EVs@Scale
U.S. Department of Energy

Jason D. Harper
ANL EV-Smart Grid Interoperability Center
Advanced Mobility and Grid Integration Technology
May 18, 2023

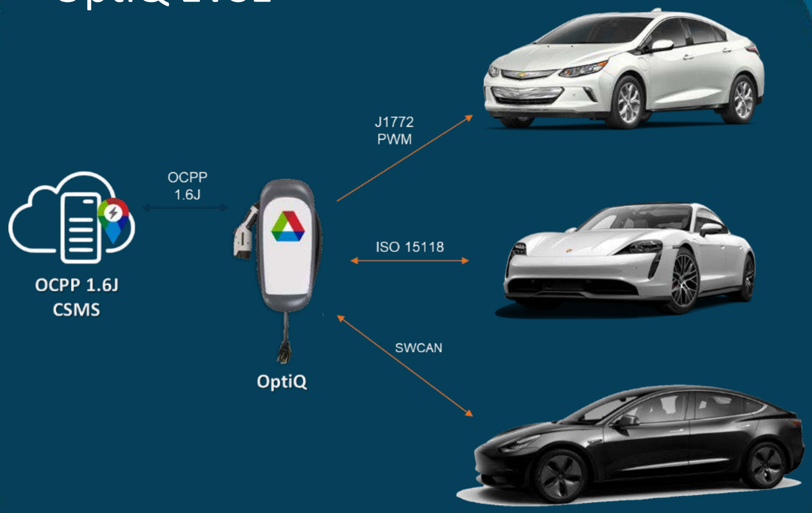
Smart Charge Management and Vehicle Grid Integration: FUSE

Research, Development and Demonstration

Argonne FUSE RD&D

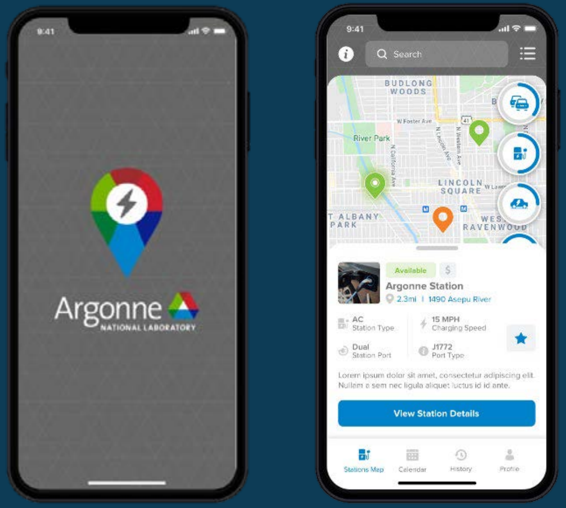
Overview

OptiQ EVSE



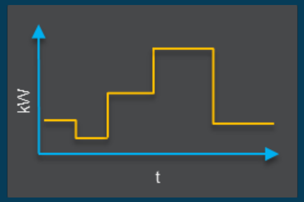
- Smart EVSE Capable of 3 "versions" of AC Charging
  - Analog (J1772 PWM)
  - Digital (ISO 15118-2)
  - Digital (Tesla SWCAN)
- 2 Proof of Concept Stations Deployed at Argonne for Employee Use
- Recently Demonstrated ISO-15118-2 Charging

EVrest



- EV Charge Reservation Mobile App
- Allows EV Drivers the Ability to Reserve a Specific Port/Station for Future Use
- Integrates with ANL's OCPP CSMS Platform to Enable Future Smart Charging Algorithm Development and EV Charging Behavior Research

Smart Charge Scheduling



- ISO 15118-2 and OCPP 2.0 based smart charge scheduling demonstration
- Smart charge scheduling meets the needs of all actors in the charging ecosystem
- Developed a charge scheduler bridge application to integrate non-ISO-15118 vehicles into the charging scheduling platform

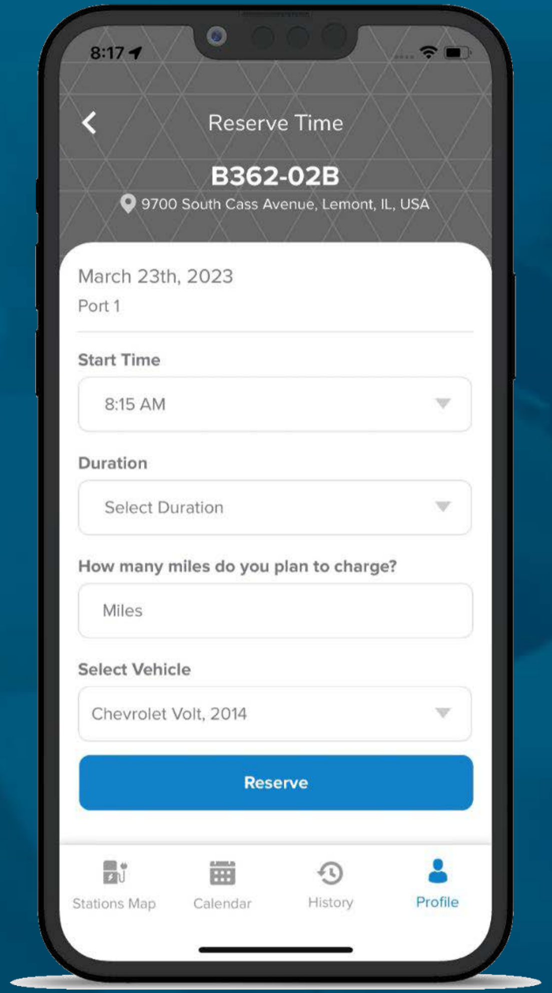
Charge Scheduler Bridge Development

Charge Scheduler Bridge

What is it and Why is it needed?

Charge Scheduler Bridge

- **Middleware Application that Integrates with EVrest and the ISO 15118 Charge Scheduler to Schedule EV Charging on Behalf of non-ISO 15118 EV/EVSE**
- **Needed to enable optimized charge scheduling for non-ISO 15118 EV/EVSE**



Goal

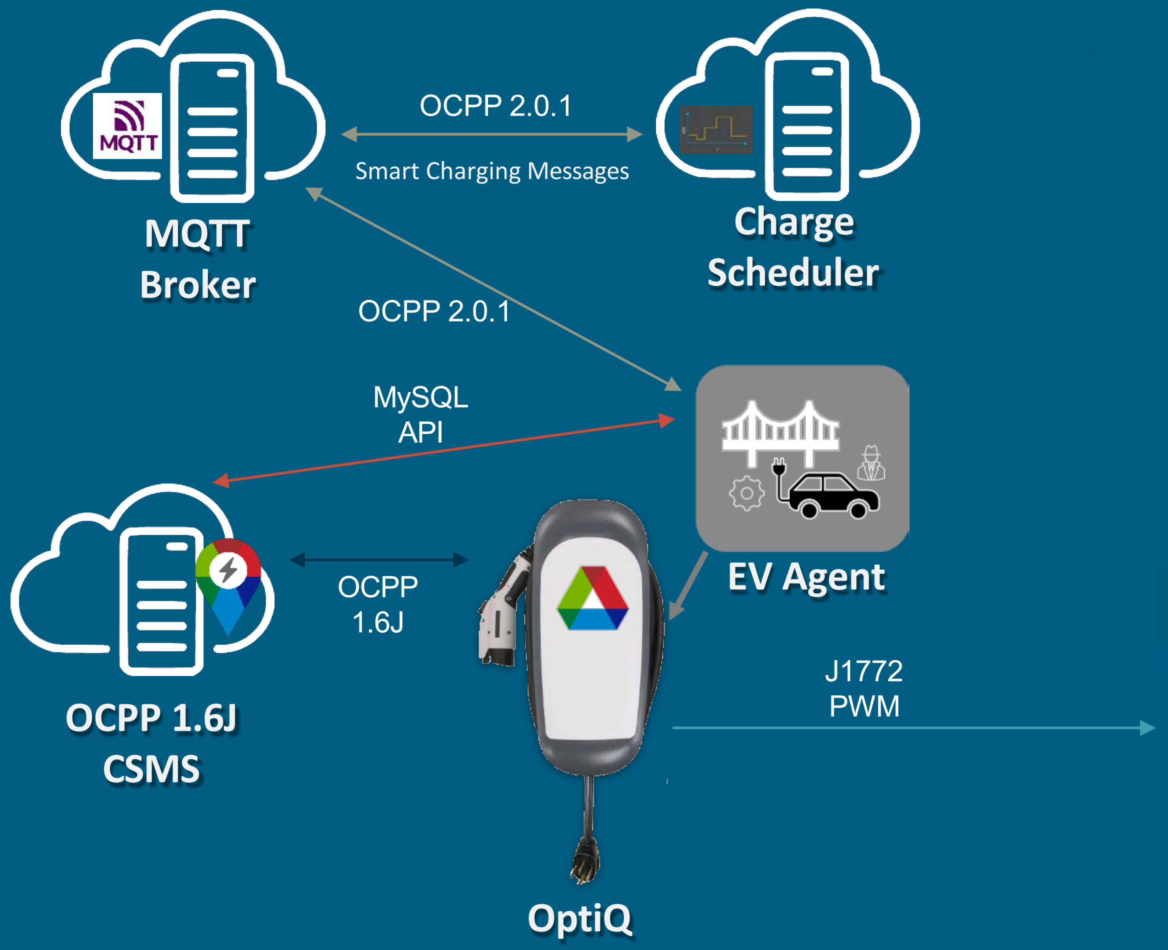
- **Work with any OCPP 1.6J station (integrated in EVrest)**
- **Work with any AC J1772 EV**

Key Elements of a Charge Schedule:

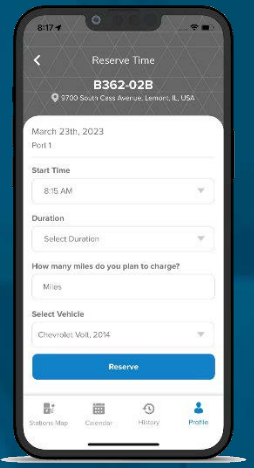
- Charge Start Time
- Charge End Time
- Requested Energy (kWH)
- Max Rate of Charge (kW)

System Diagram

POC Demonstration Setup

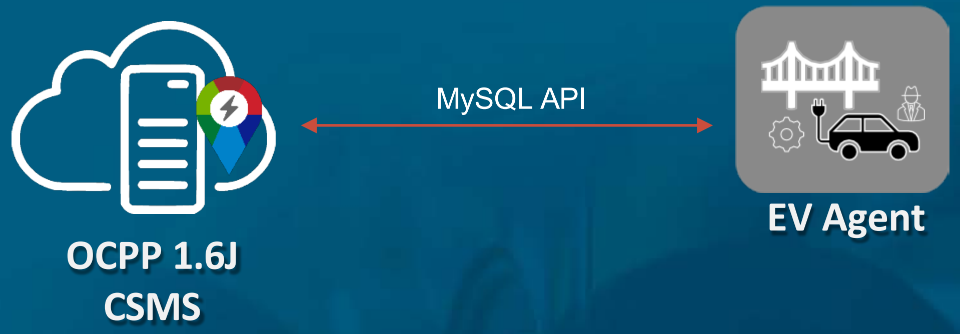


- EV Agent deployed on OptiQ EVSE
- Communicates with EVrest (MySQL) and Charge Scheduler via MQTT



EV AGENT

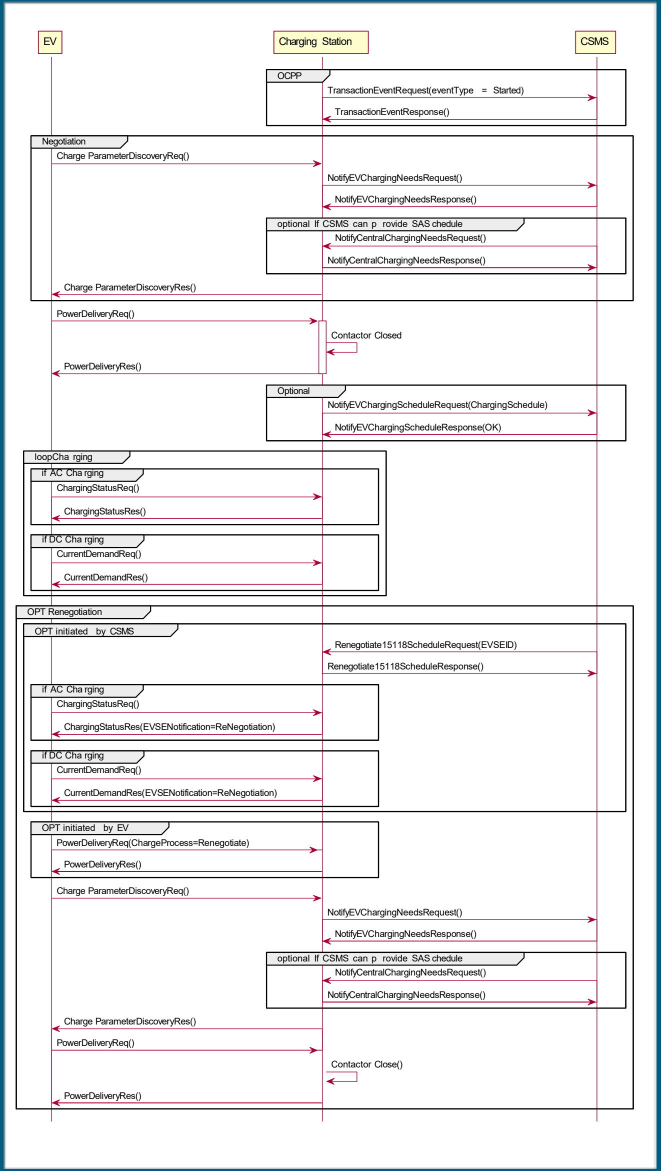
- 1 Agent per EVSE port deployed on platform
- Upon PEV plugin, Agent queries EVrest platform for any active reservations (within 15 minutes)
- Active Reservation?
  1. Record the following for future use:
     a) EVSE Port ID
     b) Reservation ID
     c) Driver Vehicle ID
     d) Reservation Start Time
     e) Departure Time
     f) Requested Electric Miles
  2. Utilizing the Driver Vehicle ID, fetch the electric mile to kWH conversion factor for that make/model of EV
  3. Fetch the average peak power of this vehicle over the past charging history

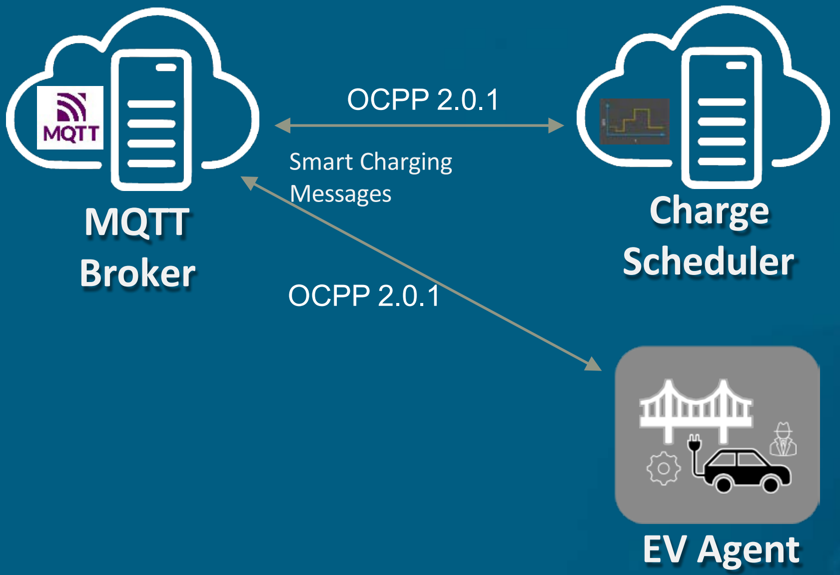


Key Elements of a Charge Schedule:

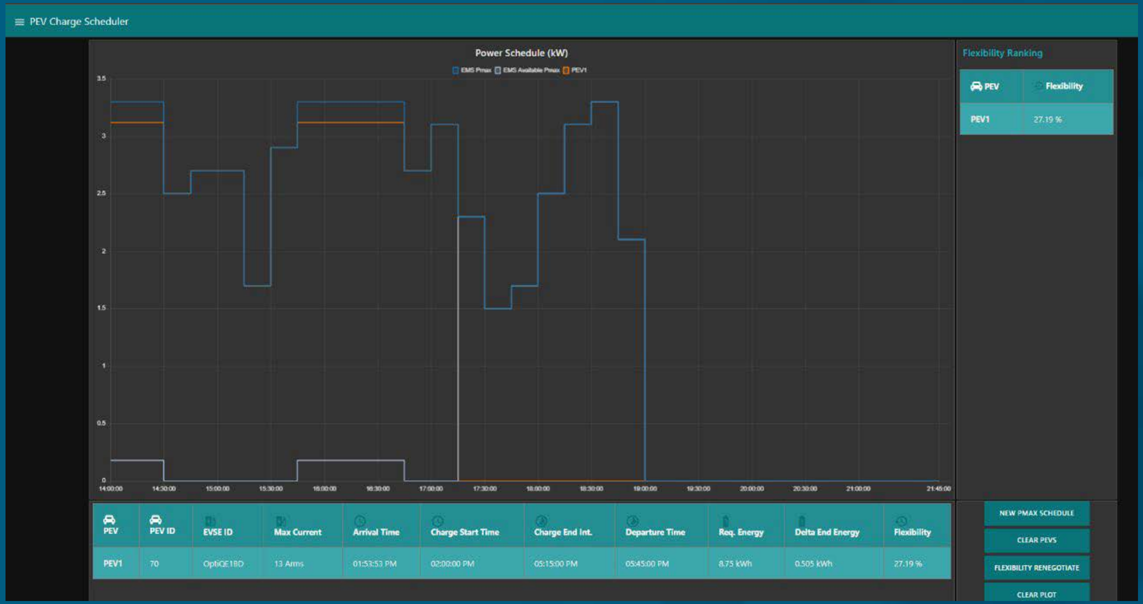
- Charge Start Time
- Charge End Time
- Requested Energy (kWH)
- Max Rate of Charge (kW)

EV AGENT





EV Agent negotiates initial charge schedule with the Charge Scheduler



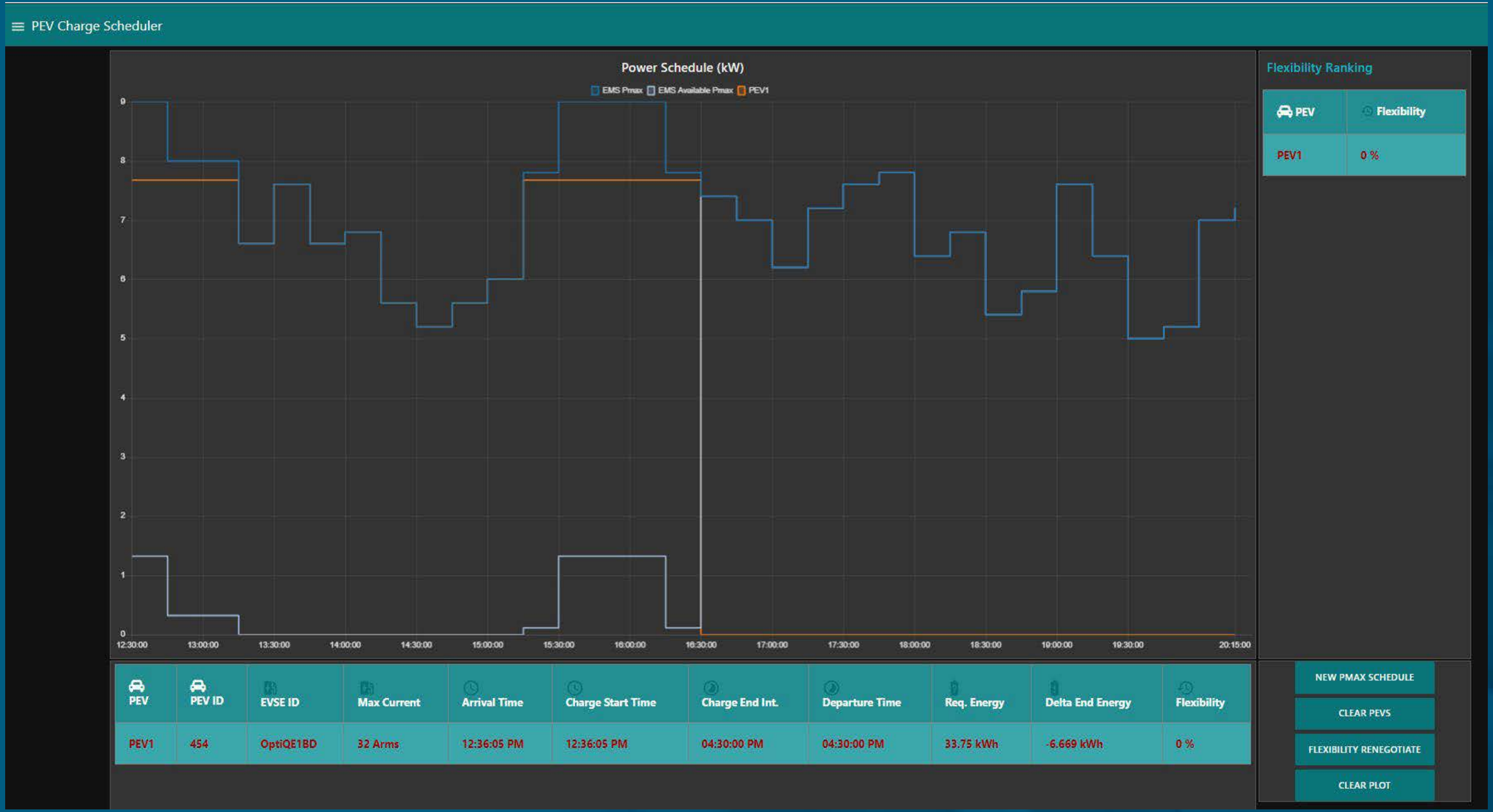
Schedule is shared with OptiQ OCPP Client

Duty Cycle is changed by OptiQ application following the charge schedule

2021 Porsche Taycan

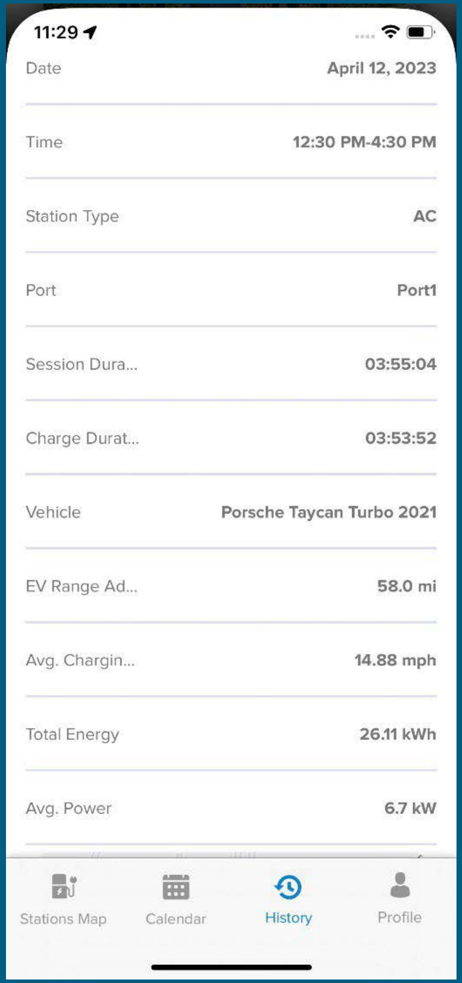
Scheduler Bridge Demo

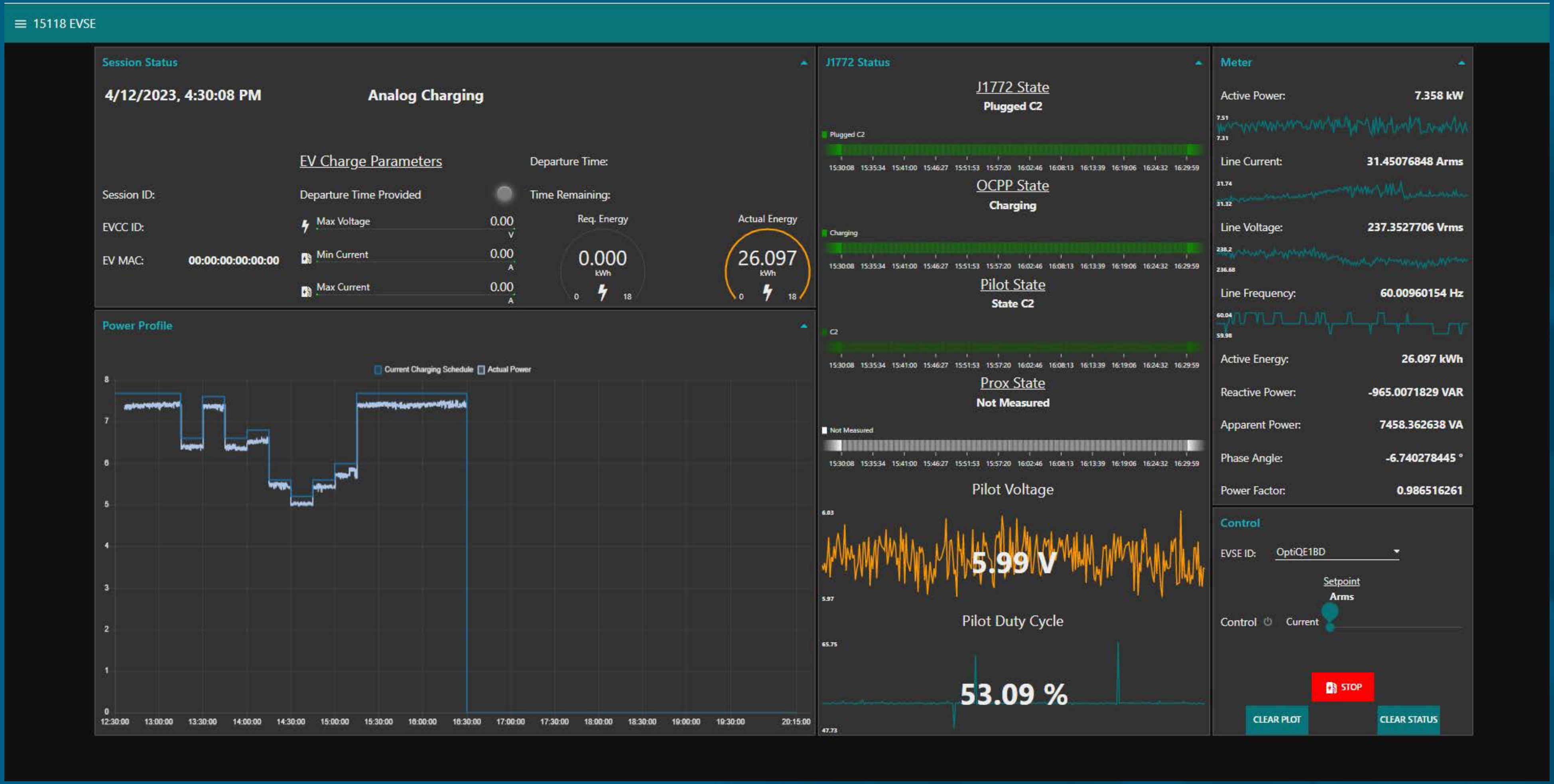
- Requested Range: **75 miles**
  Requested Energy: **33.75 kWh**
- Reservation Start Time: **12:30 PM**
- Reservation End Time: **4:30 PM**
  Pred. Charge End Time: **4:30 PM**
  Pred. Energy: **27.08 kWh**
- Max Rate of Charge: **7.68 kW**
  Line Voltage: **240 Vrms**
  Max Current: **32 Arms**



