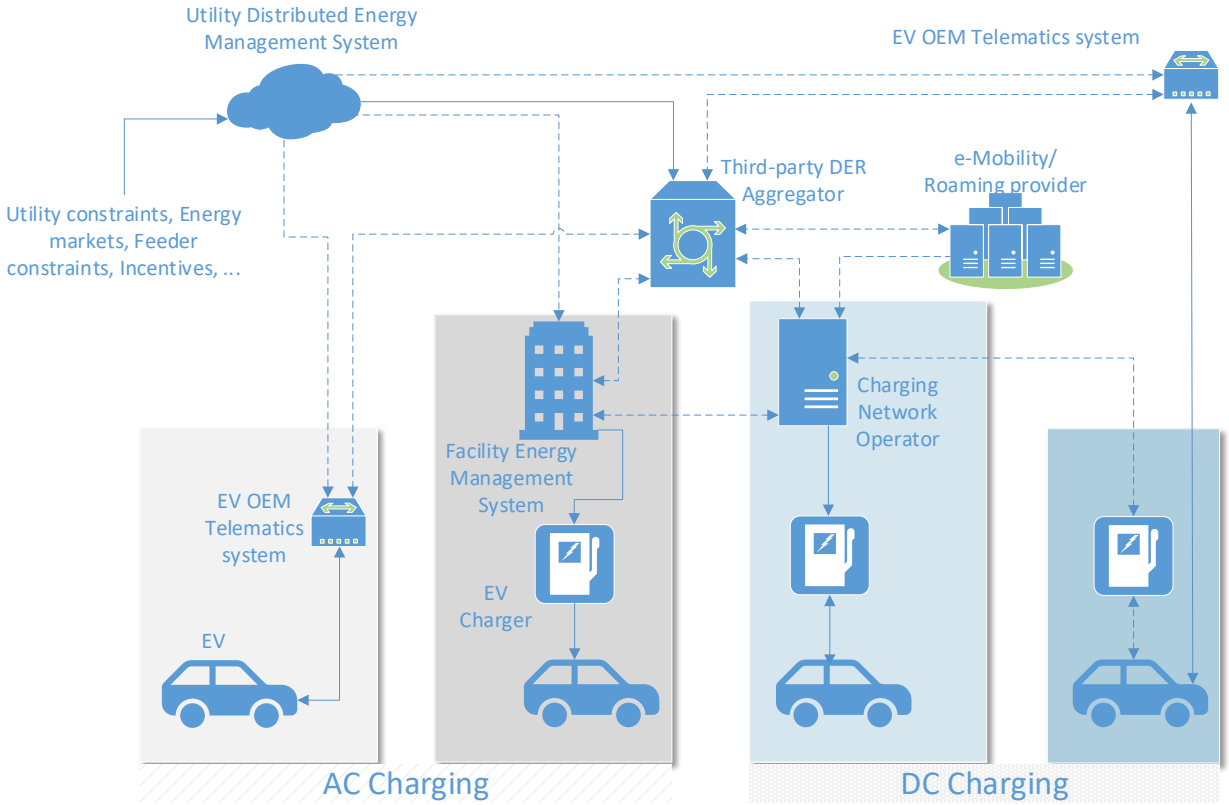
Opportunities
- PKI providers
- Roaming platform providers
- Smart/Multi-Party Contracts

6

Smart Charging

Opportunities
- Smart charging profile generation
- Utility protocol translation
- Vehicle-Grid Integration at scale and pace to buy time for distribution upgrades.

Documenting tradeoffs and implementation notes from the field with the aim to capture common considerations and opportunities for harmonization.

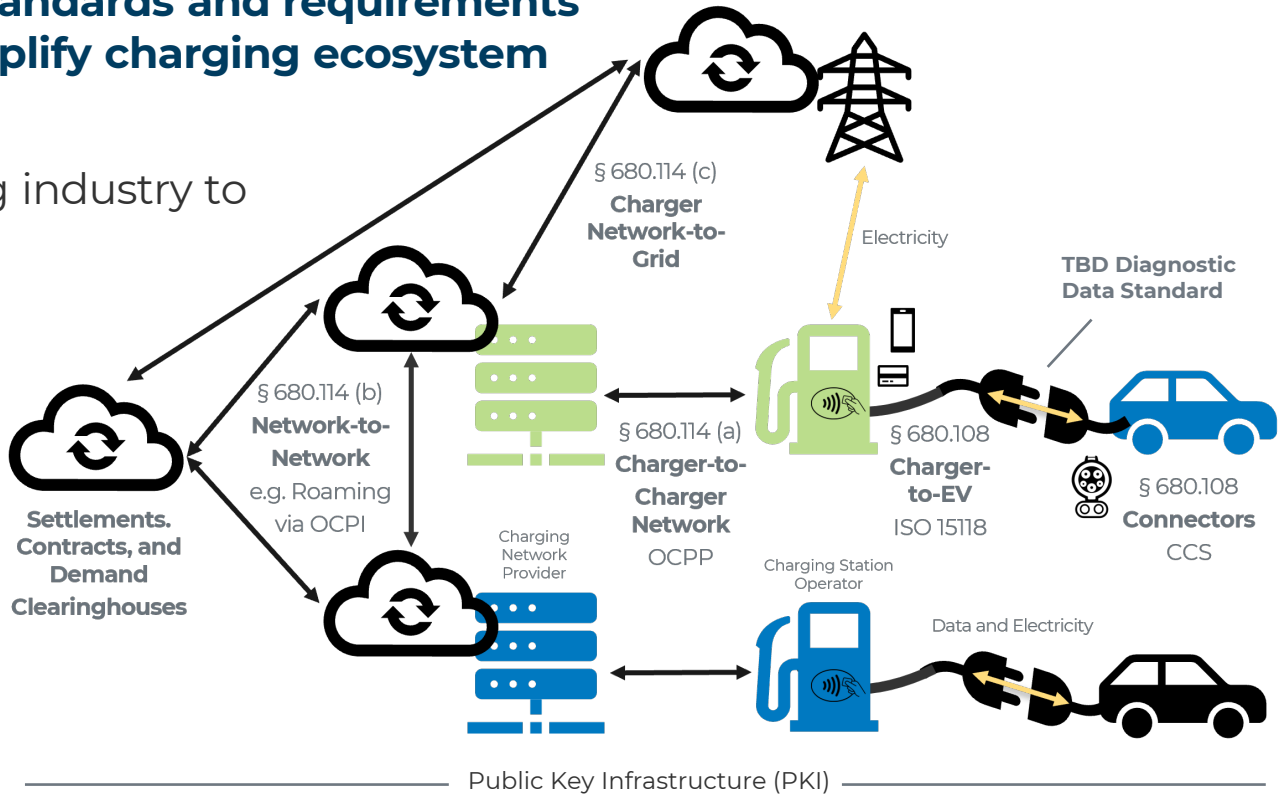


Simplifying the Charging Ecosystem

NEVI minimum standards and requirements signal how to simplify charging ecosystem

