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California PEV Infrastructure Projections 2017-2025

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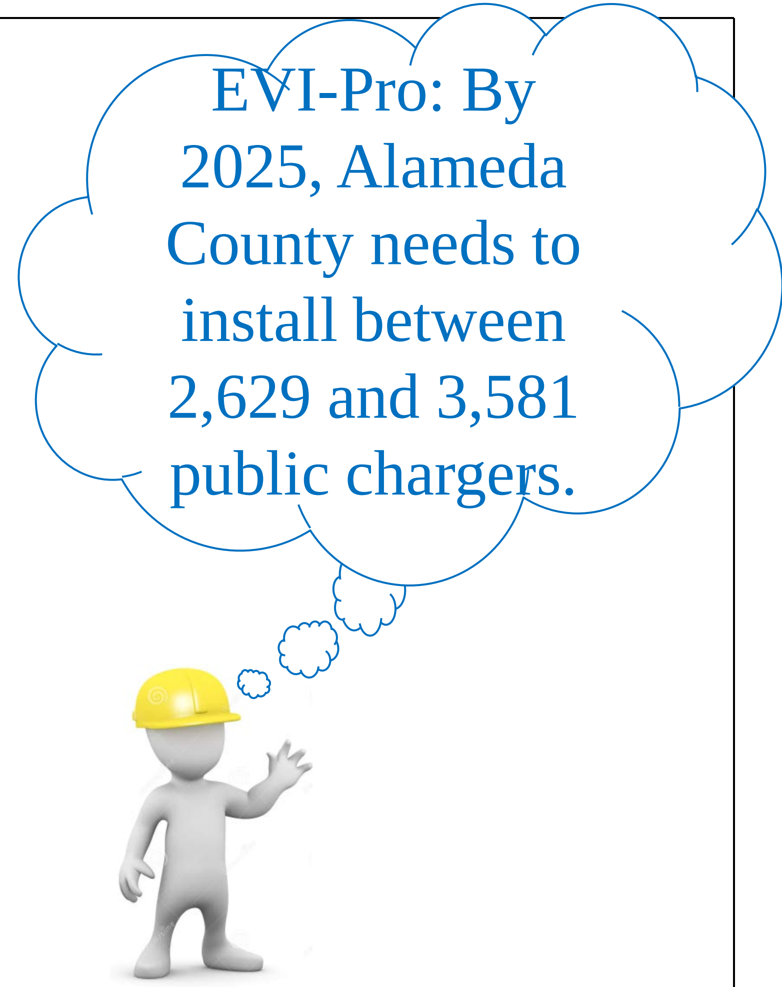
CEC Staff Workshop - 5/23/2018

EVI-Pro Development Timeline

- February 2016 – March 2016:
  - ✓ CEC proposed infrastructure modeling concept.
  - ✓ CEC developed technical support contract with NREL.
- April 2016 – December 2016:
  - ✓ CEC-NREL executed contract, and build EVI-Pro beta version.
  - ✓ CEC & NREL provide 1st interagency briefing.
- January 2017 – March 2017:
  - ✓ NREL completed model revisions.
  - ✓ CEC provides 2nd interagency briefing to present preliminary results.
- April 2017 – December 2017:
  - ✓ CEC and agencies complete statewide assessment.
  - ✓ Staff brief Commissioner Scott on final results 12/1/2017.
- December 2017 – March 2018:
  - ✓ CEC drafts report for publication.
  - ✓ Final Staff Report published on 3/16/2018.

Research Question

"How many of each charger type are needed in California to ensure that both BEVs and PHEVs can drive mostly on electricity by 2025?"



Modeling Objectives & the New Paradigm

1. Target **enabling travel** for BEVs
2. Provide PHEVs the opportunity for **maximizing their electric miles**
3. Consider mainstream demographics for **expanding the PEV market.**
4. Consider consumers' ability to **reduce the infrastructure cost** by efficient sharing.

Understanding the Variance and Uncertainty in the use of PEV Infrastructure

- Staff identified the following factors that should be accounted in interpreting the EVI-pro results
- EVI-Pro model focuses on the issues highlighted in red below.

Area	Sources of Variance and Uncertainty
PEV technology	- Battery range - Powertrain efficiency - Charging power level
PEV market trends	- PEV buyer demographics (i.e., type of residence) - PEV fleet mix of BEVs and PHEVs - Vehicle ownership and innovative mobility trends
Travel and charging behavior	- Range anxiety (or state-of-charge [SOC] tolerance) - PHEVs' willingness to plug-in - Pricing and the shared-use of chargers (accessibility and reliability)

Literature review compares methods

- Reviewed 9 studies, including for 3 CA and 1 PG&E
  - The scientific literature has focused on the following issues: charger type & location, pricing, PEV fleet mix, market size
- Key issues not currently reflected in EVSE models:
  - Shared use of chargers
  - Parking availability and potential for charging
  - Innovative mobility trends

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

California Energy Commission Statewide EVSE Assessment: EVI-Pro Methodology

May 2018

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

PEV Charging Analysis – NREL Objective

Provide guidance on plug-in electric vehicle (PEV) charging infrastructure to regional/national stakeholders to:

- Reduce range anxiety as a barrier to increased PEV sales
- Ensure effective use of private/public infrastructure investments

Key PEV charging infrastructure questions addressed by EVI-Pro…

How many?