2021 Porsche Taycan

Scheduler Bridge Demo





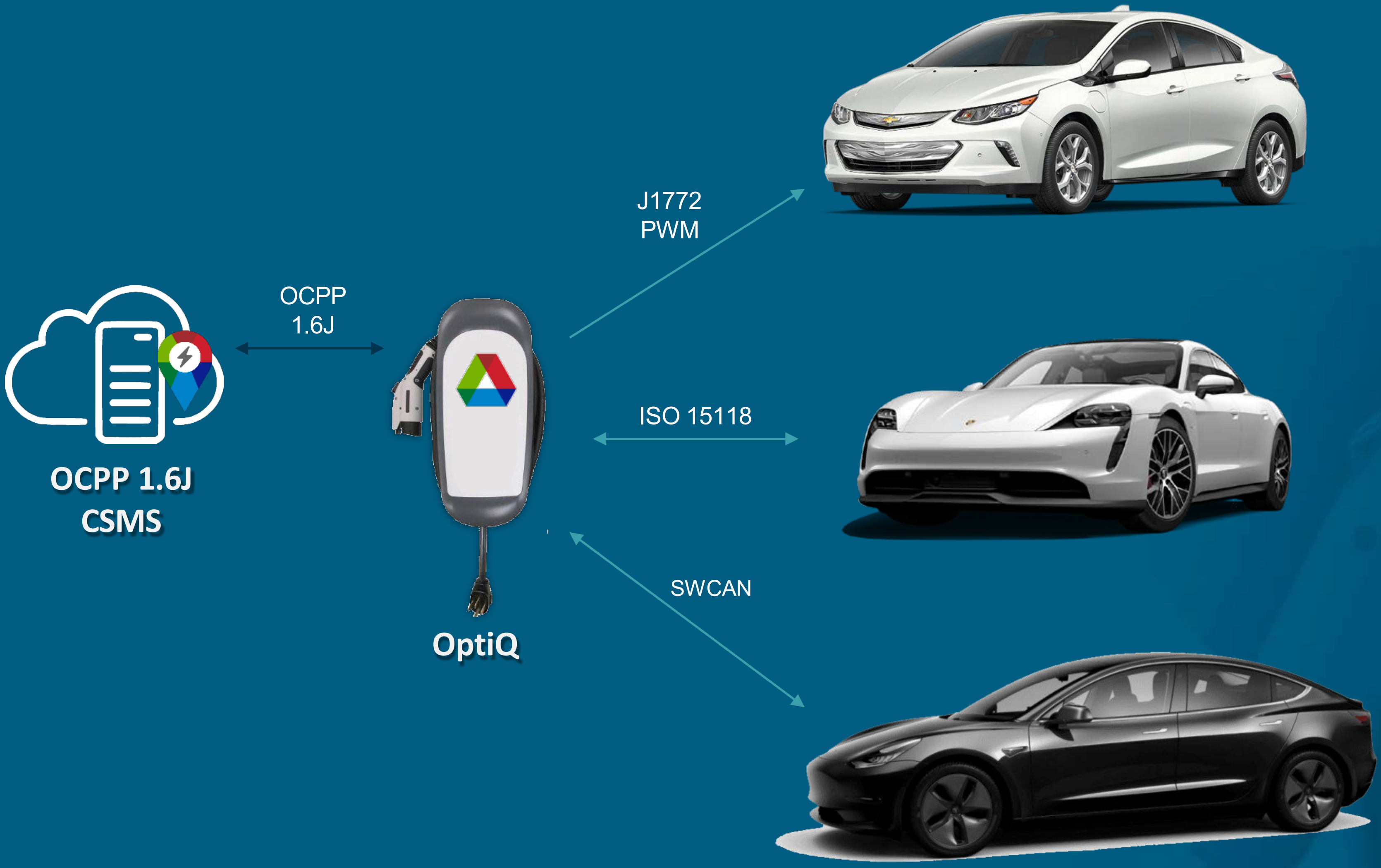
Pred. Energy: 27.08 kWh

Actual Energy: 26.11 kWH

OptiQ 15118-2 Demonstration

OptiQ

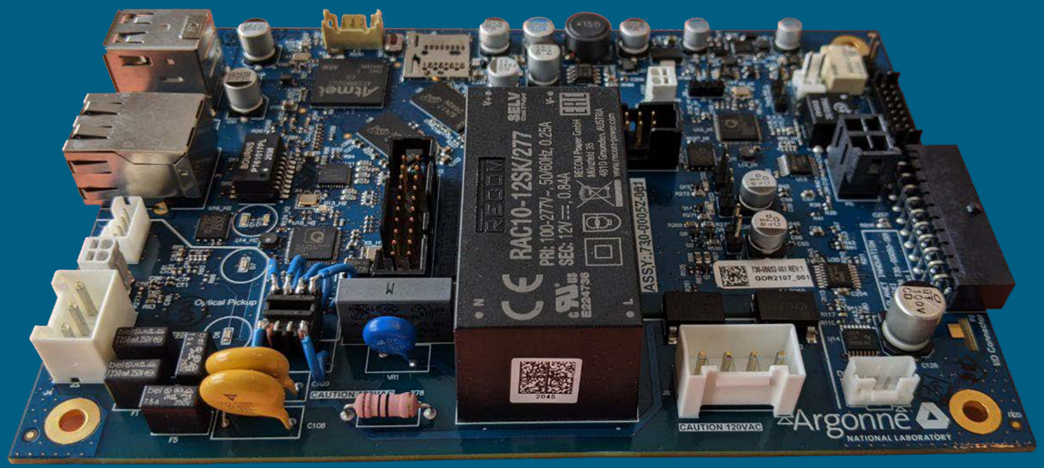
Smart AC L2 EVSE Overview



- Revenue Grade AC Submeter
- Uniqueness:
  - Tesla SWCAN
  - ISO-15118
  - J1772 (PWM)
- Configurable PHY interfaces:
  - Wi-Fi, Ethernet, Cellular, or PLC over mains
- OCPP 1.6J to CSMS
- Enables Smart Charge Scheduling

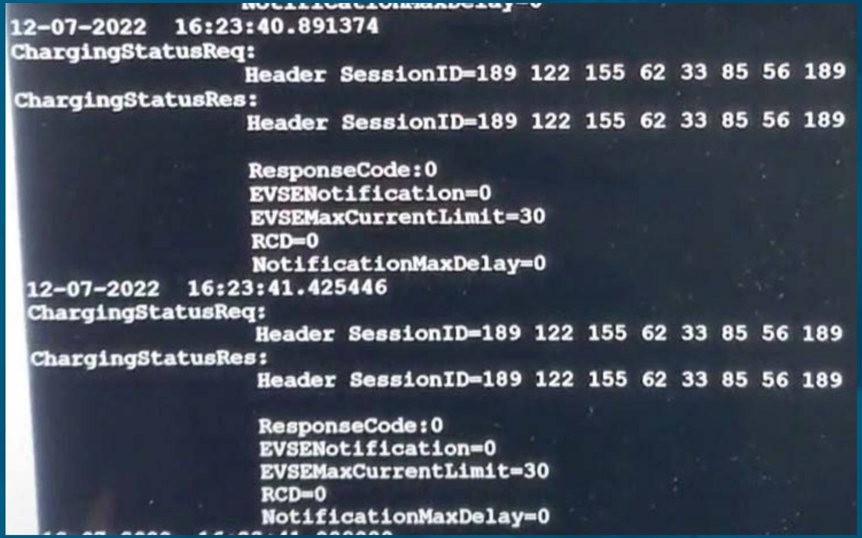
Background

- ISO 15118-2 (non-TLS, EIM) SECC application with metering developed for SpEC II module
- OCPP 1.6J client (non-TLS) also developed
- Tested with the following ISO 15118-2 AC enabled vehicles:
  - 2021 Porsche Taycan
  - 2015 Smart ED



Observations

- SOC is not provided or updated in ISO 15118-2 for AC charging
- 15118-2 ‘Pseudo’ Dynamic Controlled Charging can be accomplished by modulating the “EVSEMaxCurrentLimit” signal in the ChargingStatusRes message. The frequency of the ChargingStatusReq/Res message is EV model dependent:
  - 2015 Smart ED: ~10 sec
  - 2021 Porsche Taycan: ~ 0.5 sec
- Smart Charge Scheduling
  - 2015 Smart ED: Enabled without TLS
  - 2021 Porsche Taycan: Enabled but seems to require TLS



Next Steps

- Tesla SWCAN AC EVSE application has been developed
- Integrate Tesla SWCAN emulation into existing OptiQ application
  - Goal is for the single application to determine the “type” of EV that is connected and utilize the proper protocol
- Add TLS option to OptiQ application and test further with Taycan

Thank You

Jason D. Harper
jharper@anl.gov

EVs@ Scale
U.S. Department of Energy

VGI/SCM Deep Dive Discussion:
May 18th 2 – 5 pm EDT

We need your input to identify:

- **Partners** for our R&D efforts to help with insight, data, and other resources.
- **Progress** in our activities to ensure timely research is available to key stakeholders
- **Priorities** for R&D that accelerates the transition to EVs at Scale.

EVs@Scale
U.S. Department of Energy

Grid modeling – distribution feeders

Shibani Ghosh, NREL

Grid Analysis Approach

EVs@Scale
U.S. Department of Energy

Prototyping grid impact analysis on a utility's service territory

Selecting Regions

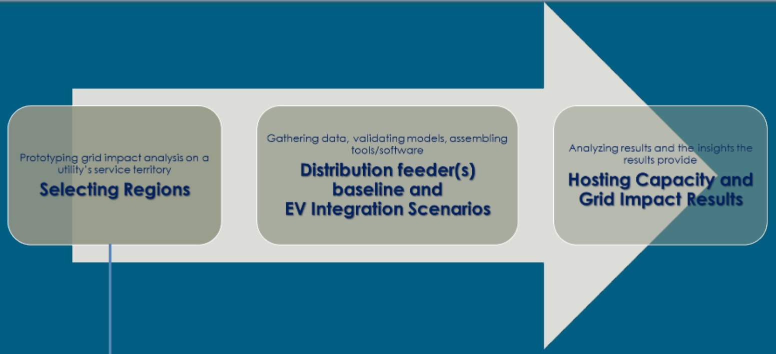
Gathering data, validating models, assembling tools/software

Distribution feeder(s) baseline and EV Integration Scenarios

Analyzing results and the insights the results provide

Hosting Capacity and Grid Impact Results

Utility Partnership



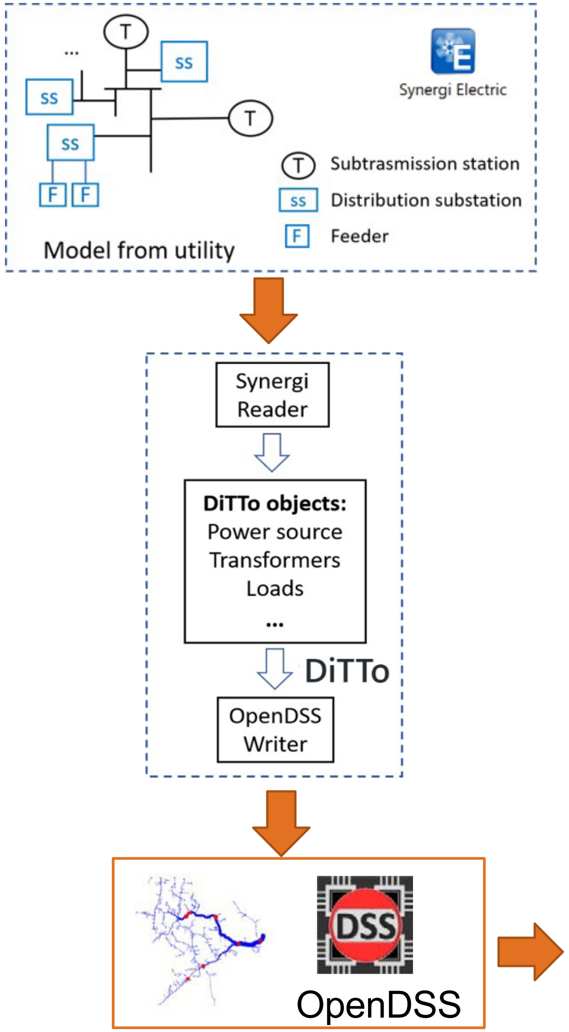
Dominion Energy

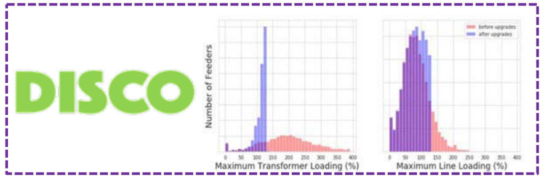
- 16 states (Selected region: **Virginia**)
- 7 million customers
- Headquartered in Richmond, VA
- Expected feeders: >100

Updates: NREL and Dominion counsels are in discussion to complete Dominion's cyber security clearance process

NREL Grid Update

- **Grid model conversion process through NREL-DiTTo**





Next steps

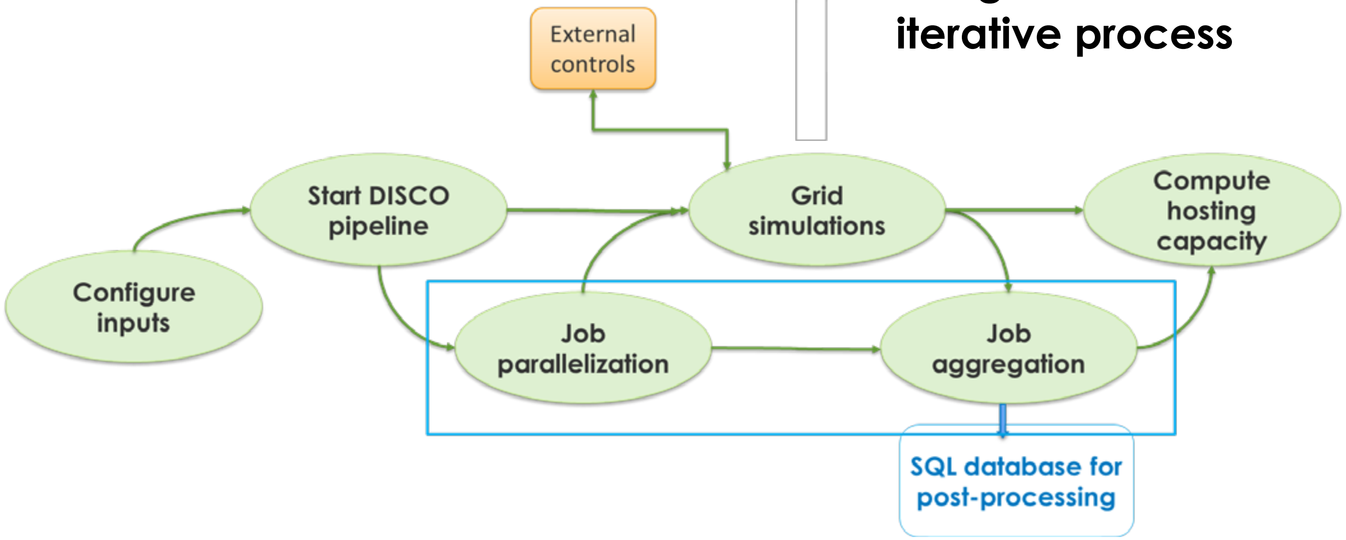
- Collect distribution grid models including topological and electrical characteristics of existing assets such as lines, transformers, loads and control devices from utility
- Transform utility dataset into OpenDSS models using DiTTo
- DiTTo has been updated to prepare for anticipated feeder models
- Conduct an initial distribution grid baseline analysis through an in-house tool, DISCO
- EV hosting capacity and placement will be evaluated for the selected feeders, revealing how much additional load the grid can accommodate in terms of EVSE loads

EVs@Scale
U.S. Department of Energy

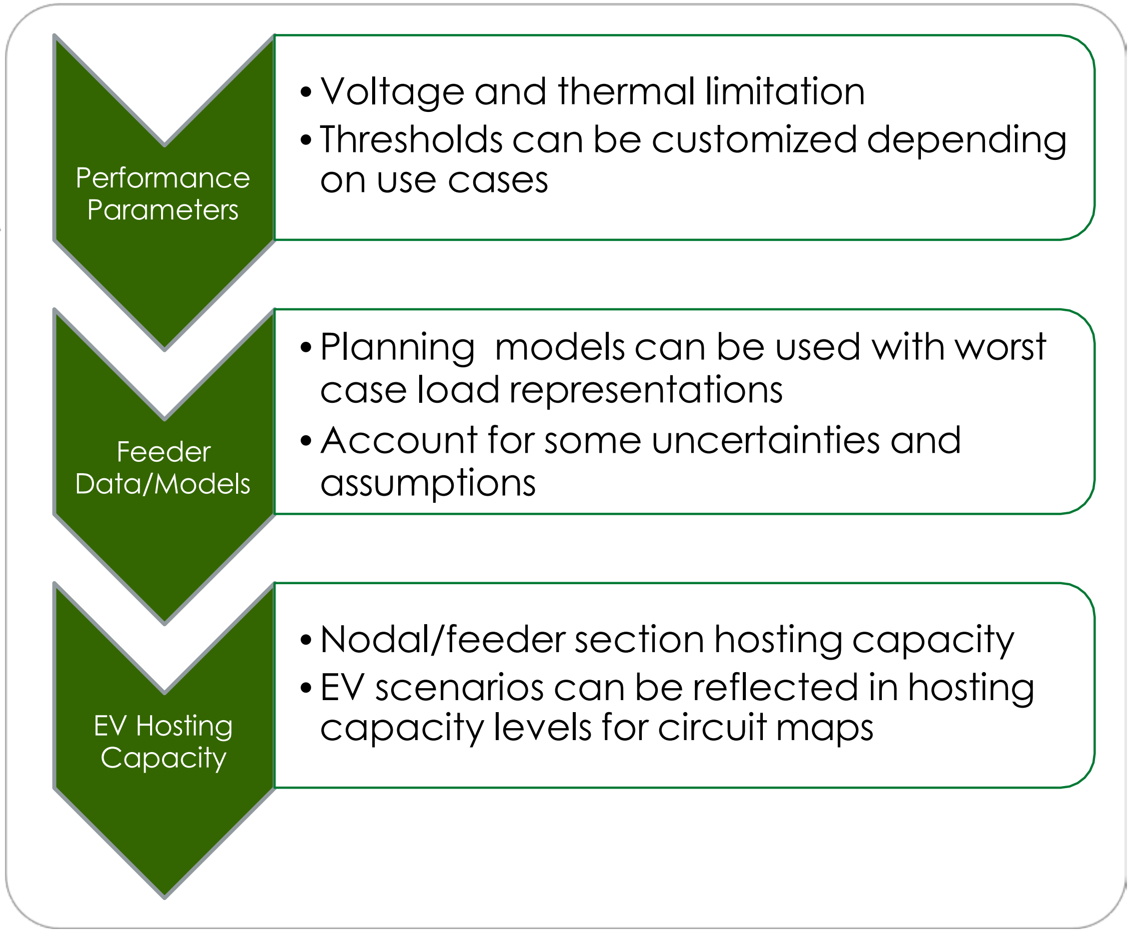
- **Computing hosting capacity at scale**

DISCO

- Provides a modular framework for distribution systems analysis
- Open-source Python application
- Can work on Laptop, standalone server, or HPC cluster to scale up number of simulations



Conducts EV hosting capacity for N number of feeders using the same iterative process



Next steps

- Collect, prepare, condition input datasets from Dominion Energy
- Convert into OpenDSS models
- Verification and validation of feeder models
- Baseline grid simulation (static and time-series)
- Perform hosting capacity analysis for current grid conditions

EVs@Scale

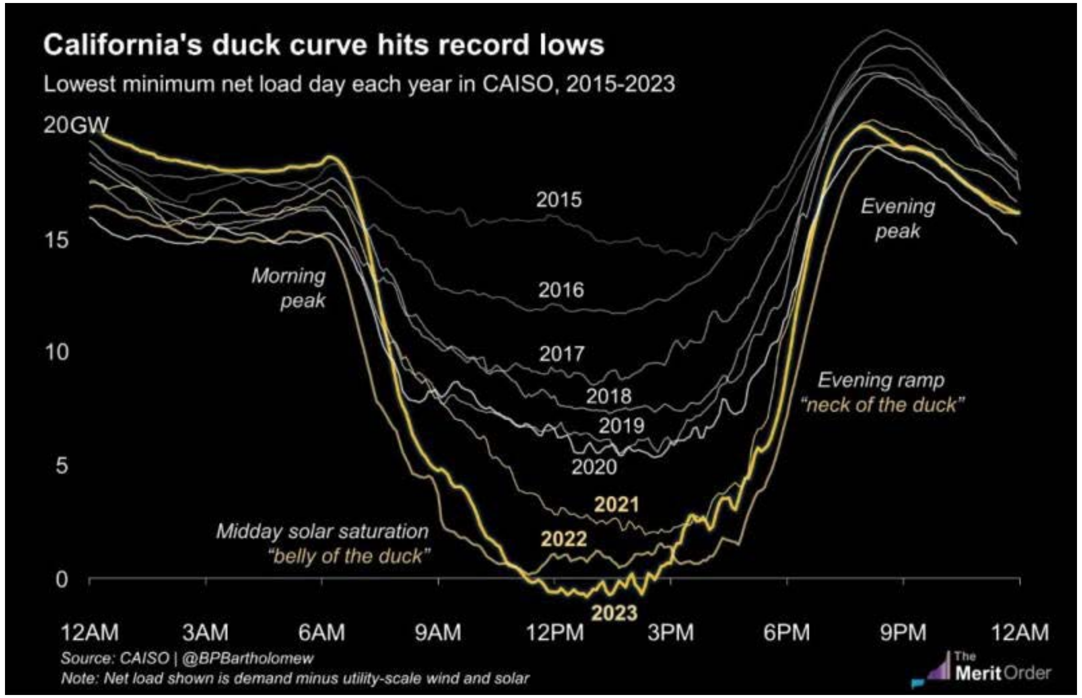
U.S. Department of Energy

EV-Specific Rate Designs and Smart Charging Management

Mingzhi Zhang (NREL)

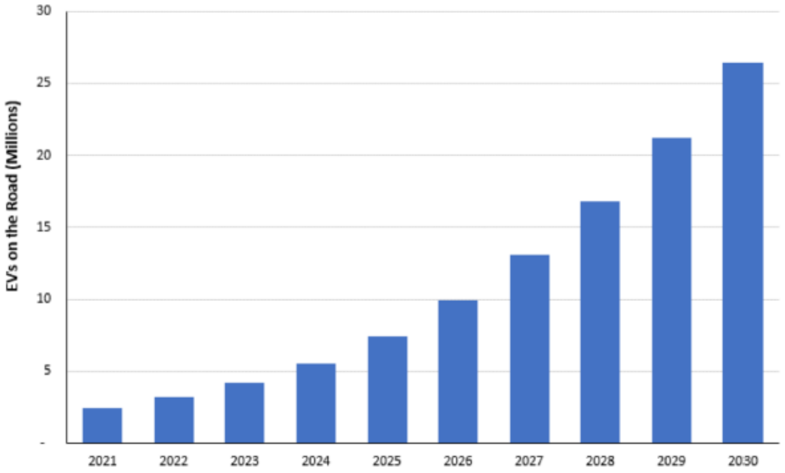
New Challenge

Duck Curve → Canyon Curve



Large scale integration of EVs into the power system: A huge burden or part of the solutions?

- On April 21, 2023, California Energy Commission (CEC) announced that California passed the 1.5 million cumulative EV sales mark. California is now focused on reaching the ambitious goal of 100% zero-emission new passenger vehicle sales by 2035.
- In the US, the total number of electric vehicle is expected to grow to over 26 million by 2030.
- **Key question: Is it possible to mitigate the potential impacts of large-scale integration of EVs by leveraging its controllability and flexibility?**



Source: EEI (2022)

Overview of Rate Designs for EVs

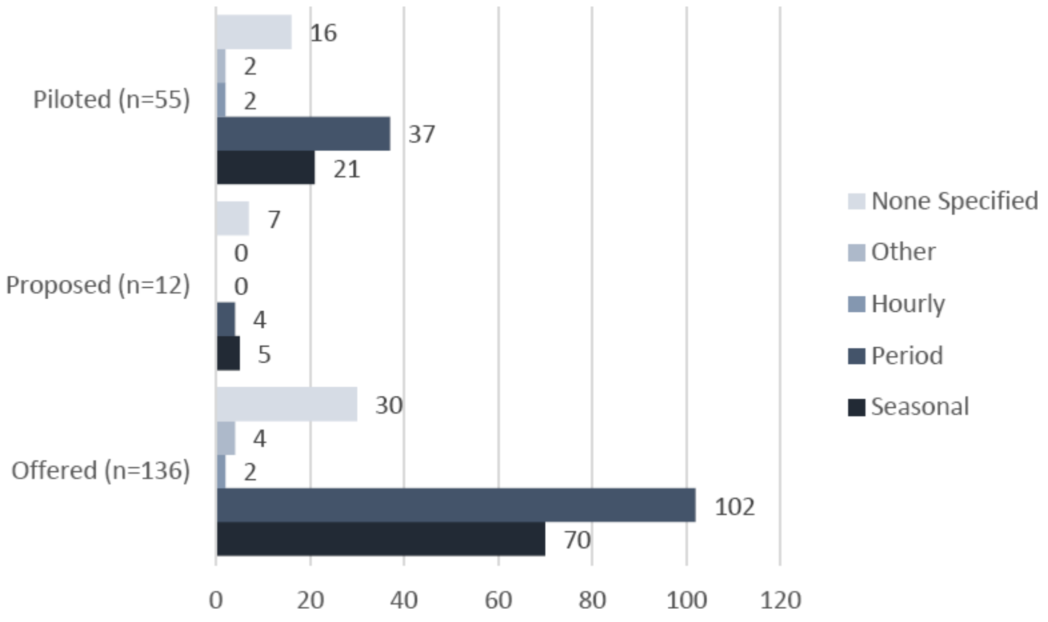
- **Time-of-Use (TOU)**
  - TOU rates during the day are usually divided into peak, mid-peak, and off-peak periods.
  - It usually changes seasonally (e.g., summer vs. non-summer months).

- **Critical Peak Pricing (CPP)**
  - CPP is activated rarely, usually with fixed time periods overlaid on top of either flat, block, or TOU rates.
  - Generally used during periods of high electricity demand, such as used for EV charging deferral.

- **Demand Charge**
  - Rate based on the maximum demand of electricity.
  - This maximum demand is measured over some period of time, typically a month.

- **Real Time Pricing (RTP)**
  - Hourly variated price signals that are updated daily.
  - Usually based on day-ahead energy market clearing results.

Count of EV-Specific Rates by Status and Temporal Differentiation [1]



- ❖ TOU is the most dominant rate design adopted by utilities for EV.
- ❖ RTP has greater temporal flexibility, there are some pilot programs for large commercial customers.

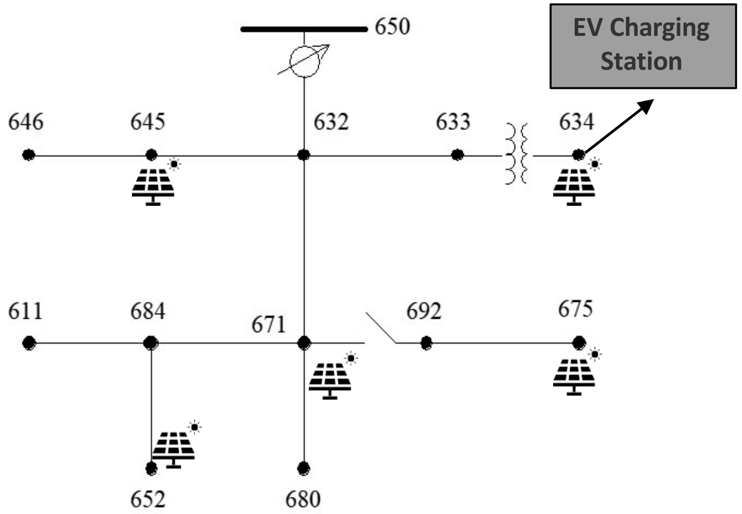
How effective the TOU and RTP for EV charging load control?

[1] Cappers, Peter, et al. "A Snapshot of EV-Specific Rate Designs Among US Investor-Owned Electric Utilities." (2023).

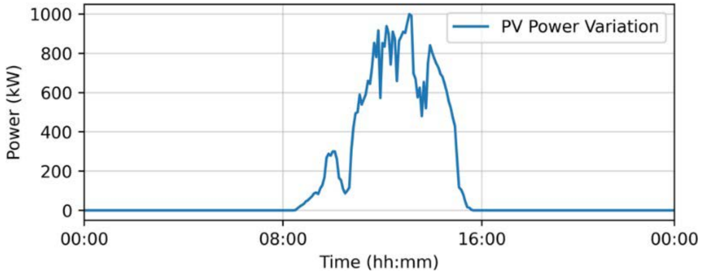
Transactive-based EV Smart Charging Control

Case Setup

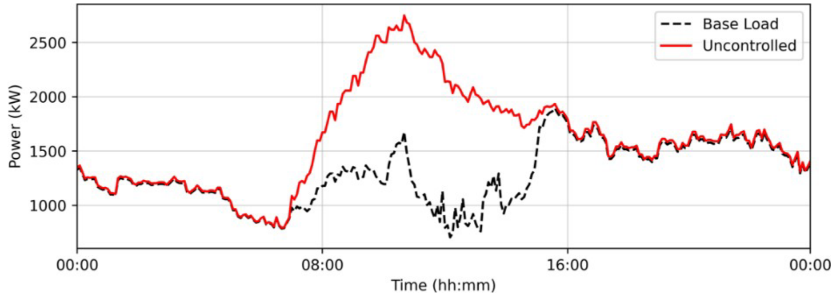
- Workplace charging scenario.
- Each EV controls its own charging process to minimize the charging cost under different rates.
- 100 EVs with different arrival and departure time.
- Each EV has a random initial SOC (20%-60%).
- EV battery size: 60 KWh.
- Maximum charging power of EV: 9.6 KW.
- Distribution system: Modified IEEE 13 bus feeder (3-phase unbalanced system) with 1000 KW PV installment capacity.
- The peak power of the distribution system can be greatly increased by uncontrolled EV charging (start charging as soon as possible).



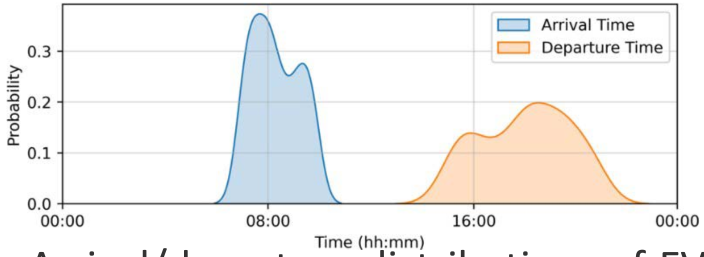
Modified IEEE 13 bus feeder



Power output variations of PVs



Feeder-level net load variation during the day



Arrival/departure distributions of EVs

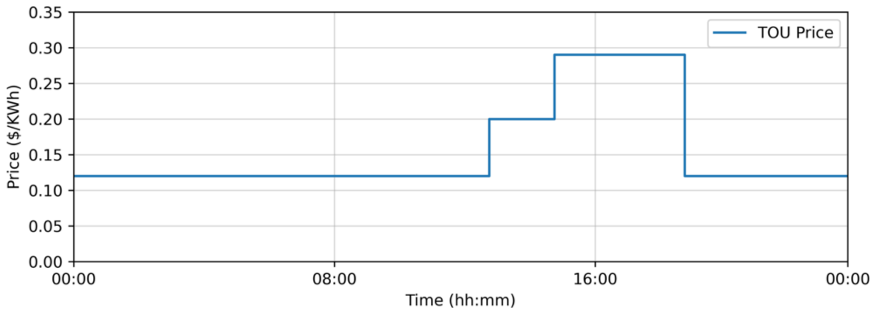
Time-of-use (TOU) based Smart Charging Control

- **Control objective**: Meet the energy needs of EVs prior to departure while minimizing the total charging costs under the *TOU price scheme*.

