Unprecedented U.S. Federal Funding for Charging Infrastructure

The Bipartisan Infrastructure Law established two major programs to fund public charging infrastructure deployment:

National Electric Vehicle Infrastructure (NEVI)
Formula Program

$5 billion for states to build a national EV charging network along highway corridors
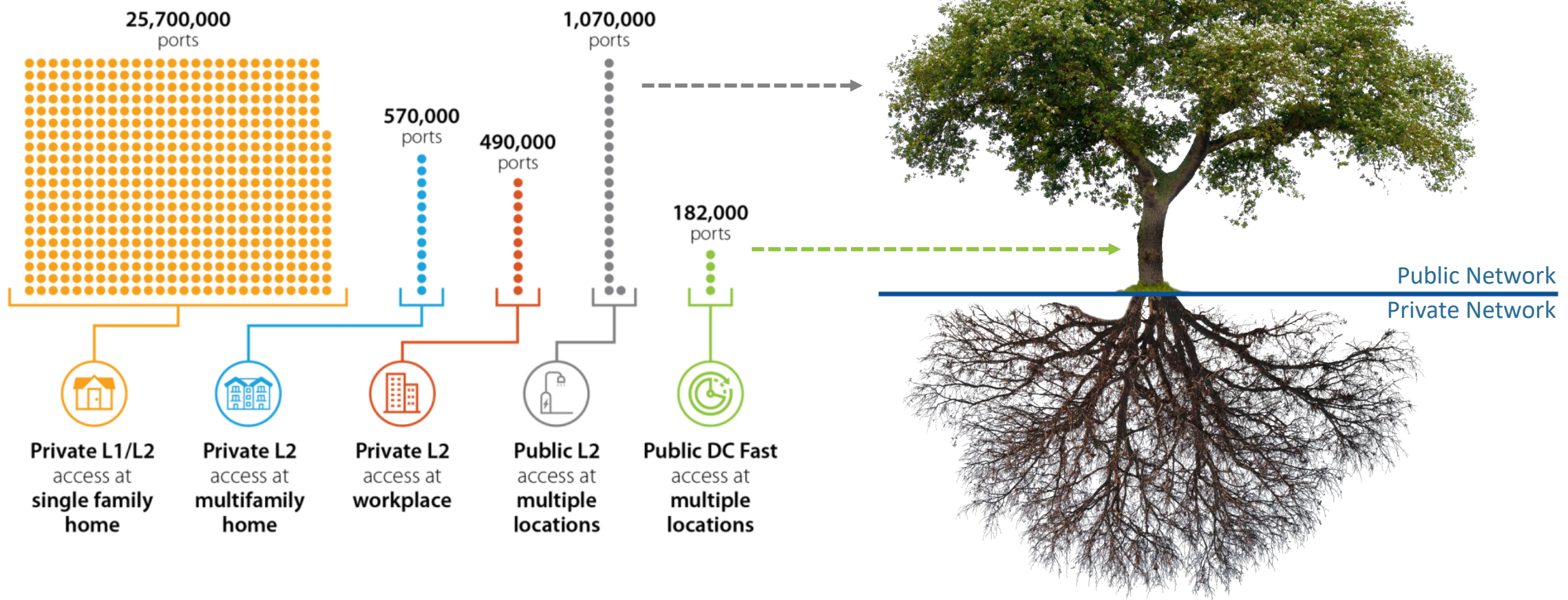
Charging & Fueling Infrastructure (CFI)
Discretionary Grant Program

$2.5 billion for EV charging in communities and on corridors, as well as hydrogen, natural gas, and propane fueling infrastructure

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Public Charging is a Critical Part of the National Charging Network

2030 charging network size to support 33M EVs

25,700,000 ports — Private L1/L2 access at **single family home**

570,000 ports — Private L2 access at **multifamily home**

490,000 ports — Private L2 access at **workplace**

1,070,000 ports — Public L2 access at **multiple locations**

182,000 ports — Public DC Fast access at **multiple locations**

Public Network
Private Network

Public Charging Experience Needs Improvement to Protect Taxpayer Investment

- Customer satisfaction with DC fast charging in 1st half of 2023 was 65%*

- Poor reliability and usability of DC fast chargers are major contributors to poor charging experience

