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Plug-in Electric Vehicles
Where Are We And What's Next?

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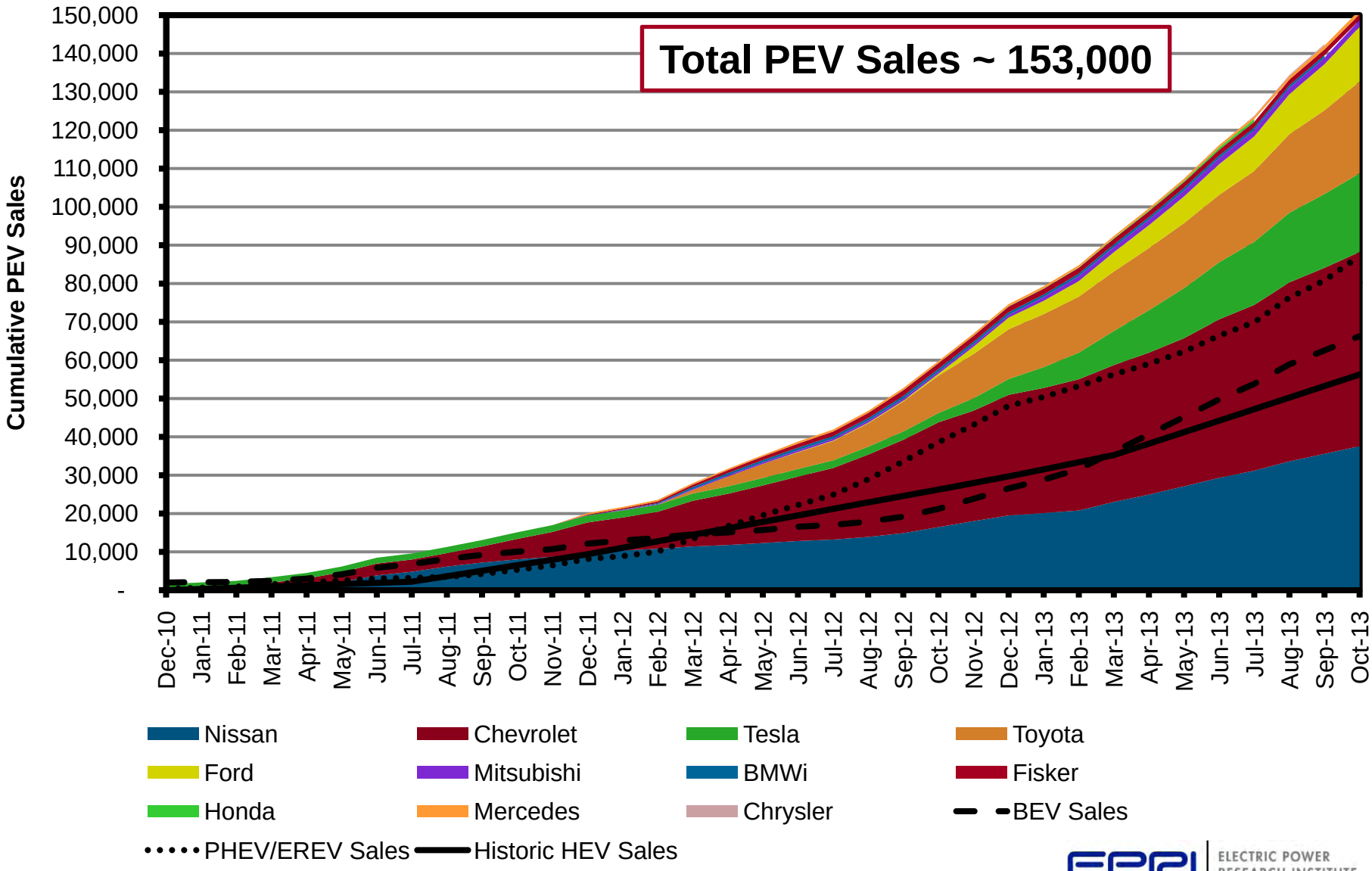
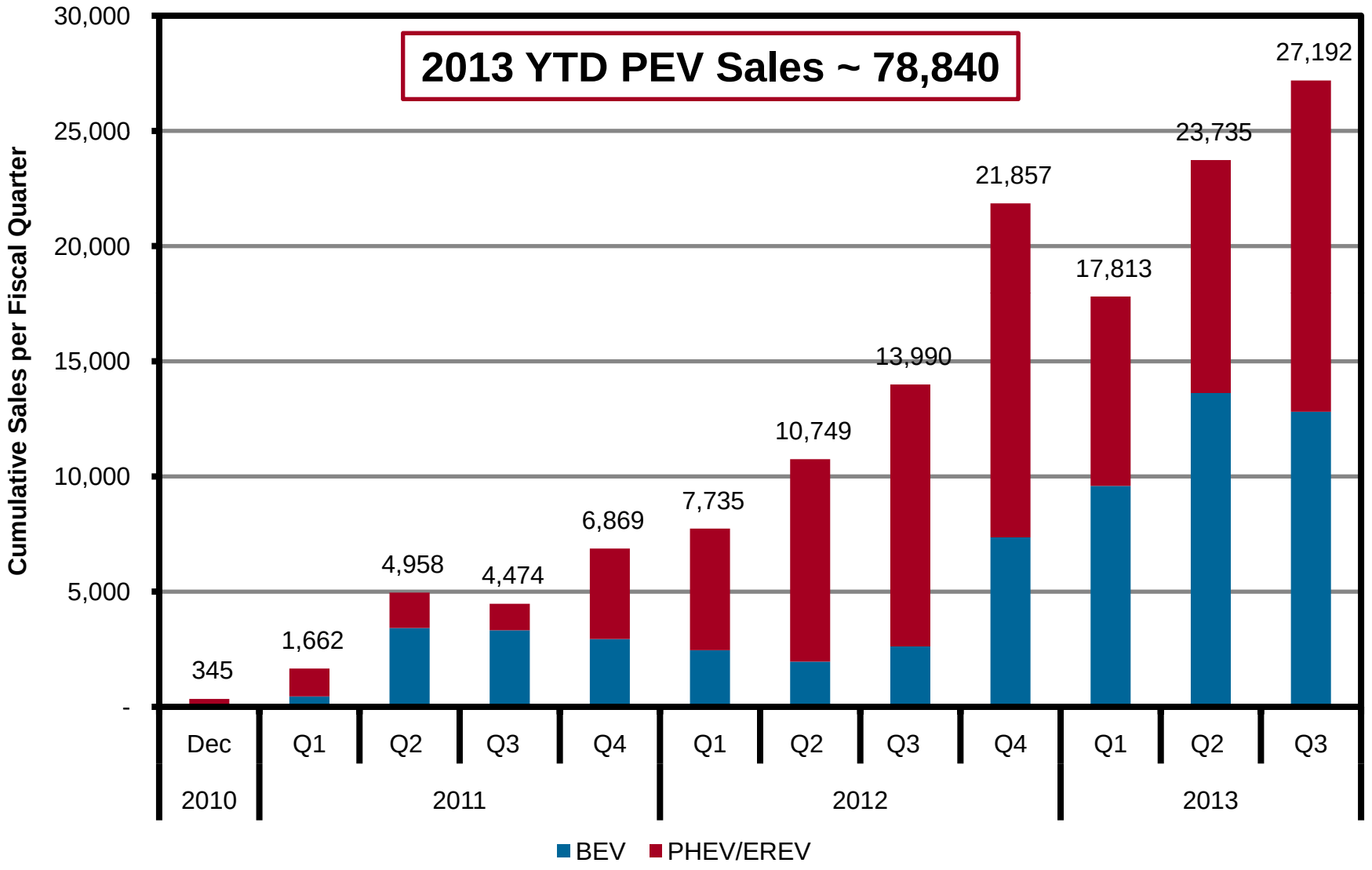
Plug-in Electric Vehicle 'State of the Nation'