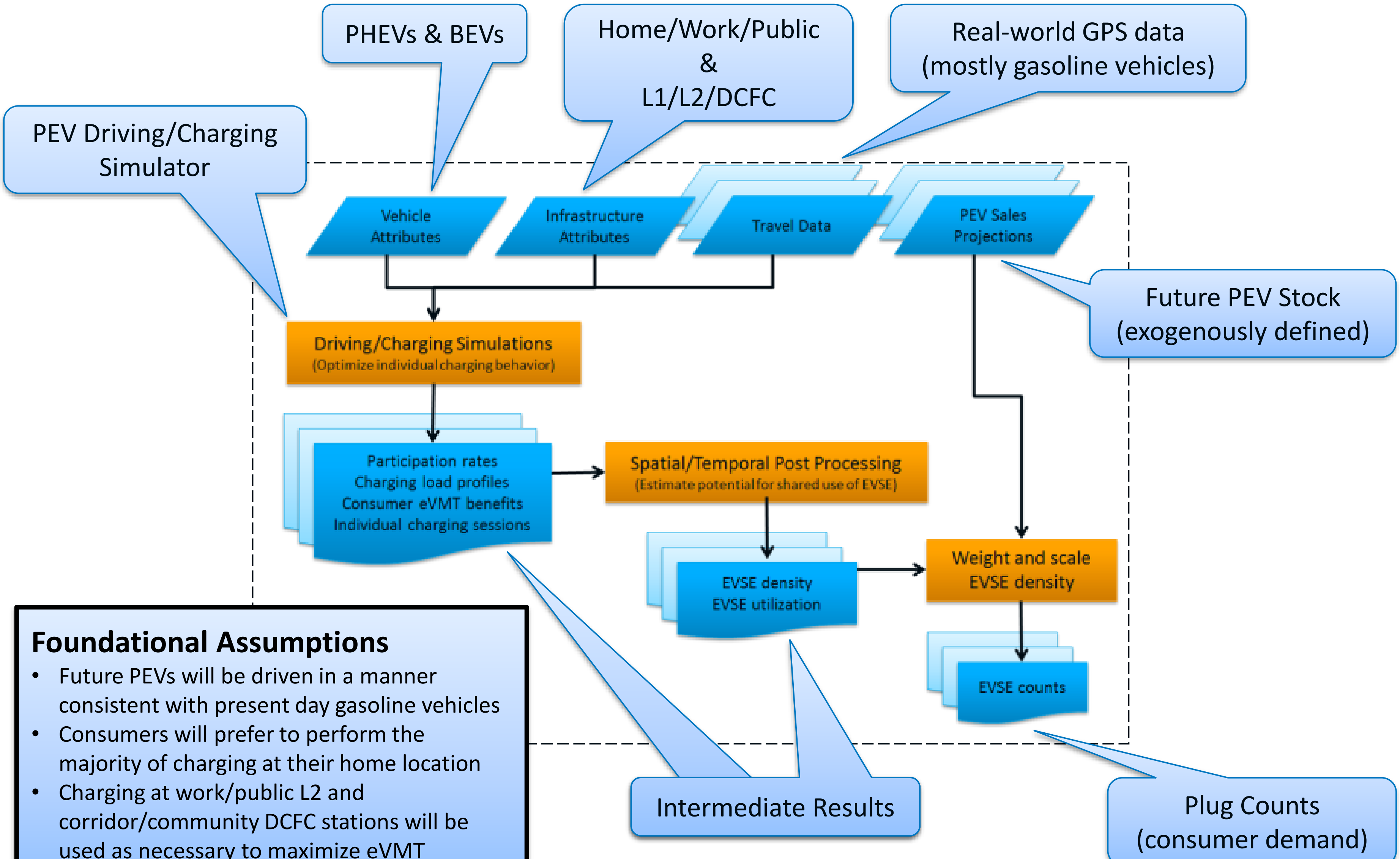
What kind?

Where?

Recent NREL EVI-Pro Studies

Massachusetts (2017)
National Analysis (2017)
Columbus, OH (2018)
Maryland (forthcoming)

Electric Vehicle Infrastructure Projection Tool (EVI-Pro)