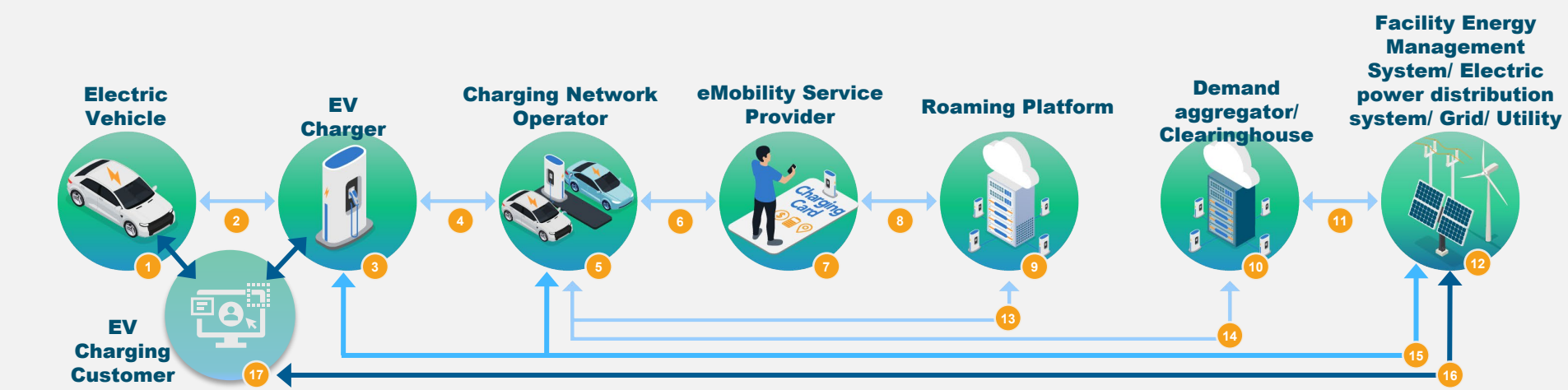
We are supporting industry to implement:

- ❑ **OCPP 2.0.1**
- ❑ **ISO 15118-2**



Ecosystem Testing

Our Charging Ecosystem (testing issues highlighted)



1

Electric Vehicle OEM
- Vendor lock in
- Tier 1 suppliers control code stack in EVCC
- Fragmented implementations 15118-2
- Hardware cable lengths affecting communication (SLAC)
- Difficult to test black box source code

2

EV to Off-board Charger
- Inconsistent reinitialization behavior
- re-authentication after session failure is not part of the standard
- Non-happy path testing capabilities
- Non-deterministic testing makes it difficult to debug errors
- Authorization/payment: contract communication

5

Charge Point Operators
- Non-happy path testing capabilities
- OCA OCPP testing is happy path only
- Poor diagnostics capabilities
- Different CSMS/OCPP implementations
- Authorization/payment
  - Remote starts
  - Credit card handling
  - Plug & Charge support

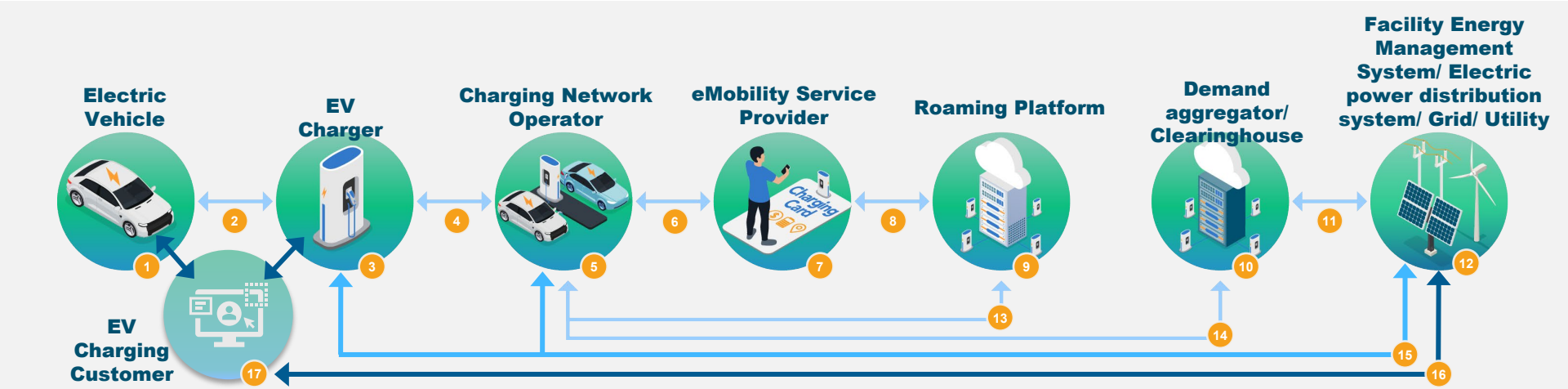
9

Roaming
- Lack of choice between roaming
- PKI providers / CTL platform
- Roaming platform providers
- Smart/Multi-Party Contracts

12

Smart Charging
- Smart charging profile generation
- Utility protocol translation
- Vehicle-Grid Integration at scale and pace to buy time for distribution upgrades.

Reliability & Safety standards and test protocols



1

Electric Vehicle
- Reliability of on-board charging components
  - ISO 17409
  - ISO 26262
  - UL 2231 (TBD)
- Security
  - SAE 21434
- **OEMs suite of Component / System validation tests for Self-Certification.**

2

EV to Off-board Charger
- Reliability and safety of Connectors, Adapters and Cable Interconnects
  - UL 2252
  - UL 2251
  - UL 2733
- Self asserted currently
  - IEC 62196-1,-2,-3

3

Off-board Charger
- Reliability and safety of off-board chargers
  - **UL 2594**
  - **UL 2202**
  - **UL 2231**
  - **UL-2941**
- Self asserted currently
  - IEC 61851-1, -23, -24
  - IEC 61851-21-2
  - IEC 61439-7
  - IEC 62752
  - IEC 62443
  - IEC 61508

4

Charge Point Operators
- Reliability and performance of wireless wide area network
  - 3GPP TS 21.201
  - 3GPP TS 36., 37.-series
- Security
  - 3GPP SA3

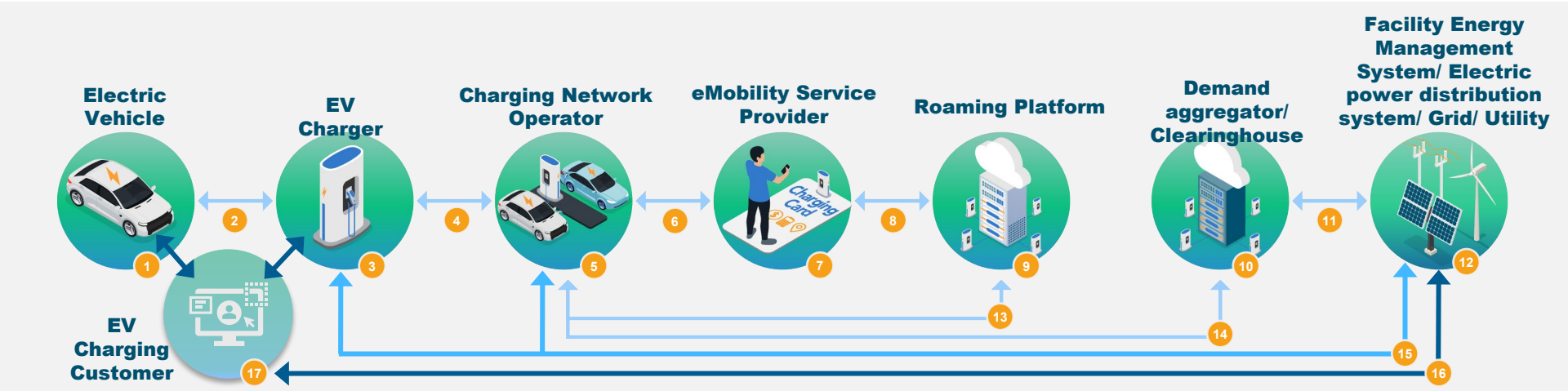
5

Roaming
- Cloud services reliability testing
  - Load testing
  - Stress testing
  - Soak/Endurance testing
  - Breakpoint testing
  - Scalability testing