- Sales continue to increase
- Vehicle selection continues to increase
- Interest in DC fast charging on the rise
- Interest in vehicle to grid applications is increasing
- EPRI and other stakeholders continue to work on smart charging
- Some confusion on infrastructure
  - EV Project Manager Ecotality bankruptcy
  - Proprietary networks with vendor lock-in
  - How much infrastructure and where?
  - How to do billing and pricing?
  - Competing DC charging standards (CHAdeMO, SAE Combo, Tesla)

PEV Sales Continue to Outpace Historical Hybrid Sales (through 10/30/2013)



PEV Sales by Quarter – up 94% over Q3 in 2012



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Plug-in Electric Vehicles Available Today

Chevrolet Volt EREV
40mi EV/275mi Total range; 16kWh, $43k

Nissan LEAF EV
70mi EV range; 20kWh, $35k

BMW ActiveE
100mi EV range; 22kWh, $599/month lease

Prius Plug-in
15mi EV range / 350 total; 5kWh, $35k

Ford Focus Electric
76mi EV range; 22kWh, $40k

FIAT 500E
87mi EV range; 20kWh, $32k

Key Features

- SAE J1772 Charging Coupler
- Lithium-Ion battery technology
- On-board charger: 1.4kW → 7.2kW
- Charging Voltage: 120V or 240V
- 10 yr / 100,000 mile warranty
- On-vehicle telematics system

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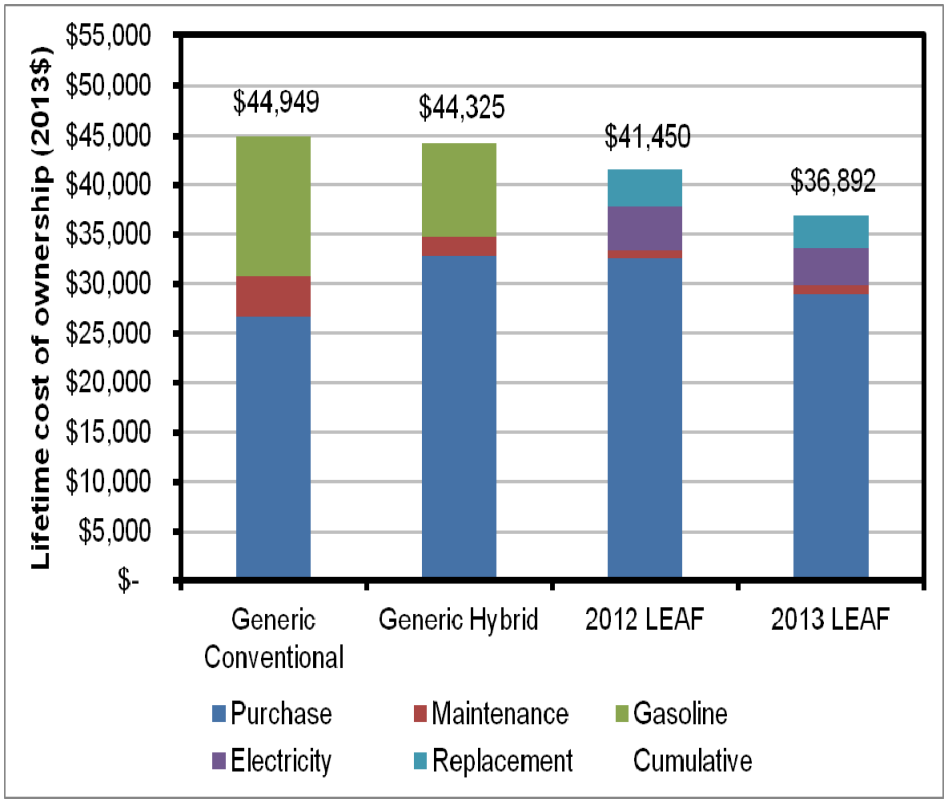
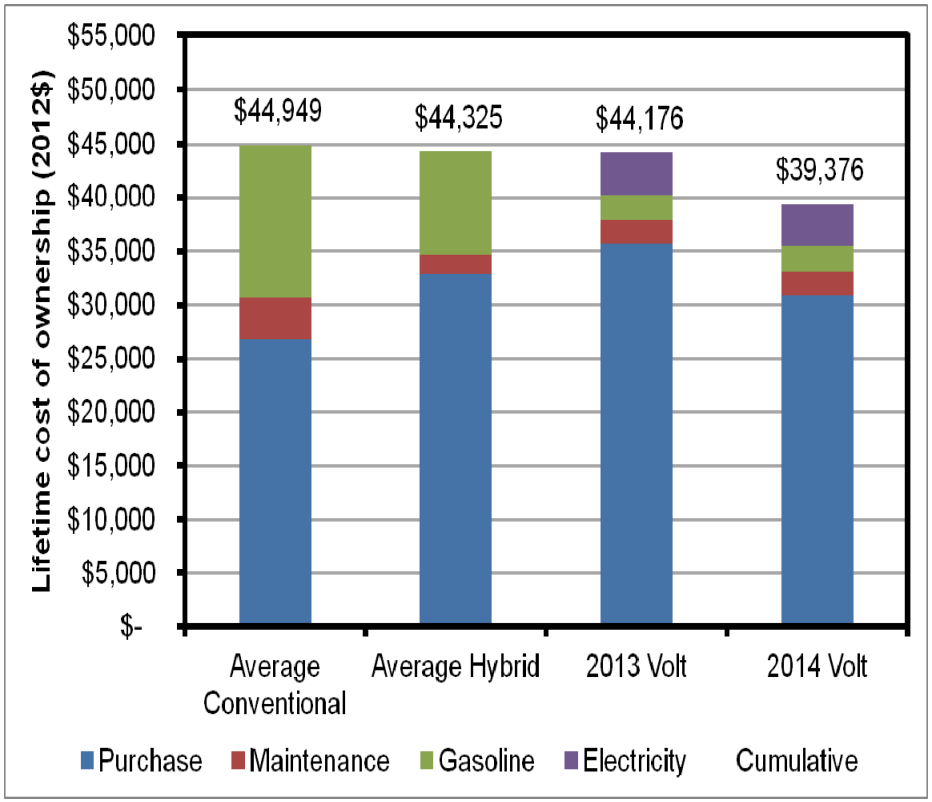
Automakers Investing $ Millions In New PEVs
10+ 2014 and 2015 Models On The Way

