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Section 1: Purpose and Background

This document summarizes current electric vehicle (EV) charging interoperability challenges, the California Energy Commission's (CEC) vision for charging interoperability, and potential CEC actions to support accessible and easy charging. Realizing charging interoperability and an easier-than-gas charging experience transcends connector standards and requires industry coordination on software, hardware, and business agreements. This document aims to provide a holistic overview of EV charging interoperability and recommendations to shepherd a better and more reliable charging experience for all EV drivers. Failure to create a positive driver experience may slow EV uptake.

Interoperability describes the ability of different products and systems to function together without special effort from the user. The North American charging ecosystem consists of many parties across multiple "links," and each link has specific interoperability challenges preventing parties on each end of the link from consistently interoperating. This non-interoperability contributes to reliability challenges and a suboptimal driver experience today.

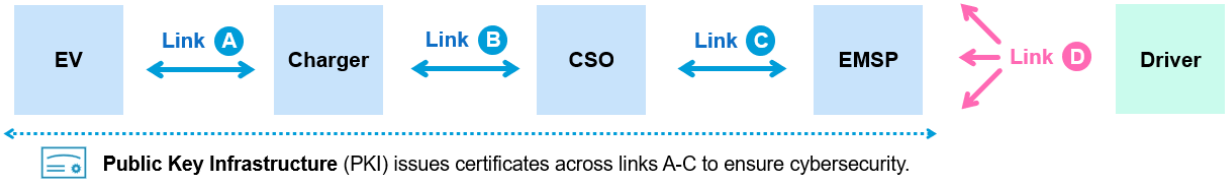

Figure 1: *The North American charging ecosystem consists of multiple parties across four links.*

- **Link A, EV-Charger:** Link A includes both the physical connector as well as the underlying communication protocols to support exchange of charging data. There are multiple connector types used in North America, with some products using the Combined Charging System (CCS/J1772) and others using the North American Charging Standard (NACS/J3400). Some older vehicle models use CHAdeMO. Both J1772 and J3400 appear to support the same variety of communication protocols, including DIN 70121 and ISO 15118 over powerline communication. Implementation of communication protocols is inconsistent across manufacturers, and there is no standardized method for verifying an EV or charger's conformance with ISO 15118-2 or ISO 15118-20.
- **Link B, Charger-Charging Station Operator (CSO).** CSOs operate a digital backend to remotely manage chargers, and CSOs may also own and maintain these chargers. Most CSOs use Open Charge Point Protocol (OCPP) to manage communication between the backend and chargers. Despite widespread use of OCPP, implementations of OCPP often deviate from the protocol specification. As a result, CSO backends and chargers may not interoperate despite both having implemented OCPP. The Open Charge Alliance (OCA), which oversees OCPP development, introduced a voluntary certification program to mitigate this problem, although few North American companies have pursued OCPP certification for their products to date. CSOs are sometimes referred to as Charge Point Operators (CPOs).
- **Link C, CSO-EMobility Service Provider (EMSP).** EMSPs provide the payment account that a driver uses to pay a CSO for charging. CSOs and EMSPs are sometimes the same company, particularly in North America. Network roaming refers to the ability of a driver with one EMSP account to pay for charging at chargers operated by other CSOs

(for example, a driver with a ChargePoint account can start and pay for charging at an EVgo charger without needing to separately set up an EVgo account). Existing California regulations require CSOs operating networked chargers to support network roaming *capability* using Open Charge Point Interface (OCPI), but do not require CSOs to use this capability and develop roaming agreements with EMSPs. Pursuing roaming agreements is a business decision, and these may be developed directly between companies or indirectly using roaming hubs.[1] In the absence of network roaming, drivers must maintain multiple accounts (using apps, keycards, or digital contracts) to access chargers managed by different CSOs, or rely on manual credit card payment where available. EMSPs are sometimes referred to as Mobility Operators (MOs) and EMobility Providers (EMPs).