12

Smart Charging
- Interconnection between EVSE and the grid
  - **UL 1741**
  - UL 9741
  - IEC 62443
- Interconnection requirements between EV on-board power converter and the grid
  - UL 1741 SC
  - UL 458A
  - SAE J3072

Communication, Conformance and Interop Tests



1

Electric Vehicle
- Communication interface interoperability
- Inlet Port Validation Test- Tier1
- EVCC Component Validation-Tier 1
- DIN 70141, ISO15118-2 / -20
- Testing with “Golden Test Device”
- Charging System level Verification
- PKI development and Certification
- EV-Charger Interop Validation Testing

2

EV to Off-board Charger
- Communication interface interoperability
  - Third party ISO 15118-2, -20 test tools
  - CharIN CCS Test System
  - CharIN Testival
- Conformance of communication interfaces
  - DIN SPEC 70122
  - ISO 15118-5
  - ISO 15118-4

3

Off-board Charger
- System level testing for conformance / Performance.
- Metering traceability/ Fiscal compliance
  - Third party PCI DSS test tools
  - OSSEC
  - ANSI C12.1 (AC)
  - ANSI C12.32 (DC)
- Diagnostics
  - MREC (SAE J in progress)
  - MRDI
- PKI development and Certification Tests
- UL2941 UL Cybersecurity Certification

4

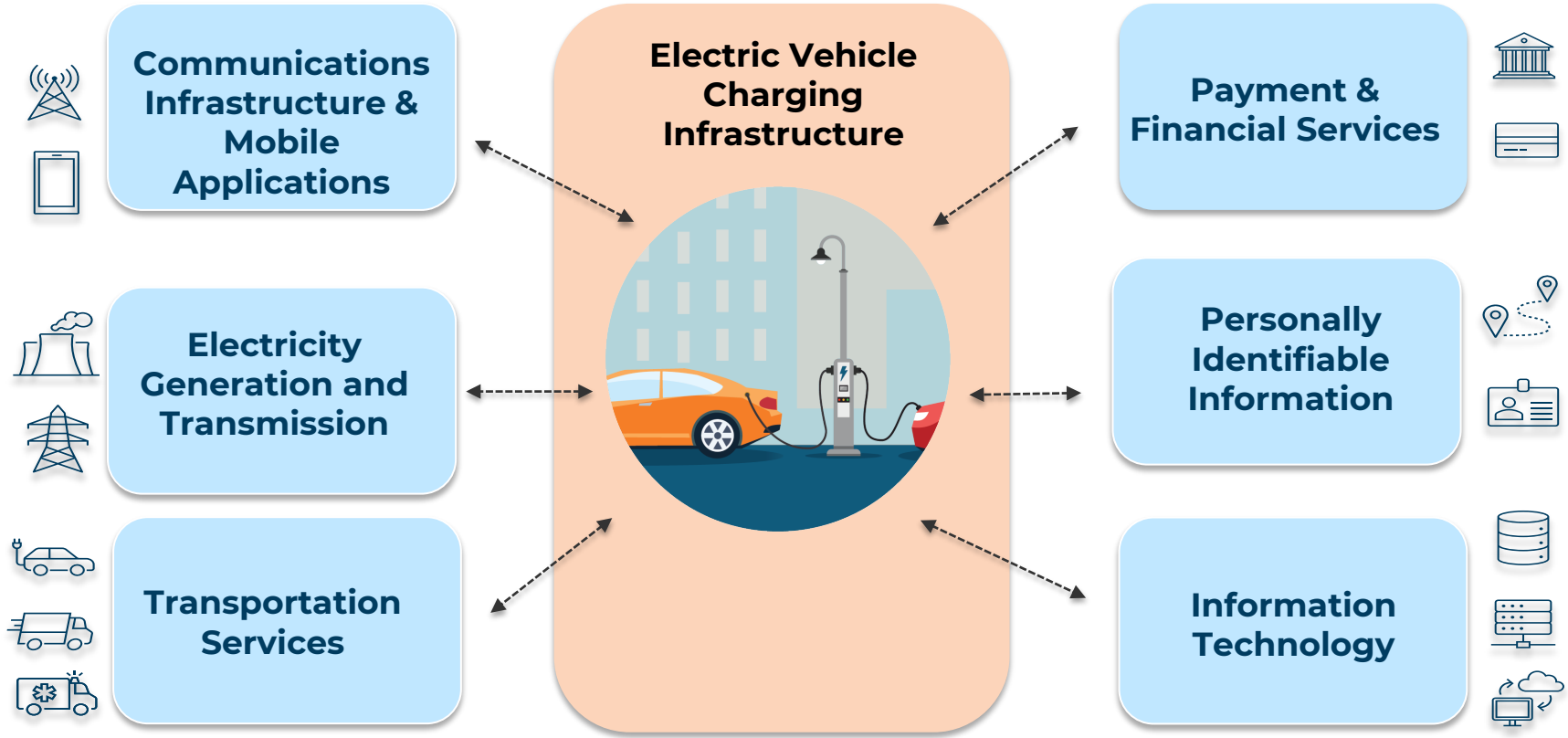
Charger to CSMS communication
- Conformance of communication interfaces
  - OCA OCPP test tool OCTT

6

Smart Charging
- Grid interface conformance tests
  - Third party 2030.5 test tools
  - Common Smart Inverter Profile (CSIP)
  - OpenADR Certification Test Tool