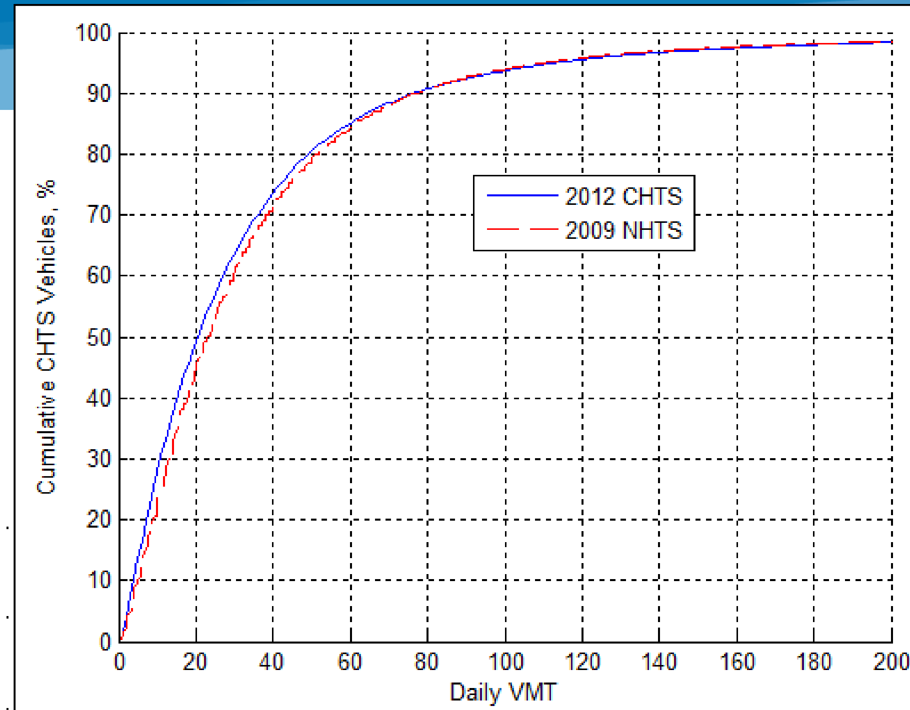


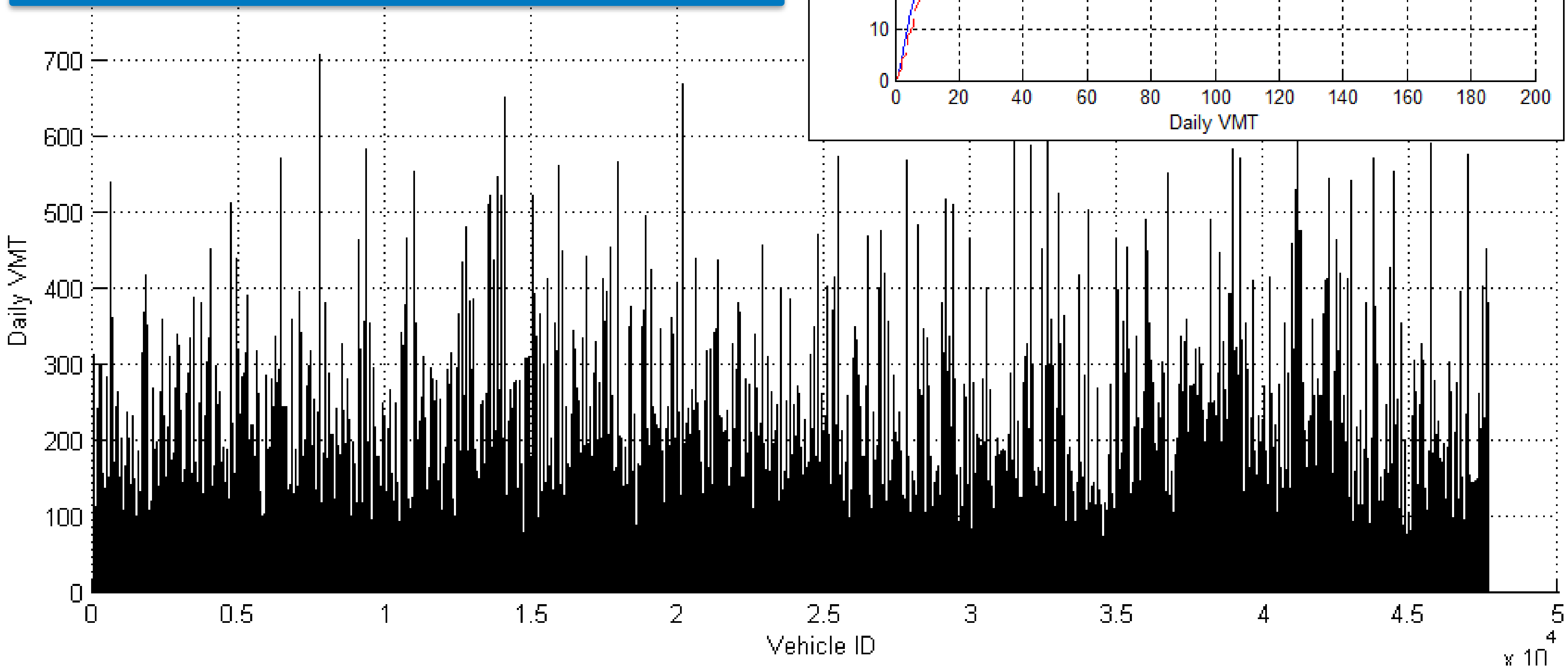
Foundational Assumptions

- Future PEVs will be driven in a manner consistent with present day gasoline vehicles
- Consumers will prefer to perform the majority of charging at their home location
- Charging at work/public L2 and corridor/community DCFC stations will be used as necessary to maximize eVMT

2012 CHTS

- 2012 CHTS single-day survey
- 47,559 vehicles from 32,300 households
- Generated 184,476 driving trips
- Coverage in all 58 CA counties
- Data compares favorably with national statistics