- **Link D, Driver-Ecosystem.** Given the diversity of driver behaviors, industry parties have developed a wide range of options for drivers to interact with the rest of the charging ecosystem – on a mobile app, using a keycard, manually tapping a credit card, clicking through the vehicle infotainment screen, and so on. Currently, most drivers are expected to be "hands-on" and there is limited ability for a driver to simply "plug and charge" to initiate and pay for a charging session. Due to the lack of network roaming in North America, drivers often maintain "folders of apps" or multiple keycards in order to access chargers on different networks.
- Separately, **public key infrastructure (PKI)** manages digital certificates and keys across Links A through C. These certificates and keys enable secure and confidential communication between different parties in the ecosystem, and are important for arranging payments and other contracts. The Plug and Charge use case in ISO 15118 relies on PKI to ensure cybersecurity, and CEC staff expects there to be multiple PKI operators in North America. Industry consensus on rules for handling multiple PKIs will help scale Plug and Charge implementation and ensure customer choice.

A link achieves interoperability when parties on both sides of the link can consistently connect to exchange power, communication, or both. As described above, interoperability problems are present in all links in the charging ecosystem today, and this contributes to a suboptimal driver experience, unsuccessful charging sessions, and reliability challenges.

Section 2: Broad Interoperability Vision

The CEC's vision is for the charging ecosystem to achieve "broad interoperability:" **A future where any driver with any EV can easily charge at any charger on any network.** Realizing broad interoperability requires attaining interoperability across each of the four links in the ecosystem and a functional PKI ecosystem. The following sections discuss the general steps to achieve interoperability for each link, and upcoming CEC actions to support those steps.

Section 3: Achieving Link Interoperability

Links A through C achieve interoperability using a five-step process, and these same general steps are applicable to any of these three links. Link D (Driver-Ecosystem) is excluded in this section due to human factors resulting in diverse driver behaviors and preferences. Importantly,

[1] Roaming hubs (or roaming platforms) provide a centralized digital exchange to enable transactions among entities across Link C. By providing a central exchange for transactions, roaming hubs may simplify CSO-EMSP integration by avoiding the need for individual CSOs and EMSPs to develop one-on-one roaming agreements.

achieving interoperability across links A through C enables industry parties to accommodate a wide range of possible interactions between the driver and the rest of the ecosystem (Link D).

A link achieves interoperability when industry parties on both ends of the link progress through the following steps. *[Examples of actions that can be taken for Link B are provided in brackets.]* Each step below also describes existing CEC actions supporting activities for that step. Broad interoperability is achieved when all links achieve link interoperability.

Figure 2: *Any link in the charging ecosystem achieves link interoperability by following the above five step process. Broad interoperability is achieved when all links achieves link interoperability.*

0. **Select a common protocol** to serve as the basis for interoperability. Without a common protocol, parties use proprietary solutions for their products and services, and then develop translation interfaces to interact with other parties' proprietary systems. Such a setup impedes innovation and is difficult to scale. CEC funding often requires chargers to conform with certain common protocols as a minimum, including CCS/J1772, ISO 15118, and OCPP. *[Coalesce around OCPP].*
1. **Implement the protocol** on products. Relevant industry parties must design and deploy the needed hardware and software on their products. Some industry parties may use pre-designed hardware or software from vendors. Prior CEC actions on ISO 15118 hardware readiness help ensure that chargers have the requisite hardware to support ISO 15118 implementation. *[Implement OCPP on CSO backends and chargers].*
2. **Certify conformance** by checking that a product's protocol implementation is consistent with the protocol specification. Protocols may offer test tools or certification programs where a third-party lab tests and verifies a product's protocol conformance. Notably, the CEC provided funding to help launch the DEKRA Vehicle-Grid Innovation Lab (ViGIL) in Concord, California. Services offered at ViGIL include ISO 15118 conformance testing and OCPP certification. CEC block grants, such as CALeVIP, require funded chargers to be certified for OCPP 2.0.1 or later by the OCA beginning 2025. *[Verify protocol conformance using OCA's certification program].*
3. **Test interoperability** to verify that different products using the same protocol work together. Conformance and interoperability are related but distinct concepts. A product conforms to a protocol if it follows the protocol specification (Step 2). A product is interoperable if it functions with other products without extra user effort (Step 3). Interoperability testing may occur on a one-on-one basis or as part of a larger industry testing symposium. In May 2023, CEC funding supported an interoperability testing symposium hosted by Innos and CharIN in Long Beach, Calif. *[Test that different CSO backends and chargers work together].*
4. **Improve the protocol** by adding new features, patching bugs, and/or clarifying existing use cases. *[Revise the OCPP specification].*

Section 4: Additional CEC Actions to Support Broad Interoperability

While no single entity is responsible for realizing broad interoperability, the CEC has developed a list of upcoming actions and potential actions to support industry activities and provide a roadmap toward broad interoperability. These actions are categorized below based on the affected link.