Cybersecurity

EVCI interfaces with critical services and sensitive information



Guiding Principles for our Cyber Activities

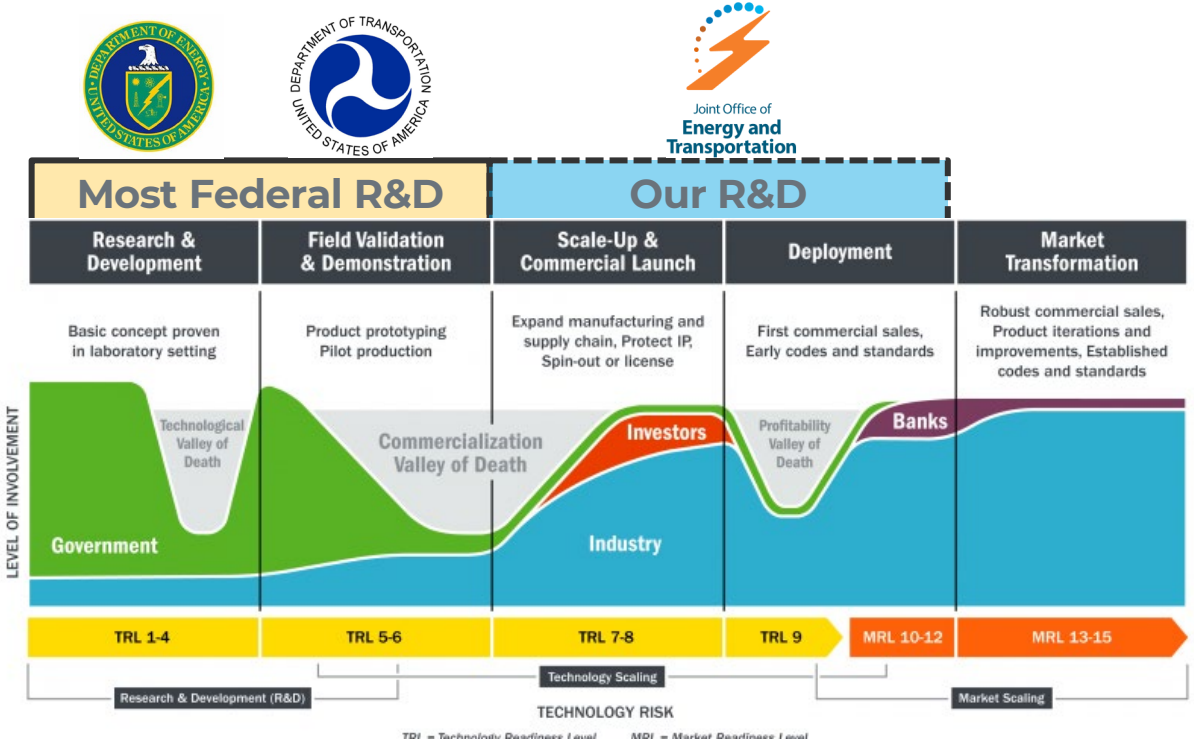
- Be the center of gravity for coordinating federal EV charging cybersecurity efforts
- Collaborate proactively with builders, deployers, and maintainers
- Match the urgency and agility we expect from industry
- Execute projects quickly with results that are useful immediately
- **Bottom Line** bring friends to achieve impactful results with aggressive timelines

What makes us different?

Our activities are focused on TRL 7+

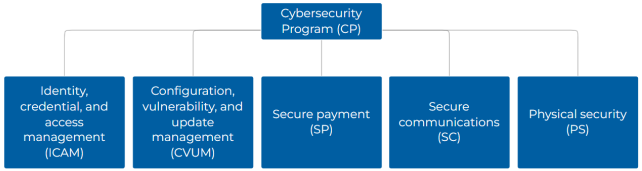
- Strategy: Waterfall
- Timeline: Years
- Success: Incremental
- Failure: Normal

- Strategy: Agile
- Timeline: Months
- Success: Transformative
- Failure: Unacceptable



Cybersecurity Activities

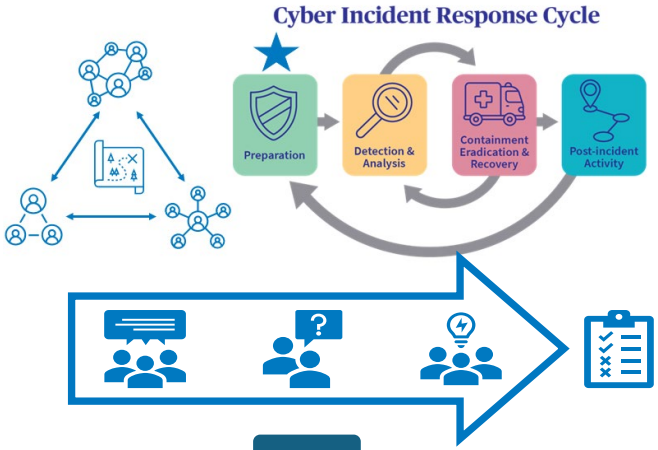
Guide:
Sample Procurement Language for NEVI Grants



Visual representation of the cybersecurity procurement language

- States are the early implementers of federal EV charging investments
- Equip states with unified set of sample language to meet the NEVI minimum standards

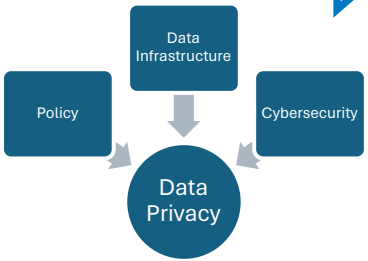
Guide:
EVSE Incident Reporting Framework



- Ensure EVSE stakeholders are prepared to respond to potential cyber incidents
- Develop & validate approach with stakeholders and incident response professionals
- Identify, prioritize, and assign short term, high impact actions that require a united approach
- Priorities identified:
  - Common Reference Architecture
  - Security assessment tools and guides
  - Professional Capacity for cyber workforce
  - Vulnerability coordination processes

Coordinate:
Charging Ecosystem Security Working Group

Guide:
NEVI Privacy Requirements Framework



- Provide technical guidance to meet 23 CFR 680.106(l)
- "Charging Station Operators must also take reasonable measures to safeguard consumer data"
- What are "Reasonable Measures"?

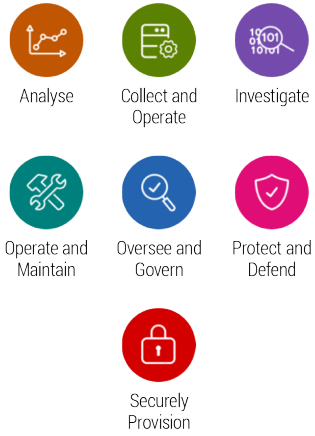
Guide:

Professional Development Tools

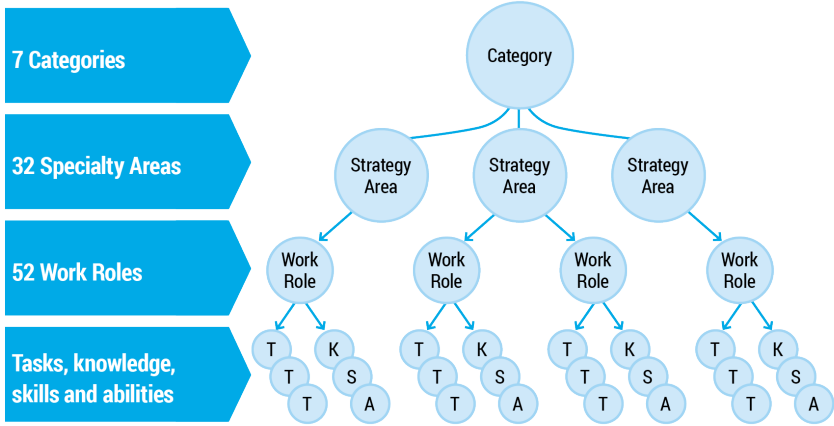
- Apply the NICE Cybersecurity Workforce Framework to the EVSE ecosystem
- Develop training modules
  - Role based
  - Hands-on