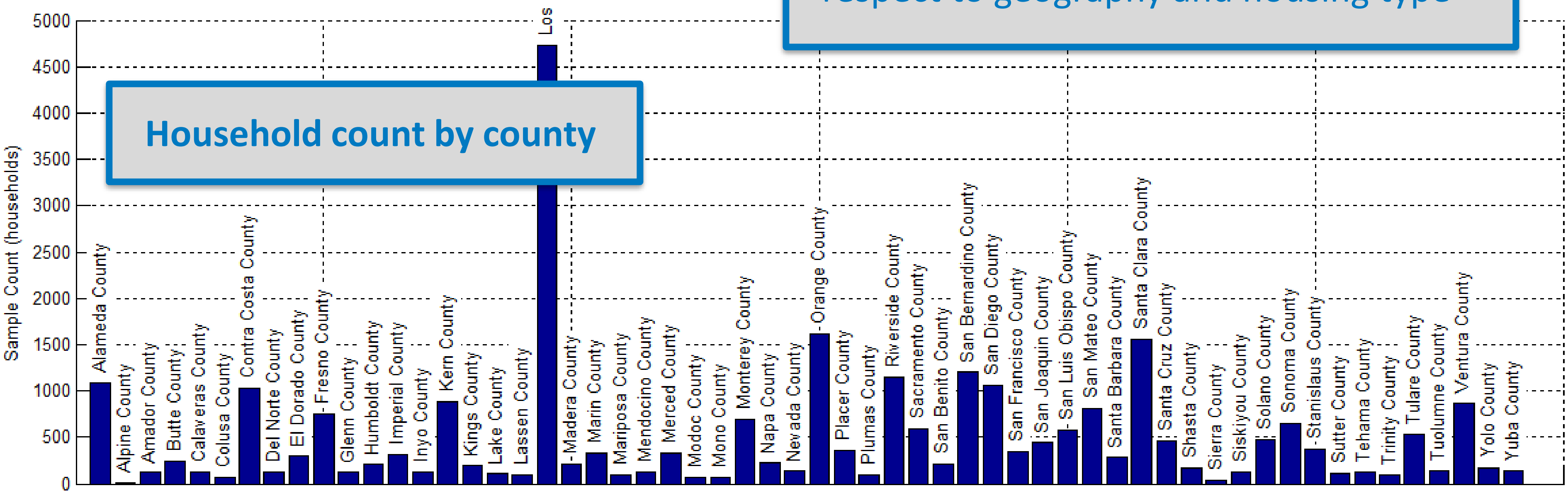




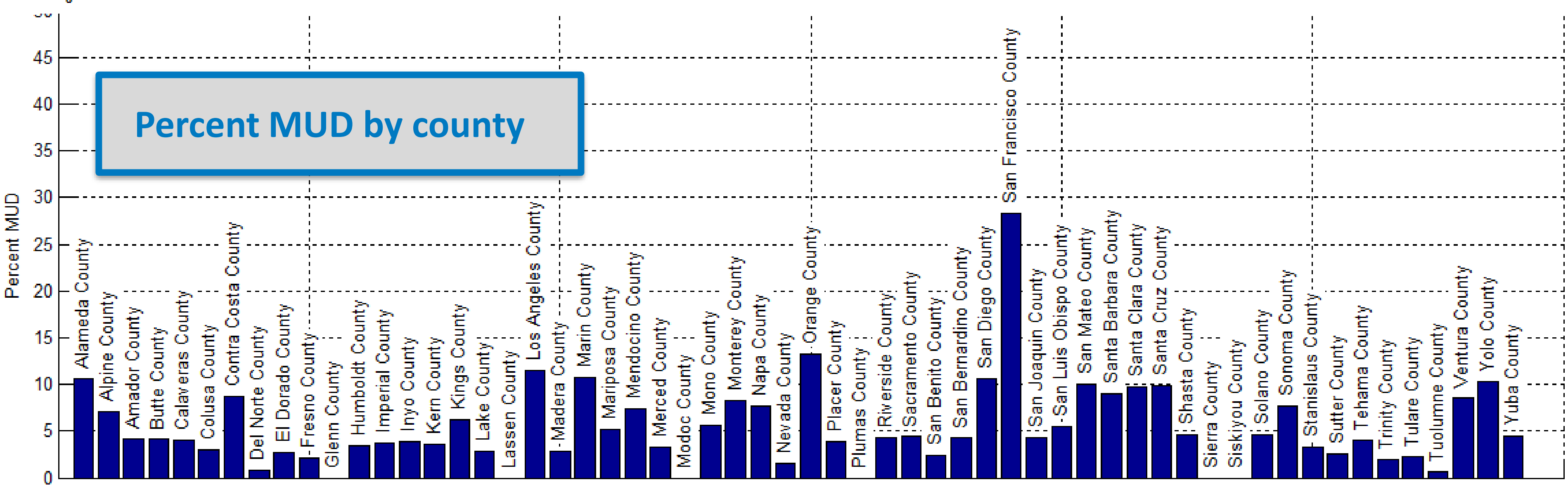
2012 CHTS

Travel survey has been stratified with respect to geography and housing type

Household count by county



Percent MUD by county



MUD Designation in EVI-Pro

Residency Type	Description	Vehicle Count	Percent of Sample	EVI-Pro MUD	EVI-Pro Home Charging Option
1	Single-family house not attached to any other house	39,018	82.0%	no	yes
2	Single-family house attached to one or more houses (townhouse, duplex, triplex), each with separate entry	2,887	6.1%	no	yes
3	Mobile home	1,055	2.2%	yes	no
4	Building with 2–4 apartments/condos/studios/rooms	1,234	2.6%	yes	no
5	Building with 5–19 apartments/condos/studios/rooms	1,701	3.6%	yes	yes
6	Building with 20 or more	1,612	3.4%	yes	yes
7	Boat, RV, van, etc.	12	0.0%	yes	no
97	Other	10	0.0%	yes	no
98	Don't know	11	0.0%	yes	no
99	Refused	19	0.0%	yes	no

- CHTS places households into one of ten residence types
- Availability of home charging in EVI-Pro is restricted to certain residence types
- EVI-Pro MUD designation is also based off CHTS residence type

Step 1: Charging Behavior Logic in EVI-Pro

Step 1.0 – Load 24-hr travel data and PEV attributes.

Step 1.1 – Identify all feasible combinations of charging opportunity by destination type (home, work, public) and power level (L1, L2, DCFC) with assumed uniform opportunity by location type (e.g. L2 charging available at all public destinations).

Step 1.2 – Iterate over all combinations of charging opportunity simulating battery SOC for each.

1.2a – Conduct preliminary simulation attempting to charge only as necessary at each opportunity (forecasting SOC forward by one trip at a time). If SOC is maintained above consumer range anxiety constraint, repeat simulation iterating on initial SOC until net energy is non-negative.

1.2b – If necessary, disable SOC forecasting and simulate with all charging opportunities utilized. If SOC is maintained above constraint, repeat simulation iterating initial SOC until net energy is non-negative.

