

Electric Vehicle Charging Reliability: What EV Drivers Say

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How Reliable are Public Electric Vehicle Chargers?

- EV Service Providers report 95 to 98 percent “uptime” (CARB, 2022)

Yet,

- 40 percent of California electric vehicle (EV) owners have contacted EV Service Providers’ customer service (CARB, 2022)
 - Charging kiosk not working; Broken plugs; Interrupted charges
- 27 percent of 657 “open” public DC Fast Chargers at 181 locations in San Francisco Bay Area were “non-functional” (UC Berkeley, 2022)
 - Unresponsive or unavailable user interface screens; Payment system failures; Broken plug; Charge initiation failures

Small Sample, Qualitative Research; early-2021

- 18 interviews with drivers of a select few EV
 - Newly released models and Tesla 3 & Y
 - Most interviewees in California, but also, Arizona, Georgia, Massachusetts, Maine, and New Jersey
 - Approximately one-hour interviews, on-line
- Spring 2021
 - COVID-19 context

“Conclusions” are hunches, hypotheses, questions...and concerns.

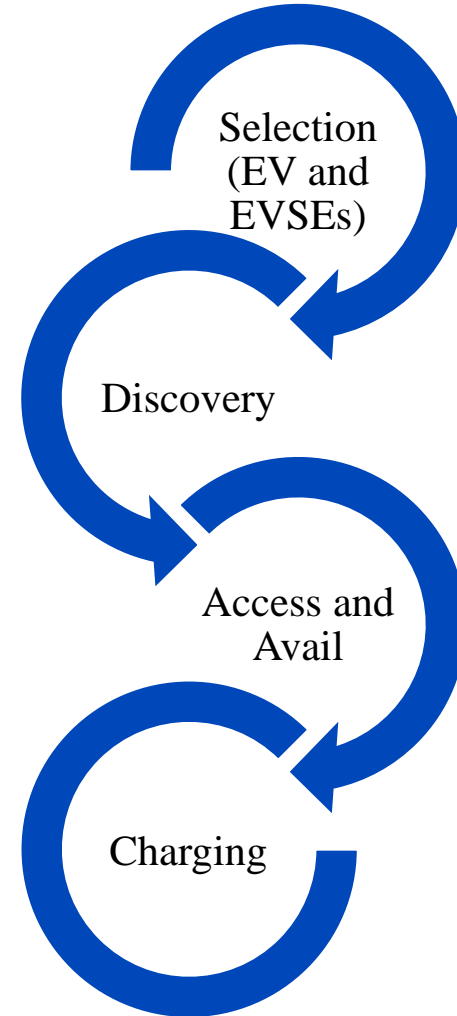
Vehicle	State	Count
Audi e-tron	California	1
	California and Georgia	1
Ford Mach-E	California	1
	Massachusetts	1
	Maine	1
	New Jersey	1
Jaguar I-Pace	Arizona	1
	California	6
Tesla Model 3	California	4*
Tesla Model Y	California	1*

*One interviewee owned a Tesla Model 3 and Y.

Two Overarching Conclusions

1. There is a world of difference in the experience of away-from-home charging between drivers of Tesla EVs and all other EV drivers in the sample.
2. A conceptual framework may be synthesized from all these EV drivers' descriptions to organize how we think about EV charging.

Conceptual Framework of Suppliers and Users of Public Charging



Electric Vehicle Drivers and their Socio-technical networks:

- On-line forums
- Crowd-sourced Charging Platforms

Conceptual Framework of Suppliers and Users of Public Charging

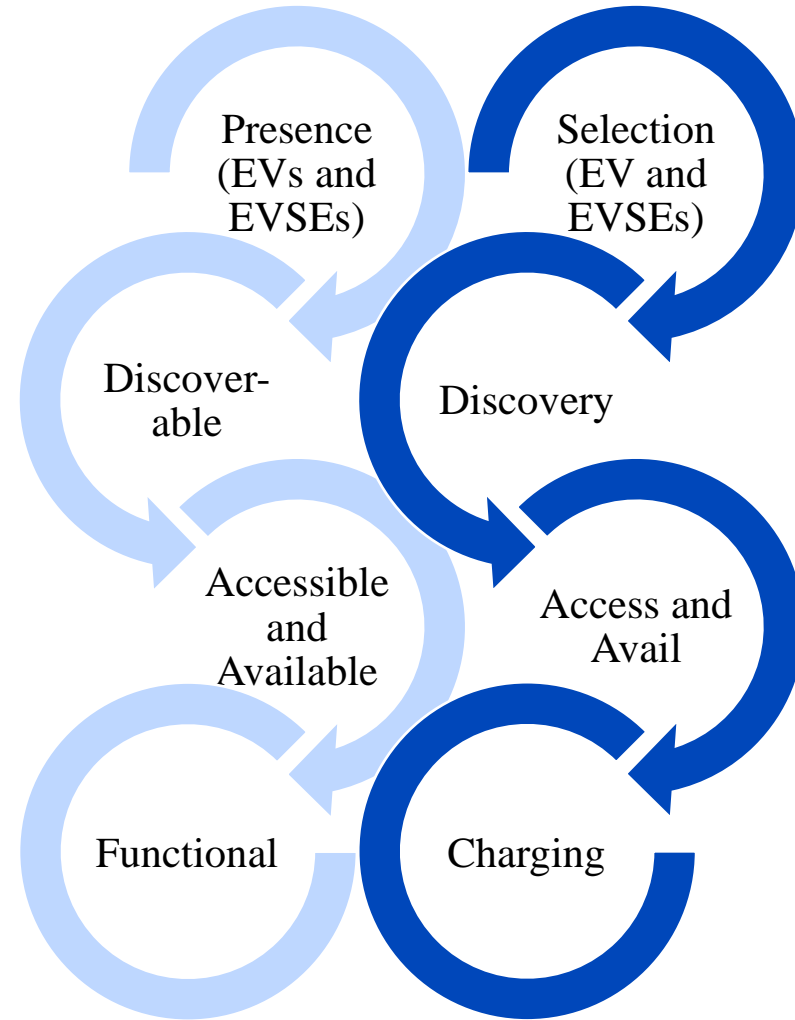
Vehicle and EVSE
Manufacturers

Charging Network
Providers

Information Providers

Host Properties;
Regulators

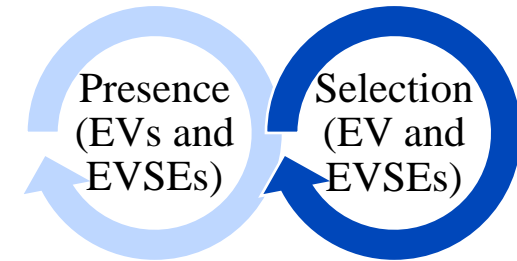
Socio-Technical
Networks



Electric Vehicle Drivers
and their Socio-
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Vehicle and Charging Network Selection



EV Drivers shape which public chargers they perceive and use when they select which EV to acquire

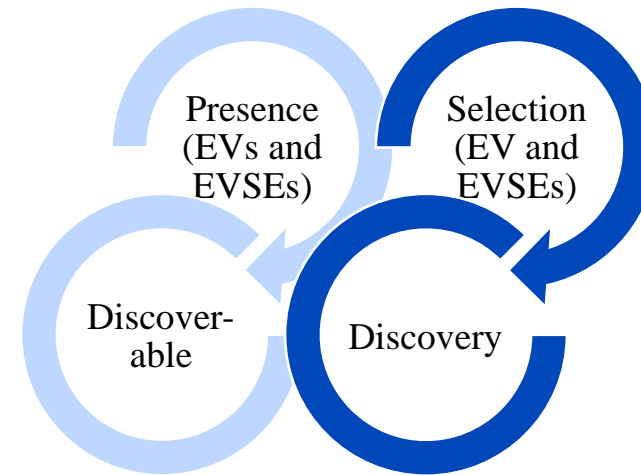
Tesla drivers operate within an integrated vehicle-charging-information system