Make	Model	Type
Cadillac	ELR	PHEV
BMW	i3	BEV
Porsche	Panamera S E-Hybrid	PHEV
Mitsubishi	Outlander PHEV	PHEV
Mercedes-Benz	B-class	BEV
VW	e-Golf	BEV
Mercedes-Benz	S-class	PHEV
Tesla	Model X	BEV
Kia	Soul	BEV
Nissan	e-NV200	BEV
Audi	A3 E-tron	PHEV

Today: Total Cost of Ownership (TCO) PEVs Are Already Competitive On Price





Recent price drops in PEVs has caused the TCO of PEVs to improve

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Today: Electric Vehicle Supply Equipment – The Fuel Pump

- Safely provides electricity to plug-in vehicles
- Vary in size and style by:
  - Application
  - Location
  - Functionality

AC Level 1

120V at up to 16A

~3 to 5 miles of range per hour of charging

AC Level 2

208/240V at up to 80A

~10 to 20 miles of range per hour of charging

DC Level 2

500V at up to 200A

~80% re-charge in 20 to 30 minutes

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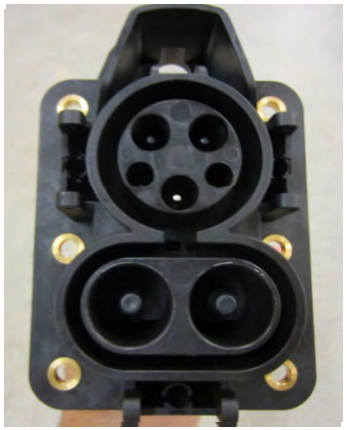
Today: Multiple Options Exist For DC Fast Charge Connectors



SAE Combo

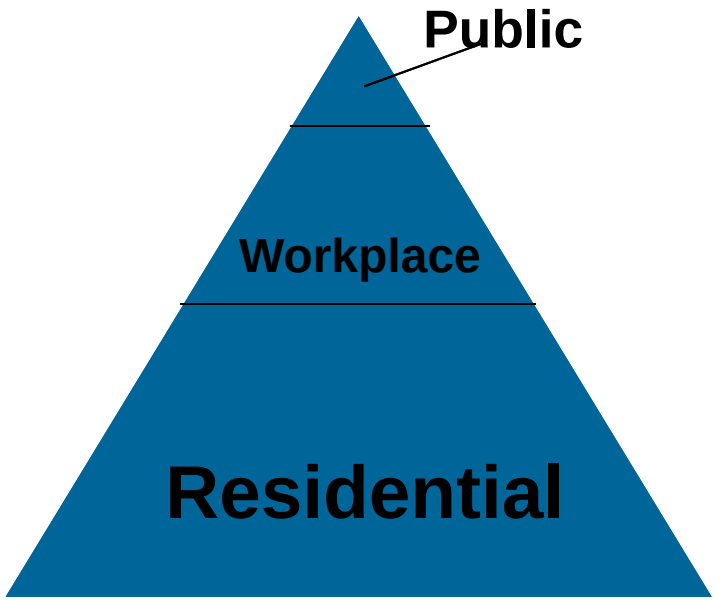
(USA and Europe)

CHAdeMO (Japan)

Tesla

Building Out Charging Infrastructure

- Residential charging
  - Can simply plug into 110V outlet
  - Seamless installations
  - Permits, electricians, inspections
  - Rates and customer programs
  - Multi-family dwellings are a challenge
- Workplace
  - Cost, fairness, access control
- Public charging
  - Smallest part of pyramid but still very important
  - Installation cost challenges
  - Most visible to consumers