Step 1.3 – From scenarios considered, discard simulations that were unable to satisfy minimum SOC constraint. From remaining scenarios, identify minimum energy cost option (including gasoline consumption for PHEVs). Identify all options within 1% of minimum cost. From this group select the option that maximizes coincidence of charging with long dwell times (effectively minimizing total daily charge events).

Step 1.4 – Log results

Semi-exhaustive list of EVI-Pro driving/charging algorithm.
Let's review an example simulation…

Driving/Charging Simulations (Step 1.0)

Destination	Departure	Arrival	Drive Miles	Dwell Hours
Work	8:20 AM	9:00 AM	32.8	5.00
Public	2:00 PM	3:30 PM	68.9	0.25
Public	3:45 PM	4:00 PM	6.3	0.25
Public	4:15 PM	4:20 PM	0.9	0.67
Public	5:00 PM	5:30 PM	9.2	0.25
Public	5:45 PM	6:00 PM	5.0	0.50
Home	6:30 PM	7:30 PM	46.8	12.83

Single travel day from conventional vehicle in CHTS with 170 miles of driving in a single day

Driving/Charging Simulations (Step 1.1)

Destination	Departure	Arrival	Drive Miles	Dwell Hours
Work	8:20 AM	9:00 AM	32.8	5.00
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Public	5:45 PM	6:00 PM	5.0	0.50
Home	6:30 PM	7:30 PM	46.8	12.83

A large number of potential charging combinations exist for each individual travel profile

Home →	Work →	Public →	Public →	Public →	Public →	Public →	Home
None	None	None	None	None	None	None	None
L1	L1	L1	L1	L1	L1	L1	L1
L2	L2	L2	L2	L2	L2	L2	L2
		DCFC	DCFC	DCFC	DCFC	DCFC	

Example for BEV100

Driving/Charging Simulations (Step 1.1)

Destination	Departure	Arrival	Drive Miles	Dwell Hours
Work	8:20 AM	9:00 AM	32.8	5.00
Public	2:00 PM	3:30 PM	68.9	0.25
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Public	5:45 PM	6:00 PM	5.0	0.50
Home	6:30 PM	7:30 PM	46.8	12.83

EVI-Pro allows users to manually restrict individual charging types

Level 1 charging at work and public locations is restricted in this example

Home →	Work →	Public →	Public →	Public →	Public →	Public →	Home
None	None	None	None	None	None	None	None
L1	~~L1~~	~~L1~~	~~L1~~	~~L1~~	~~L1~~	~~L1~~	L1
L2	L2	L2	L2	L2	L2	L2	L2
		DCFC	DCFC	DCFC	DCFC	DCFC	

Example for BEV100

Driving/Charging Simulations (Step 1.1)

Destination	Departure	Arrival	Drive Miles	Dwell Hours
Work	8:20 AM	9:00 AM	32.8	5.00
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Public	5:45 PM	6:00 PM	5.0	0.50
Home	6:30 PM	7:30 PM	46.8	12.83

EVI-Pro allows users to manually restrict charging to locations with some minimum dwell time

A 30 minute minimum dwell time requirement is enforced in this example

Home →	Work →	Public →	Public →	Public →	Public →	Public →	Home
None	None	None	None	None	None	None	None
L1	L1	L1	L1	L1	L1	L1	L1
L2	L2	L2	L2	L2	L2	L2	L2
		DCFC	DCFC	DCFC	DCFC	DCFC	

Example for BEV100

Driving/Charging Simulations (Step 1.1)

Destination	Departure	Arrival	Drive Miles	Dwell Hours
Work	8:20 AM	9:00 AM	32.8	5.00
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Public	5:00 PM	5:30 PM	9.2	0.25
Public	5:45 PM	6:00 PM	5.0	0.50
Home	6:30 PM	7:30 PM	46.8	12.83

All remaining combinations of charging options are simulated

Results in 18 unique combinations of charging opportunity

Home →	Work →	Public →	Public →	Public →	Public →	Public →	Home
None	**None**	**None**	**None**	**None**	**None**	**None**	**None**
L1	L1	L1	L1	L1	L1	L1	**L1**
L2	**L2**	L2	L2	**L2**	L2	**L2**	**L2**
		DCFC	DCFC	**DCFC**	DCFC	**DCFC**	

Example for BEV100

Driving/Charging Simulations (Step 1.2)

Let the change in state of charge (SOC) for battery with capacity C subject to power P_n at event n be defined as:

$$\Delta SOC_n = \frac{P_n \Delta t_n}{C}$$

where:

$P(Event\ Type) \in \{Drive, Charge, Rest\}$

$P_{drive} = \eta_{drive} * v_n$

$\boldsymbol{P_{charge} = \min(P_{EVSE,i,q}, P_{ACDC})}$

$P_{rest} = 0$

$\boldsymbol{P_{EVSE,i,q} = rated\ charger\ power}$

$\boldsymbol{i(Location\ Type) \in \{Home, Work, Public\}}$

$\boldsymbol{q(EVSE\ Power) \in \{L1, L2, DCFC\}}$

$P_{ACDC} = onboard\ ACDC\ converter\ rating\ (AC\ EVSE\ only)$

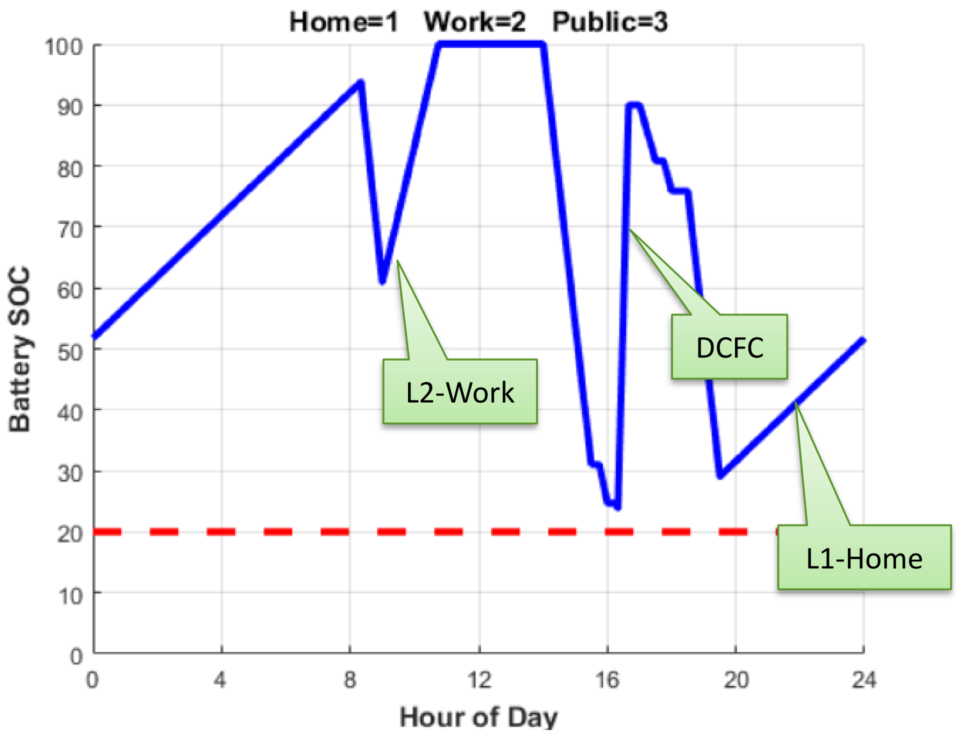
$\eta_{drive} = nominal\ driving\ efficiency$

$v_n = mean\ driving\ speed\ of\ trip\ n$

$\Delta t_n = duration\ of\ timestep\ n$

Individual 24-hr simulations are evaluated as a sequence of drive/charge/rest events with battery power for each event determined using attributes including mean driving speed, location type, and EVSE power rating

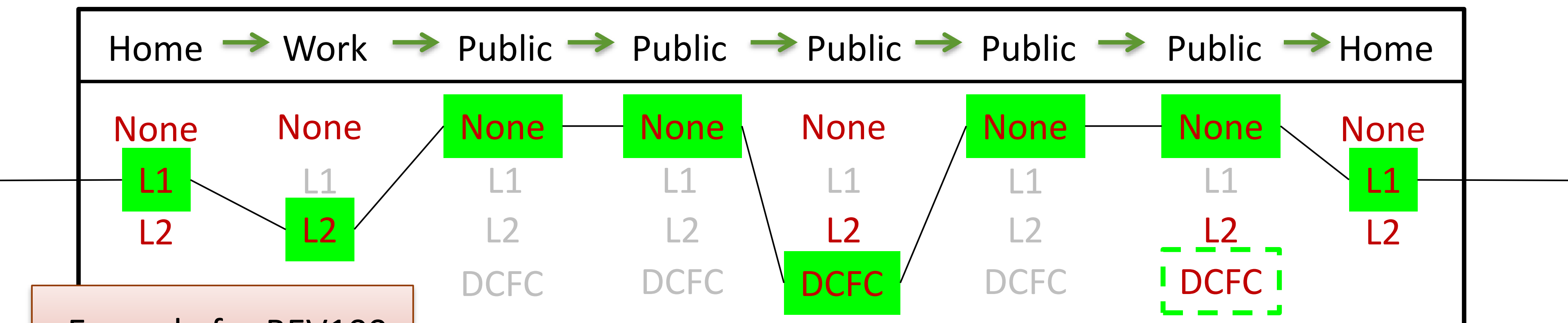
Driving/Charging Simulations (Step 1.2)



Simulated result with opportunity for:
Home-L1
Work-L2
Public-DCFC

Note that Step 2a attempts to "trim" unnecessary charging opportunities. In this example, the second DCFC opportunity is trimmed as it is not required in order to meet the SOC constraint.

If necessary, charge event "trimming" is disabled in Step 2b and all charging opportunities are seized (not necessary in this example).