- Many reliability problems require cross-industry collaboration to solve

No one company can fix this alone. National labs are ideally positioned to help

*J.D. Power 2023 U.S. Electric Vehicle Experience (EVX) Public Charging Study, Aug 2023

Vision

Any driver of any 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 lab support to solve and simplify

Scope of Work

Defining the Charging Experience

- Define KPIs
- Develop and verify implementation instructions

Reliability/Usability Triage

Create fixes for:

- Payment
- Communication
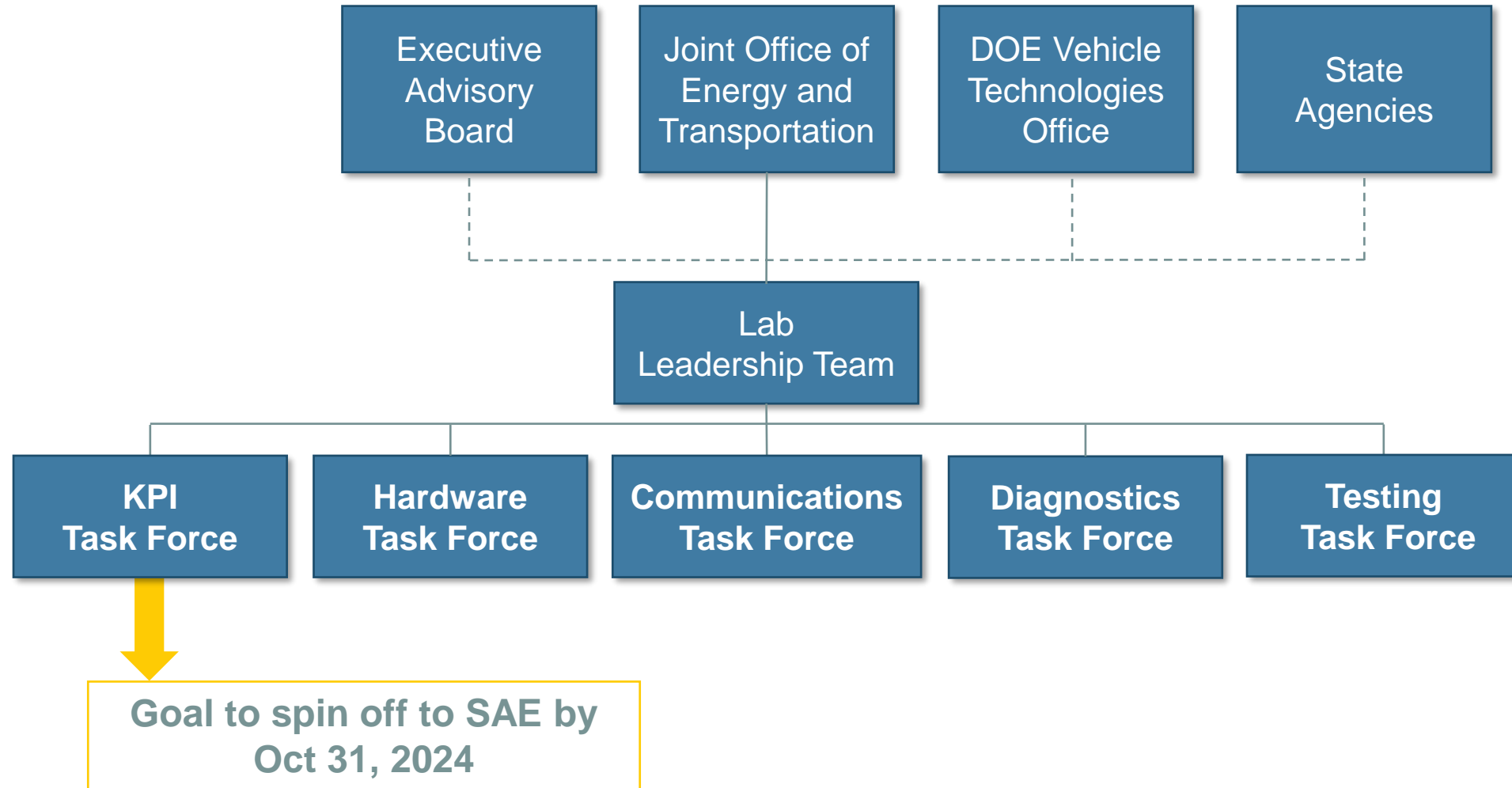- Hardware

Solutions for Scaling Reliability

Improve:

- Diagnostics
- Interoperability testing methods

Outcomes

- Labs produce recommended practices, prototype tools
- Industry adopts practices and tools, improves standards

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Structured Industry Engagement

Executive Advisory Board — Joint Office of Energy and Transportation — DOE Vehicle Technologies Office — State Agencies

Lab Leadership Team

KPI Task Force — Hardware Task Force — Communications Task Force — Diagnostics Task Force — Testing Task Force

Goal to spin off to SAE by Oct 31, 2024

Participants (89 as of 9/30/2024)

Charger Manufacturers and Suppliers	ABB e-Mobility, Amphenol, Autel, Bosch, BTC Power, Dover Fueling Solutions, Eaton, Evalucon, EVBox, Heliox, IoTecha, Qualcomm, Siemens, SK Signet, Wallbox