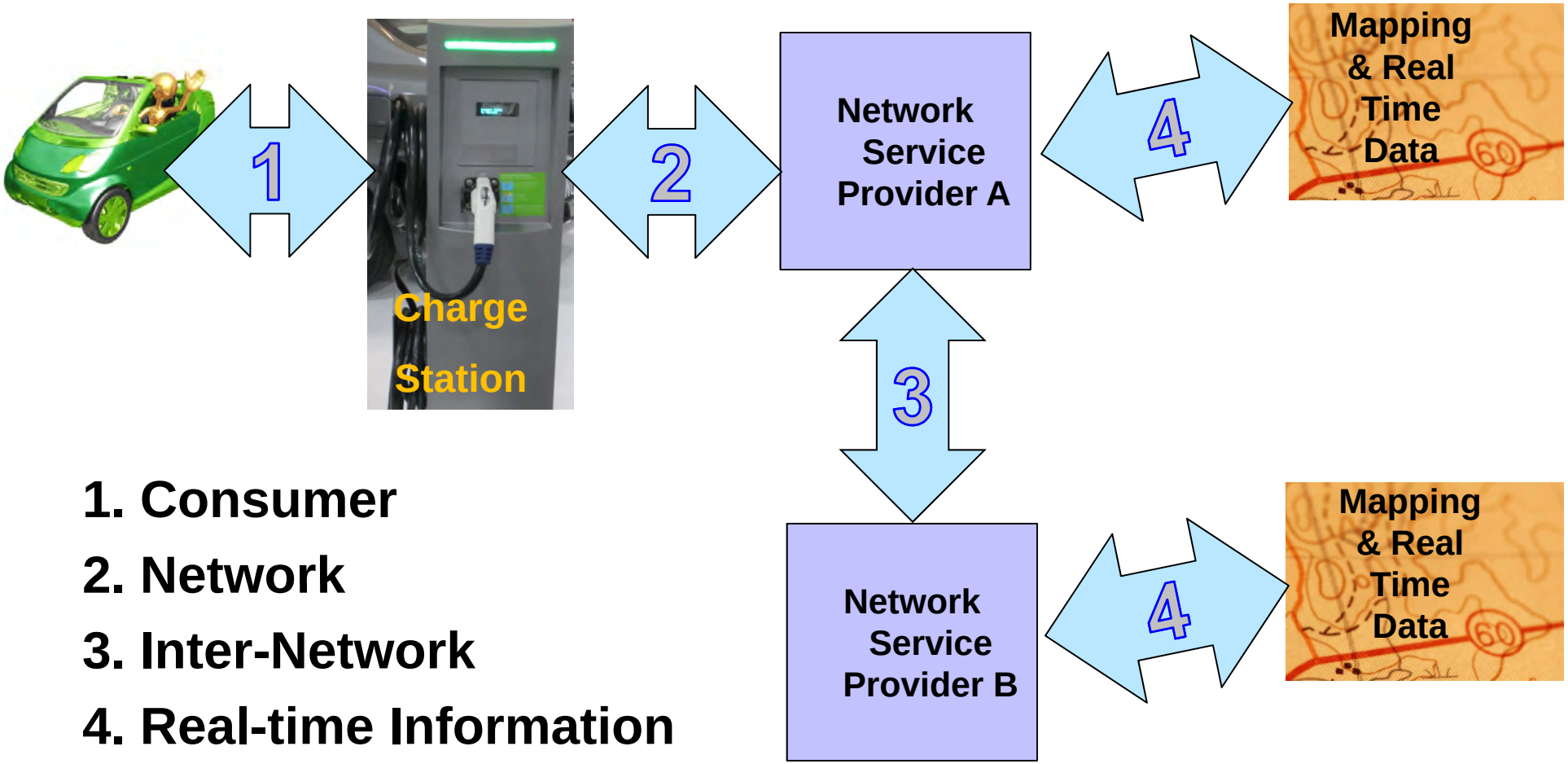


We expect most charging to occur at home

Today: Four Key Points of Interoperability for Public Charging Are Not Yet Finalized

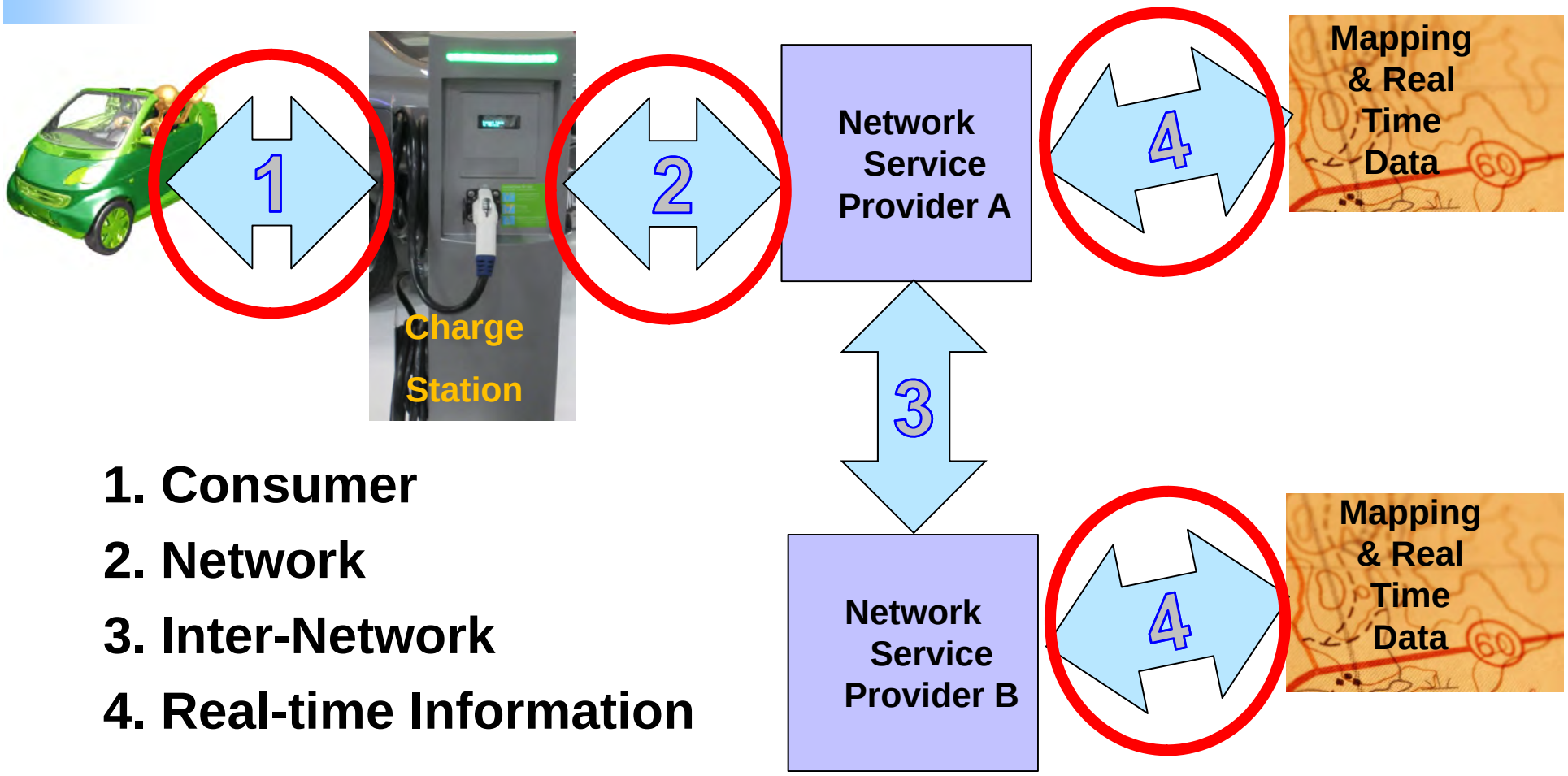
- **ATM-like access** (consumer-facing interface at the charging station)
  - Multiple forms of user authentication
  - Users must carry multiple cards and or device to roam
- **Host site lock-in** (Link from charging station to EV Service Provider)
  - Transaction and control data flow path
- **Roaming and billing** (Bridging back offices of EV Service Providers)
  - Cross network billing and data flow
- **Location and reservations** (Interfaces to external mapping/status)
  - Charge station maps
  - Real time station status
  - Ability to reserve a charge station