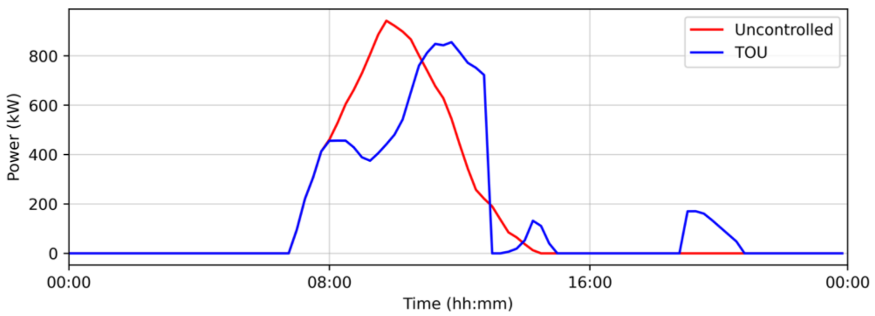
- Seasonal TOU rate in Colorado
  - ➢ Seasonal variation:
    - a) Summer months (June-September)
    - b) Non-summer months (October-May)
  - ➢ Daily variation:
    - a) On-peak: 3:00 P.M. to 7:00 P.M. on non-holiday weekdays only
    - b) Mid-peak: 1:00 P.M. to 3:00 P.M. on non-holiday weekdays only
    - c) Off-peak: All other hours

- A majority of electric vehicles will charge in the off-peak hours (i.e. 7 A.M.-3 P.M.), the total power of charging will decrease significantly after 3 P.M.

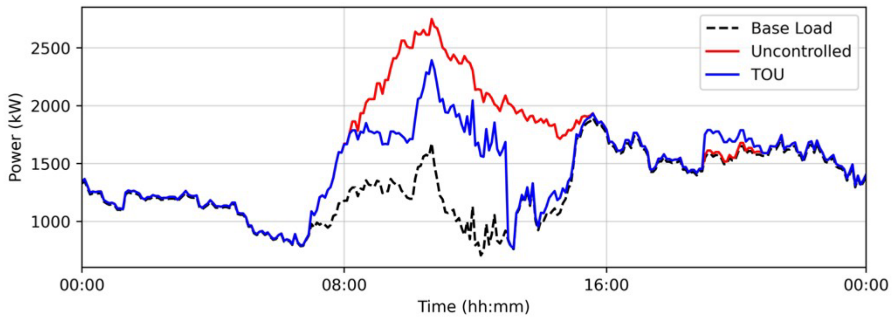
- However, since the workplace charging dwell period coincides with off-peak hours, the charging load shifting effect is not significant.



TOU price scheme in Colorado (Xcel Energy)



Total EV charging load variations



Feeder power variations during the day

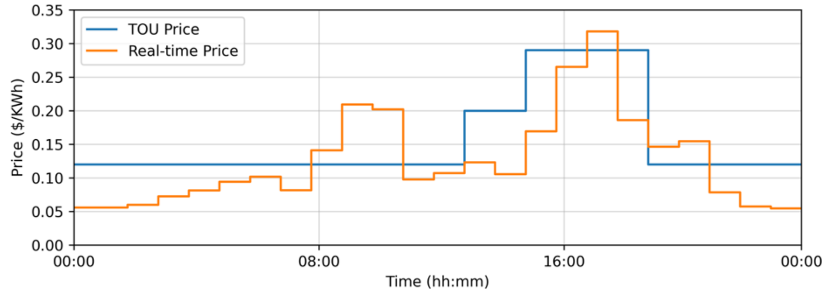
Real-time Pricing (RTP) based Smart Charging Control

- **Control objective**: Meet the energy needs of EVs prior to departure while minimizing the total charging costs under the under the *RT pricing scheme* (**hour-to-hour variations based on the day-ahead locational marginal prices from PJM**).

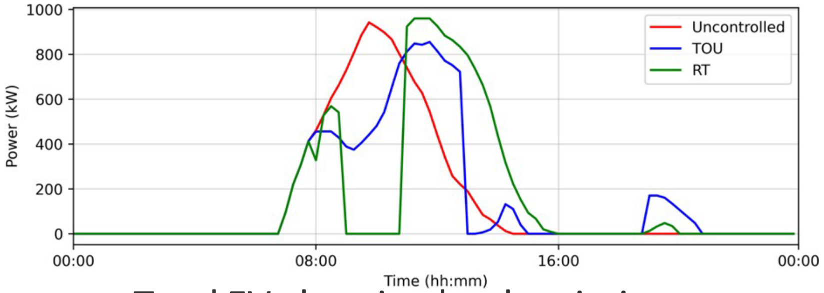
- Due to the real-time price scheme, the majority of EVs tend to charge during low-price periods in order to minimize charging costs.

- EV charging loads have great temporal flexibility and dynamic pricing scheme can effectively shift the EV charging loads to less-demanding periods.

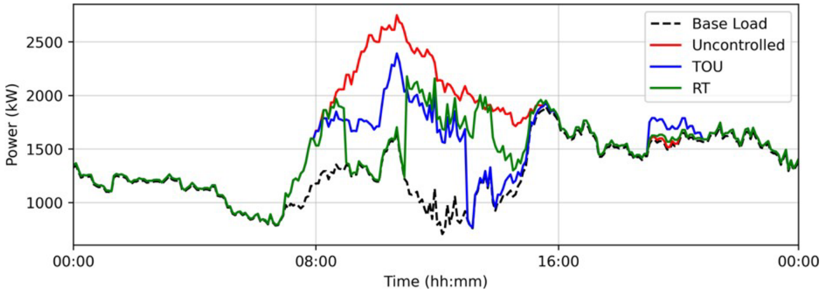
- The real-time pricing scheme updated on a daily basis in order to reflect the current power supply and demand conditions more accurately than the seasonal time-of-use (TOU) pricing system.



RT vs TOU price scheme



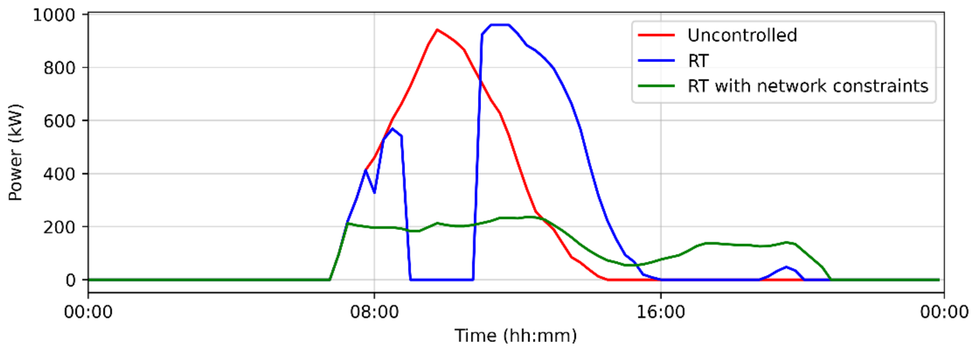
Total EV charging load variations



Feeder power variations during the day

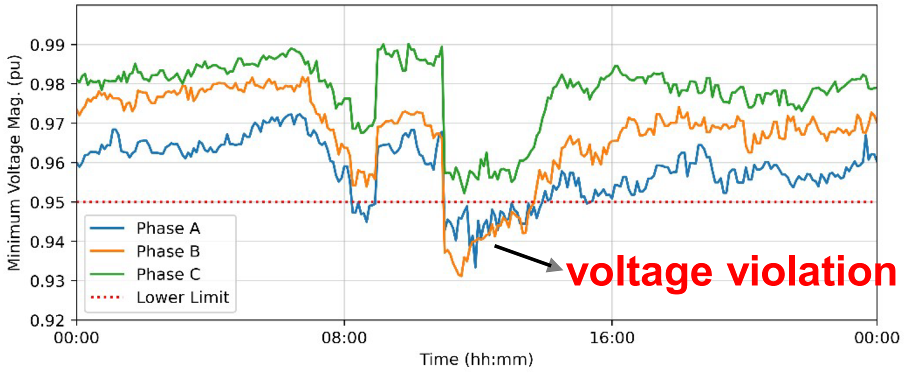
Transactive-based Grid-aware Smart Charging Control

- **Control objective:** Meet the energy needs of EVs prior to departure while minimizing the total charging costs under the TOU and RT pricing schemes without violating distribution system operation constraints.
- Distribution system nodal voltage constraints (0.95-1.05 p.u.) and line flow constraints are considered.
- The voltage violations can be mitigated using the grid-aware smart charging control.
- The maximum charging power of EVs in this case is greatly limited by the grid operation constraints (lower voltage limit).
- The interactions between the grid operator and EV SCM system are critical for large-scale vehicle grid integration.

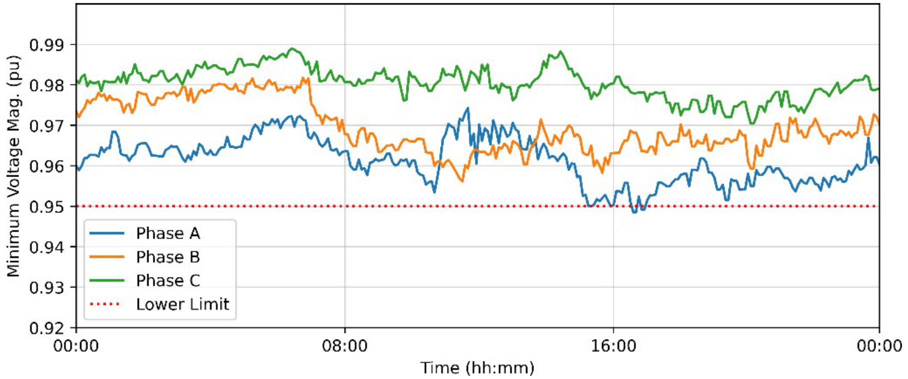


Total EV charging power during the day

Feeder minimum voltage variations during the day



RTP without network constraints



RTP with network constraints

Conclusion and Next Steps

Conclusion:

- Due to its simplicity, time-of-use (TOU) is still the most dominant rate design adopted by utility companies. However, herding behavior can also cause unexpected peak load.

- While real-time pricing (RTP) provides greater temporal flexibility, it is still in its pilot phase for large commercial customers. The main challenge for RTP is the lack of corresponding metering infrastructure.

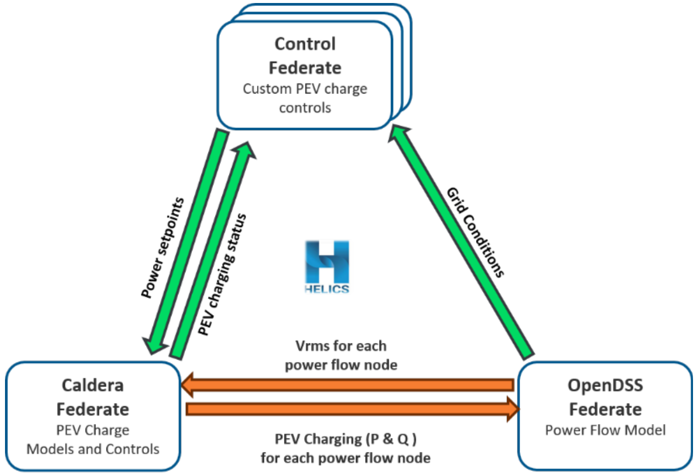
- By leveraging the flexibility potential of controlled EVs, the challenges of operating a high renewable penetration power system can be mitigated.

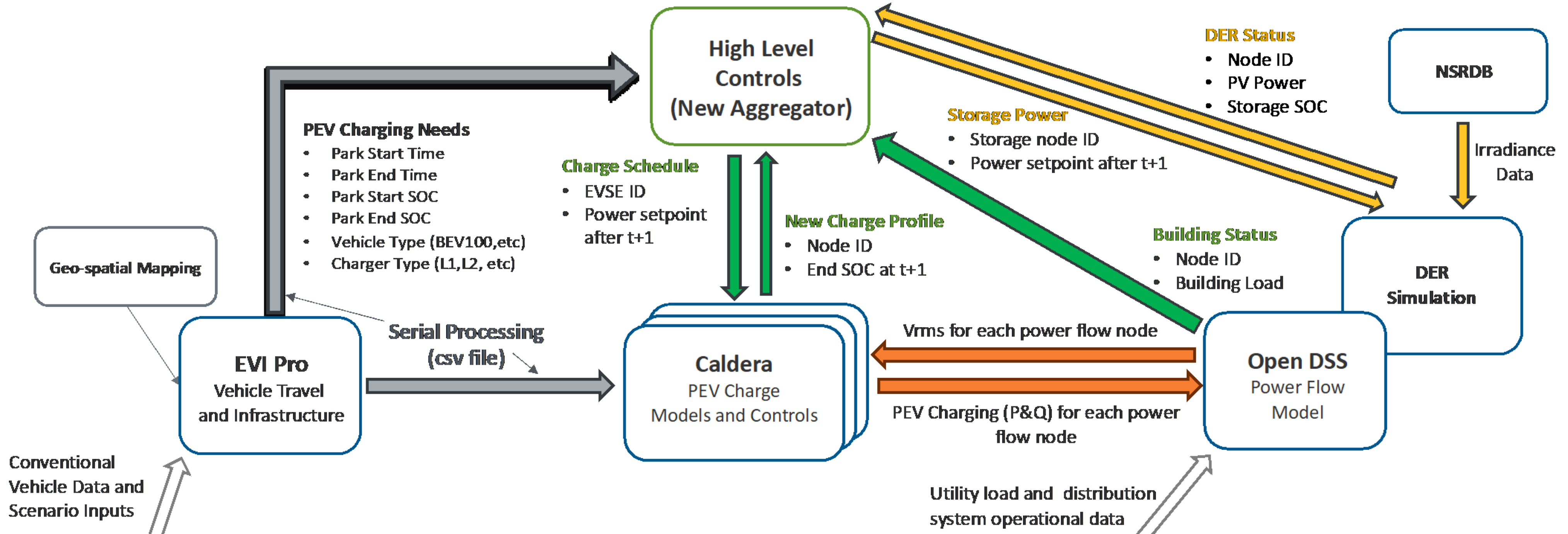
Next Steps:

- Investigate the RTP applications for EV depot or fleet operators.
- Assess the feasibility of EV aggregators and fleet operators participating in the energy market.
- Identify the bottlenecks of large-scale EV integration by integrating mobility analysis and more realistic grid models.

HELICS based Co-simulation Analysis Framework

- The HELICS (Hierarchical Engine for Large scale Infrastructure Co-Simulation) co-simulation framework facilitates communication and synchronization between the federates.
- The following three entities are co-simulated in the following framework:
  - Caldera: High-fidelity EV charging models
  - OpenDSS: Distribution system power flow calculation
  - Control Module: Control the charging behaviors of EVs using Caldera or custom defined SCM strategies.





Thank You

Q & A

EVs@Scale
U.S. Department of Energy

EVs@Scale

U.S. Department of Energy

Update: Medium & Heavy Duty Vehicle Charging Analysis

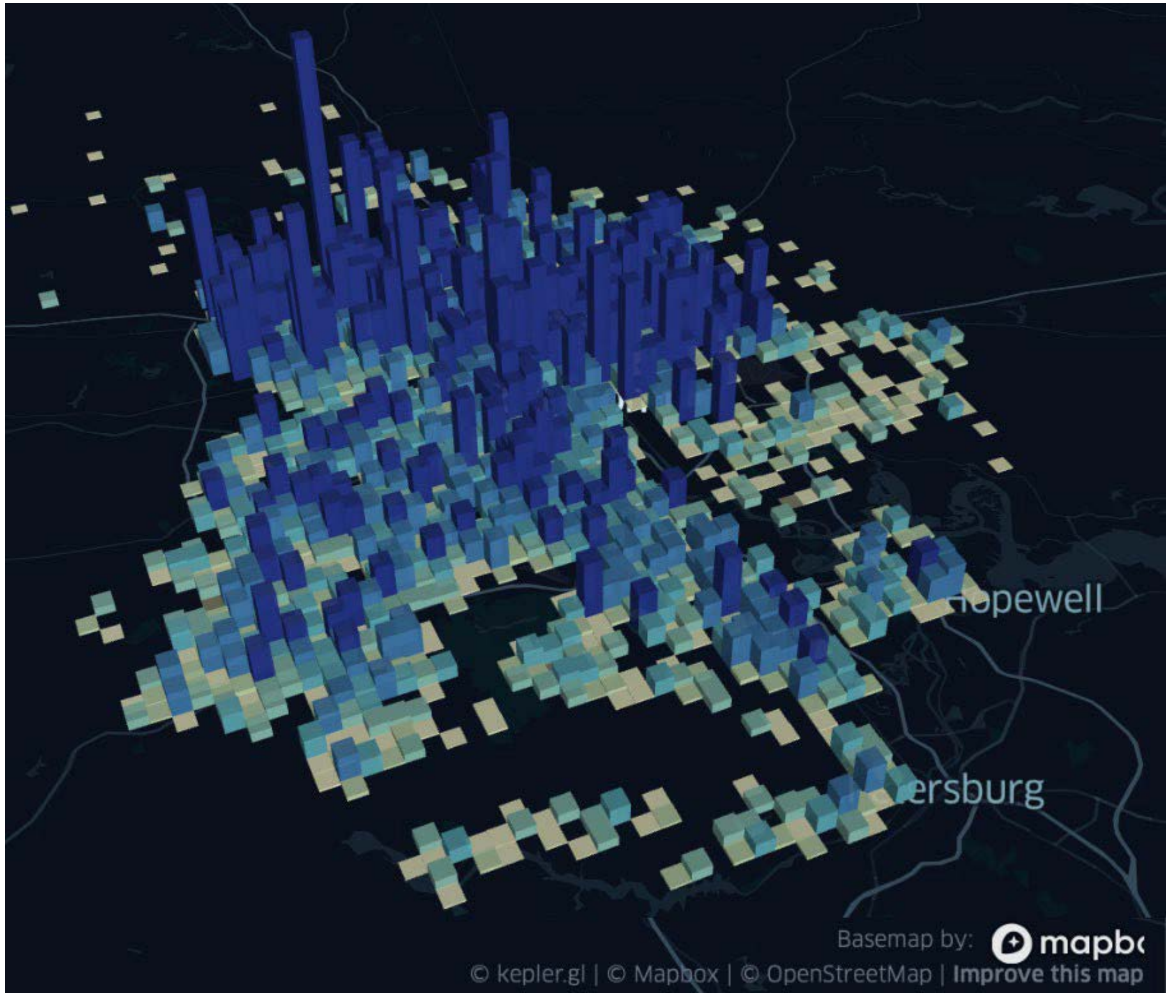
May 18, 2023

FUSE EV charging demand models inform grid and smart charge analysis

- **For EVs@Scale, EV charging demands must be determined across vehicle segments to understand the energy requirements and smart charge management opportunities**
- **Year 1 of the FUSE project charging analysis focused on light-duty vehicles (LDV)**
  - Outputs included passenger EV charging datasets
- **Year 2 is focused on medium and heavy duty vehicles (M/HDV)**

Projected light-duty charging energy

One week of travel, September 2040, Richmond, VA



We integrate travel data, an adoption model, and charging simulation

EVs@Scale
U.S. Department of Energy

1. Trip Data Acquisition & Preprocessing

Representative regional travel data is joined with geographically determined locational characteristics obtained from multiple data sources.

2. EV Adoption Modeling

For a given analysis year (2040), assign PEVs to charging locations by vehicle model (battery size, efficiency, & max kW acceptance required for simulation).

3. Determine Travel Itineraries

Use telematics data to form travel itineraries for each vehicle type. For less depot-centric travel, travel itineraries must be synthesized since telematics data typically lacks a persistent vehicle identifier.

4. Simulate EV Charging Demand

EV charging is simulated for travel itineraries considering (1) EV adoption assumptions; (2) charging behaviors and location-specific EVSE availability; (3) charger type assumptions.

5. Generate Location-Specific EV Load Profiles

Charging demand for a given analysis year (2040) is assigned to specific locations (i.e., land parcels) by location type.

M/HD vehicles include a diverse set of weight classes and vocations

EVs@Scale
U.S. Department of Energy

M/HDV weight class and vocation breakdowns

Rank	Population			
	Class_Body	Vehicles	%	Cumul %
1	8_Sleeper Cab	1,305,953	14.4%	14.4%
2	8_Day Cab	1,091,019	12.0%	26.4%
3	3_Pickup	929,805	10.2%	36.6%
4	7_Bus, school	451,361	5.0%	41.6%
5	3_Van	366,297	4.0%	45.6%
6	6_Specialty Hauling	274,335	3.0%	48.6%
7	8_Dump	272,703	3.0%	51.6%
8	4_Specialty Hauling	266,238	2.9%	54.6%
9	6_Box Truck	262,879	2.9%	57.4%
10	7_Day Cab	212,937	2.3%	59.8%

Rank	Fuel Use, Diesel Gallon Equivalent			
	Class_Body	million DGE	%	Cumul %
1	8_Sleeper Cab	19,021	45.1%	45.1%
2	8_Day Cab	9,469	22.4%	67.5%
3	7_Day Cab	1,460	3.5%	71.0%
4	8_Bus, nonschool	1,227	2.9%	73.9%
5	3_Pickup	1,219	2.9%	76.8%
6	8_Dump	971	2.3%	79.1%
7	7_Bus, school	755	1.8%	80.9%
8	6_Box Truck	567	1.3%	82.2%
9	8_Refuse	454	1.1%	83.3%
10	7_Box Truck	432	1.0%	84.3%

Estimates by NREL from analysis of 2013 IHS Polk vehicle registrations, the 2002 Vehicle Inventory and Use Survey*, 2018 data from the American Public Transportation Association, Federal Highway Administration data, and other data sources*

In our M/HD EV model, adoption varies by class and vocation

- **In our adoption scenario, local and regional travel vehicles electrify more rapidly than long-haul**

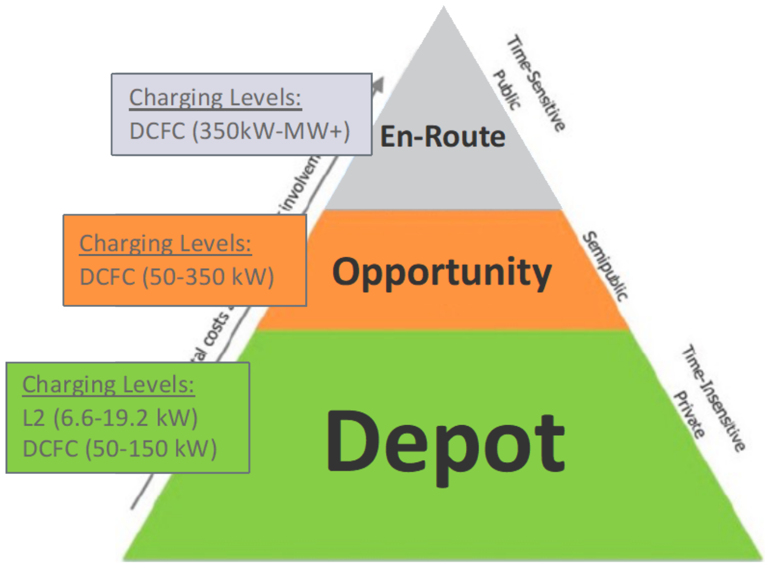
	Weight Class		
Segment	Light-Medium	Medium	Heavy
Local (<100 miles)	52%	42%	33%
Regional (100-249)	66%	59%	30%
Long-Haul (>250)	17%	42%	17%

- **The first stage of our analysis will focus on vehicles with travel patterns amenable to rapid electrification:**
  - **Local or regional** travel patterns
  - **Consistent depot** from which vehicle operates each day
  - Relatively **long dwell times**

TEMPO is an all-inclusive transport demand model that projects household-level vehicle ownership and technology choices based on heterogeneous consumer preferences considering socio-demographics, technology attributes, geography, and population-specific multi-day mobility and travel requirements.

TEMPO

https://nrel.gov/transportation/tempo-model



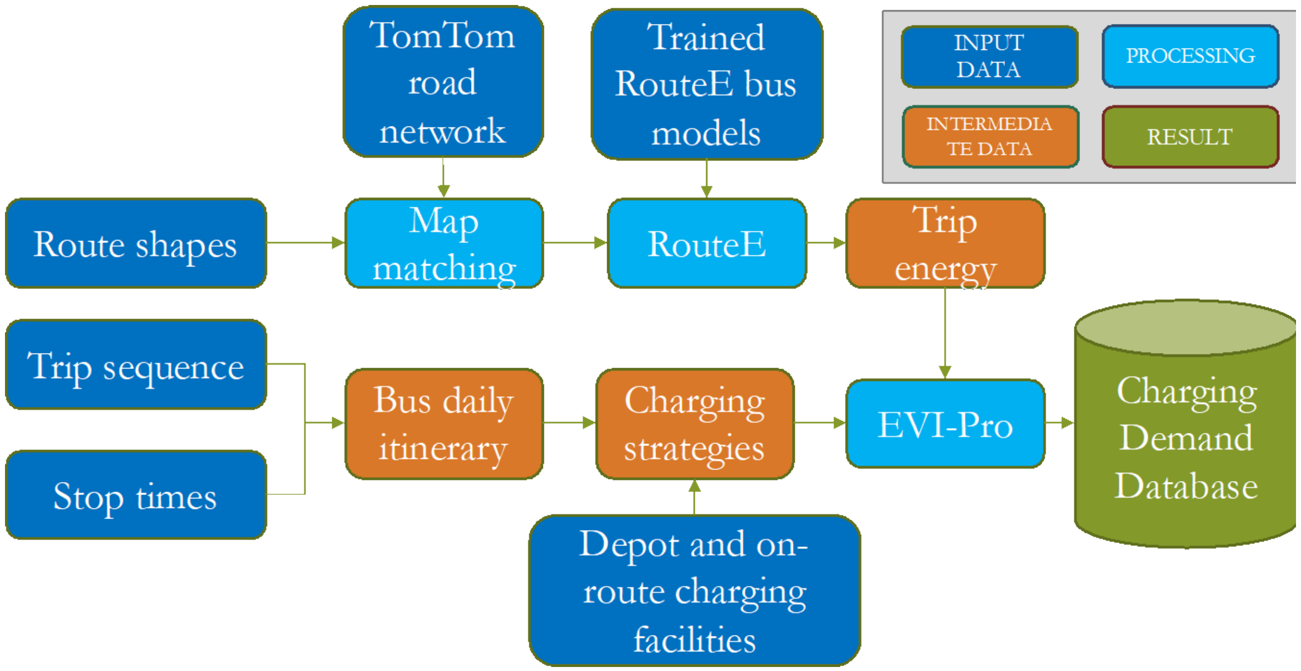
Inspired by National Research Council. *Overcoming barriers to deployment of plug-in electric vehicles*. National Academies Press, 2015.