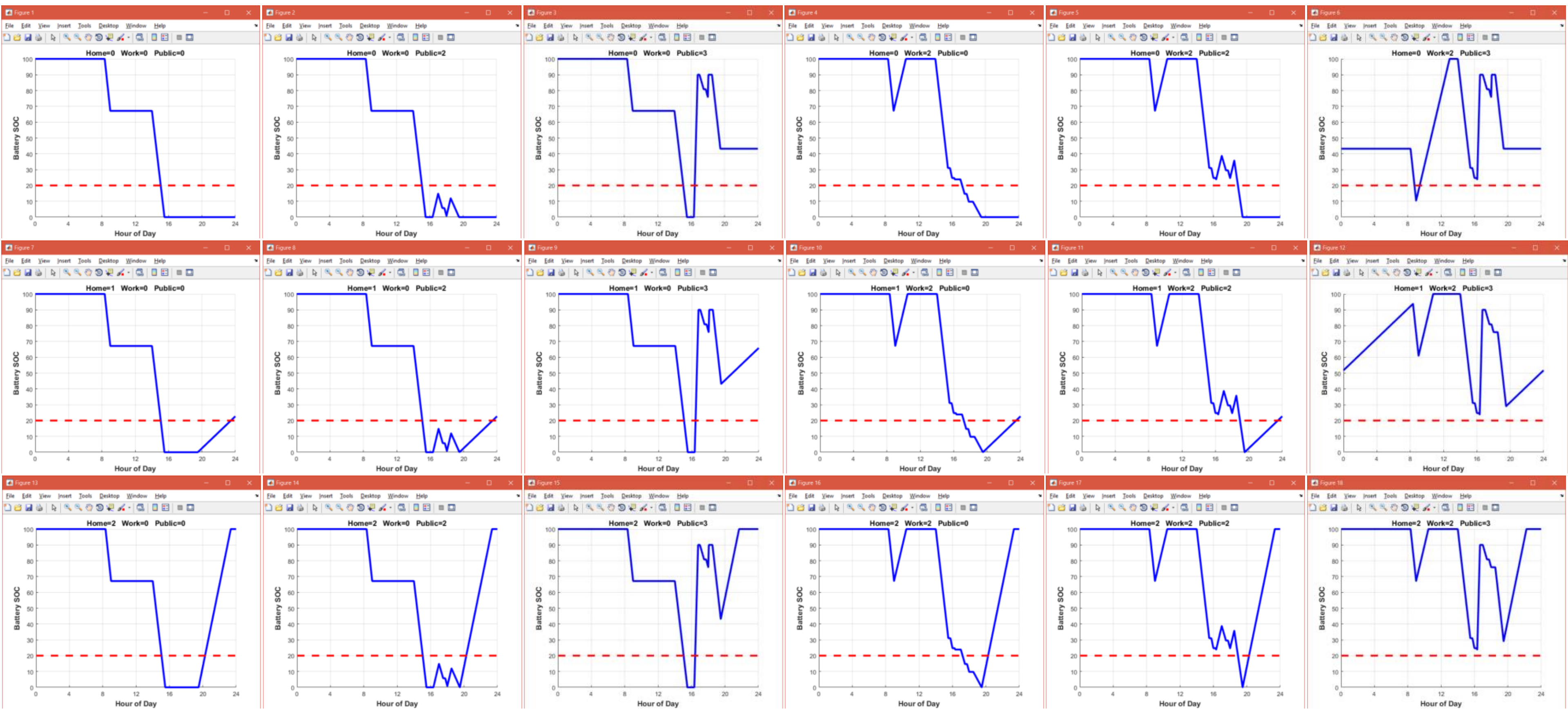


Example for BEV100

Driving/Charging Simulations (Step 1.3)

EVI-Pro internally reviews all combinations of charging behavior (18 in this example)

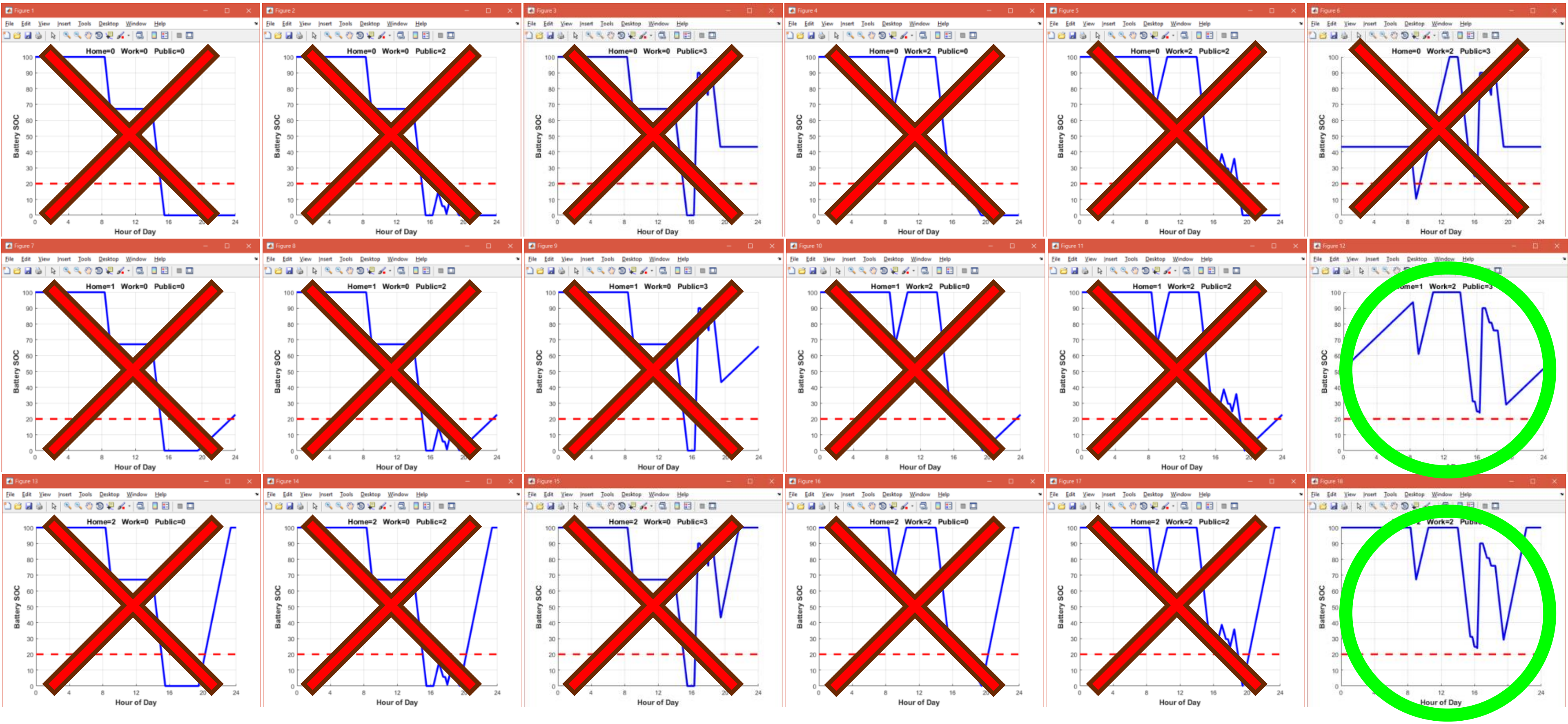
Example for BEV100



Driving/Charging Simulations (Step 1.3)