- Tesla L2 chargers (technically available to all EVs with appropriate plug adapters)
- Tesla Supercharger (DC Fast) remain available only to Tesla EVs
- For some Tesla drivers, the charging system is treated as an attribute of the car

Everyone else charges across multiple networks

- More than a dozen charging networks, each with their own app, multiplicity of payment methods
- Charging network selection influenced by vehicle manufacturer incentives
 - Allotments of free charging within a single charging network
 - Branded charging networks

Charging Discovery



Public Charging Discovery

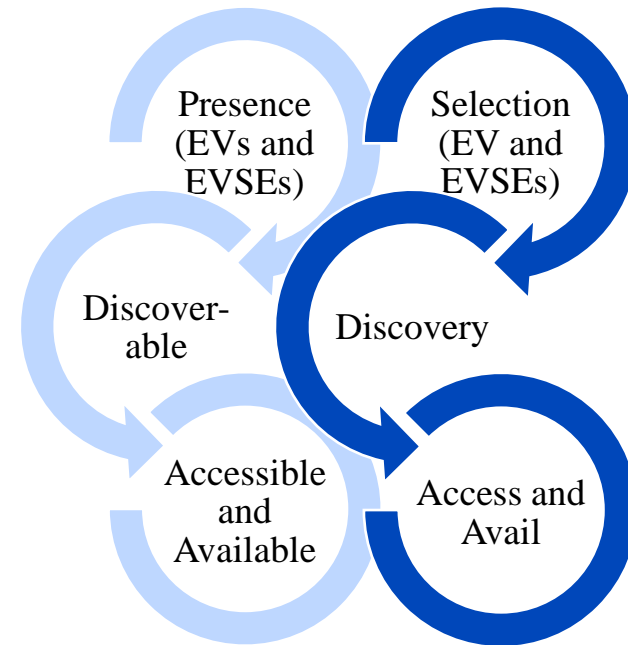
Tesla

- Tesla drivers know what their in-vehicle information systems and smartphone app can do, because they use them.
 - Charging Recommendations, i.e., itineraries of locations and durations
 - Dynamic Trip Planning
 - Real Time Charging Information Display (during vehicle charging)

Everyone else in the sample

- Don't know what their OEM-navigation systems do because they don't use them
- Third-party apps to discover chargers
 - PlugShare; A Better Route Planner (ABRP)
 - Learned while driving a prior EV or new EV drivers learn from other EV drivers
 - Problems, real and imagined
 - Phone-vehicle integration
 - Uncertain information updates