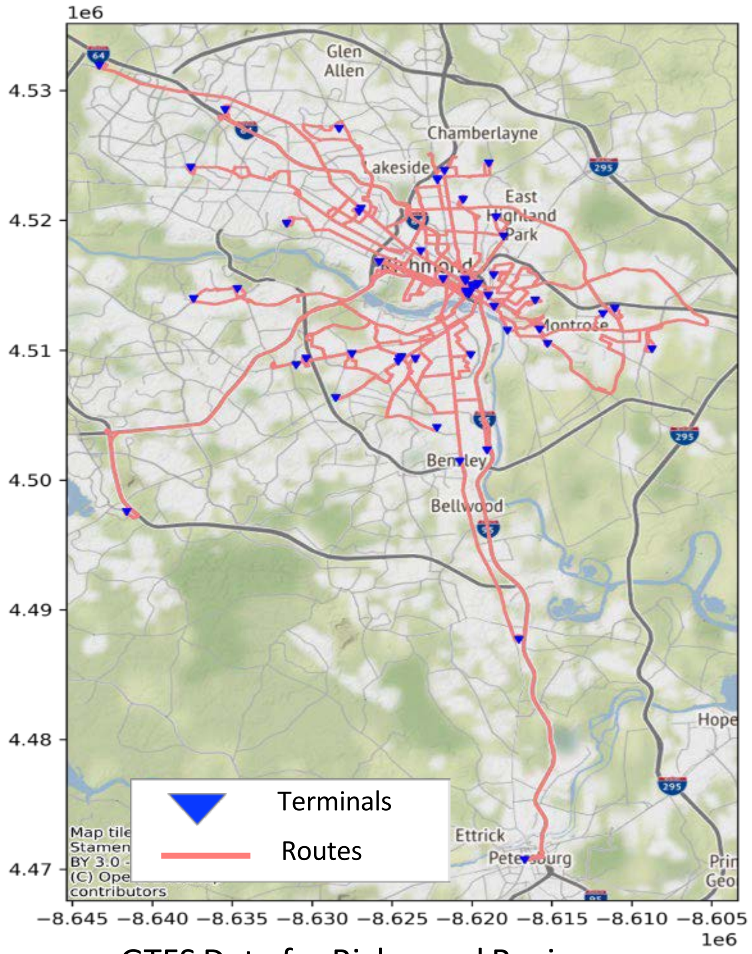
Our M/HD analysis began with vocation prioritization

- **We have begun analysis on transit buses**
- **We will use Geotab to identify other vocations that may have appropriate travel patterns, such as:**
  - Local delivery vans
    - Stable depot location and duty cycle
    - Several manufacturers have market-ready or on-market EV options
  - School buses
    - Stable depot location and long depot dwell times
    - Clean School Bus program funding

Our transit bus system analysis will use GTFS data

- Transit system characteristics: relatively fixed routes and timetables, depot and terminal locations are known
- Obtained General Transit Feed Specification (GTFS) data for the Richmond region, working on charging demand analysis for transit buses





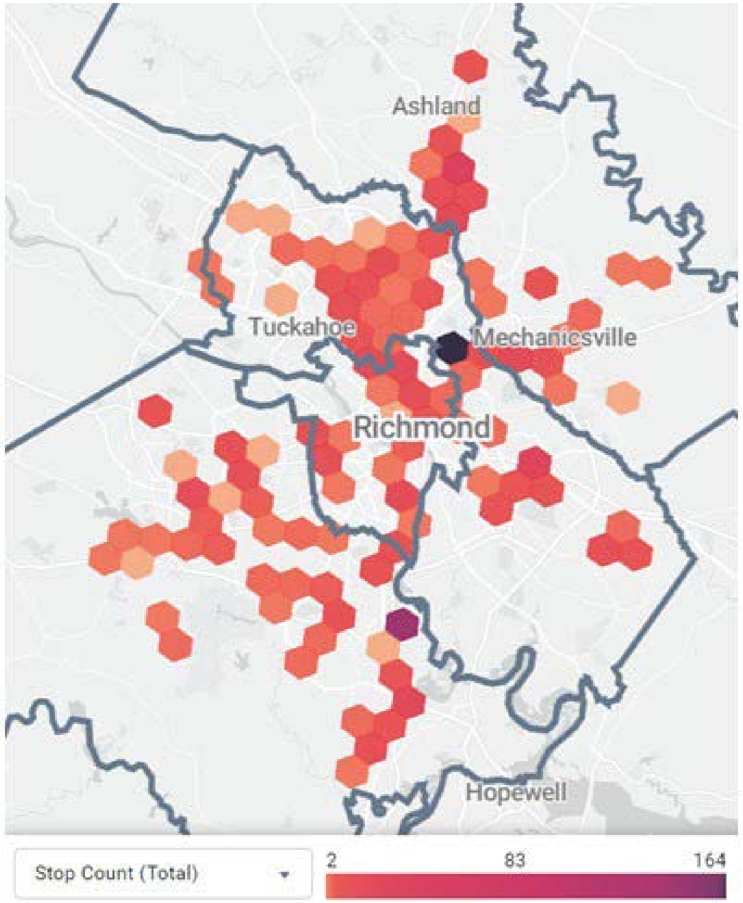
GTFS Data for Richmond Region
Fleet size: 157
Num of routes: 45
Daily VMT per vehicle: 184 miles

Long-dwell locations and times can be seen in Richmond with Geotab

EVs@Scale
U.S. Department of Energy

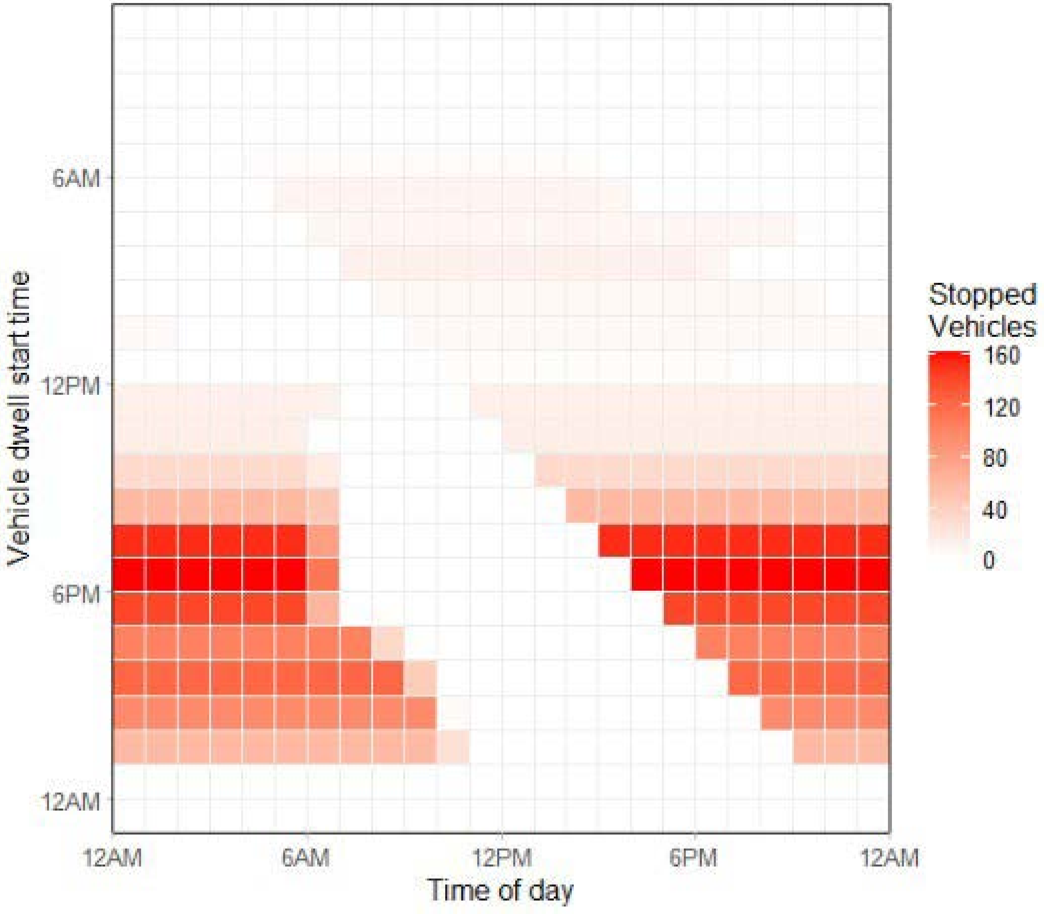
Long-dwell locations

Class 2-5, dwell longer than 9 hours, local travel vehicles, 9/12/2021



Long-dwell time periods

Class 2-5, dwell longer than 9 hours, local travel vehicles, 9/12/2021



Next steps

- Build travel itineraries and identify charge locations for depot-centric, long-dwell M/HD vehicles
- Use identified “hotspots” to inform feeder selection
- Develop 2040 vehicle archetypes for each vocation of M/HD vehicle

EVs@Scale
U.S. Department of Energy

Broad regional analysis

Manoj Kumar Cebol Sundarrajan

Research Software developer
Vehicle Grid Integration Group
Idaho National Laboratory

May 18, 2023

Smart charge management limitations

- **Smart Charge Management strategies are developed to improve the impact of EV charging on the grid.**
- **But they must be based on the conditions of a particular grid at a particular time.**

When is the best time to charge EVs?

It depends.

Depends on what?

Which way the wind blows…

And your regions: Wind deployment, Solar deployment, Air Conditioning load, Electric Heat, Existing load shape (residential, commercial, industrial), the current season, the daily weather, and many other characteristics

Regional Characteristics

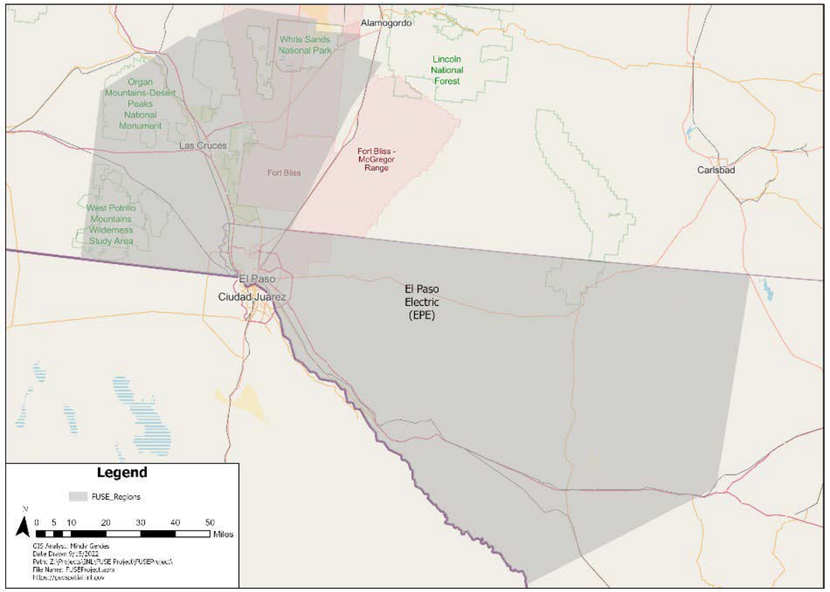
EVs@Scale
U.S. Department of Energy

- Renewable Generation Adoption
  - Solar
  - Wind
    - Inland
    - Offshore
- Electrical Demand
  - Summer Peaking
    - High AC Loads
  - Winter Peaking
  - Small City
  - Rural Region
  - Large City
- Transportation
  - Port City with Drayage
  - Major Highway
    - In small lightly loaded region
    - Significant truck traffic

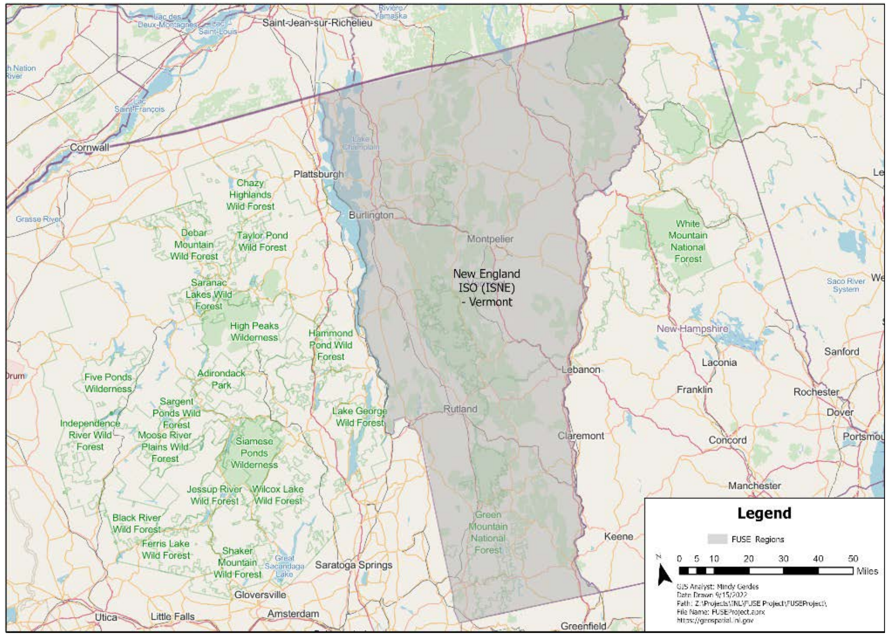
Broad Assessment Study Regions

FUSE Regions

El Paso Electric (EPE) Region



New England ISO (ISNE) - Vermont Region



Regional Characteristics Matrix

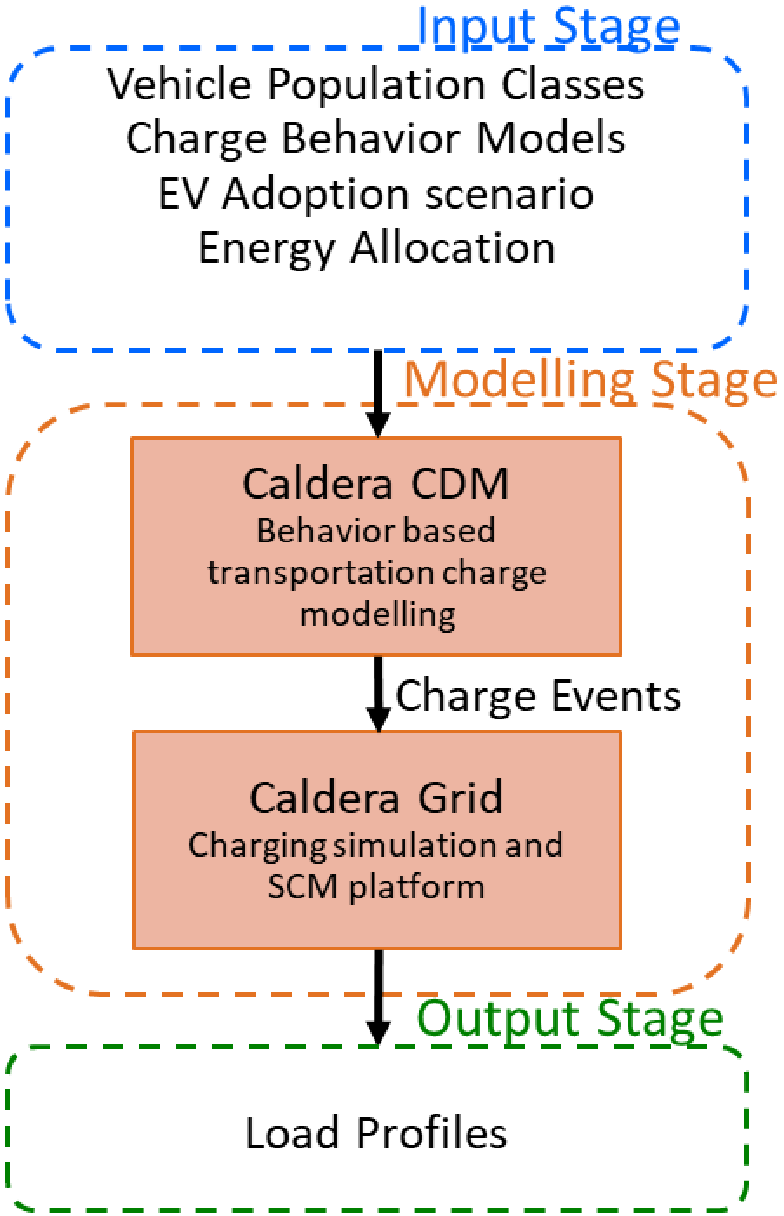
EVs@Scale
U.S. Department of Energy

Characteristics	ERCOT Coast	El Paso Electric (EPE)	Evergy	New England ISO (ISNE) - Vermont	Dominion Energy	Final
High Solar	X	X				**X**
Inland Wind	X		X			**X**
Offshore Wind				X	X	**X**
Extreme Summer Peaking		X				**X**
Winter Peaking				X		**X**
Large Metro Area	X	X				**X**
Rural Region				X		**X**
Large Seaport	X					**X**
Large Airport	X					**X**
Pass-Through Truck Traffic			X			**X**
International Truck Traffic		X				**X**

Renewable generation adoption – **Green**
Electrical demand – **Yellow**
Transportation – **Blue**

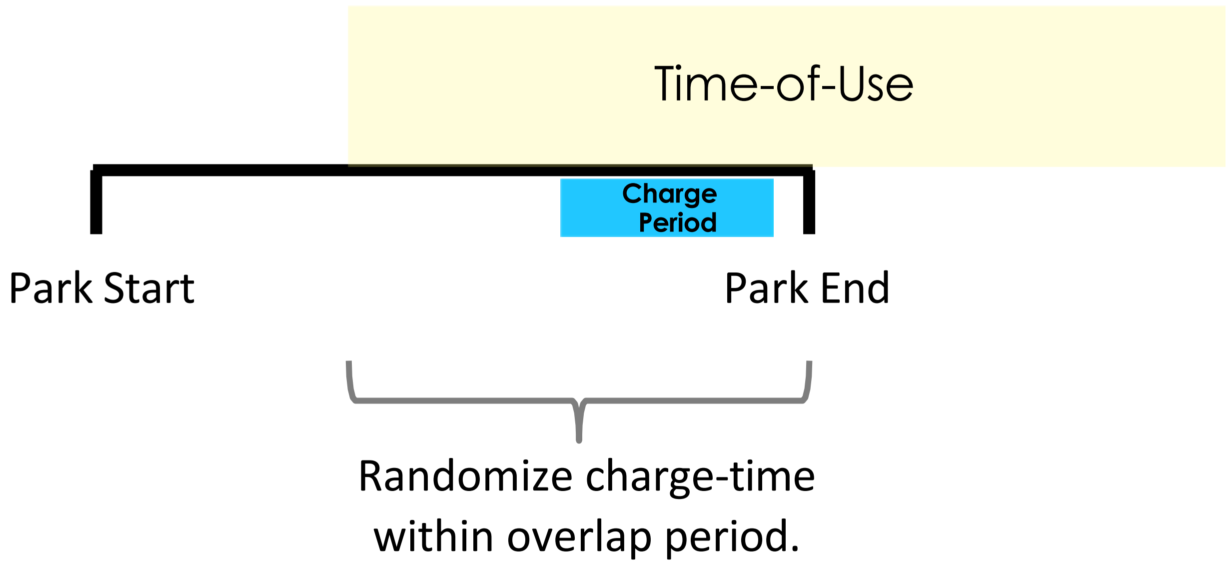
Computational modelling approach

- **Input stage**
  - Eleven Light-Duty vehicle classes were used
  - Charging behavior models were derived from purchased WEJO itinerary data for the Virginia region
  - LD EV adoption scenario for 2040 was modeled using TEMPO tool with 50% EV adoption rate
  - Two energy allocation scenarios were used
    - home dominant (Home : 60%, Work : 10%, Public : 30%)
    - work dominant (Home : 20%, Work : 50%, Public : 30%)
- **Modelling stage**
  - The Caldera Charging Decision Module (CDM) software tool using stochastic modelling generated charge events from the charging behavior models
  - The Caldera Grid software tool generated power profiles by applying SCM strategies on the charge events
- **Output stage**
  - Time series load profiles were used in post-processing for analysis

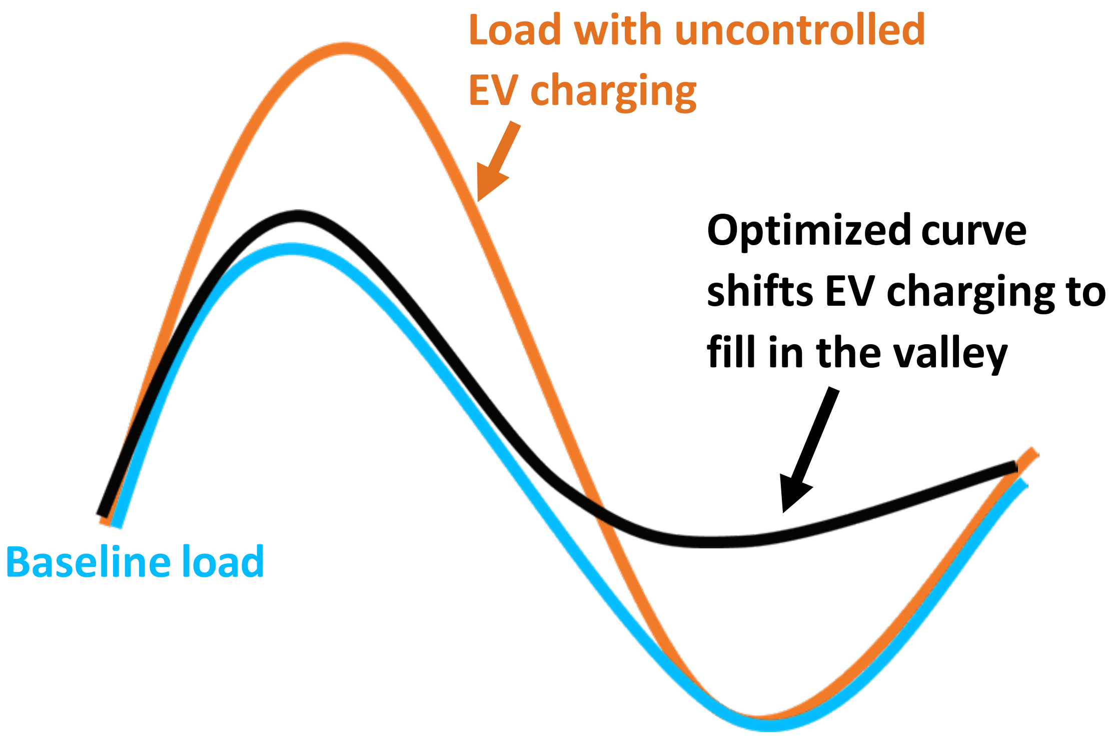


SCM strategies

- **Solar TOU-Random**
  - EVs prefer to randomly distribute charging in the TOU window
  - Updated Time of Use (TOU) period from nighttime to daytime.



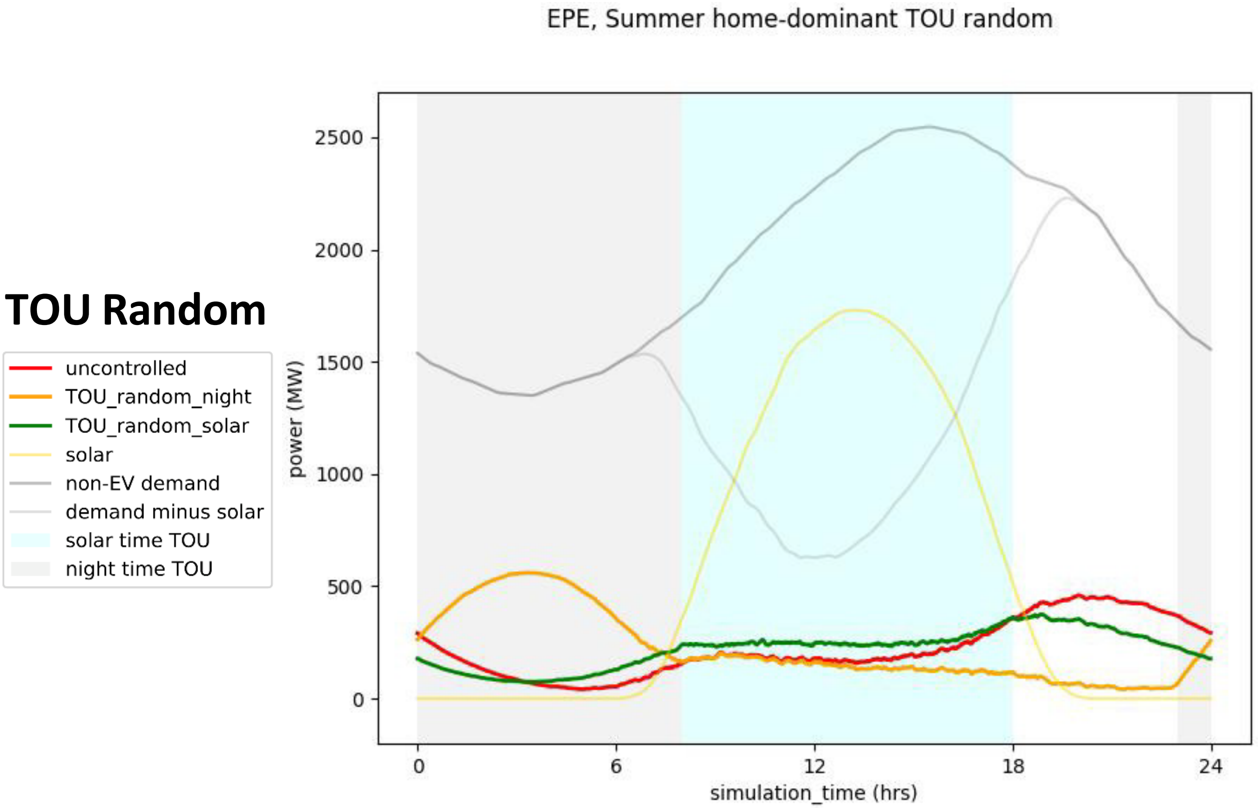
- **Solar Centralized Aggregator**
  - Centralized strategy shifts EV charging within vehicle dwell to minimize feeder peak
  - New objective function to maximize charging following solar curve.



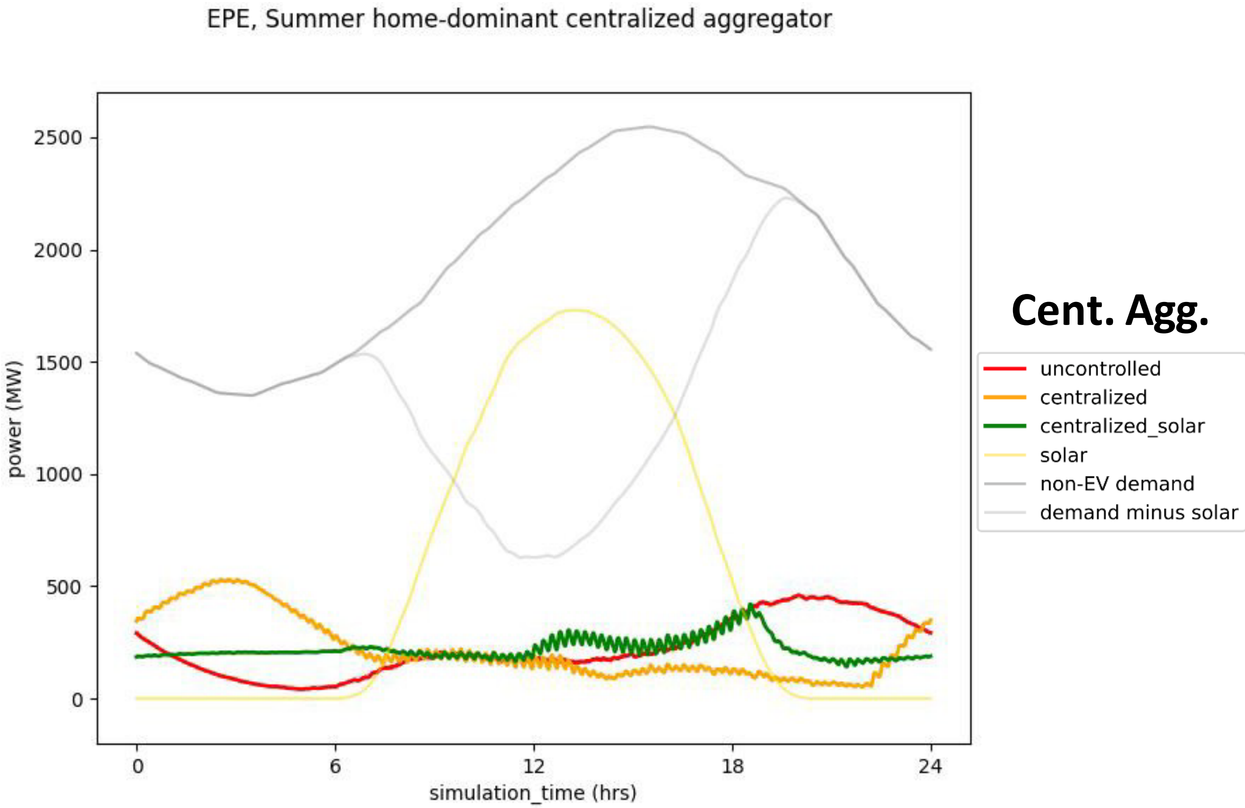
Home-dominant – El Paso summer

- **Both solar TOU random and solar centralized aggregator strategies struggled to shift charging towards the solar period due to most cars only charging at home at night.**

TOU Random



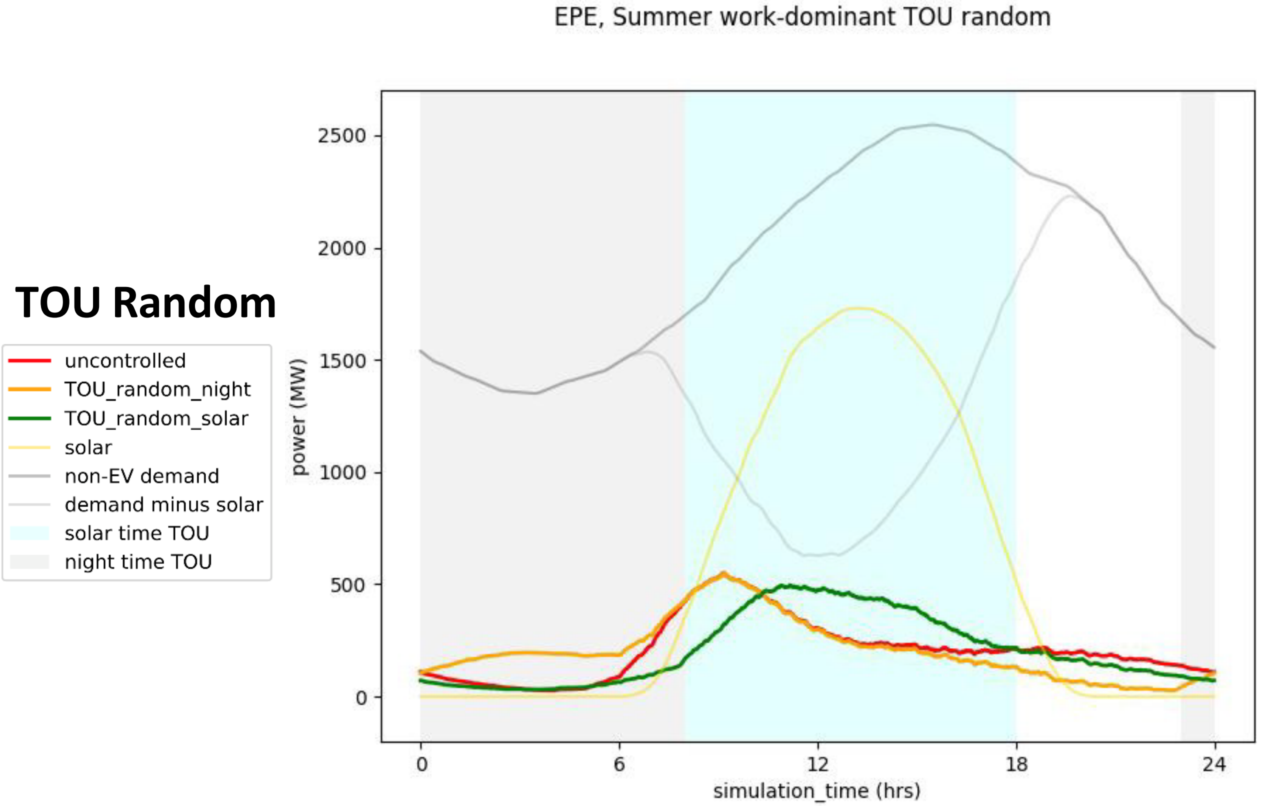
Cent. Agg.