Customer-Facing Charging Station Operators	Apple Green Electric, Blink Charging, bp pulse, ChargePoint, Electrify America, EVgo, FLO, Francis Energy, HeyCharge, KIGT, Koulomb, NovaCHARGE, NYPA, Rove, SWTCH, Xeal Energy
Charging Network and Software Providers	ampcontrol, AMPECO, ampUp, ChargeMate, Driivz, EV Connect, Noodoe, PIONIX, Switch
Auto Manufacturers	American Honda, BMW of North America, Ford Motor Company, General Motors, Lucid, Mercedes-Benz North America, Rivian, Stellantis, Subaru of America, Tesla, Toyota Motor North America, VinFast Auto, Volvo Car USA
3rd-Party Roaming Hubs and eMSPs	AeonCharge, Bluedot, ChargeHub, Emobi, Hubject
Field Services and Analytics Firms	Atlas Public Policy, ChargerHelp!, Energetics, EVSession, Field Advantage, ReliON, Uptime Charger, WattsUp
Consumer Advocates	Cool the Earth, Consumer Reports, EVinfo, J.D. Power, Plug In America
Fleets	Hertz
Payment Industry Stakeholders	Discover Global Network, Nayax, Payter, WEX
Standards Organizations and Technology Alliances	CharIN North America, COVESA, NEMA, Open Charge Alliance, SAE Sustainable Mobility Solutions
Research Organizations and Universities	American Center for Mobility, EPRI, Transportation Energy Institute, University of California, Davis; University of Washington
State Agencies	California Air Resources Board, California Energy Commission, Caltrans