The National Initiative for Cybersecurity Education (NICE) Workforce Framework

7 categories of work



Structure of the Framework

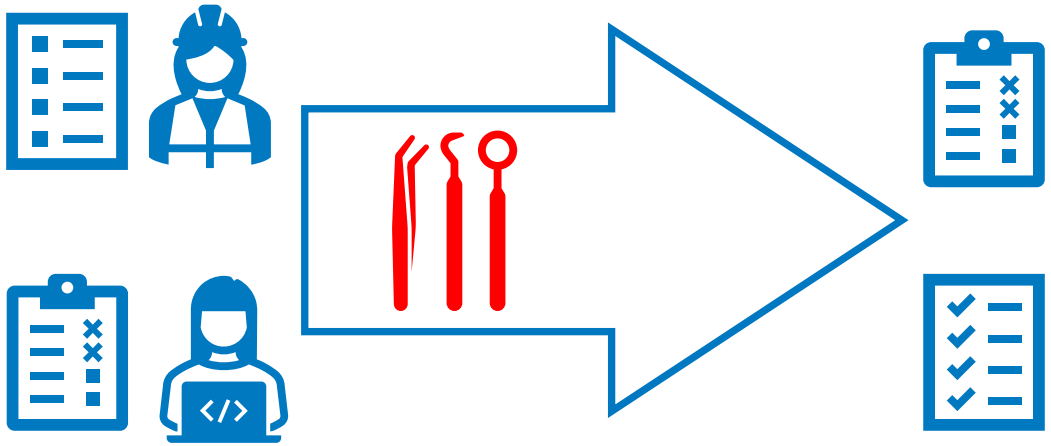


SOURCE: Nice Framework

Analyze/Guide:

EVSE Cybersecurity Assessment Tools

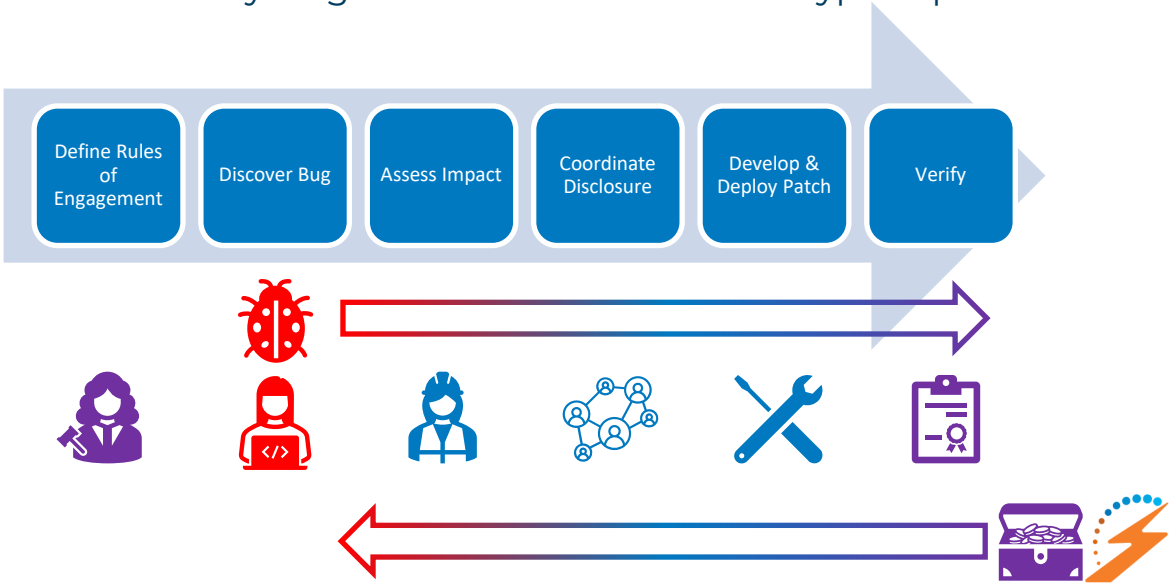
- Use findings from field testing to develop security testing tools
- Integrate with open-source
  - Security tools
  - EVSE Reference Implementation
  - Professional development tools



Analyze:

Industry-led EVSE Vulnerability Research and Mitigation

- Empower industry to:
  - Interface with security research community
  - Coordinate multi-stakeholder vulnerability disclosure
  - Respond to and recover from vulns in their systems by deploying security patches
- Investigating the creation of incentives for security research in EV charging
  - Potential DOE bug bounty & remediation prize
  - Feasibility stage - DOE has not done this type of prize



Funding Opportunity Announcements (FOA)

Roll-up on Reliability Topics for Ride and Drive FOA:

3a – Increasing Commercial Capacity for Testing and Certification of High-Power EV Chargers

3b – Validating High-Power EV Charger Real-World Performance and Reliability

5

Projects across five states

$13.3M

In Federal Cost Share

$9.7M

In partner cost share

John Smart
Idaho National Laboratory

Reliability Strategies for Electric Vehicle Charging

Updates from the ChargeX Consortium

CHARGEX consortium

LED BY

Argonne NATIONAL LABORATORY | INL Idaho National Laboratory | NREL Transforming ENERGY

Joint Office Webinar
5/23/2024

John Smart
Idaho National Laboratory

Frank Marotta
General Motors

Ken Tennyson
Electrify America

Cuong Nguyen
ABB e-Mobility

Vision

Any driver of any electric vehicle (EV) can charge on any charger the first time, every time

Mission

Bring together EV charging industry members, national laboratories, consumer advocates, and other stakeholders to measure and significantly improve public charging reliability and usability in North America **by June 2025**

Scope

Focus on complex issues that require multi-stakeholder collaboration and national laboratory support to solve and simplify

Scope of Work

Working Group 1

Defining the Charging Experience

- Define key performance indicators
- Write implementation guide
- Compare to customer sentiment

Working Group 2

Reliability/Usability Triage

Create fixes for:

- Payment and user interface
- Communication
- Hardware

Working Group 3

Solutions for Scaling Reliability

Improve:

- Diagnostics
- Interoperability testing methods

Outcomes

- Labs produce recommended practices, prototype tools, voluntary recognition program design
- Industry adopts practices and tools, improves standards

Working Group 1

Defining the Charging Experience

Industry Co-Chair: Frank Marotta, General Motors
National Lab Co-Chair: Casey Quinn, Idaho National Laboratory (INL)

Argonne NATIONAL LABORATORY
INL Idaho National Laboratory
NREL Transforming ENERGY

CHARGEX consortium

What is the Charging Experience?