The Key Interfaces for Public Charging



1. Consumer
2. Network
3. Inter-Network
4. Real-time Information

The Key Interfaces for Public Charging



1. Consumer
2. Network
3. Inter-Network
4. Real-time Information

Currently these three are proprietary

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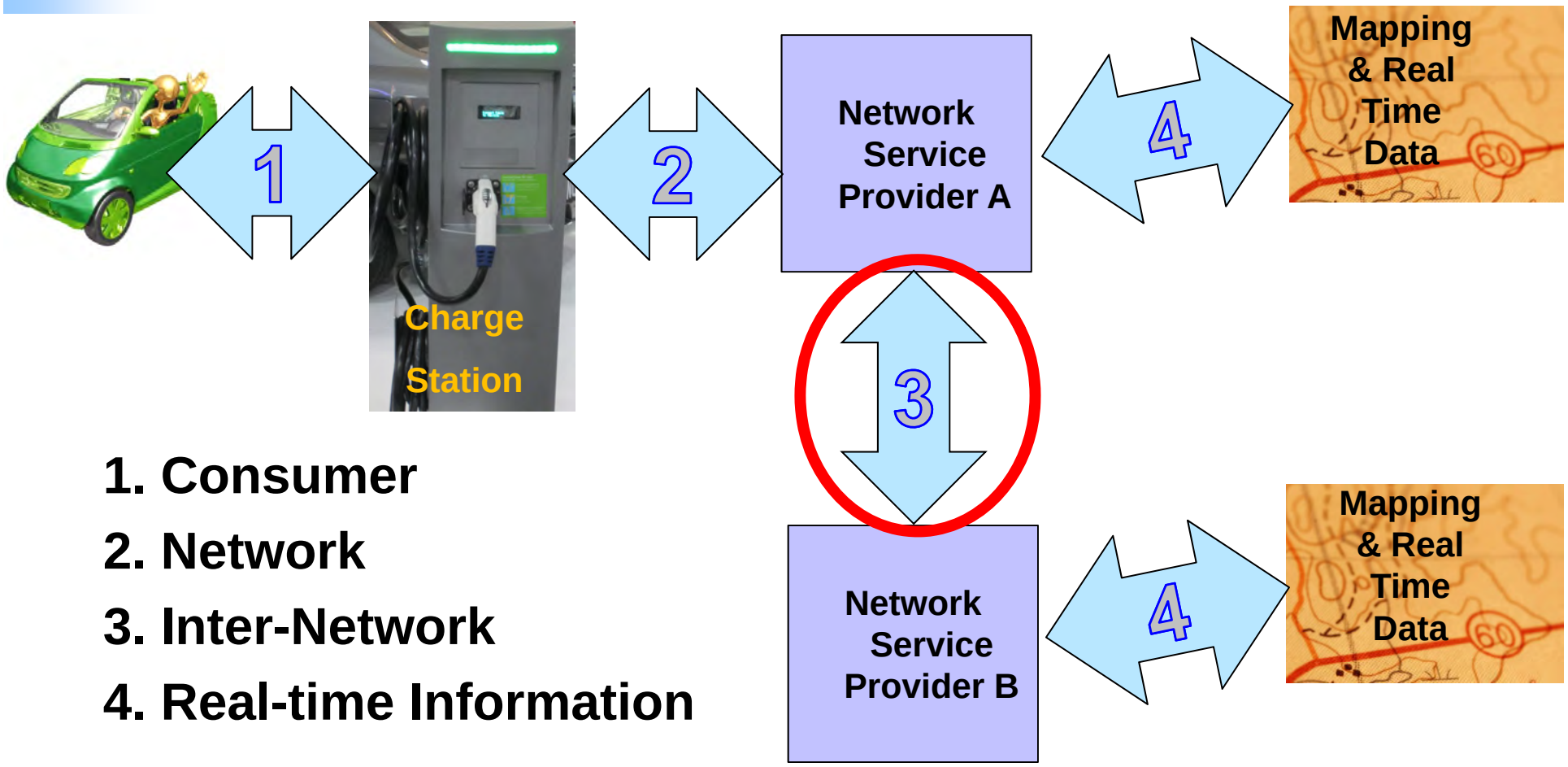
The Key Interfaces for Public Charging