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Consortium Highlights

Defining the Charging Experience

Goal: establish customer-focused key performance indicators (KPIs) to provide industry with standard methods to measure the customer charging experience
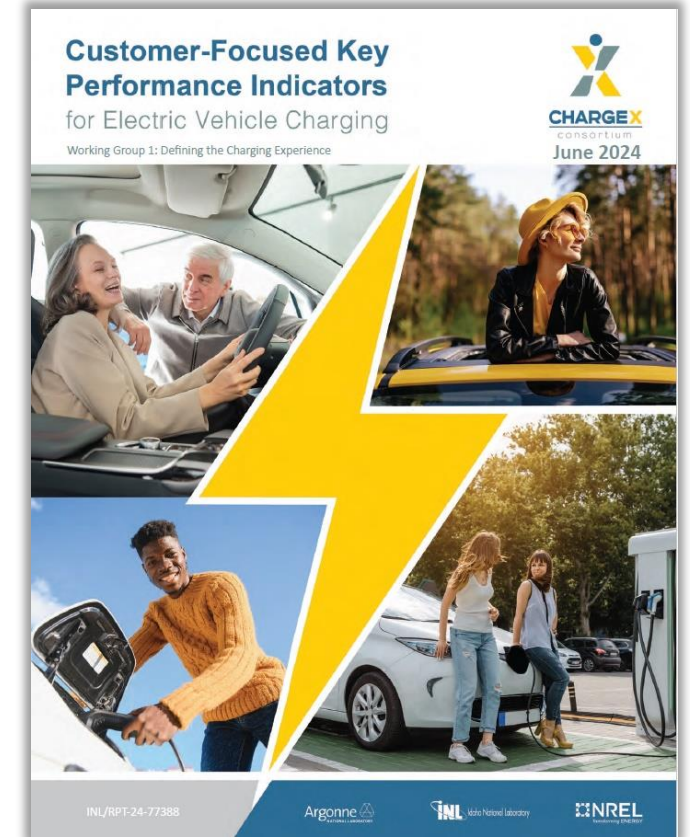
Progress:

- Published a report detailing KPIs on chargex.inl.gov

- Drafted implementation guide for interim KPIs, working with industry partners to verify it

- Conducting implementation pilot with a CSO

Next steps:

- Verify and publish implementation guide for Interim KPIs

Hand off ownership of KPI development to SAE International in Fall 2024

Customer-Focused Key Performance Indicators for Electric Vehicle Charging

Working Group 1: Defining the Charging Experience

CHARGEX consortium
June 2024

INL/RPT-24-77388

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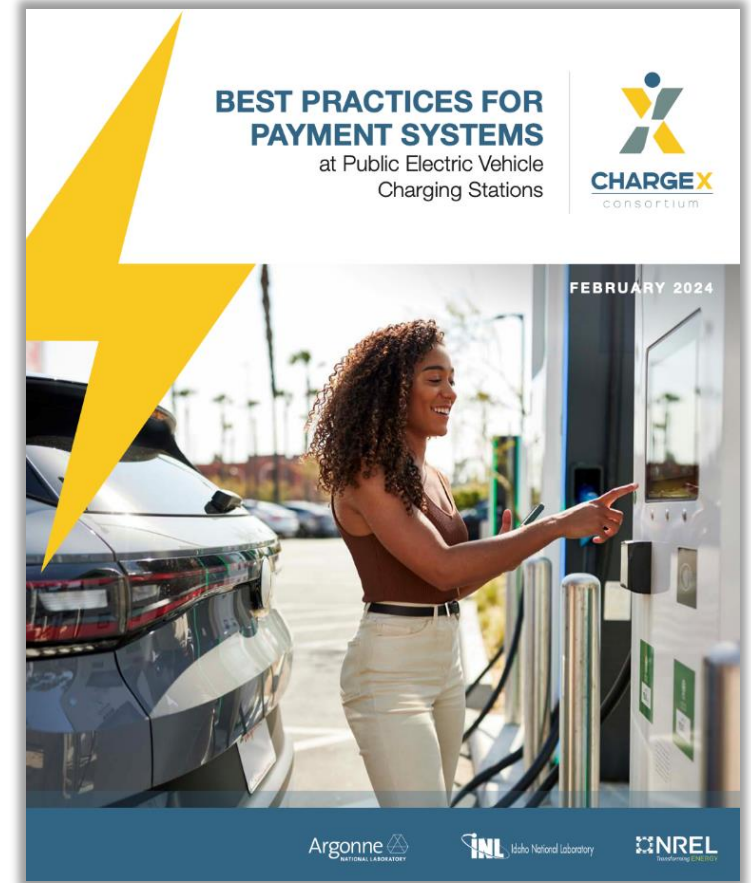
Improving Payment System Reliability

Goal: document problems and recommend solutions for wide range of payment system issues seen in the field

Progress:

- Published a best-practices report documenting problems and recommending solutions for wide range of payment system issues seen in the field

Next Steps:

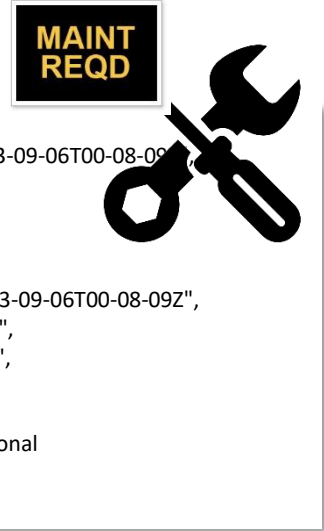- Project complete

Enabling Diagnostic Data Sharing

Goal: Institute common set of error codes and supporting diagnostic information across industry to accelerate problem resolution

Progress:

- Published charger-focused Minimum Required Error Codes (MRECs) and implementation instructions on developer-friendly website (inl.gov/chargex/mrec)

- List of Minimum Required Diagnostic Information (MRDI) drafted to help identify the source/responsibility of common errors in the charging process

Next Steps:

- MREC demonstration as part of interoperability testing at CharIN North America Testival – California in Nov 2024

- Implement in open-source code repository EVerest

- Complete and publish MRDI specification

```
{
  "generatedAt": "2023-09-06T00-08-09...
  "tbc": false,
  "seqNo": 0,
  "eventData":
   {"eventId": 1,
    "timestamp": "2023-09-06T00-08-09Z",
    "trigger": "Alerting",
    "actualValue": "50",
    "cause": "",
    "techCode": "3",
    "techInfo": "Additional
   }
}
```

EVgo demonstrated subset of MRECs at CharIN North America Testival in Nov 2023

Improving the Rigor of Interoperability Testing

Goal: Develop comprehensive set of interoperability test cases to accelerate EV and charger product development

Progress:

- Completed a comprehensive EV/EVSE Interoperability Test Plan (v1)

- Demonstrated subset of test plan in prescribed testing program (PTP) at CharIN North America Testival in June 2025

Next Steps:

- Update EV/EVSE Interoperability Test Plan (v2.0)
  - Add test cases for adapters, J3400 implementations, MRECs, smart charging
  - Targeting industry handoff by Jun 2025

- Conduct second prescribed testing program at CharIN North America Testival – California in Nov 2024
 - Refine test plan based on learnings from testing events and feedback from individual companies

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Creating Remote Test Harness (RTH)

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

Progress:

- Developed proof-of-concept RTH for remote EV/EVSE communication interoperability testing
- Successful demonstration of remote charge initiation process in laboratory environment
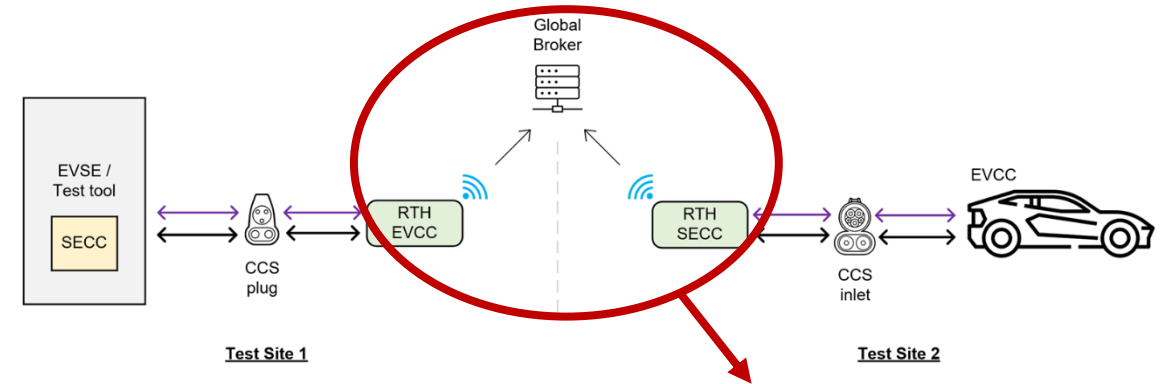
Next Steps:

- Develop proof-of-concept device with commercial off-the-shelf communication controller
- Develop the RTH minimum viable product
- Test and demonstrate RTH minimum viable product

Ensuring Adapters are Reliable and Safe

Goal: ensure performance standards, conformance standards, and industry practices catch all major failure modes

Progress:

- Completed rigorous failure mode and effects analysis for CCS/J3400 adapters

- Yielded numerous recommended actions to harden design and conformance standards for adapters, published on ChargeX website

Next steps:

- Connector / adapter / inlet hardware evaluation
  - Thermal evaluations, including demonstration of reference inlet
  - Pin cap retention, drop and side-load, arc flash/blast testing
- Work with UL and SAE committees to incorporate recommended actions into standards (J3400, J3400/1, UL2202, UL2251, UL2252)

Failure analysis completed for four adapter types

Increasing Charge Start Success with Seamless Retry

Goal: institute process to automatically retry session initialization after failure to prevent customer from needing to unplug and re-plug if issues arise during session startup

Progress:

- Developed and demonstrated recommended practices for seamless retry

Next Steps:

- Publish recommended-practice report

- Seamless Retry 2.0 update to document in FY25

Electrify America, BTC Power, and Ford Motor Company demonstrated at major industry test event in June 2024

Streamlining Timeouts

Goal: identify timeout issues in EV-EVSE communications and document industry best practices

Progress:

- Identified root causes of timeout issues in EV-EVSE communication and drafted recommended-practice report
  - Main timeout issues only persist with legacy equipment
  - Some issues warrant updates to standards

Next Steps:

- Publish recommended-practice report in Fall 2024

# Increasing Information Exchange between EVs and Chargers

Goal: support the creation and adoption of ISO 15118-200 to enable flexible exchange of additional messages between EV/EVSE

Progress:

- Identified scope for lab implementation
  - Identification of EV and EVSE make/model/year
  - Adapter detection
  - Ongoing current/power requested vs. response
  - Error codes

Next Steps:

- Labs implement and demonstrate in EVerest framework, feed back findings to -200 committee

- Partner with industry for testing and demonstration

PLC

Addl. info

DIN/ISO
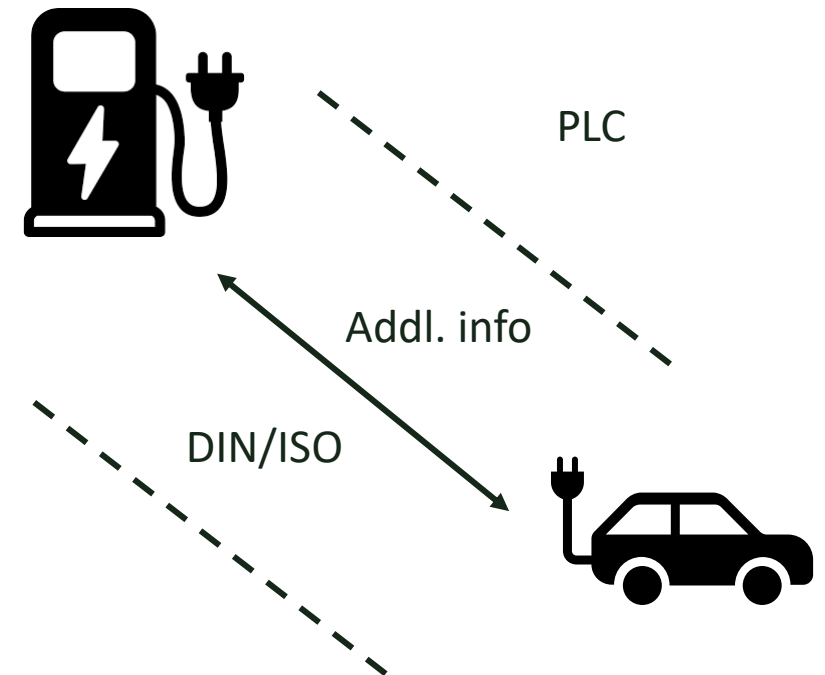
Ensuring Smart Charging is Reliable

How is standards-based smart charge management supposed to work?