FINDING A CHARGER | **ACCESSING A CHARGER** | **STARTING A CHARGE** | **COMPLETING A CHARGE**

CHARGE ATTEMPT ▸ START OF POWER TRANSFER ▸ END OF POWER TRANSFER ▸ DISCONNECT

power delivery
◂ event ▸

FEELING SAFE AND COMFORTABLE

GETTING HELP

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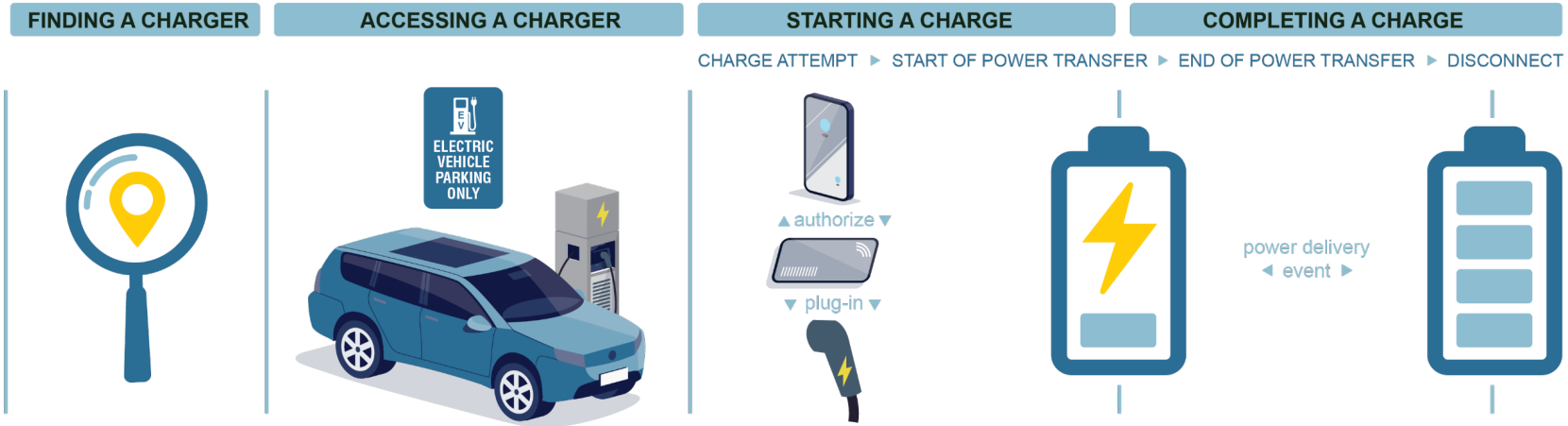
Measuring the Charging Experience



Defined Key Performance Indicators (KPIs) to measure and improve performance:

Interim set of KPIs (for near-term implementation)

Ideal set of KPIs (requires development for long-term implementation)

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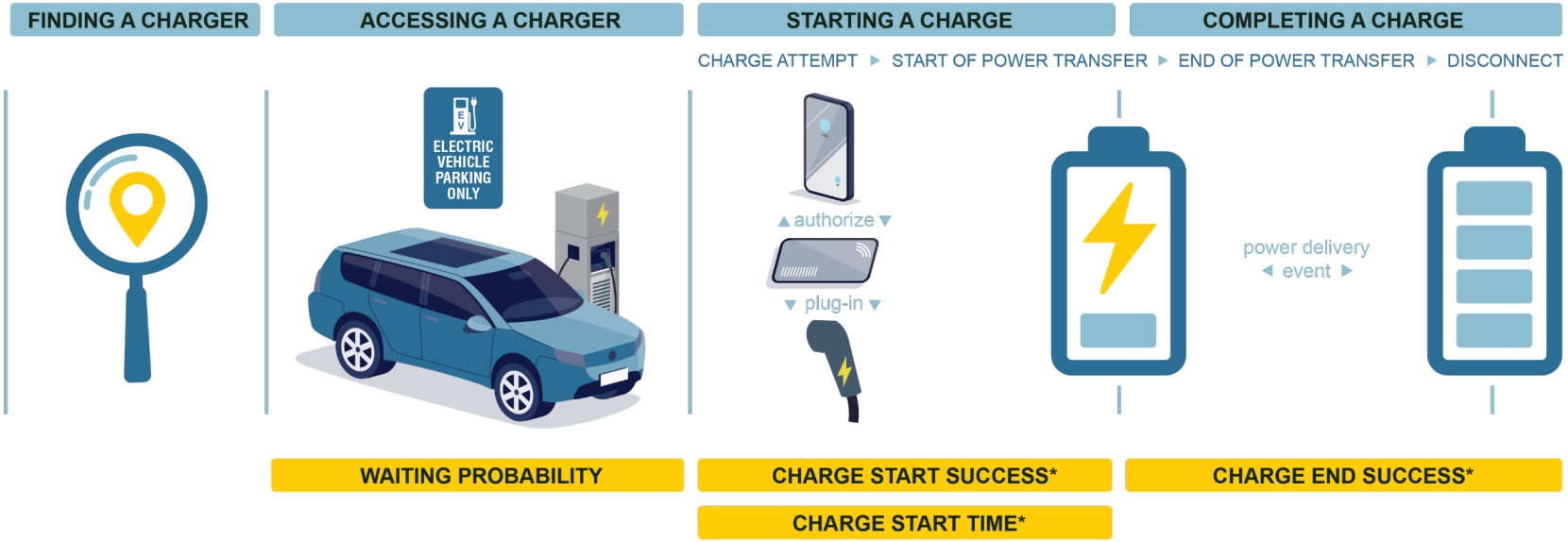
Interim Set of KPIs

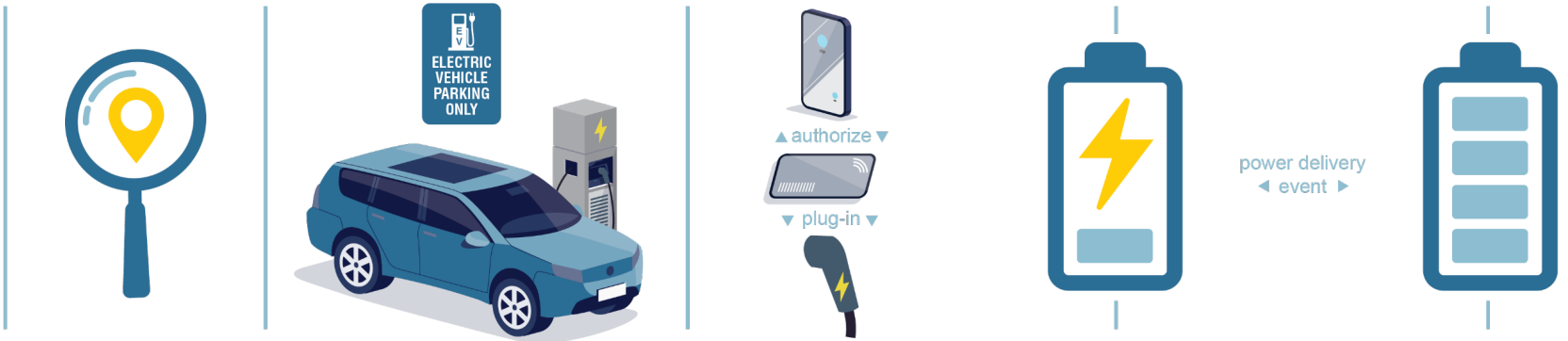


* Included in both interim and ideal sets

Ideal Set of KPIs

FINDING A CHARGER	ACCESSING A CHARGER	STARTING A CHARGE	COMPLETING A CHARGE

CHARGE ATTEMPT ▸ START OF POWER TRANSFER ▸ END OF POWER TRANSFER ▸ DISCONNECT



LOCATION ACCURACY	WAIT TIME	CHARGE START SUCCESS*	CHARGE END SUCCESS*
		CHARGE START TIME*	EXTENDED CHARGE TIME
		SESSION SUCCESS	
		FIRST TIME SESSION SUCCESS	
		VISIT SUCCESS	

* Included in both interim and ideal sets

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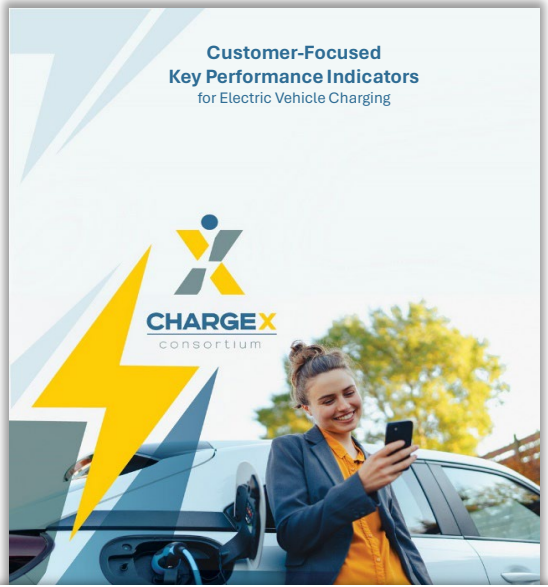
Next Steps for Defining the Charging Experience

Report with KPI definitions to be published in early June to chargex.inl.gov and driveelectric.gov.