1. Consumer
2. Network
3. Inter-Network
4. Real-time Information

Currently this interface does not exist

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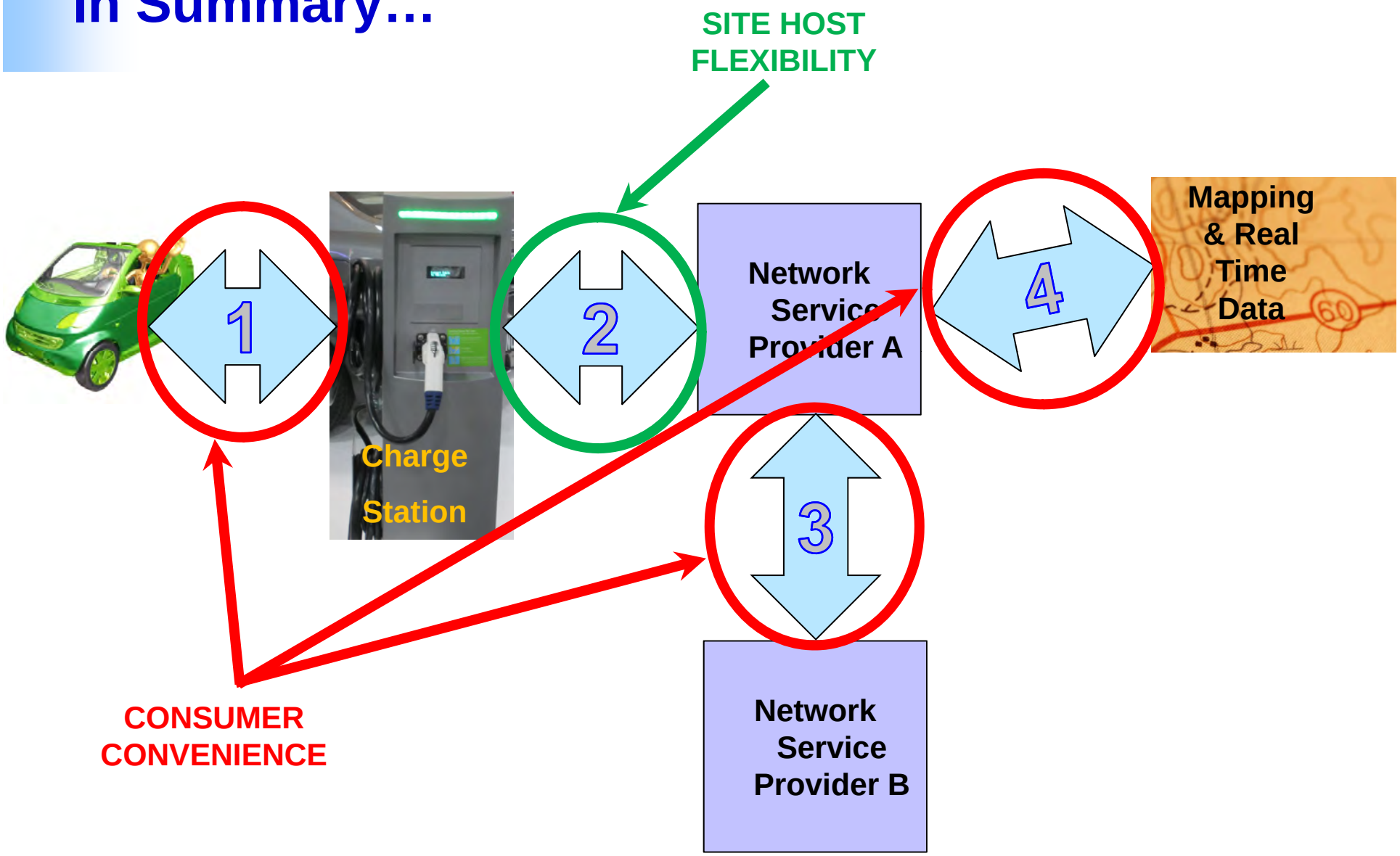
In Summary…



The Short-Term Future: DOE/South Coast AQMD PHEV Medium-Duty Truck and Van Demonstration

- Deploy ~290 plug-in trucks and vans
- 60+ utilities, municipalities, and companies
- 23 states plus Washington DC
- Collect driving and operational data through July 2015