1. Develop performance metrics for AC Level 2 smart charge management
   - Define quantitative objectives and constraints for utilities, aggregators, and other stakeholders
2. Develop V1G state machine and sequence diagrams for J1772 pulse-width modulation (PWM) and ISO 15118 high-level communication (HLC)

What doesn't work (that we already know)?

1. Identify root causes of <u>pilot wake</u> failure and recommend solutions to fix

What else doesn't work (that we don't know about yet)? Focus first on charging controls

1. Perform failure mode and effects analysis for smart-charging use cases
2. Conduct EV benchmarking for 80% of available U.S. makes/models to determine smart-charging capabilities
   - PWM-based charge control response, pilot wake response, reg D
   - HLC-based response for ISO 15118-compliant vehicles

Any Driver, Any EV, Any Charger
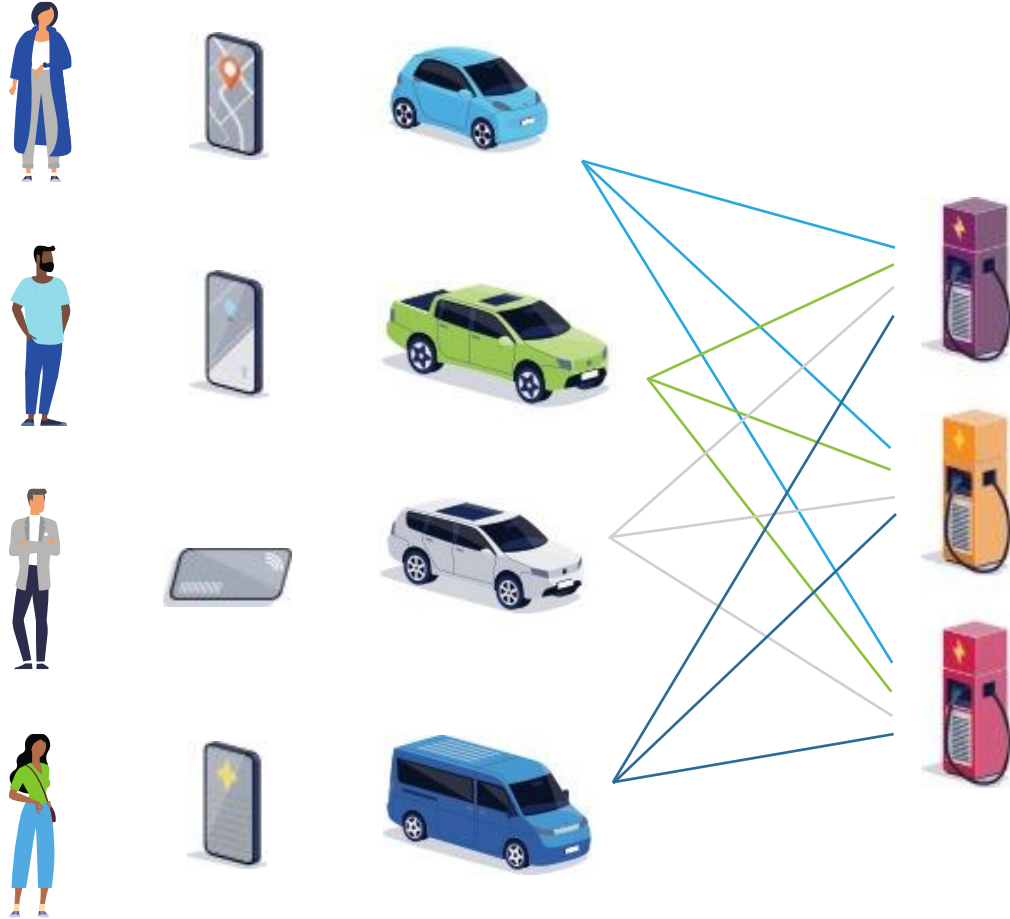
FIRST TIME,
EVERY TIME

chargex.inl.gov

19