Link A

A.1 Given the continued use of CCS by nearly all vehicle models through 2025-2026, the CEC will continue specifying CCS/J1772 and ISO 15118 as minimum technical requirements in the immediate term for block grant projects, including CALeVIP, Communities In Charge, and EnergIIZE. The CEC will consider expanding these requirements to other charger funding opportunities as appropriate. Projects may exceed these minimum requirements, for example by including additional connector types.

A.2 The CEC will monitor ongoing J3400 standardization activities, including implications for smart charging, bidirectional charging, Plug and Charge, network roaming, and other important elements of a driver- and grid-friendly charging ecosystem. The CEC will explore pathways to encourage a one-connector future for North America, and may revise minimum connector requirements when appropriate. *(See the CEC's published NACS statement for additional details. The CEC may update policies relating to NACS/J3400 without updating the NACS statement).*

A.3 The CEC anticipates that the industry's use of specific versions of ISO 15118 will evolve rapidly over the coming years. As such, the CEC may consider publishing a report outlining recommendations to achieve widespread implementation of ISO 15118-20, including discussion about hardware requirements, software implementation, certifications, and migration pathways from older communication protocols (such as DIN 70121 and ISO 15118-2). ISO 15118-20 has the potential to enable widespread, interoperable, and cybersecure bidirectional charging and Plug and Charge.

A.4 The CEC may consider including ISO 15118-20 implementation activities as eligible costs in future funding solicitations related to charging. Such activities may include implementation of software stacks, conformance testing, and certification testing.

A.5 The CEC may consider requiring third-party certification of ISO 15118 implementation for chargers funded by the CEC. The CEC is aware that such certifications are under development. Subject to further industry feedback, it may be appropriate to begin requiring ISO 15118 certifications for chargers funded through CEC block grant projects beginning in 2025.

A.6 The CEC may continue exploring appropriate ways to fund and support EV-charger interoperability testing, for example through the Charge Yard solicitation concept.

Link B

B.1 The CEC will continue specifying OCPP with certification as the minimum requirement for block grant projects, including CALeVIP, Communities In Charge, and EnergIIZE. This includes a 2025 deadline for certification to OCPP 2.0.1 or later.

B.2 The CEC will consider expanding OCPP certification requirements to other charger funding opportunities as appropriate. Importantly, OCPP can support standardized data reporting.

B.3 The CEC may consider including implementation and certification of OCPP as eligible costs in future charging related funding solicitations.

Link C

C.1 The CEC will explore whether minimum network roaming requirements may be appropriate for block grant projects such as CALeVIP, Communities In Charge, and EnergIIZE. The CEC will explore methods to encourage CSOs to develop roaming agreements with EMSPs. Subject to further industry feedback, it may be appropriate to begin requiring networks to maintain minimum network roaming capabilities beginning 2025-2026.

Link D

D.1 The CEC may explore working with the federal government to support industry consensus on national PKI governance and rules. PKI is important for ensuring cybersecurity and enabling widespread availability of Plug and Charge.

D.2 The CEC may explore working with relevant agencies to encourage driver choice for EMSP selection. Many automakers offer or will offer EMSP products that are natively integrated with the EV. For a variety of reasons, drivers may prefer to use an alternate EMSP, and drivers should have the ability to select and use an alternate EMSP on their EV (for example, to process payments for charging sessions initiated using Plug and Charge).

Section 5: Next Steps

The CEC is already implementing some of the actions described in Section 4. The CEC is evaluating the feasibility and timeline for other actions considering staff resources, industry acceptance and readiness, and legal authority. Updates and public workshop notices relating to CEC's actions supporting broad interoperability will be posted to the docket 22-EVI-06.