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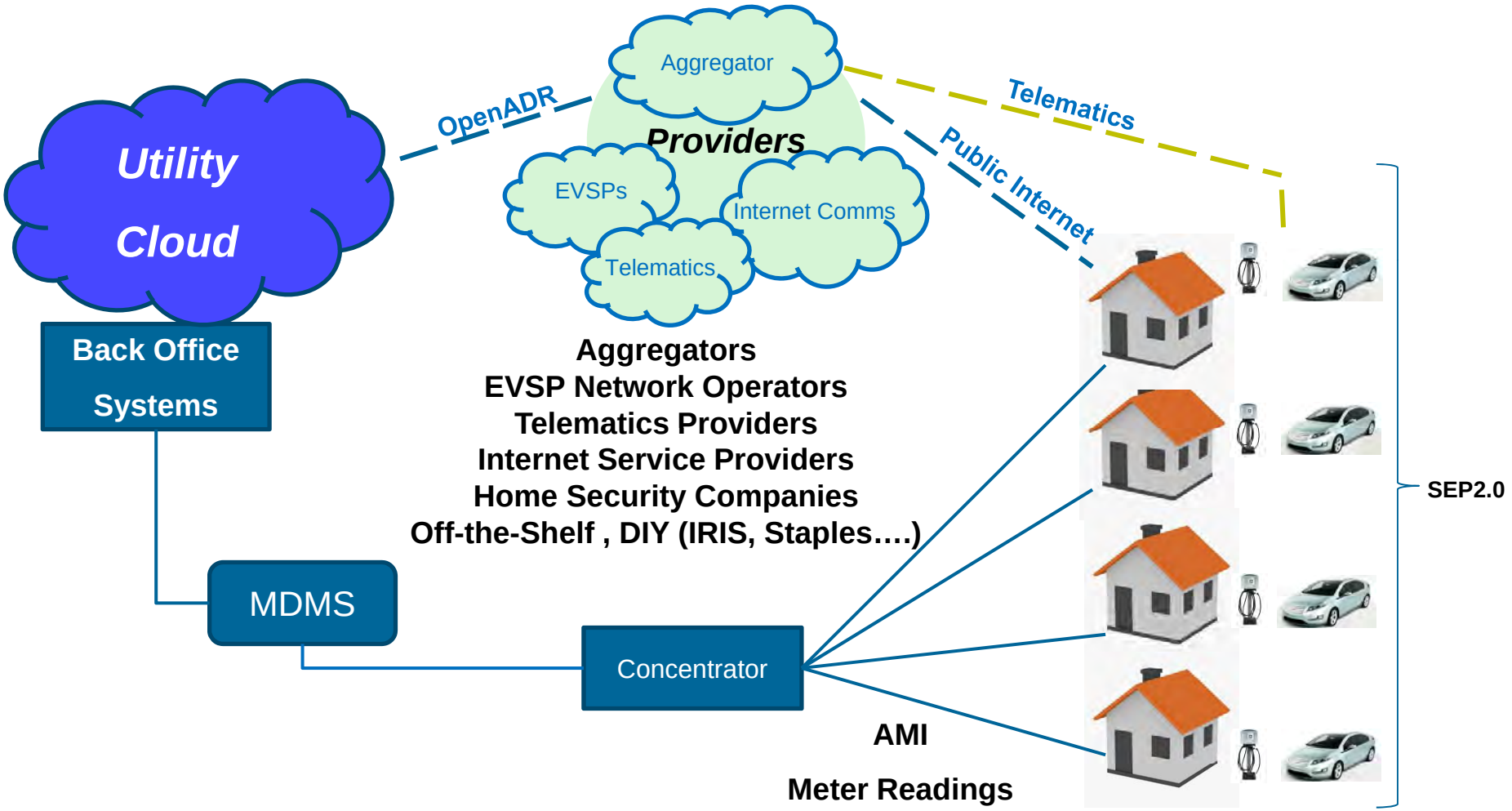
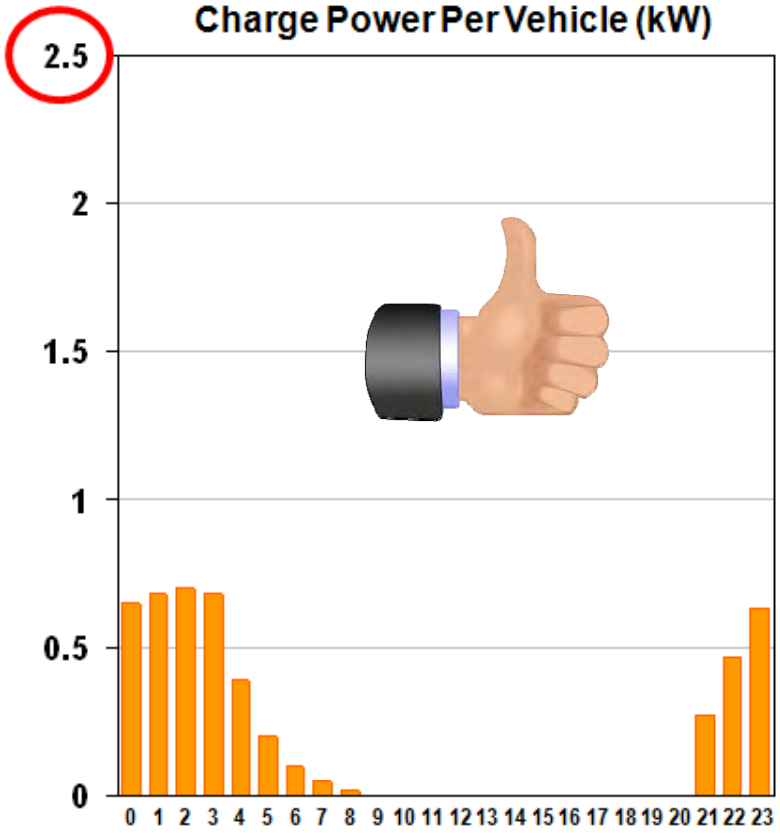
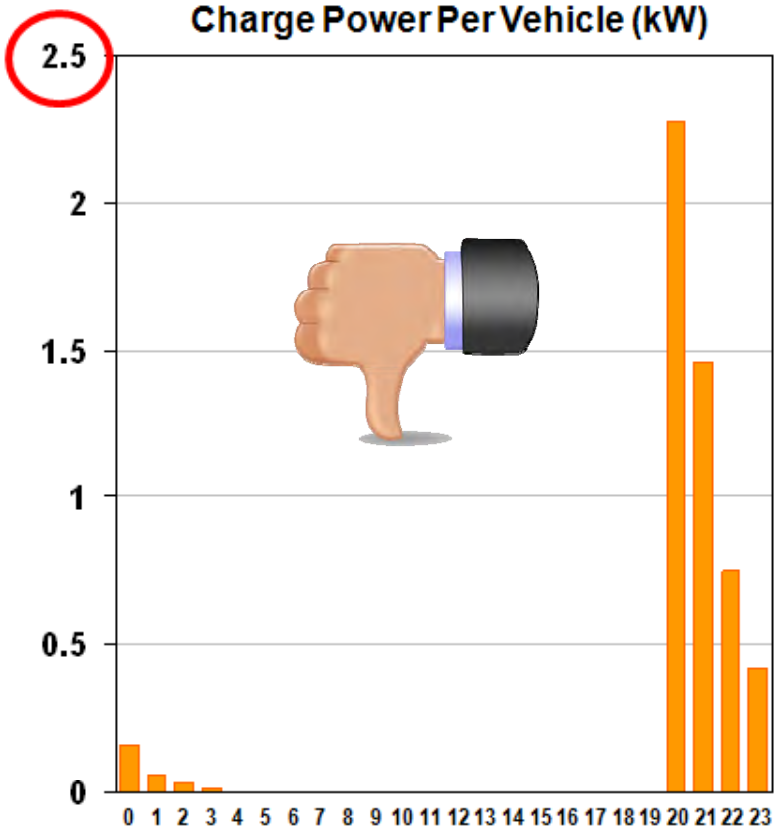
The Future: The Emerging Smart Charging Landscape Is Complex With Unknown Outcome(s)



The Future: Smart Grid-Enabled PEVs Performing Smart Charging To Alleviate Stress On Grid



Shifts the charge load to nighttime, but spreads it out relatively evenly over 6 hours



Only shifting the time without evening out the profile can make the situation worse

Smart Charging can eliminate significant impact on grid if done right

***Source**: EPRI Analysis*

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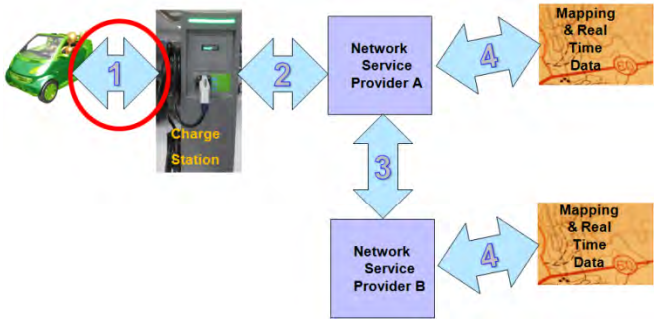
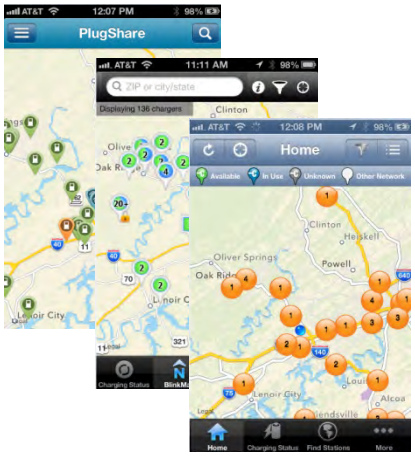
Together…Shaping the Future of Electricity

1A. The Consumer Interface



- Authenticates user
- Enables payment collection
- Many forms:
  - Phone app
    - Log-in
    - Scan a QR code
  - Credit card
    - Non-contact
    - Swipe
  - Call a Phone Number
  - RFID card
  - Key fob/dongle
  - PIN number



How many cards/dongles/phone apps/PIN numbers do I need?