Discovery, Access, and Avail



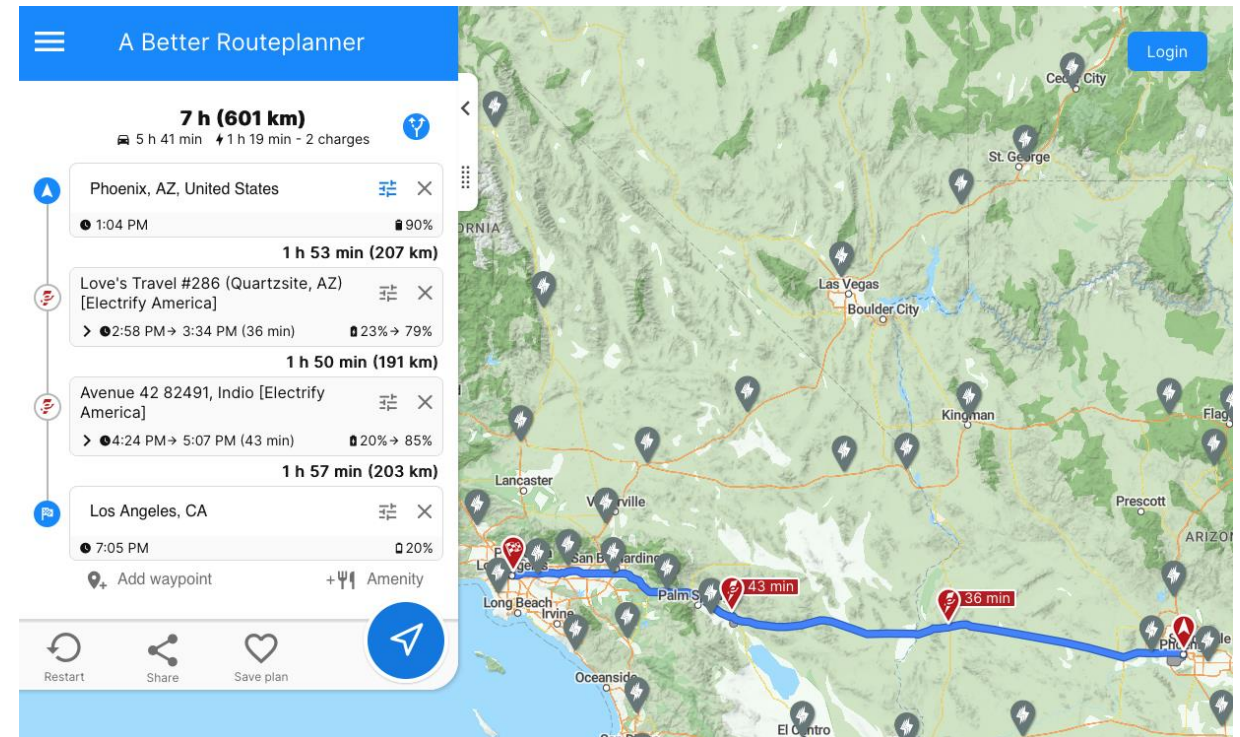
Creating Pre-trip Charging Itineraries

Long-trips (requiring at least one charge to return home)

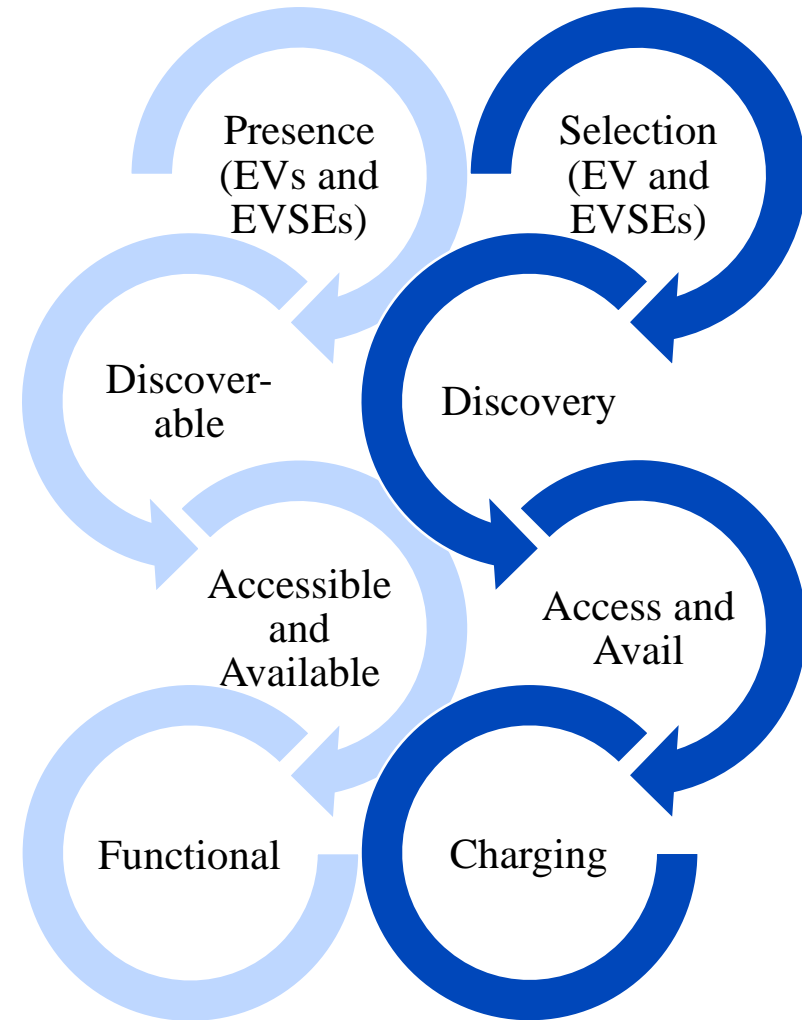
1. Long trip is in the households travel history, but first time in the EV
2. Novel long trips/tours
 - A pre-trip charging itinerary facilitates the trip, but actual charging is managed as conditions change throughout the trip.