Implementation guide for calculating interim KPIs from OCPP data to be published in Fall 2024.

- Working Group 1 using data from chargers in the field to verify implementation guide

Data needs to calculate ideal KPIs to be addressed by Working Groups 2 and 3.



Charge Start Success is measured as a percentage and applies to one or more charging ports at one or more charging stations, as follows:

$$\left(\frac{\sum EVSE\ port\ charge\ attempts\ that\ successfully\ start\ power\ delivery}{\sum EVSE\ port\ charge\ attempts}\right) X100 \quad (2)$$

Where:

- A *charge attempt* is defined as a customer's attempt to start a charging session by either (a) plugging the EVSE connector into the EV or (b) presenting valid credentials and/or payment or taking another appropriate action to authorize a charging session.
- *Start of power delivery* is defined as the instant when electricity starts being transferred from EVSE to EV.

Working Group 2

Reliability & Usability Triage

Industry Co-Chair: Ken Tennyson, Electrify America

National Lab Co-Chair: Kristi Moriarty, National Renewable Energy Laboratory (NREL)

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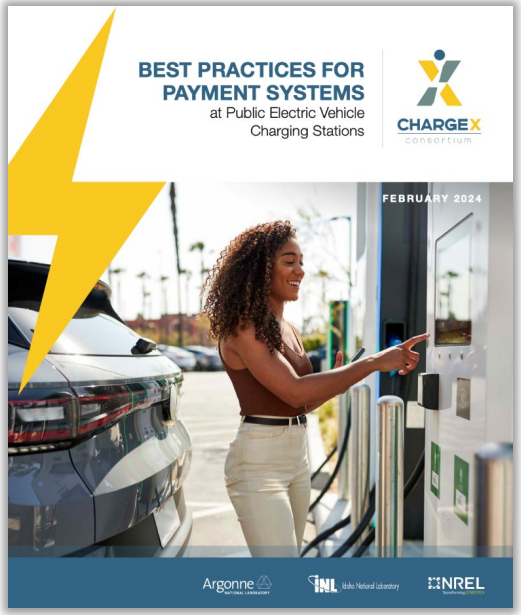
Improving Payment System Reliability

Payment & User Interface Task Force

Challenge: Failure to accept and process payment is a cause of public EV charging session failures

Best-Practice Report documents problems and recommends solutions for wide range of payment system issues seen in the field

- **Network Connectivity** is essential to both payment and starting a session
  - Site Signal Strength (Cell, Wifi), wired solutions where feasible
  - Wi-Fi hot spot & Data Security
- **Credit Card Readers** need to be rugged and integration with electric vehicle supply equipment (EVSE) is critical
  - PCI-compliant devices that are tested and ruggedized
  - Interoperability with the EVSE and point-of-sale software
- **User Interface** design should present clear, easy to understand instructions for all payment methods
  - Create a consistent user experience by following “Public Electric Vehicle Charging Terminal Payment Flow Guidelines” (U.S. Payments Forum 2023)



Report available at chargex.inl.gov or driveelectric.gov/files/payment-system-best-practices.pdf

Increasing Charge Start Success with Seamless Retry

Communications Task Force

Challenge: Customers must sometimes unplug and re-plug if problem occurs during session start-up.

Goal: Institute a process to initialize an automatic retry of the session after a failure to prevent the need for the customer to unplug/re-plug.

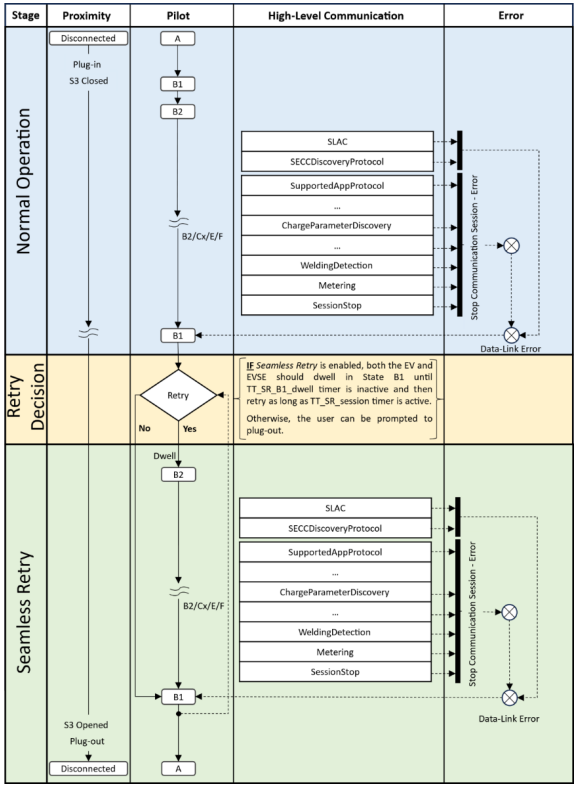
Implementing a seamless reset of all state variables and timers, where both the EV and EVSE replicate an unplug/re-plug as closely as possible.

Progress:

- Wrote recommended-practice document and received industry feedback
- Electrify America completed preliminary demo in their lab

Next Steps:

- Demonstrate with industry partners the effectiveness of this solution; validate technical specifications of this technique
- Evaluate relevant changes in new International Standards Operations (ISO) 15118-2, Edition 2
- Publish final version of Seamless Retry document



Stateflow diagram for seamless retry process

Ensuring Adapters are Reliable and Safe

Hardware Task Force

Challenge: Risks (such as shock, arc flash, fire, vehicle battery damage, etc.) from adapters of varying quality that entered the market prior to testing standards and certification.

Goal: Develop a clear path to evaluate adapters to ensure performance standards (J3400/1), conformance standards (UL 2252), and industry practices to catch all major failure modes.

Motivation:

- Numerous automakers adopt the North American Charging Standards (NACS)
- Opening of Supercharger network to non-Tesla vehicles

Progress:

- Failure Mode & Effects Analysis (FMEA) completed for four adapter types
- 140 failure modes identified for each adapter type with approximately 18 recommendations (evaluation and/or standards proposals)
- Completed study on standard reference inlet thermal properties

Next Steps:

- Complete recommended actions for high-priority failure modes
- Perform failure testing to validate FMEA

Failure analysis completed for four adapter types

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Working Group 3

Solutions for Scaling Reliability

Industry Co-Chair: Cuong Nguyen, ABB e-Mobility
National Lab Co-Chair: Dan Dobrzynski, Argonne National Laboratory (ANL)

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Improving Charging System Diagnostics

Diagnostics Task Force

Challenge: Lack of common error codes and diagnostic data sharing across industry slows problem resolution.

Goal: Define set of minimum required error codes (MRECs) and minimum required diagnostic information (MRDI) for broad industry adoption.