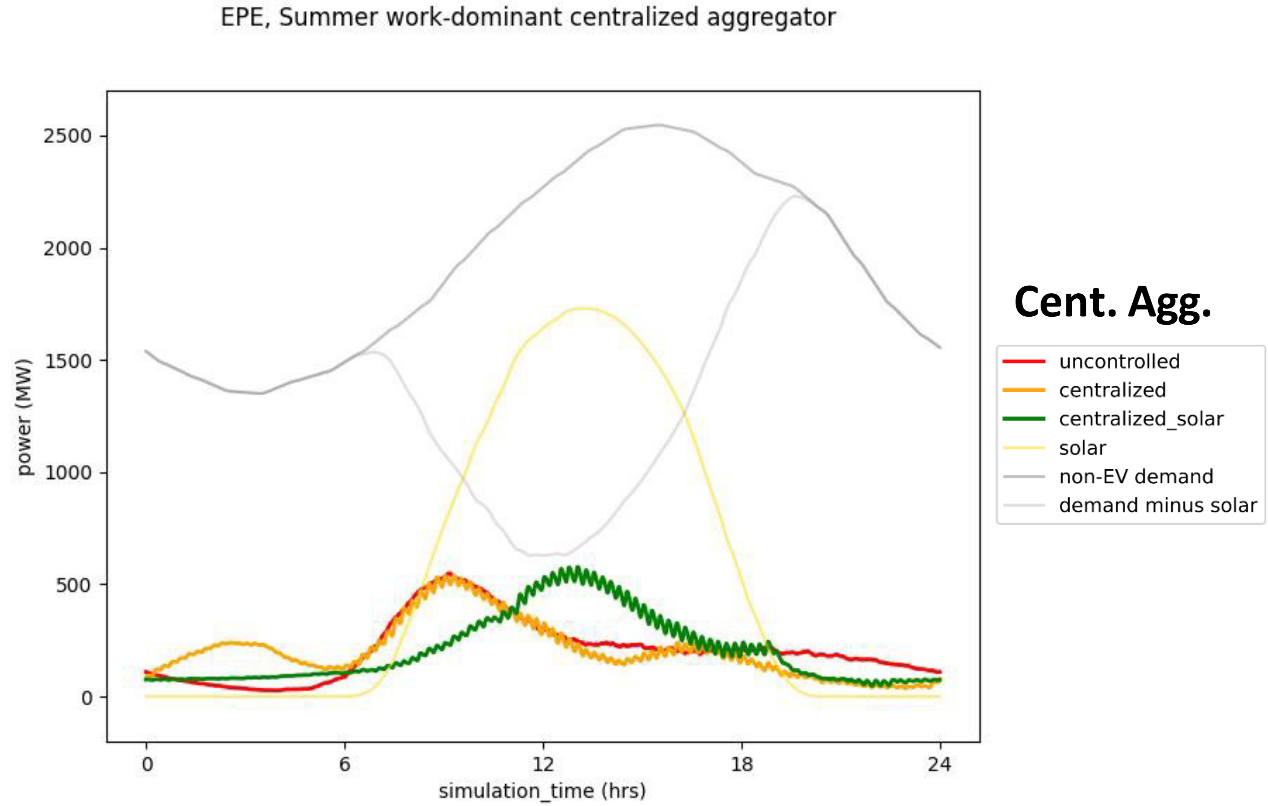
Work Dominant – El Paso summer

- **A significant amount of charging shifted from nighttime to daytime due to EVs charging at work, but the charging peak does not coincide with the solar peak.**
- **Both solar TOU random and solar centralized aggregator strategies were able to shift charging towards the solar peak.**

TOU Random



Cent. Agg.



Next steps

- **Medium- and Heavy-Duty Vehicle (MHDV) charging behaviors will be added to the charging behavior models.**
- **SCM will be updated for regions with other renewable sources such as wind generation.**
- **Agent-based simulations will be studied to understand the impacts of charge scheduling and stationary energy storage (SES).**

EVs @ Scale

U.S. Department of Energy

Thank You

Smart Electric Power Alliance

Managed EV Charging

Accelerating Transformation

Regulatory and Business Innovation | Grid Integration | Electrification

May 2023

Who Are We?

Smart Electric Power Alliance

- A membership organization
- Staff of ~50
- No Advocacy – 501c3
- Founded in 1992
- Unbiased
- Research, Education, Collaboration and Standards
- Technology Agnostic
- Local, State and National Focus

Membership

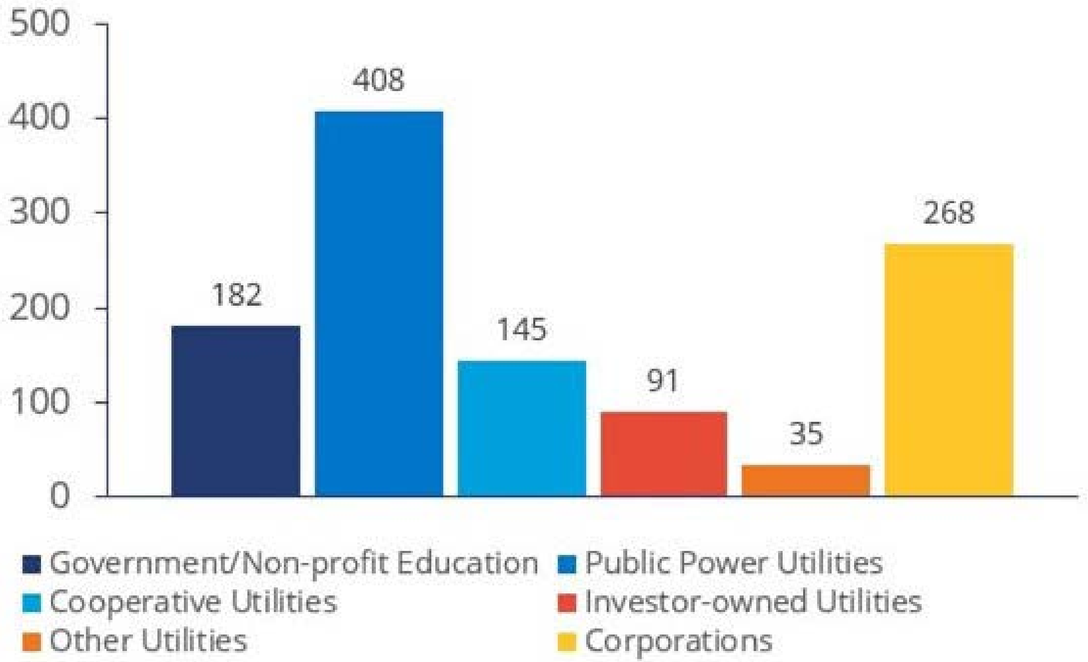
SEPA is a **membership organization** comprised of utilities, technology solution providers, regulators, and other stakeholders.

1,100+
Total Members

80%
Of utilities with carbon-free or net-zero emissions goals

72%
Of U.S. customer accounts served

72%
Of utility commissions



Smart Electric Power Alliance

What We Do

We Accelerate the Transformation to a Carbon Free Energy System through:

EDUCATION

Raise awareness of practical and actionable solutions

FACILITATION

Drive collaborative problem solving

CREATION

Develop and deliver strategies and guidance our members can use

Smart Electric Power Alliance

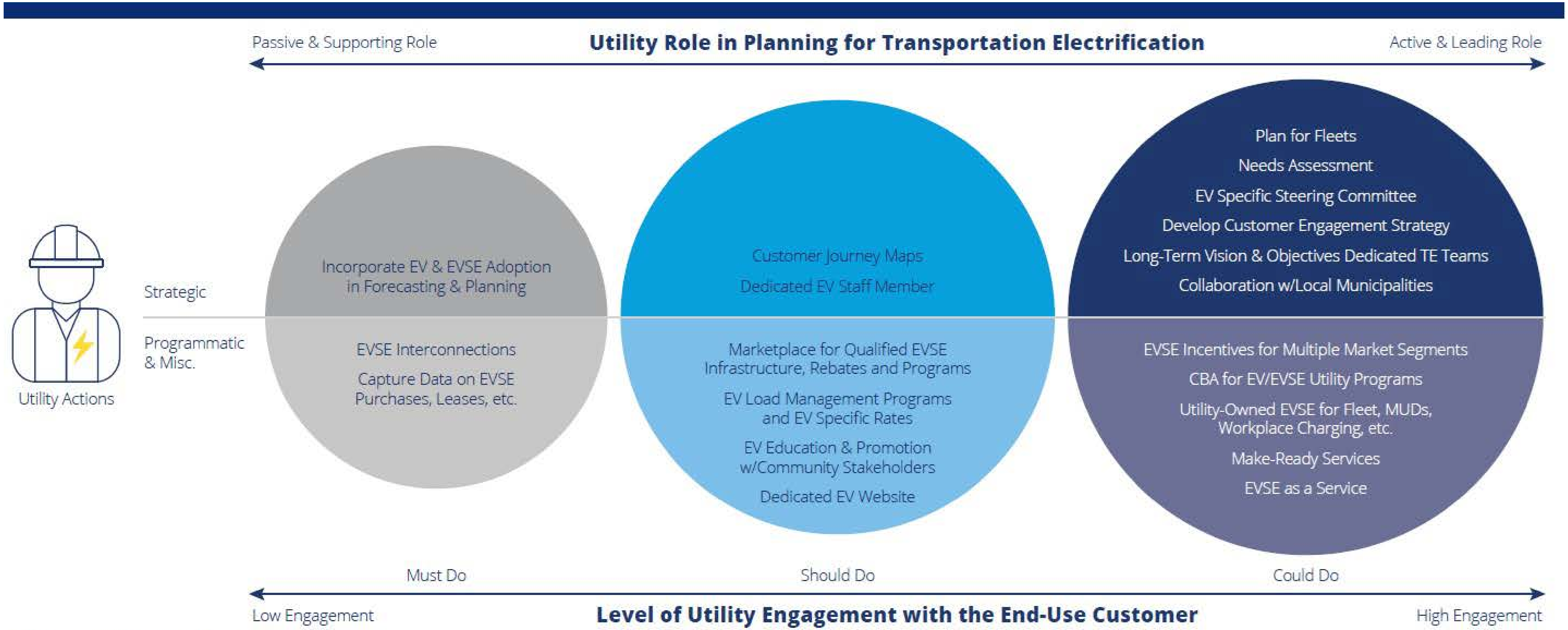
Smart Electric Power Alliance

Utility Activities

Staff, Plans, Programs

A spectrum of utility engagement

Smart Electric Power Alliance

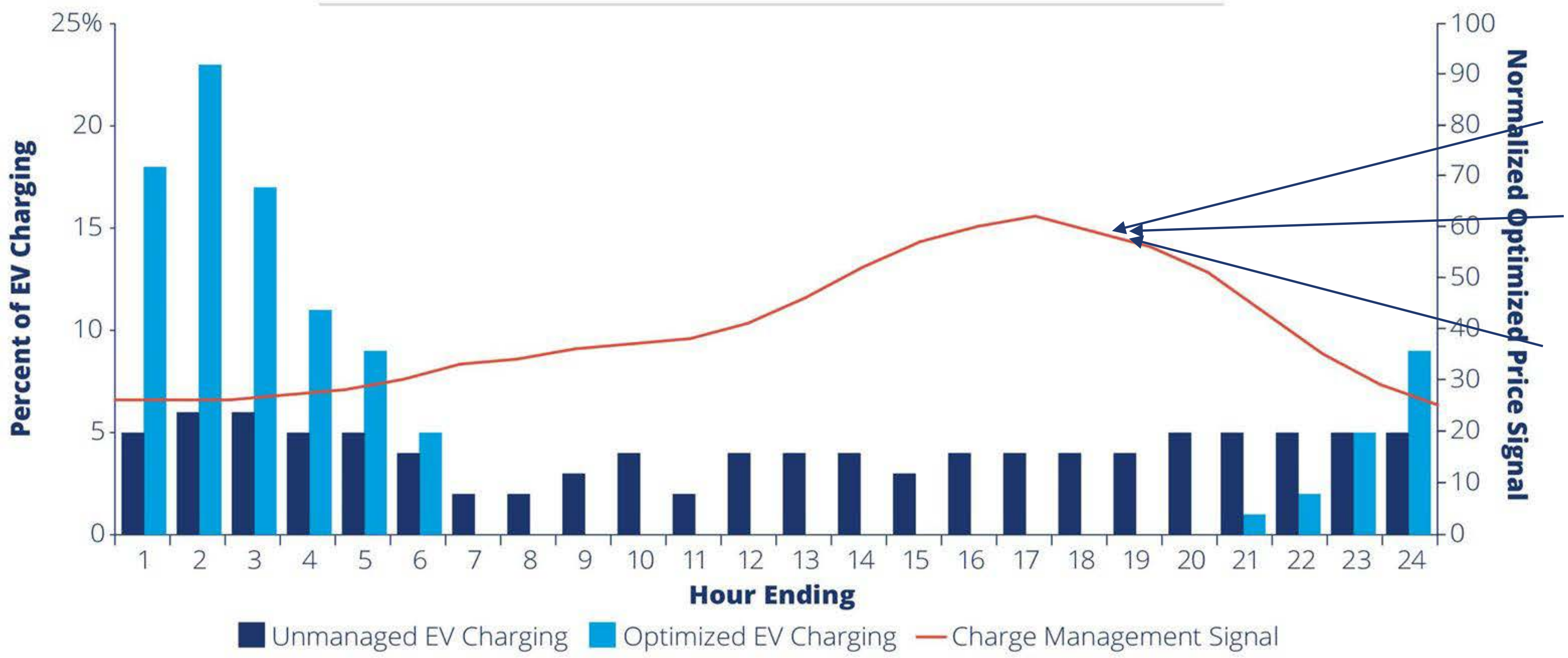


Source: Smart Electric Power Alliance, 2021

For additional information on the role of the utility in TE strategic planning see SEPA's report, Utility Best Practices for EV Infrastructure Deployment.

Managing EV load

Figure 1. Using Dynamic EV Managed Charging to Optimize Charging Behavior



Source: Data and charts provided by WeaveGrid, Inc.

Bulk System Cost or

Distribution Constraints or

Carbon Intensity or

Other signal

Smart Electric Power Alliance

Passive (behavior) and Active (direct control)

Smart Electric Power Alliance

Passive

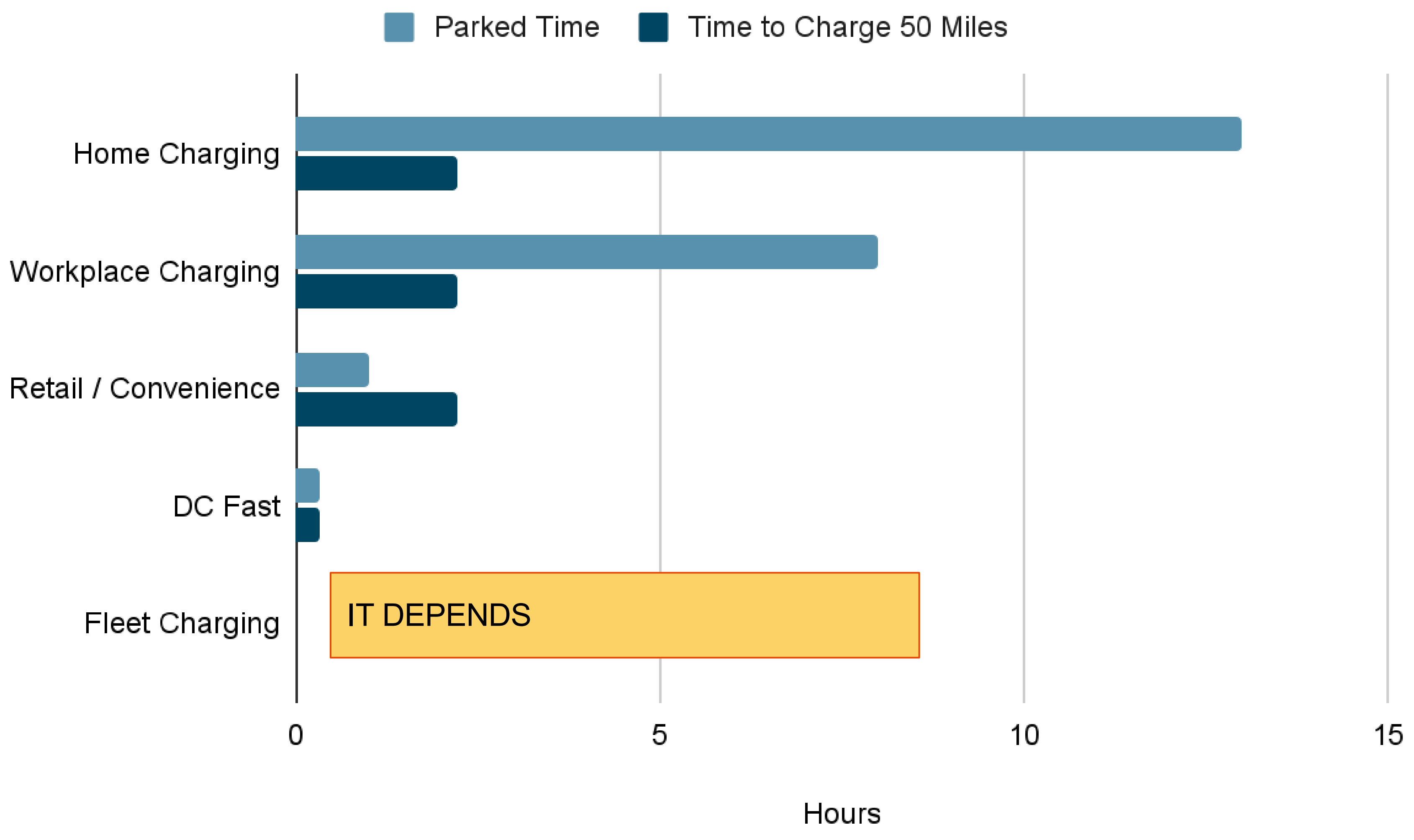
Relies on customer behavior to affect charging patterns. For example, EV time-of-use rates provide predetermined price signals to customers to influence when they choose to charge their vehicles

Active

Relies on dispatch signals originating from a utility or aggregator to be sent to a vehicle or charger to adjust the time and/or rate of charge (both load curtailment and load increase)

Source: "A Comprehensive Guide to Electric Vehicle Managed Charging" (SEPA, 2019)

Residential charging is inherently flexible…



Smart Electric Power Alliance

…and has become more flexible in the new world of hybrid working

Smart Electric Power Alliance

Earlier plug-in time

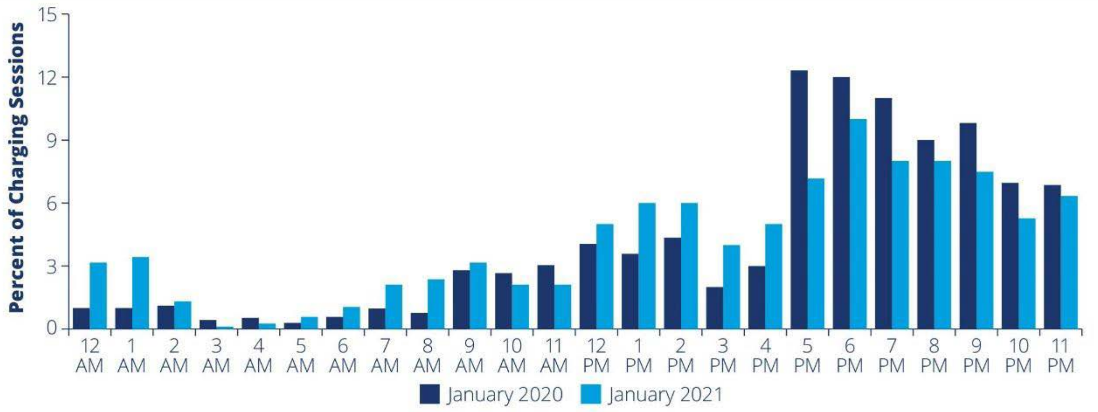
+

Delayed unplug time

↓

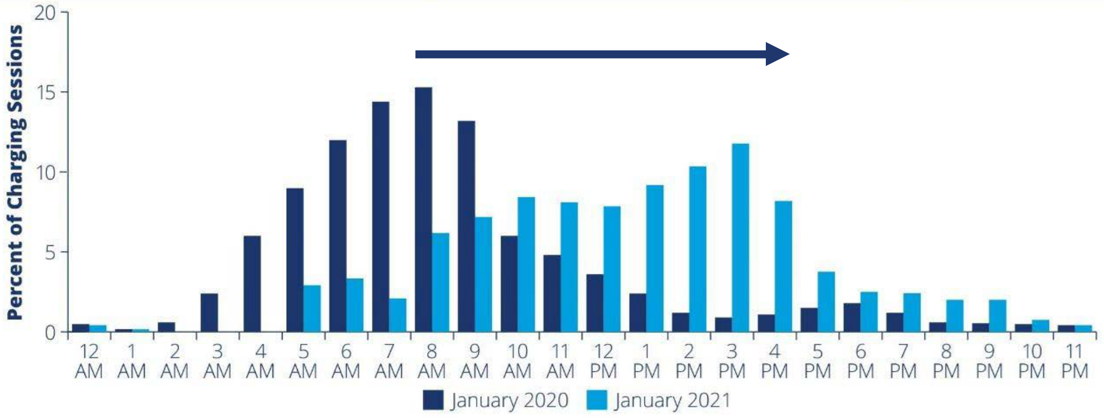
3-5 hours of increased dwell time

Figure 14. EV Plug-In Times of Residential Customers



Source: ev.energy, 2021

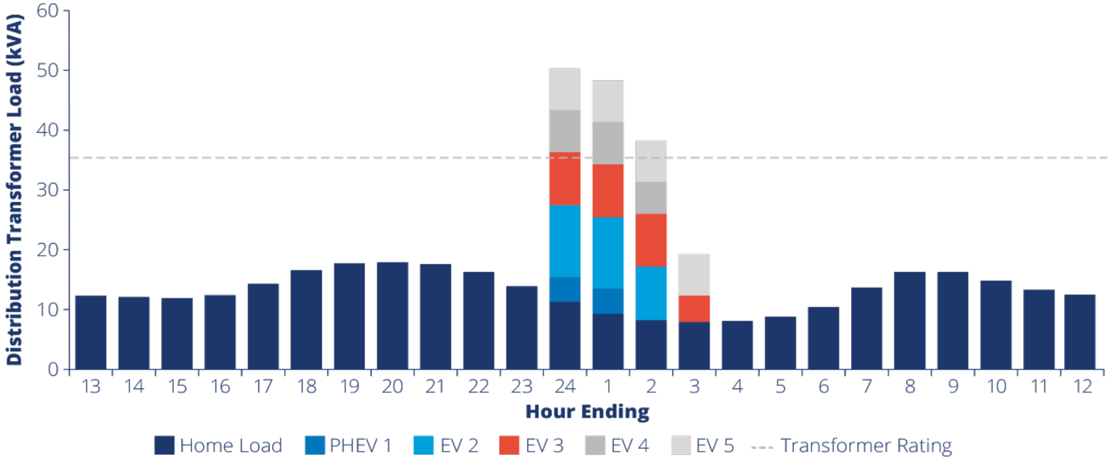
Figure 15. EV Unplug Times of Residential Customers



Source: ev.energy, 2021

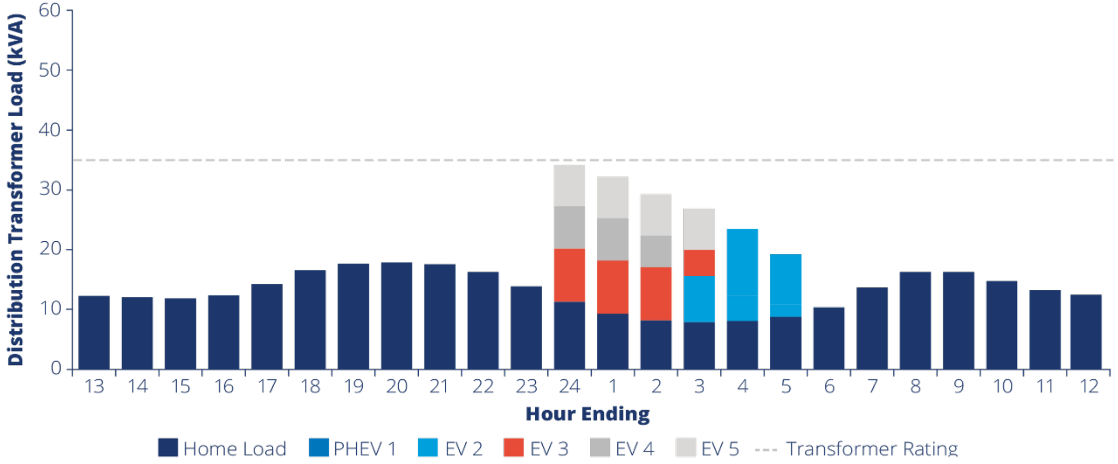
Multi-Level Optimization: Bulk and Distribution

Figure 2. Illustrative Example of How Time-of-Use Optimization at the Bulk System Level can Create Overload Situations at the Distribution Transformer Level



Source: Data and charts provided by WeaveGrid, Inc.

Figure 3. Illustrative Example of How Multi-Layer Optimization can Co-optimize for Bulk System Time-of-Use Signals and Distribution Level Constraints and Maintain Driver Charging Needs

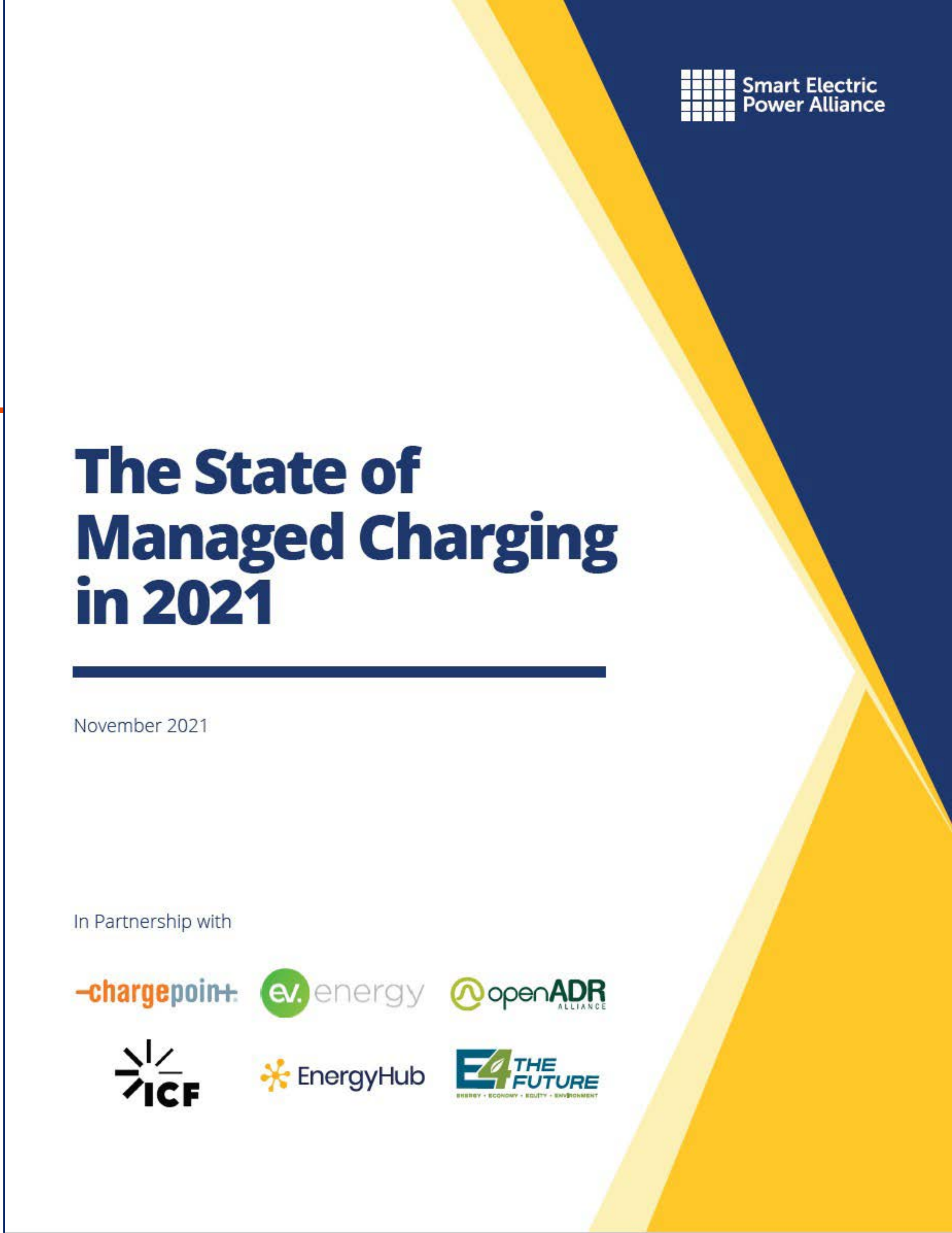


Source: Data and charts provided by WeaveGrid, Inc.