Novel long trips: Managing Charging within a Pre-Trip Itinerary

- Drivers' "objective functions," travel routes, waypoints, destinations, and charging availability at destinations all affect pre-trip itineraries
 - May change from trip to trip and in the course of any given trip
 - Reported objective functions include minimizing stops, travel time (including charging time), or charging cost.
 - I-PACE, Phoenix, AZ to Los Angeles, CA round-trip



Charging



What EV drivers say they want sounds like a modern gas station

- **Better Design of the EVSE**
 - DC Fast charger cords are heavy and awkward
- **Better Design of, and Amenities at, Charging Locations**
 - Clean bathrooms, trash cans, discoverable (ahead of time) food and beverage options
 - Shade/rain/snow canopies
- **Better Design of the EVSE Location vis-à-vis the Parking Spot**
 - Pull-through rather than pull-in or back-in parking
- **Simplify payment mechanisms across charging networks**

And they want charging that works.

“I just want to leave home and not have to think about it. I just want to leave home knowing there is charging if I need it.”

(Tesla, southern California)

CHARGING, LOOKING FORWARD

These EV Drivers Exhibit “Innovator” Behaviors

- **e-tron, Los Angeles**
 - e-tron is her only car; she has no home charging
 - Routine charging during commute to work
 - Preferred DC Fast Charge location with a backup location
 - Does her makeup in the car while charging
- **e-tron, moving to Atlanta**
 - Created complete LA-to-Atlanta charging itinerary in a spreadsheet
 - At each charging stop, used Plugshare to check status of next planned charger
 - And spiders; lots and lots of spiders
- **Mach-E, Maine**
 - Escalating public charging failures—in a single attempt to charge
 - Experience was so bad the EV driver didn't risk a subsequent business trip in his Mach-E with his boss—a non-EV Driver

These EV Drivers Exhibit “Innovator” Behaviors

- Innovators are hypothesized to be willing to pay more, not just higher price but greater hassle, too
- **Public Charging (Un)reliability**
 - 17 of 18 interviewees offer stories of the unreliability and hassle of public charging; the only one not to tell such a story, hasn't used it
- **What reasonable expectation can we have later EV drivers will put up with any of this?**

People-centered concepts to inform EV Charging Reliability

- **Hassle**—mundane nuisances of daily life—has been associated with well-being
- **Trust**—willingness to make oneself vulnerable to others, including trust in expert systems—is study broadly across the social sciences
- **Convenience**—time and effort as experienced by people, and thus the units might not be seconds and joules
- **Practical consciousness** (rather than reflexive)—when do we simply not have to think about EV charging?
- For the supply-side actors
 - What metrics are required for EV drivers to experience charging as hassle-free, trustworthy, convenient, routine?
 - Who is responsible for achieving and maintaining the conditions under which those metrics are achieved?