Progress:

- Published charger-focused MRECs and implementation instructions (see inl.gov/chargex/mrec)
- Completed preliminary demonstration of MRECs at industry test event
- ChargeX industry participants implementing and preparing to demonstrate MRECs
- Open Charge Alliance to include MRECs in Open Charge Point Protocol (OCPP)
- Implementing MRECs in EVerest open-source software for OCPP 2.0.1

Next Steps:

- Collaborate with CharIN and EVRoaming Foundation to address EV and roaming-specific MRECs
- Develop MRDI data specification and pilot with industry participants

Error Code	Fault Code
CX001	ConnectorLockFailure
CX002	GroundFailure
CX003	HighTemperature
CX004	OverCurrentFailure
CX005	OverVoltage
CX006	UnderVoltage
CX007	WeakSignal
CX008	EmergencyStop
CX009	AuthorizationTimeout
CX010	InvalidVehicleMode
CX011	CableCheckFailure
CX012	PreChargeFailure
CX013	NoInternet
CX014	PilotFault
CX015	PowerLoss
CX016	EVContactorFault
CX017	EVSEContactorFault
CX018	CableOverTempDerate
CX019	CableOverTempStop
CX020	PartialInsertion
CX021	CapacitanceFault
CX022	ResistanceFault
CX023	ProximityFault
CX024	ConnectorVoltageHigh
CX025	BrokenLatch
CX026	CutCable

Charger MRECs

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Improving Interoperability Testing

Testing Task Force

Challenge: Testing is needed to verify successful communication between every make/model EV and EVSE.

- Resources for interoperability test events are increasing, but current practice centers on opportunistic, ad hoc testing

Goal: Increase the rigor and efficiency of interoperability testing by developing a comprehensive set of test cases for industry use.

Progress:

- Completed test plan for optional prescribed test program at June 2024 CharIN Testival

Next Steps:

- Update and publish full set of test cases based on learnings from Testival

DIN 70121

- External Identification Means (EIM) Authentication Types after Plug-in
- EIM Authentication Types before Plug-In
- Timeout after Plug-in
- Timeout after Authentication

ISO 15118

- EIM Authentication Types after Plug-in
- Plug and Charge (PnC) with Valid Certificates
- PnC with EV Contract Certificates having Incorrect Fields
- PnC with EV Contract Certificates being Expired
- EIM Authentication types after Plug-in

9 test cases to be piloted at June 2024 CharIN Testival

Developing a Remote Test Harness (RTH)

Testing Task Force

Challenge: EV/EVSE interoperability testing currently requires EVs and EVSE in same location, which is expensive and limits opportunities.

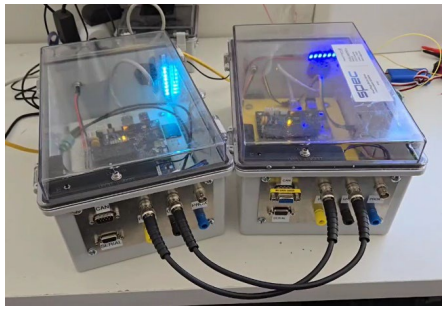
Goal: Develop first-of-a-kind testing system to conduct remote interoperability testing with EVs and EVSE at separate locations.

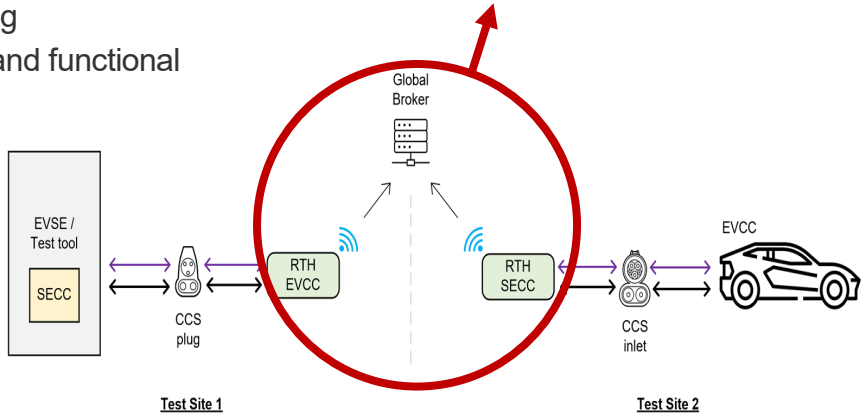
Progress:

- Completed system design specification and feasibility testing
- RTH-to-RTH hardware and software interfaces developed and functional

Next Steps:

- Build EV and EVSE interface hardware and software
- Complete proof-of-concept demonstration for DIN 70121
- Recruit industry champions for minimum viable product testing





Prototype RTH-to-RTH hardware and software interface completed

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Conclusion

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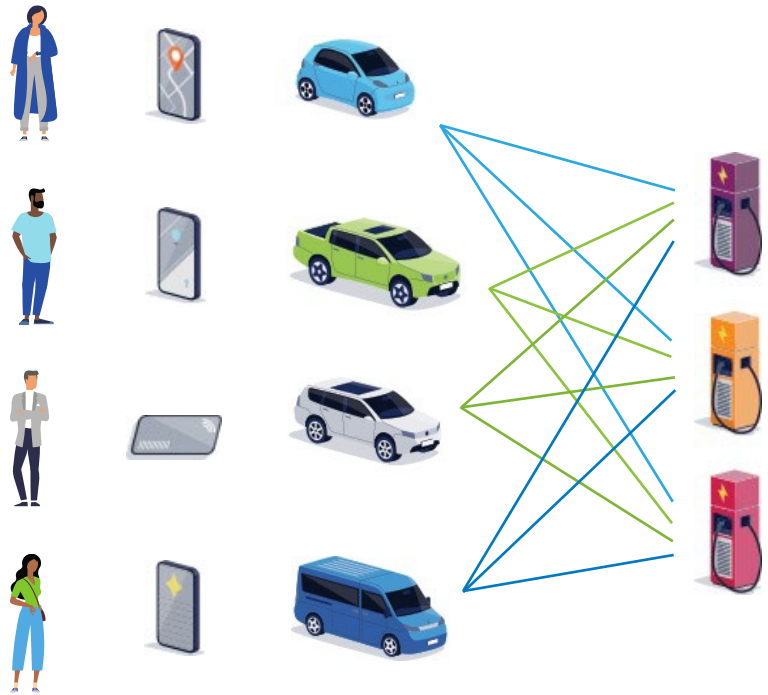
What We've Learned

- The problems that sour the charging experience *are* solvable, but many cannot be solved by any single company
- Collaboration is key to:
  - Define the charging experience with common KPIs
  - Solve issues in hardware and software with complex interfaces
  - Create solutions to scale reliability and interoperability
- Success is in the implementation!
  - ChargeX Task Forces demonstrate and verify
  - ChargeX Working Group members implement
  - Industry adopts

Any Driver, Any EV, Any Charger



FIRST TIME,
EVERY TIME

For more information and to contact us, go to chargex.inl.gov

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Panel Discussion and Audience Q&A

Resources

[About the ChargeX Consortium]

[Best Practices for Payment Systems at Public Electric Vehicle Charging Stations (driveelectric.gov)]

[Recommendations for Minimum Required Error Codes for EV Charging Infrastructure]

[ChargeX Implementation Guide for Minimum Required Error Codes in EV Charging Infrastructure]

[New Project Strengthens Reliable EV Charging Infrastructure · Joint Office of Energy and Transportation (driveelectric.gov)]

Thank you!

Today's Presentation:
Reliability Strategies for Electric Vehicle Charging

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