Smart Electric Power Alliance

State of the Industry

- **Survey results** from 51 utilities with managed charging programs
- **Recommendations for program design**, rollout, implementation, and evolution
- Six utility-led **case studies** and one customer fleet initiated managed charging program.
- Early observations of the **impacts of COVID** on EV charging
- **Trends in EVSE** and Network Service Providers (NSP)
- Appendix containing a comprehensive guide to utility managed charging programs, EVSE vendors and NSP providers


Smart Electric Power Alliance

The State of Managed Charging in 2021

November 2021

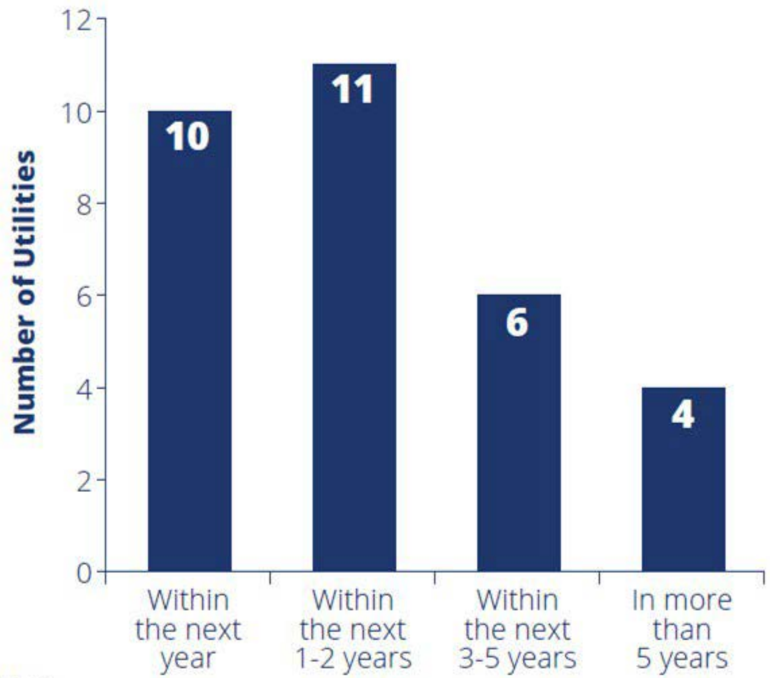
In Partnership with

chargepoint
ev.energy
openADR ALLIANCE
ICF
EnergyHub
E4THE FUTURE

Planning for managed charging is universal

Most utilities without a program today plan to implement soon

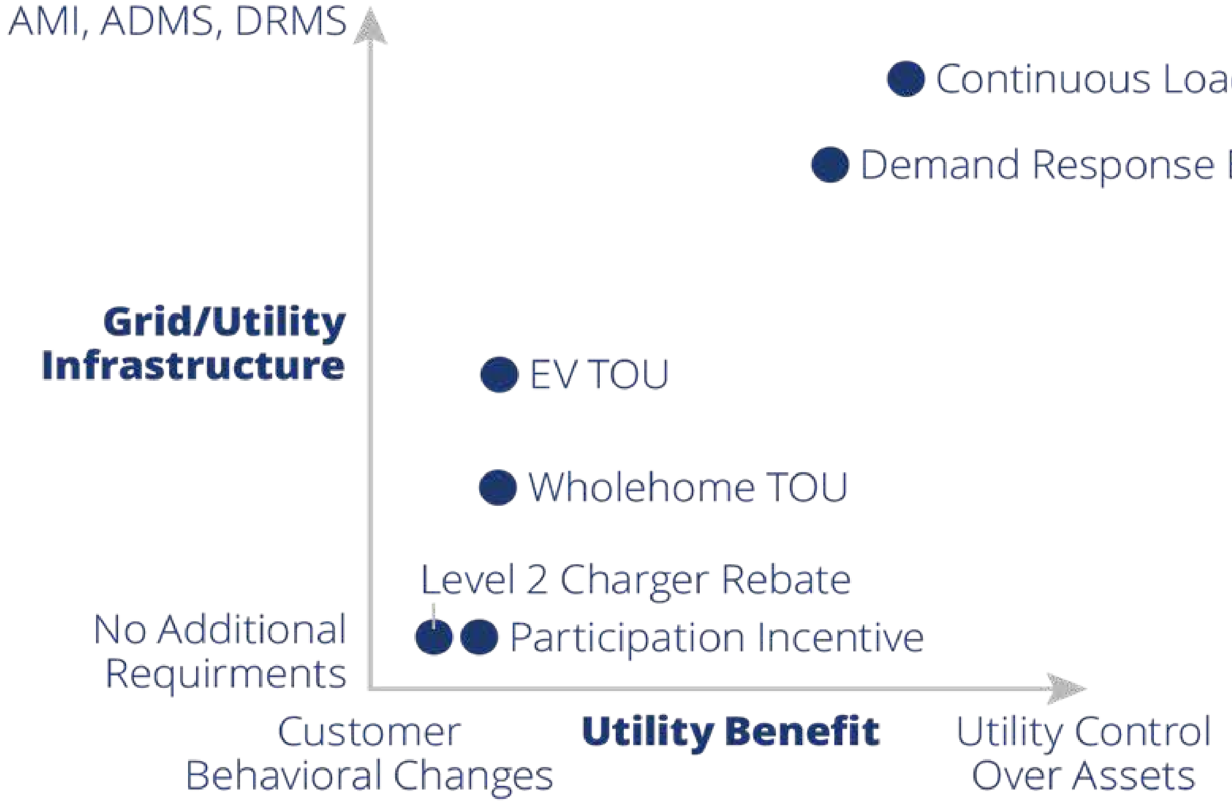
Figure 7. Utility Outlook on Implementing New Managed Charging Programs



N=31.

Source: SEPA, 2021

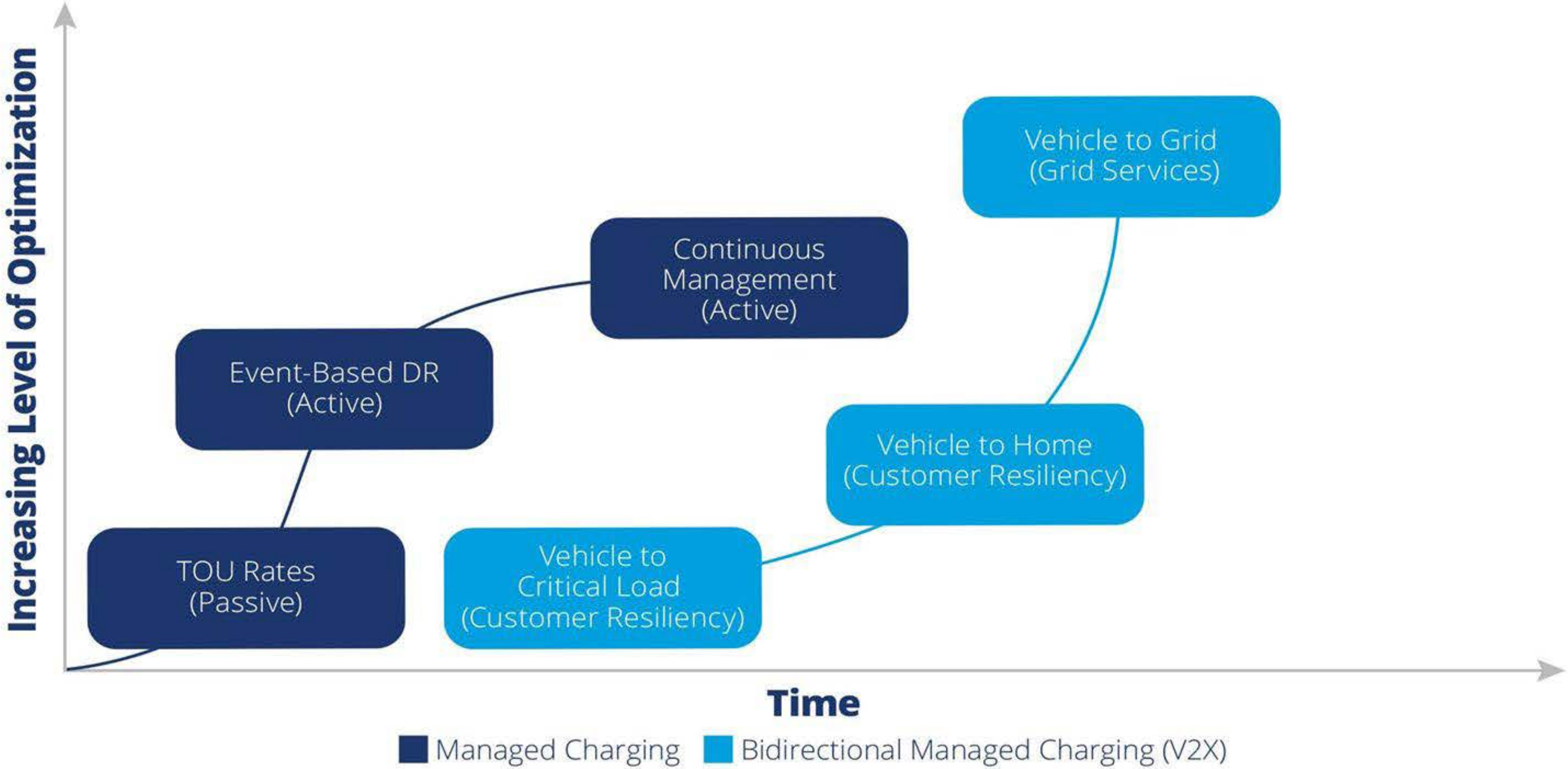
Utilities are moving to capture greater benefits



Source: SEPA, 2021

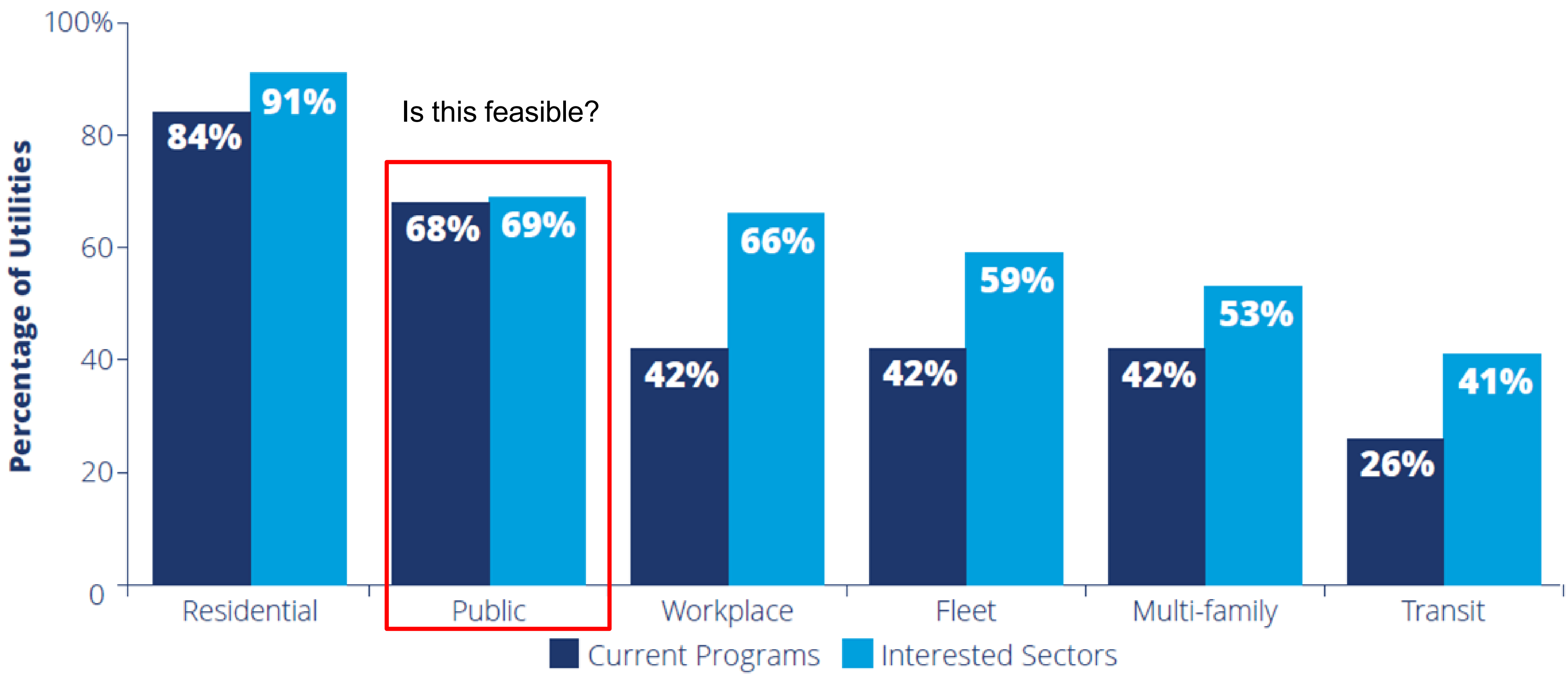
Smart Electric Power Alliance

Passive → Event Based → Continuous



Source: SEPA, 2021

Interest across customer segment



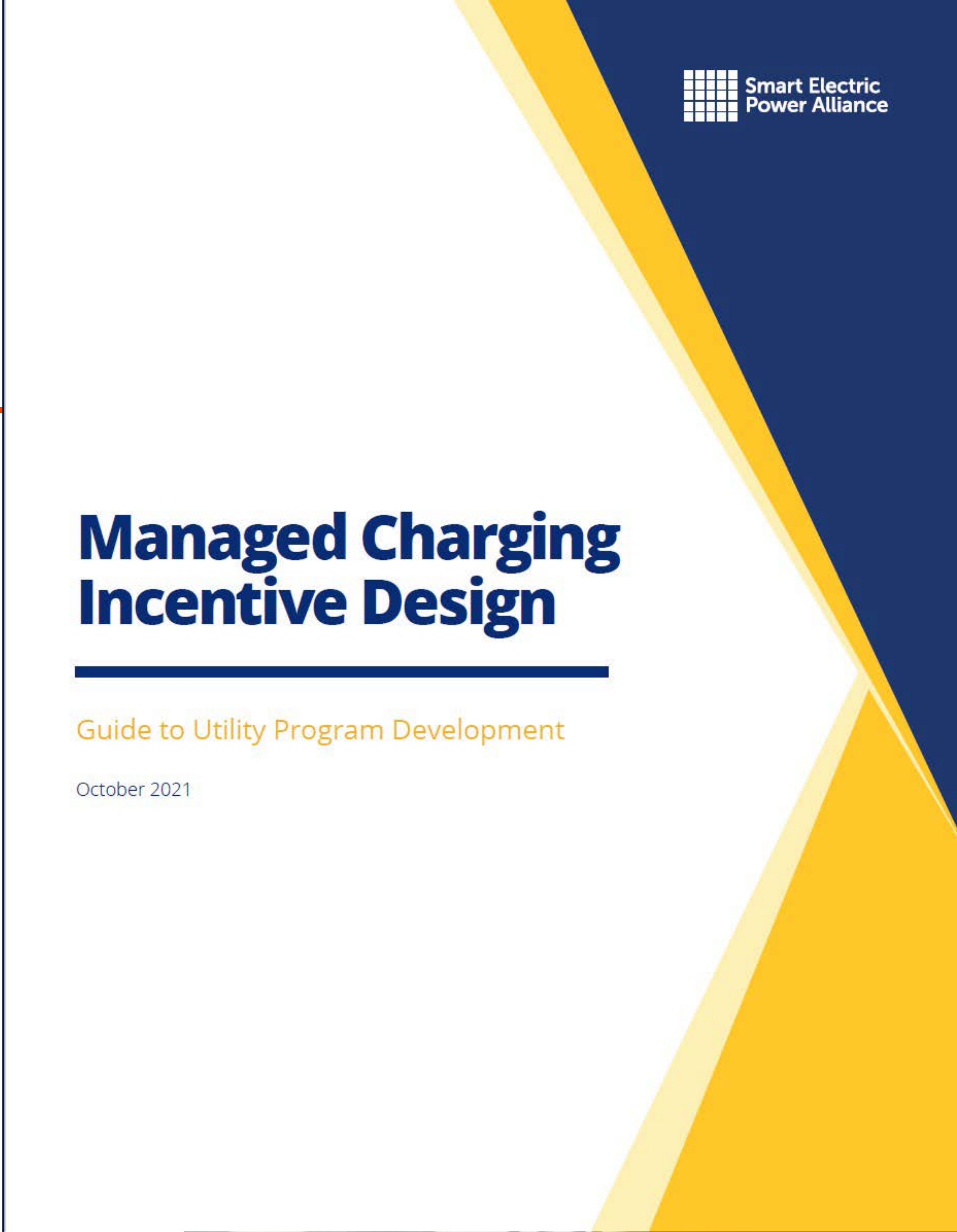
N=50

Source: SEPA, 2021

Guide for Program Design

To assist utilities in their efforts, SEPA recently published a report entitled, Managed Charging Incentive Design: Guide to Utility Development.

- Six-step managed charging program design process
- Detailed case study featuring Baltimore Gas and Electric (BGE) and Potomac Electric Power Holdings (PHI)
- Analysis of forty managed charging programs and insights from twenty utility interviews
- Actionable recommendations


Smart Electric Power Alliance

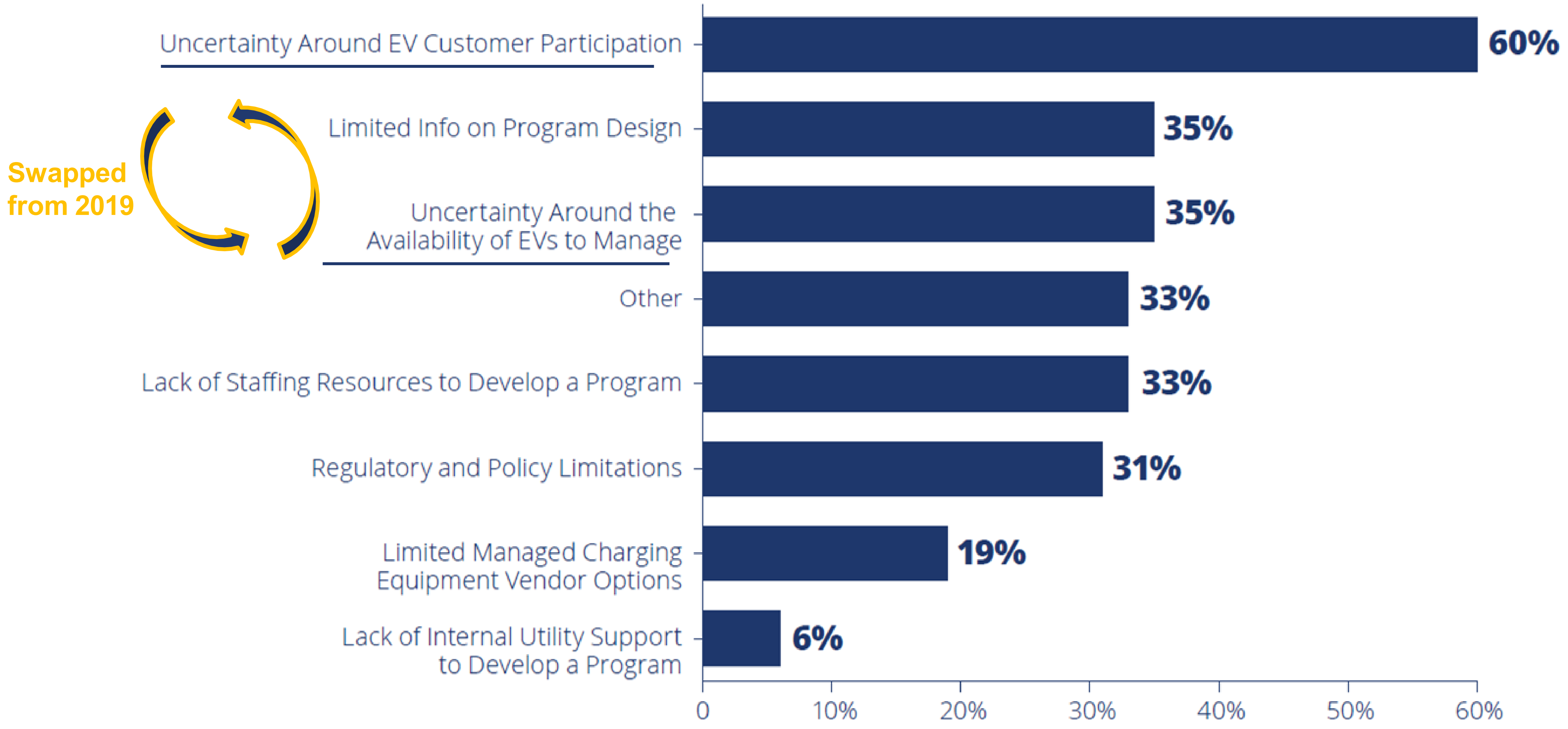
Managed Charging Incentive Design

Guide to Utility Program Development

October 2021

Participation uncertainty is high

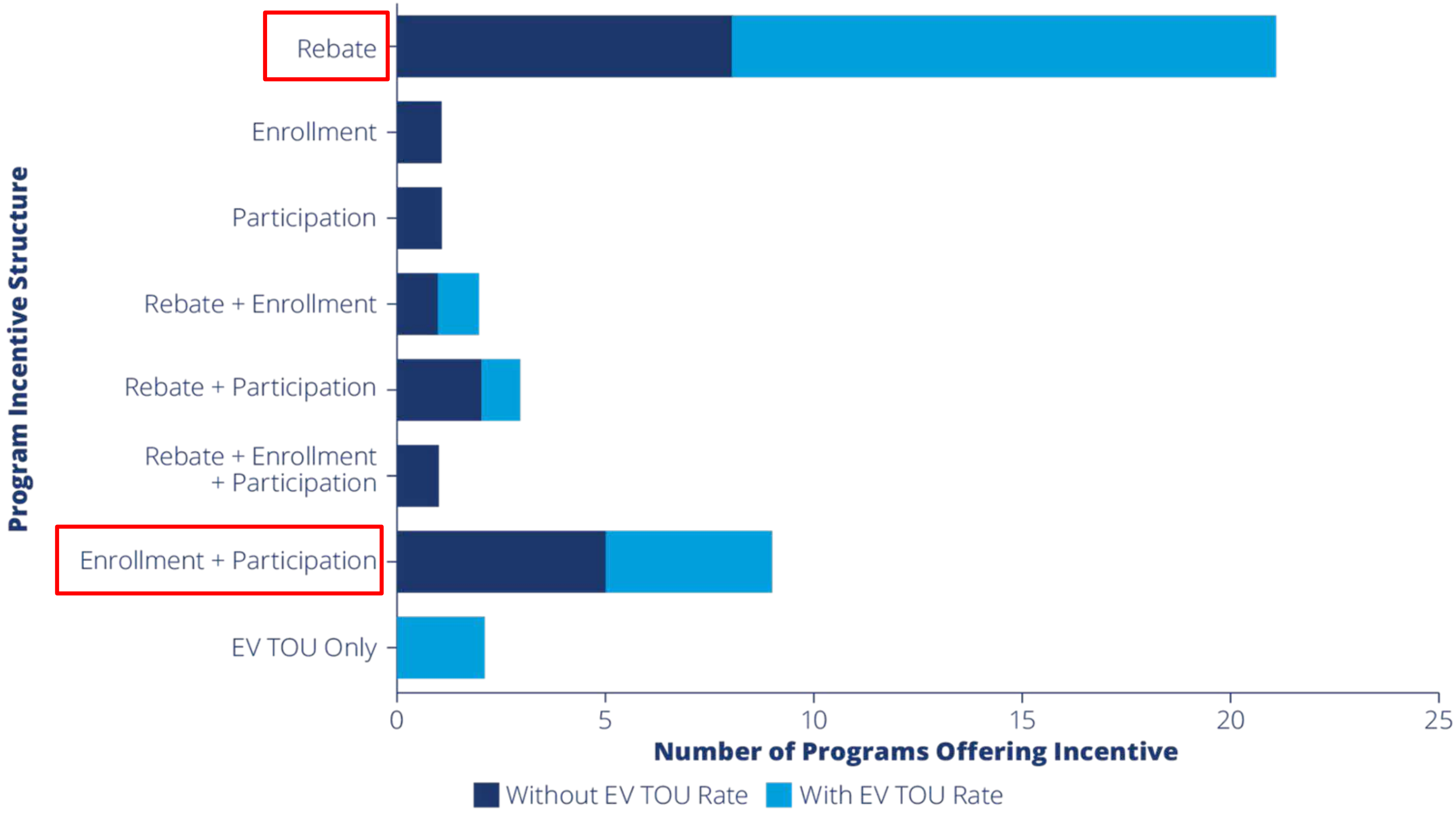
Barriers to Implementing a Managed Charging Program – Utility Perspective



N=48. Note: Utilities selected all that applied.

Source: SEPA, 2021

Rebates, or enrolment and participation

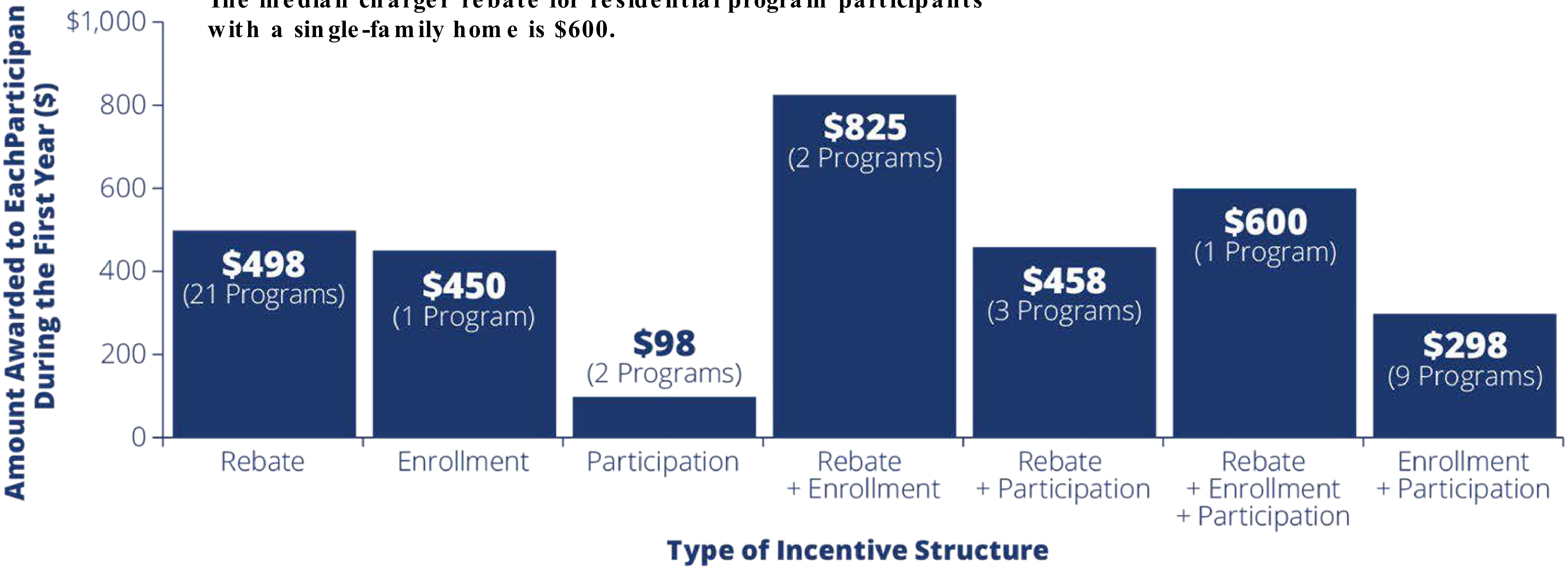


Source: Smart Electric Power Alliance, 2021.

Incentive offered in year one (average)

Smart Electric Power Alliance

The median charger rebate for residential program participants with a single-family home is $600.



Source: Smart Electric Power Alliance, 2021.

Vehicle to Grid (V2G, V2H, V2L) – getting closer

Smart Electric Power Alliance

Ford Intelligent Power can use the truck to power homes during high-cost, peak-energy hours.

Ford is also teaming up with Sunrun, to facilitate easy installation of the 80-amp Ford Charge Station Pro and home PV system.

GMC Hummer EVs Power Station Generator onboard bi-directional charger can export 25 amps of AC current.

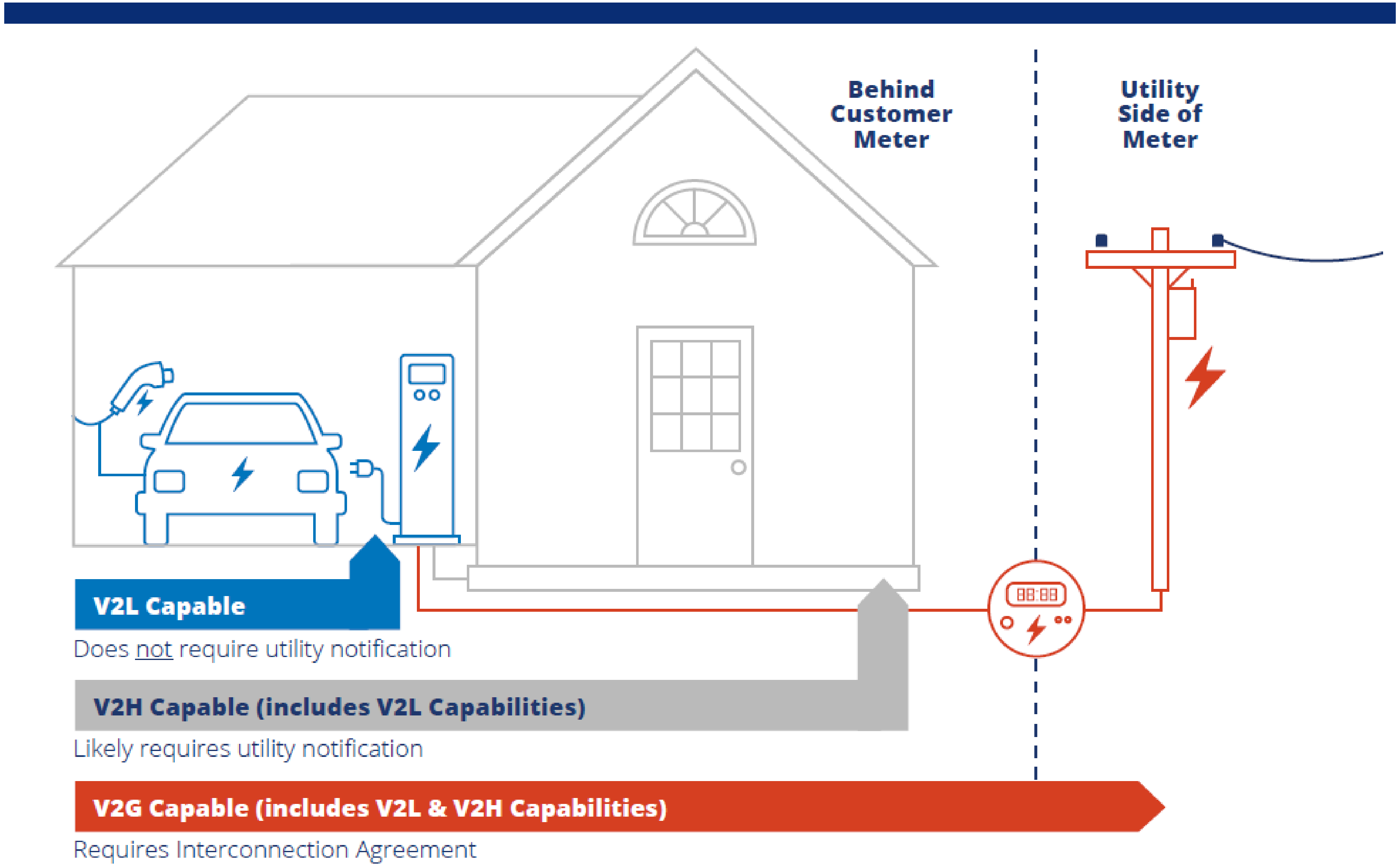
Rivian has also highlighted their Vehicle to Load and Vehicle to Vehicle Charging

From 2022 onwards, new electric vehicle models from **VW** will support bi-directional charging.