Do all public EVSEs need to be on a network?

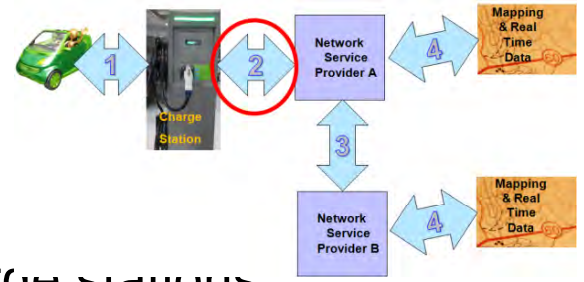
1B. Power/Energy Metering Data

- **NEMA – EVSE Embedded Sub-metering Work Group**
  - **Contacts: Ken Brown; Andrie Moldoneavu**
  - **http://www.nema.org/Products/Pages/Electric-Vehicle-Supply-Equipment-System.aspx#technical**
  - **http://www.nema.org/news/Pages/New-EVSE-Working-Groups-Created-to-Address-Key-Gaps-in-EV-Standards.aspx**
- **NIST – U.S. National Work Group on Measuring Systems for Electric Vehicle Fueling and Submetering**
  - **Juana Williams**
  - **http://www.nist.gov/pml/wmd/usnwg-evfs.cfm**
- **NIST – SGIP PAP 22 – EV Fueling Submetering Requirements**
  - **http://sgip.org/pap-22-ev-fueling-submetering-requirements/**
- **ANSI C12 Committee – starting an update to ANSI C12**
  - **Alex Yan (PG&E) is chair of subgroup**
- **California ISO - Expanding Metering and Telemetry Options**
  - **http://www.caiso.com/informed/Pages/StakeholderProcesses/ExpandingMetering-TelemetryOptions.aspx**

1C. Direct Connection to Vehicle

- SAE J2836/J2487/J2953 –
  - HomePlug GreenPHY over Pilot wire
  - Using SEP2.0 protocol
- Telematics
- Hybrids of SAE J2836 and Telematics
- EPRI has several projects underway in this space

2. The Network



- This connection supports data flow between the charge stations (EVSE) and the network operator (EVSP)
  - User authentication; Payment; Station management
- Often uses public internet (via cellular modem or a wired connection)
- Might support other services
  - Maintenance
  - Data collection
  - Advertising

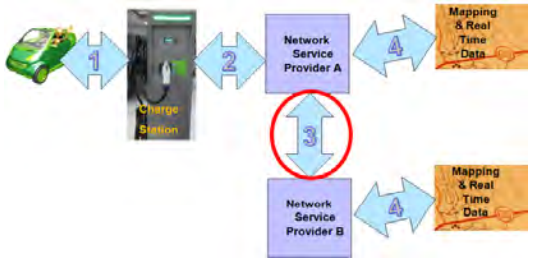
A Proprietary Network Means:

Selection of a charge station is limited to those that support a particular Network

Installed charge stations are locked to only those networks they can support

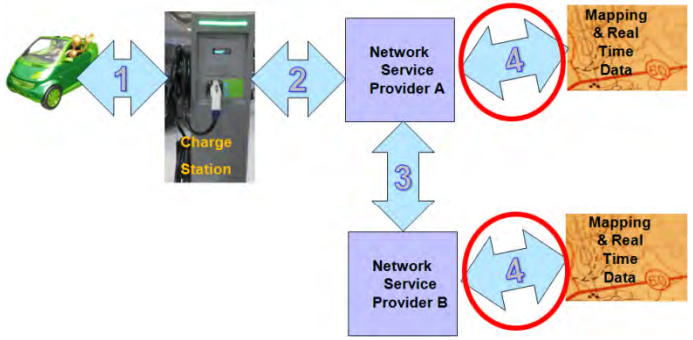
- Open Charge Alliance formed to developed “Open Charge Point Protocol” – OCPP version 2. Open protocol designed to allow any charging station to use any OCCP based network; a site owner is not locked in to specific network provider

3. The Inter-Network Interface



- Currently consumers must have an account with each network provider they wish to use
- Linking networks would allow consumers to roam across networks but receive a single bill
- If **all** network providers participated, then consumers need only carry one set of credentials
- Offers potential for combined real-time data and mapping
- The National Electrical Manufacturers Association (NEMA) has a group working in this area.
- This link does not exist today
  - Collaboratev is an organization designed to fill this role (http://www.collaboratev.com/)

4. REAL-TIME INFORMATION



- Enables mapping applications that include all network brands
- Ability to make a station reservation across networks from one application
- Consumer won't have to consult several maps to see all charge station options
- Collaboratev plans to provide unified mapping
  - Would only support members of Collaboratev

Link for third parties to see Network data – primarily station status for map applications and potentially reservations

What's Different About a standard like OCPP and clearing house like Collaboratev?

- Standard Backhaul (like OCPP)
  - Provides a standard path from EVSE to EVSP
  - Enables EVSE owner to change networks without replacing hardware
  - Prevents EVSE being stranded by a network provider going out of business
  - Doesn't address roaming across networks or common user credentials
- Network Clearing House (like Collaboratev or Hubject)
  - Allows consumers to roam across networks (note that the consumer may have to pay a roaming charge)
  - All networks must participate to enable seamless roaming for consumers
  - Needs to provide a common user credential to fully address roaming
  - There is a cost for this service – someone must pay
  - EVSE can still use a proprietary backhaul and participate
  - Doesn't prevent stranded EVSE if a network provide fails

Provide Complementary Functions

Summary

Proprietary Interfaces Lead To:	Interoperable Solutions Offer:
Consumers must carry multiple credentials	One Standard Credential
Consumers must belong to multiple networks	Networks Linked
Fielded chargers locked to a particular network	EVSE can work on any network
Charge stations forced to support multiple proprietary network protocols	EVSE only need to support a single protocol
Limited access to real-time data for mapping, reservations	Broad consumer access to real time charge station data