Hyundai, Kia and Lucid all have future vehicles that the companies say will include this capability.

V2L, V2H, and V2G – the X in V2X Matters

Smart Electric Power Alliance

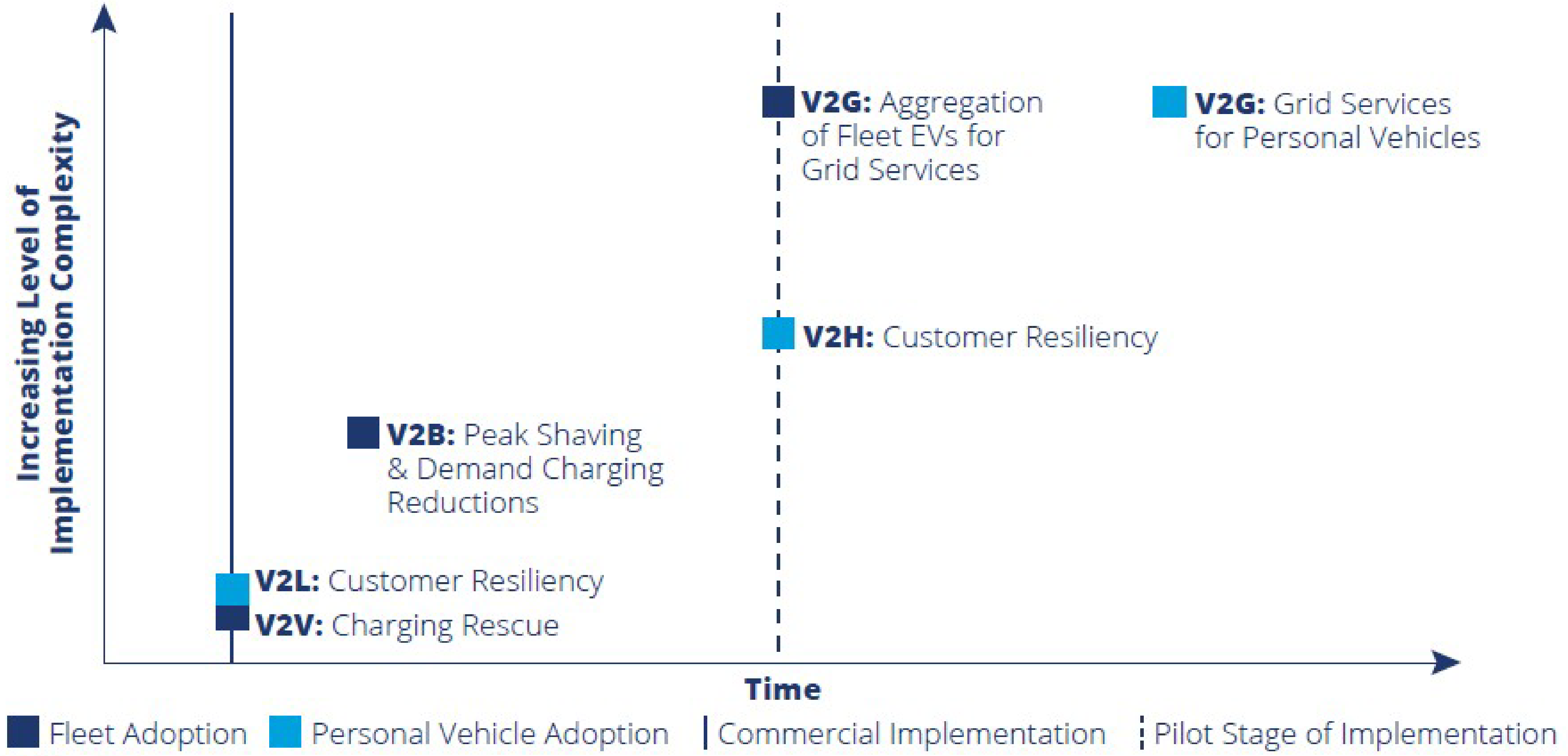


Source: SEPA, 2022

Customer-centric Pathways to V2X Adoption

Stages of Mass Market Adoption of V2X

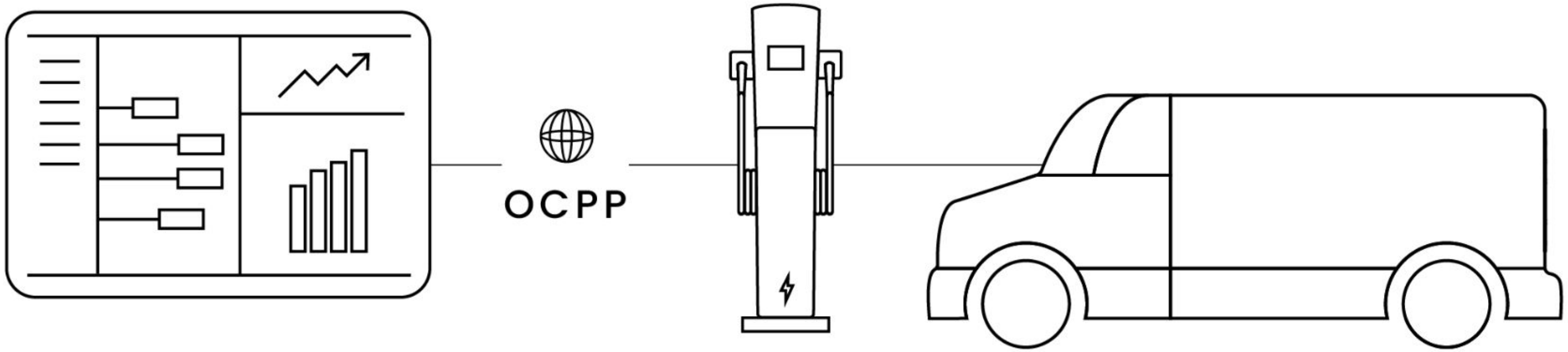
Smart Electric Power Alliance



Source: SEPA, 2022

Panel

Current State of Managed Charging: Progress, Barriers, & Solutions



ampcontrol

Joachim Lohse
CEO & Founder

Ampcontrol is a charging management software for electric vehicle optimization. The AI-powered software uses real-time data to make automated EV charging decisions.

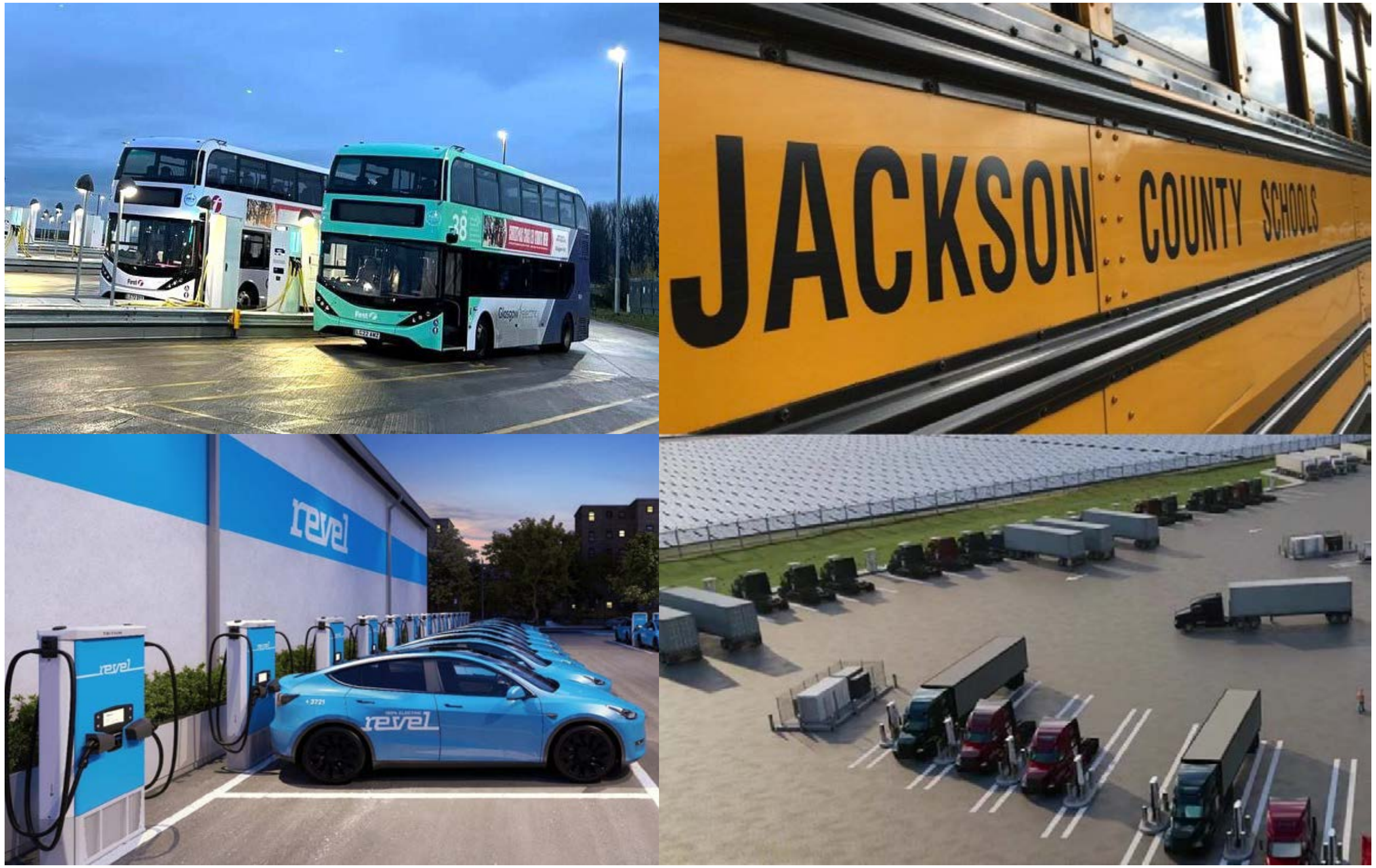
www.ampcontrol.io

How customers use Ampcontrol

Ensure high charger uptime

Reduce charging costs

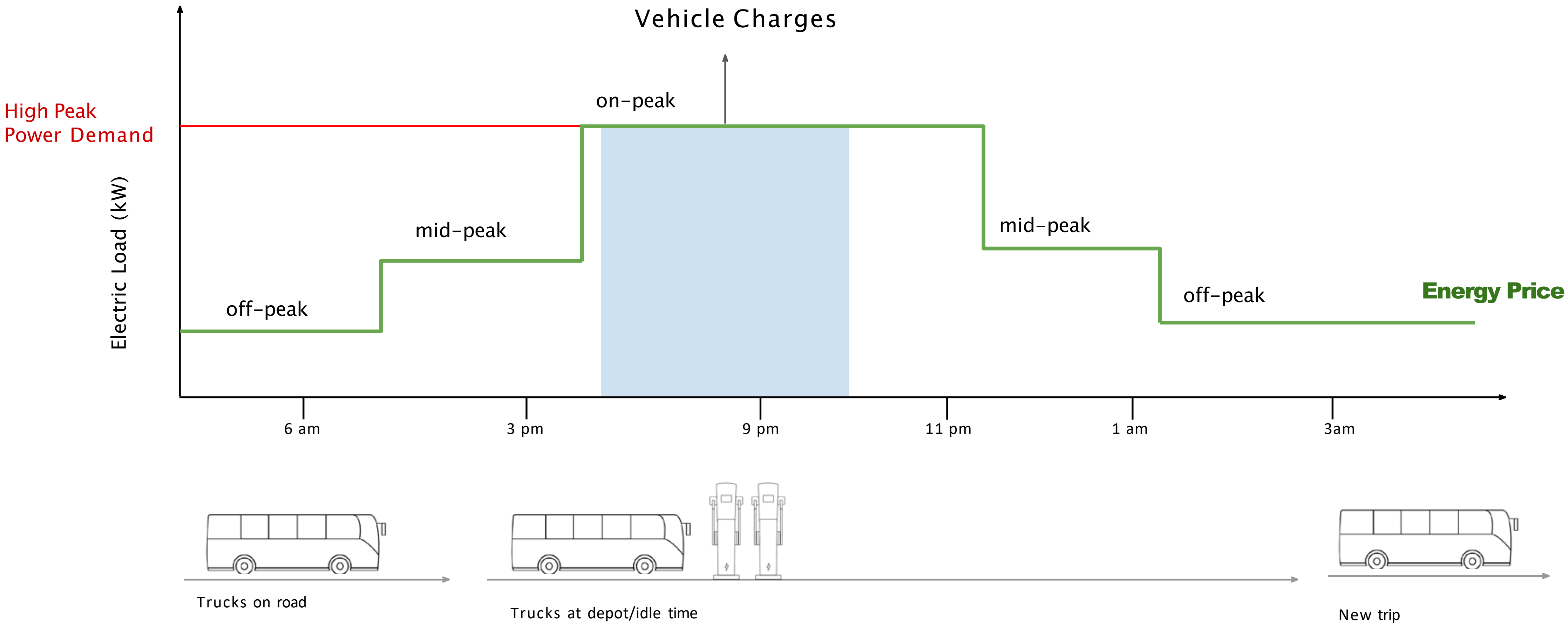
Monitor fleet availability



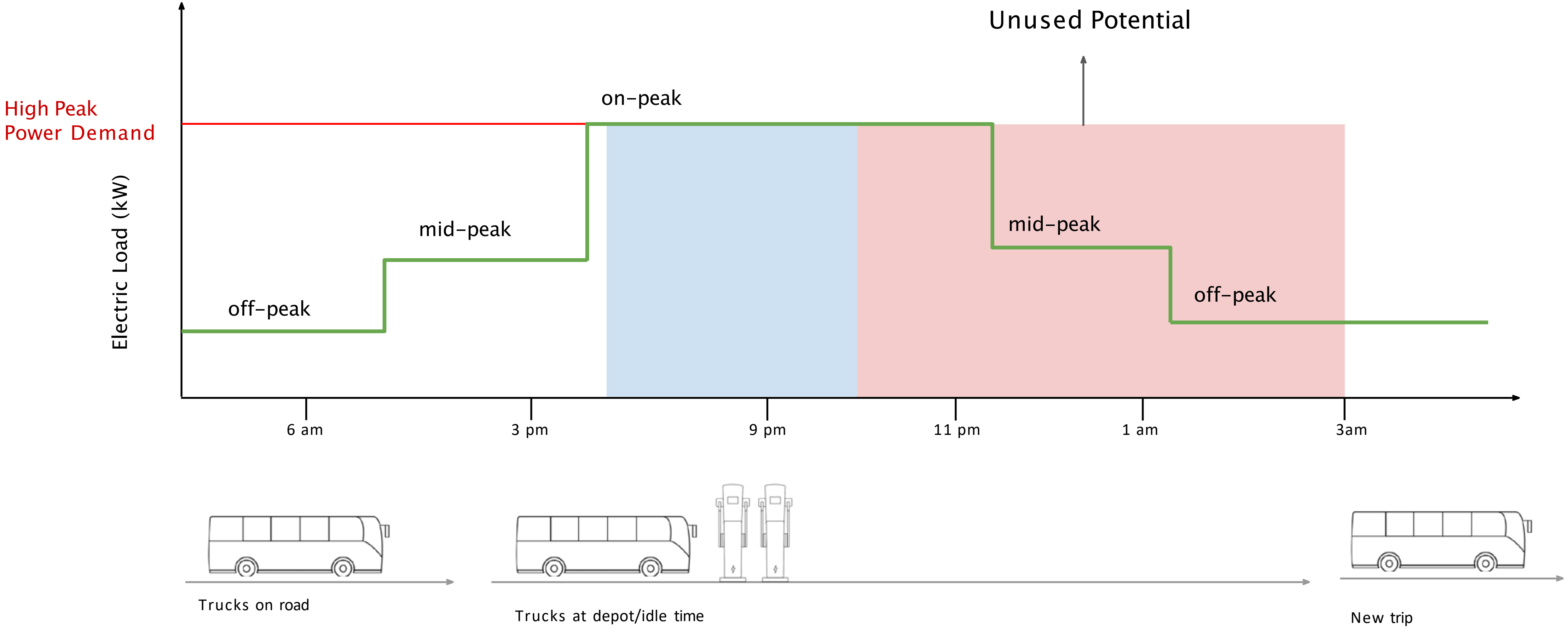
Managed Charging today:

What is possible?

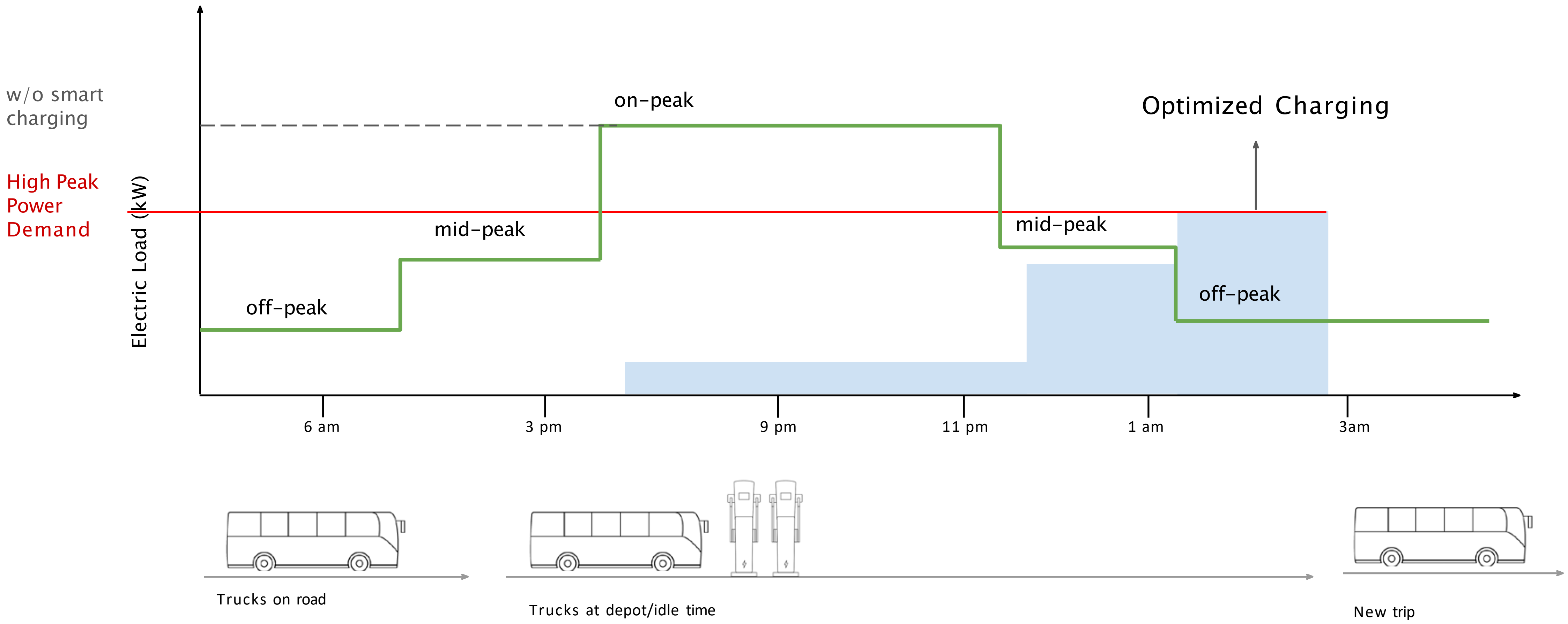
Unmanaged Charging Leads to High Costs



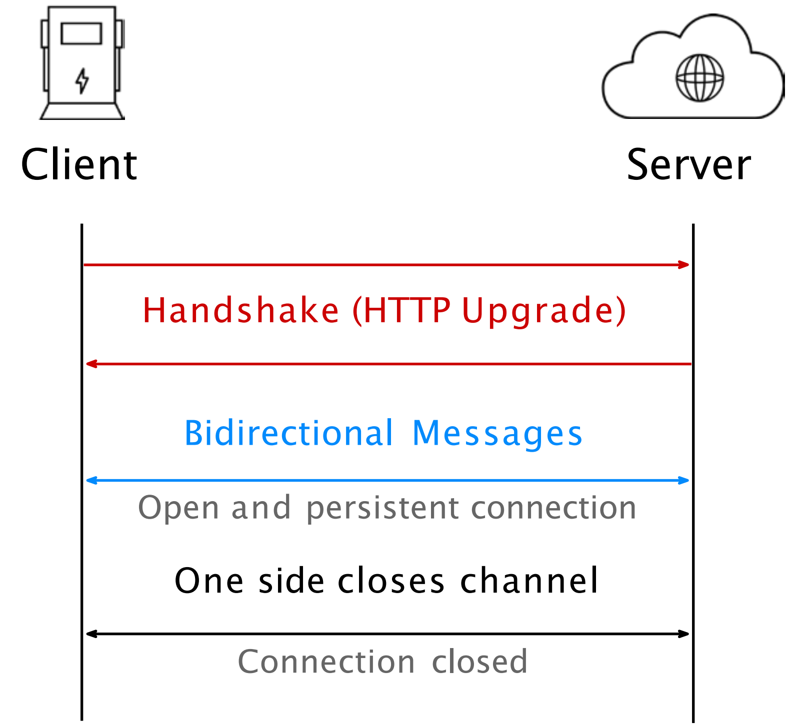
Unmanaged Charging Leads to High Costs



Optimized Charging Reduces Charging Costs



Reminder: How does OCPP work?



1 Initial connection start always by client

2 Server provides “handshake”

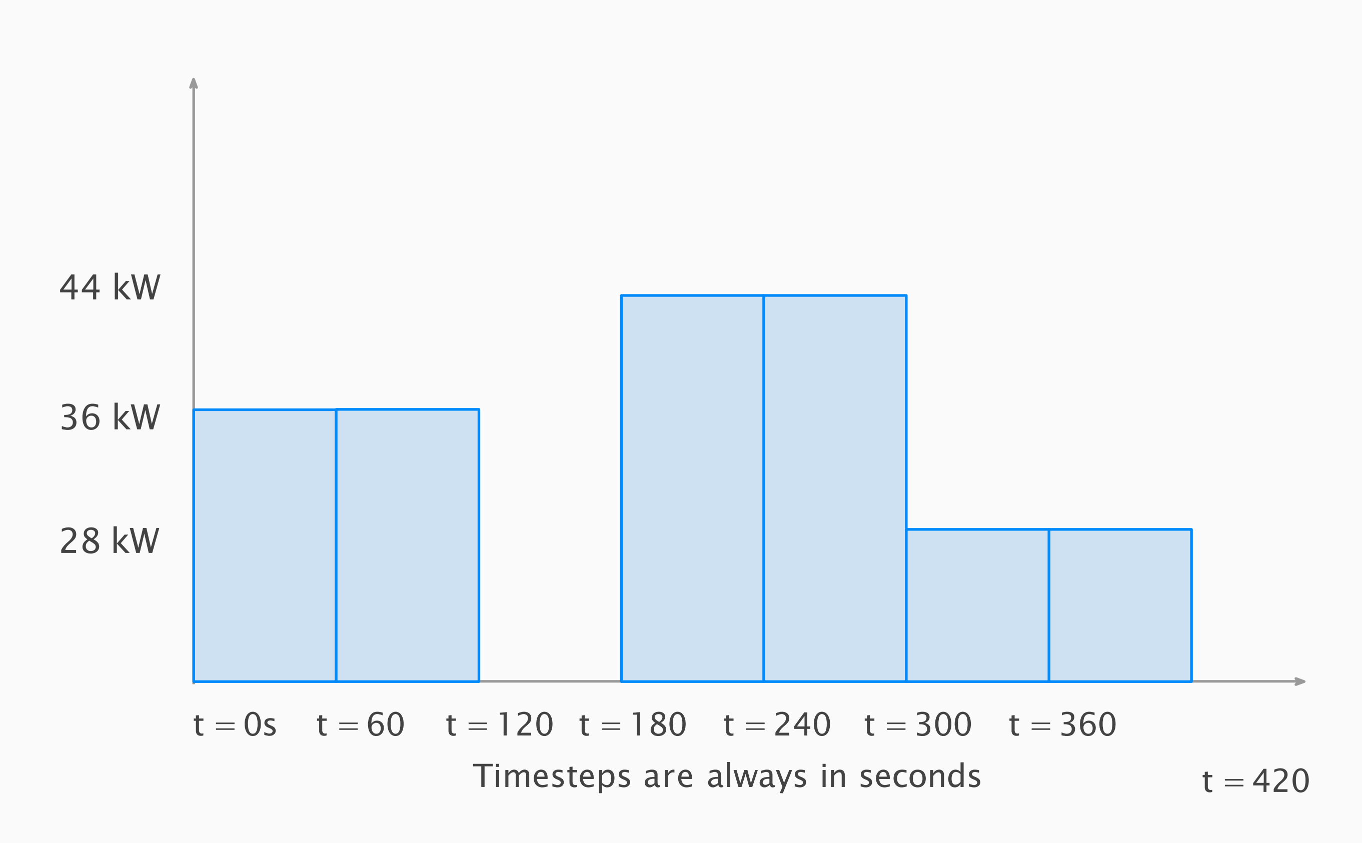
3 Both sides can send messages

4 Both sides can close the connection

EV charger receives charging profiles via OCPP's setChargingProfile.req

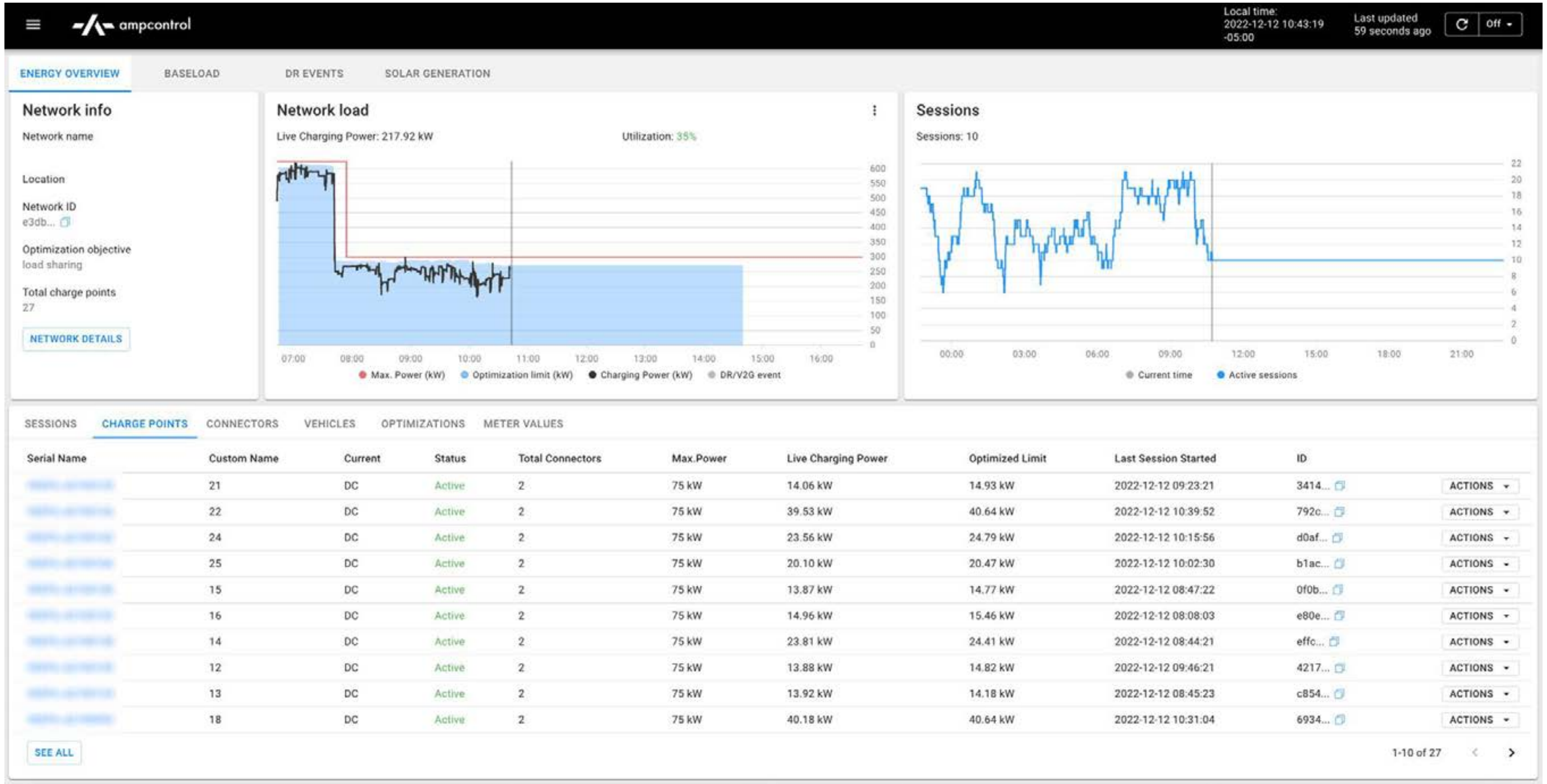
The optimization software creates individual charging profiles. OCPP chargers will typically receive multiple charging profiles between the start and stop of the session.

Charging Profile Example



- OCPP uses a message type "setChargingProfile"
- Charging profile = Ampere or Power per time interval
- Always sent from server to client
- Time steps are variable: 1s, 3s, 120s, etc.
- Can be replaced with new profile any time

OCPP allows reliable and dynamic load management



Benefits

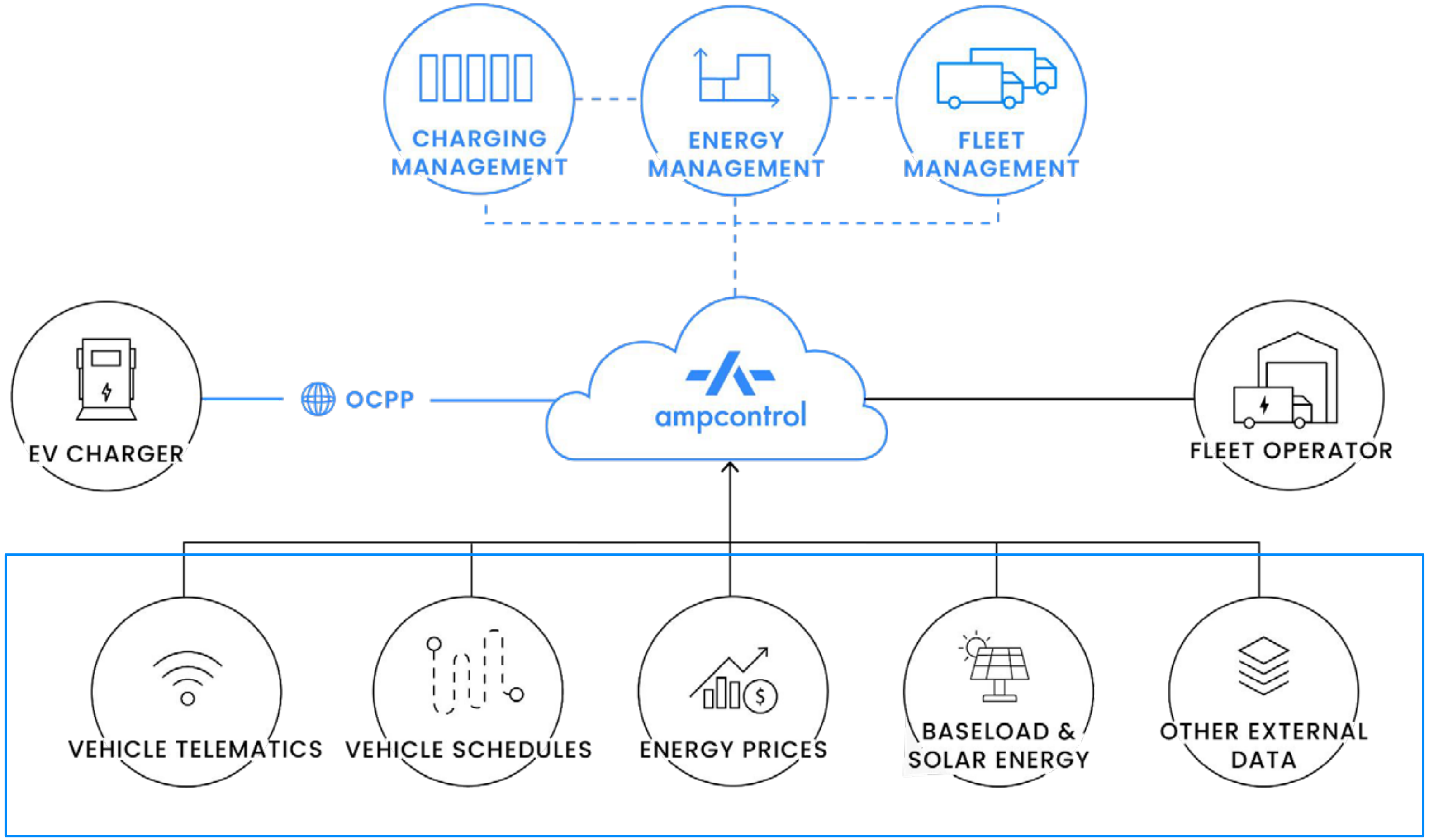
Works for AC and DC chargers

Redistribute charging during CV-Phase

Update charging profiles several times during session

Takes into account vehicle data (departure time, target SoC, etc.)

Smart charging enables connections that extend beyond the charger hardware



Case Study: revel

Confidential

Ampcontrol ensures higher charger uptime and reduces costs by >55%.

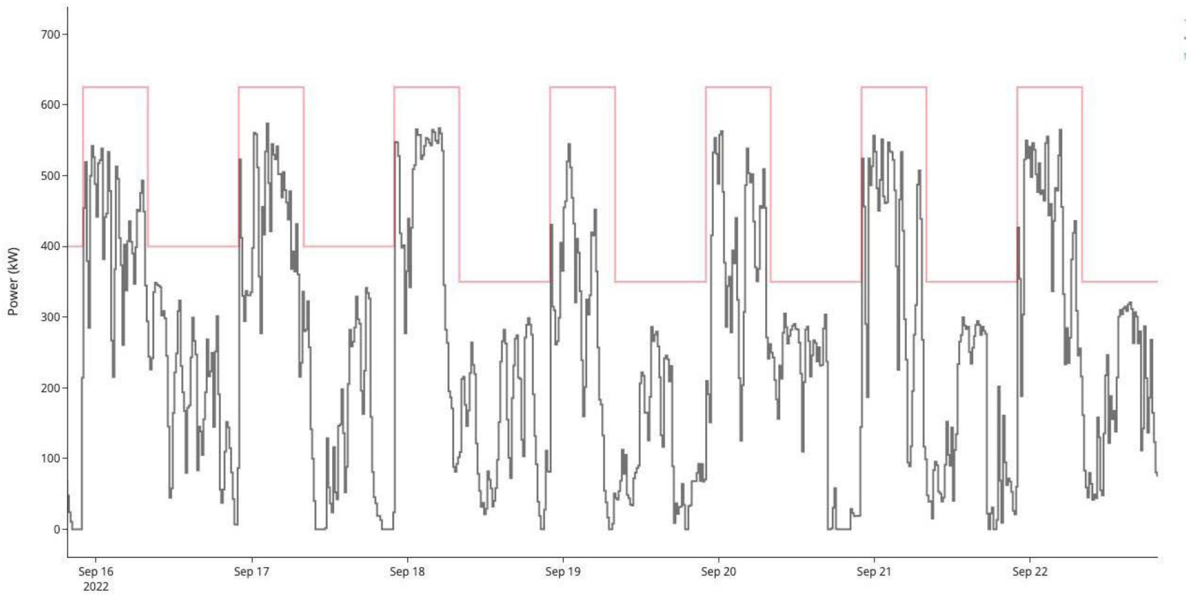
TESLA
Vehicle OEM
(Telematics data)

ampcontrol
Real-Time
Control System

TRITIUM
EV Charger

- >55% saved energy costs per month
- >100k charging sessions per year

Site Power Output (1 week)

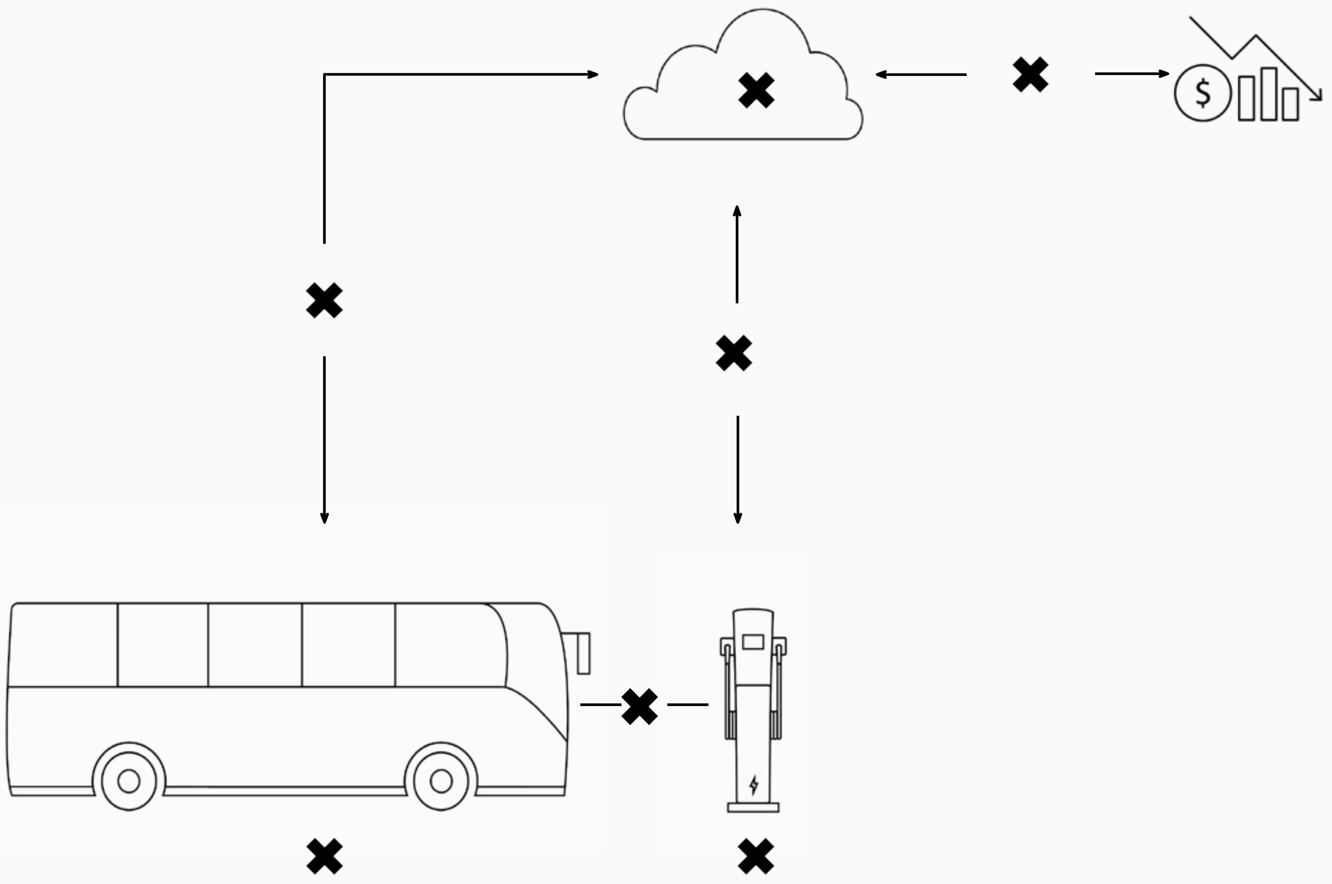


Ampcontrol significantly reduces energy costs by constraining the site's power output at different time of the day. This reduces Demand Charges, and optimizes charging depending on TOU rates.

What are challenges?

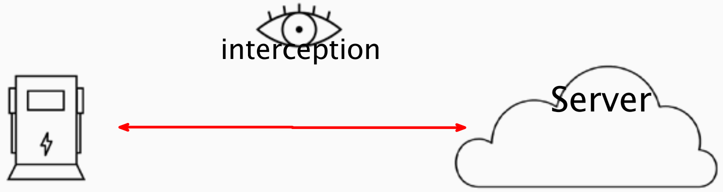
Typical error source

- ✖ Hardware broken
- ✖ **Synchronization incorrect**
- ✖ **Connection broken**
- ✖ Charger-vehicle communication
- ✖ Charger firmware bug
- ✖ CMS software bug
- ✖ **Incomplete OCPP integration**
- ✖ Unregistered idTag (RFID, etc.)

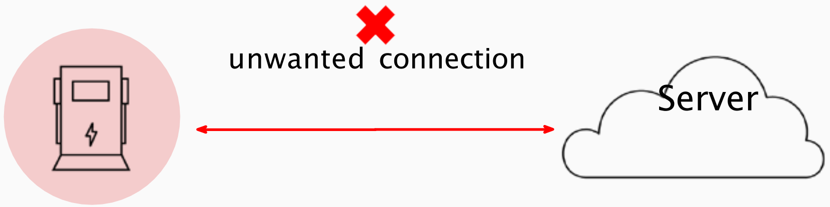


Charger exchange data and require the correct security

Security breach 1



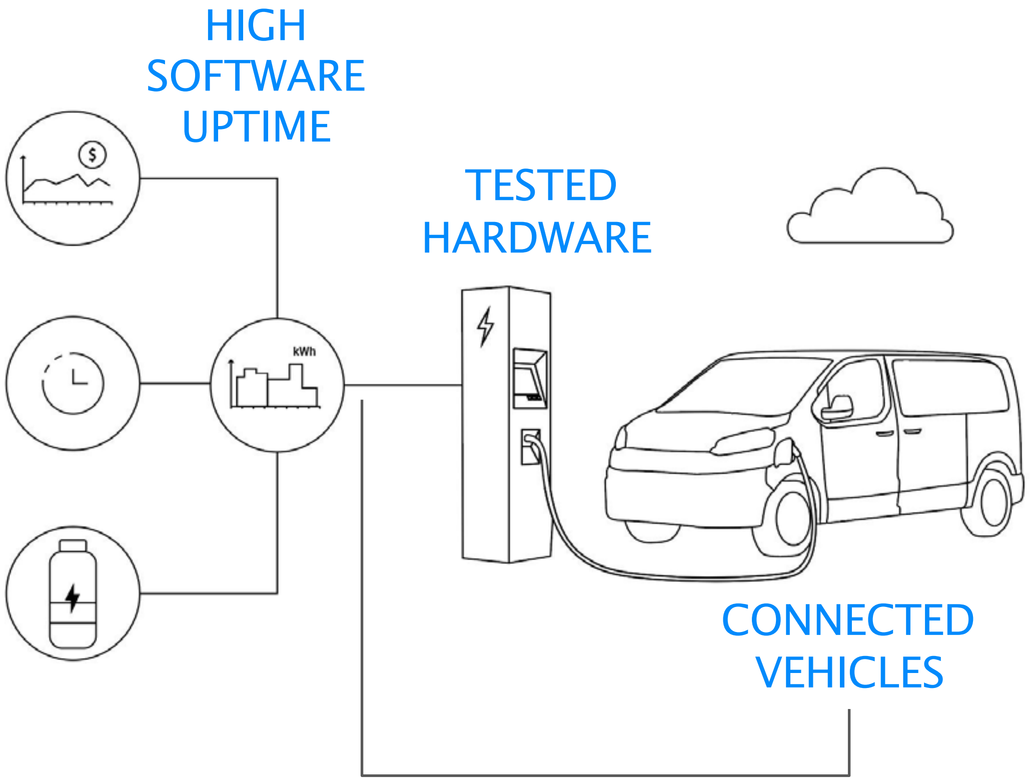
Security breach 2



1. Only use **secure WebSocket** to connect chargers (URL starts with “wss” instead of “ws”)
2. Your CMS provider AND charger must use the **highest TLS version** (TLS 1.2 or higher)
3. A URL should use a **custom secret** (“password”) per location
4. Ask your CMS provider for additional **security options**

Increase uptime through hardware test, alert systems, and more

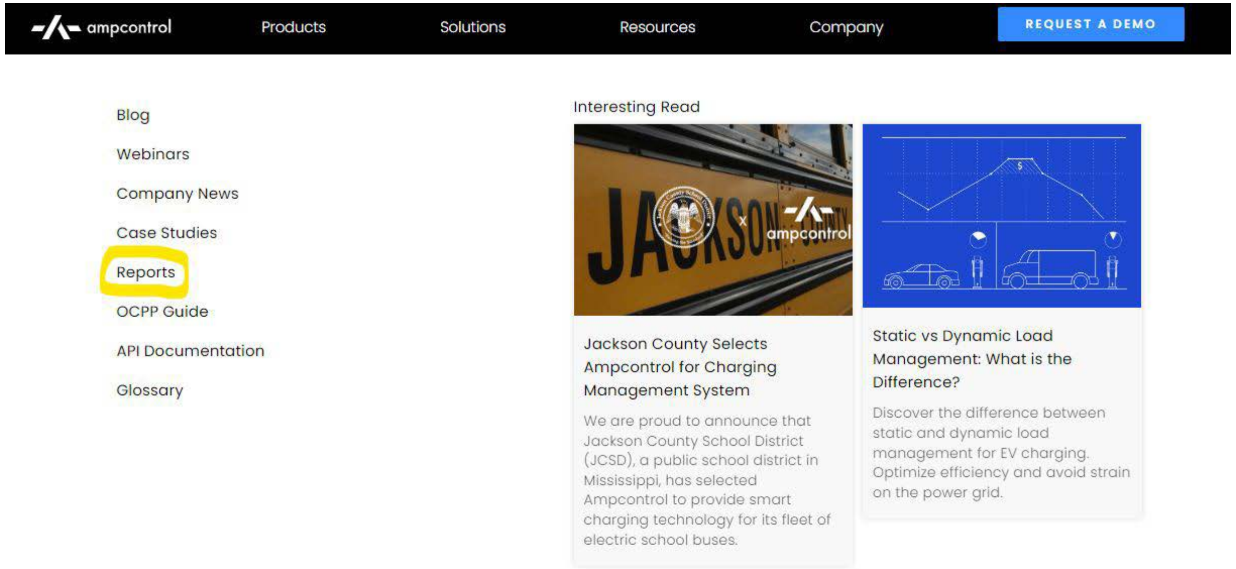
- Test hardware with CMS partner before purchase
- Evaluate CMS uptime and smart charging capabilities
- For fleets: Integrate vehicle data to ensure on-time departure



https://www.ampcontrol.io/reports/ocpp-report

Interested in OCPP?

In our report, "What is OCPP and How to Use It For Smart Charging," discover how OCPP eases communication of charging station networks and its potential for energy management and grid integration.



Thank you for joining

If you have any questions, please email us at:
contact@ampcontrol.io

or visit us at
www.ampcontrol.io

GSA | EVSE & Managed Charging

Christie-Anne Edie | GSA R8 Sustainability Program Manager | May 18, 2023

GSA

Christie-Anne Edie

GSA Region 8 Sustainability Program Manager

Applied Innovation Learning Lab (AILL) | Managed Charging Progress

Background:

On April 13, 2022 GSA Administrator Carnahan announced that GSA will be launching demonstration projects, called Applied Innovation Learning Laboratories, at the DFC and other locations around the country.

One of the first-ever GSA Green Proving Ground collaborations between multiple Industry and Federal partners, including Department of Energy National Renewable Energy Laboratory and Sandia National Laboratories.

Learning Labs Phase I – EV Charging Infrastructure (EVSE)

- Supports glide path to an all Zero Emission Vehicle (ZEV) federal fleet
  - 2027: 100% light duty vehicles in fleet = ZEVs
  - 2035: 100% all vehicles in fleet ZEVs
- External Alignment / Leading by Example
  - 2030: construction of a national network of 500,000 electric vehicle (EV) chargers
  - $7.5 Billion funding to state and local government for EVSE in Bipartisan Infrastructure Law

Additional resources:

GSA - Press Release

GSA -Administrator Carnahan's Remarks

WH- Executive Order 14057

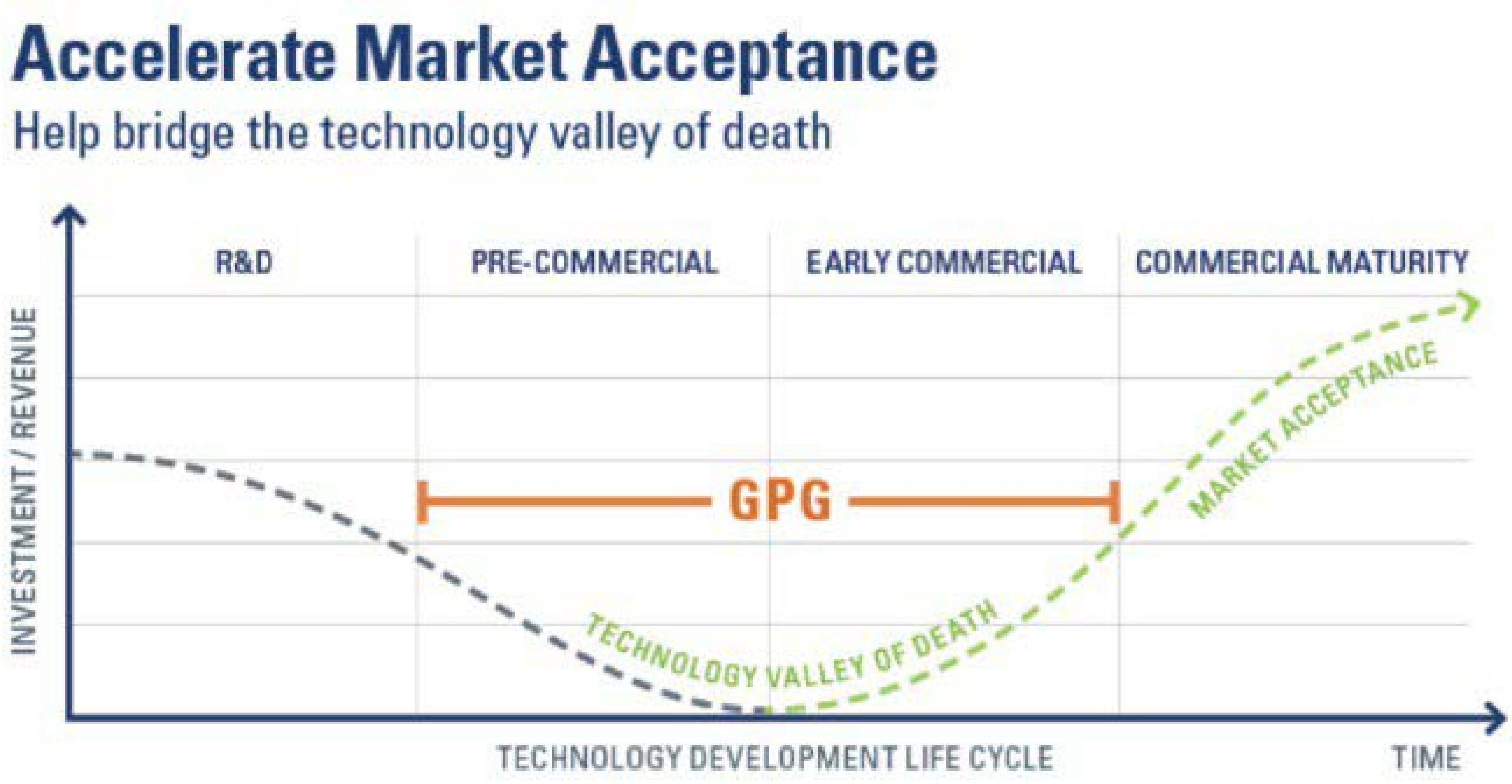
WH- EV Charging Action Plan

WH-FACT SHEET: The Biden-Harris Electric Vehicle Charging Action Plan

Local coverage

GSA's Green Proving Ground

GPG leverages GSA's real estate portfolio to evaluate innovative building technologies.



AILL: Electric Vehicle Supply Equipment (EVSE)

Coordinated Approach:

Consolidate resources and leverage Green Proving Ground Program M&V to develop EVSE requirements and acquisition tools needed to support an all-electric fleet.

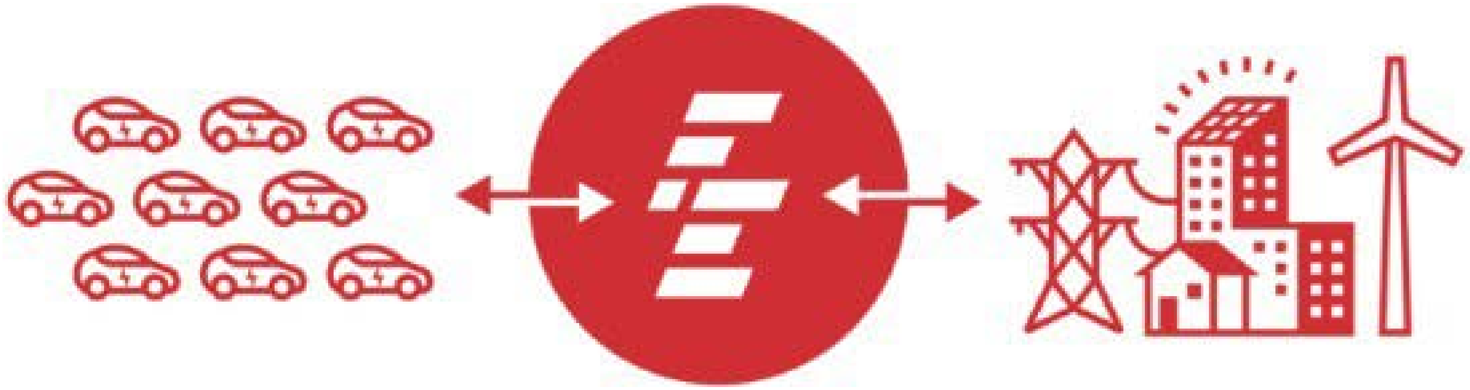
- EVSE GPG Technologies (Lab M&V)
  - **Fermata Energy | Bi-directional EV charging** turns EVs into energy storage assets, increasing resilience and lowering the cost of EV ownership.
  - **Beam Global | Renewable, transportable EV charging station** combines solar, battery storage and emergency power. Can be independent or grid tied.
  - **EV charge management** optimizes charging based on vehicle use, utility rates, and the carbon content of delivered power. CANCELLED
- Existing EVSE Technologies (Internal Guidance)
  - ChargePoint chargers with capability to bill back to public customers as well as GSA Fleet customers

Additional resources:

[2023 GPG Program Press Release]

Bi-Directional EV Charging by Fermata (Charlottesville, VA) | GPG

Bi-directional EV charging can be used to stabilize the grid by strategically using EVs to either power local building loads or send energy back to the grid. This vehicle-to-everything (V2X) technology turns EVs into energy storage assets, increasing resilience and lowering the cost of EV ownership.



Value to GSA if Validated

- Reduces electricity costs with demand charge management
- Reduce C02 emissions, 10-ton/yr for 1 charger
- Reduce fleet electric vehicle cost
- Pilot project for new initiative: Applied Innovation Learning Lab
- Currently, the Nissan LEAF is the only EV with bidirectionally equipped battery in the U.S.
- Greatest value for facilities with demand that varies and peaks over the course of the day and average 15-minute load that exceeds bidirectional charger capacity

Modular Charging Stations by Beam (San Diego, CA) | AILL

Renewable, transportable, off-grid EV charging station combines solar, battery storage and emergency power panels. Can be independent or grid tied.

Value to GSA if Validated

- Reduce C02 emissions, 10-ton/yr for 1 charger
- Reduced EVSE infrastructure cost and flexibility to easily move to match fleet needs
- Quickly deployed in a standard 9x18 parking space. ADA compliant.
- No required construction permitting. No associated trenching, switch gear upgrades, interconnection agreements
- Ideal for building with small number of EV. 1 unit can deliver 265 e-miles per day.

EV Charge Management CANCELLED | GPG

The Biden-Harris Administration is committed to electrifying the 450,000 vehicles in the federal fleet. This EV charge management solution supports that goal by integrating embedded vehicle telematics with utility signals to optimize charging based on vehicle use, utility rates, and the carbon content of delivered power.

Value to GSA if Validated

- 30% fuel cost savings
- 10% GHG savings
- Charger agnostic with no additional hardware costs.
- Includes predictive analytics and dashboard insights.
- Applicable throughout the portfolio

Smart Charging: GSA/Federal Challenges

Pricing/Management Policy: Multi-tenant facilities with varying mission requirements and charging needs. GSA manages the facility, the Customer Agency ultimately decides which station to purchase. GSA and most federal government do not have automated fleet reservation systems. We are relying on human planning charge management. GSA is not prepared to manage this at an individual building level = widespread uncontrolled charging.

Smart Charging: GSA/Federal Challenges

IT Security: Each agency has their own network and each building has its own BAS = integration issues. Unique Secured networks (Cloud-based services) must be FedRAMP certified. This includes any hardware, remediation, and software. This process can take years.

Smart Charging: GSA/Federal Challenges

Utilities cannot keep up with the increase in electrical demand. Some locations (such as Salt Lake City, are already experiencing blackouts. Often Utilities do not have a demand response programs.

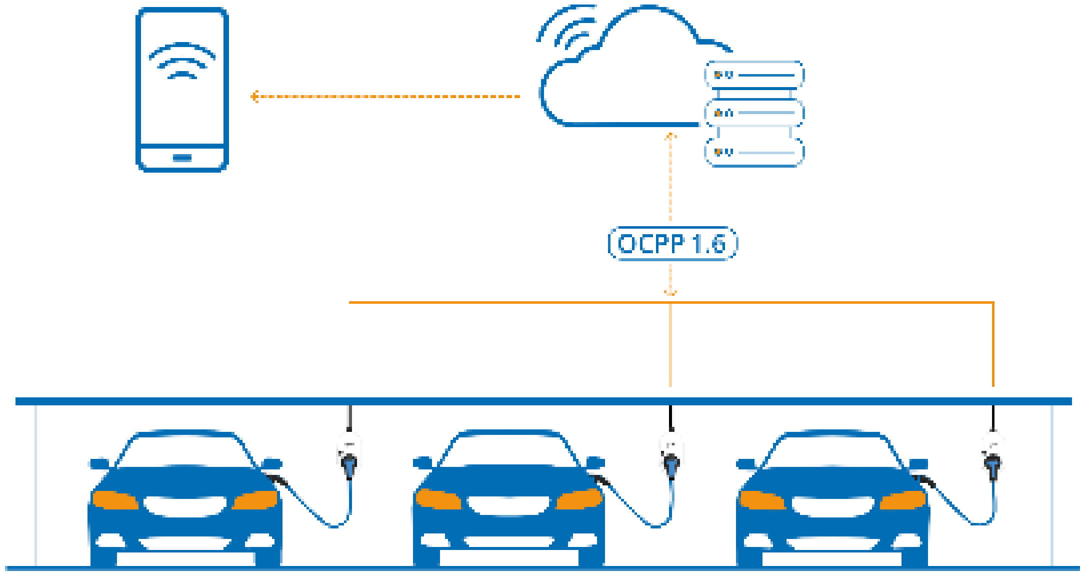
Managed Charging: Solutions

FedRAMP - Each respective agencies' CIO shares information with other agencies.

Ensure all Government-purchased stations are OCPP - Open Charge Point Protocol (industry standard). Most stations on GSA's Blanket Purchase Agreement are OCPP.

Encourage the pilot of an fleet reservation software system that can integrate smart charging.

We need a low-cost, scalable solution that can communicate across all varying brands of charging stations and vendors.



The Future of Managed Charging

GSA will continue to pilot managed charging software options via Green Proving Ground in 2024 including Automated Demand Response programs (ADR) - integrated software.

The Administration is driving the initiative but the market hasn't caught up. The technology is at a tipping point of functionality.

Thank you!

Christie-Anne Edie

GSA Sustainability Program Manager

christie.edie@gsa.gov