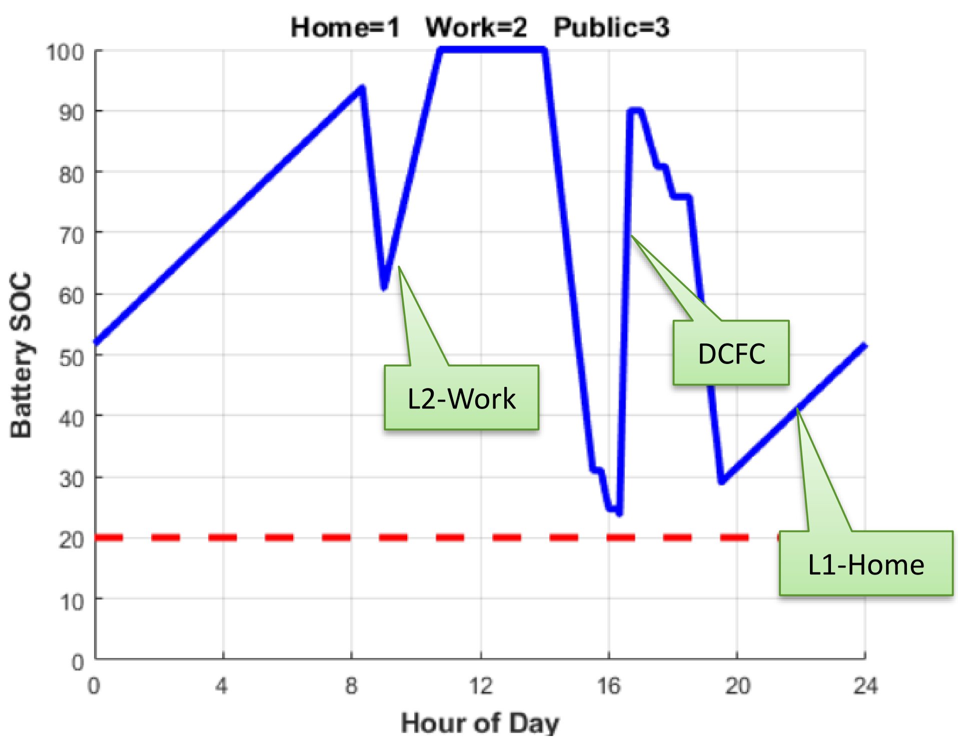
Any charging behavior combination that violates the minimum SOC threshold is discarded (20% SOC in this example)

If no charging behavior combinations are viable, travel day is excluded from simulation set used to determine EVSE/PEV ratios



Driving/Charging Simulations (Step 1.4)

Destination	Departure	Arrival	Drive Miles	Dwell Hours	Simulated Charging
Work	8:20 AM	9:00 AM	32.8	5.00	L2
Public	2:00 PM	3:30 PM	68.9	0.25	---
Public	3:45 PM	4:00 PM	6.3	0.25	---
Public	4:15 PM	4:20 PM	0.9	0.67	DCFC
Public	5:00 PM	5:30 PM	9.2	0.25	---
Public	5:45 PM	6:00 PM	5.0	0.50	---
Home	6:30 PM	7:30 PM	46.8	12.83	L1



Selected low-cost option is recorded (using user-defined charging cost by charger type) and next travel-day & PEV-type combination is evaluated.

Step 2: Uncertainty Propagation (Sharing Assessment)

Bottom-up driving/charging simulations are used to derive multi-dimensional charger to vehicle ratios considering a range of uncertainty regarding sharing potential

For county c, the ratio of chargers to electric vehicles

(at location type i, with power rating q, and vehicle type m)

necessary to support maximal eVMT

(for drivers of residence type r with travel requirement on day of week j)

***are expressed as*:**

$$\left[\frac{C.E.}{PEV}\right]_{i,q,m,r,j,k,c}$$

Collapse on m, r using user defined vehicle distributions by PEV type and residence type

High Estimate

$$H.E._{i,q,j,c} = \frac{\sum_{k=1}^{144} C.E._{i,q,j,c,k}}{2}$$

Low Estimate

$$L.E._{i,q,j,c} = C.E.^{p}_{i,q,j,c} + \frac{\left(H.E._{i,q,j,c} - C.E.^{p}_{i,q,j,c}\right)}{10}$$

k= time interval (up to 24x6 for a 24 hour period [by increments of 10-minutes])

C.E. = Total Charging Events occurring within any 10-minute time interval

$C.E.^{p}$ = Total Charging Events occurring during the peak 10-minute interval

Step 3: Weighting/Scaling

Multi-dimensional charger to vehicle ratio estimates are scaled using user defined inputs for distribution of PEVs by county to estimate infrastructure requirements by charger type and county, which can be further aggregated to statewide estimates as necessary

EVI-Pro Output   Derived by EVI-Pro   User Input

$$EVSE_{i,q,c,e} = \left[\frac{EVSE}{PEV}\right]_{i,q,c,e} * PEV_c$$

Supplemental outputs of EVI-Pro include:

Aggregate charging load profiles
Participation rates by EVSE type
Consumer eVMT benefits
Individual simulated charging sessions

Aspects not currently addressed by EVI-Pro:

Demand from transportation network companies
Impacts of automation on ownership/driving
Supply side distribution/generation capacity

Thanks! Questions?

This work was funded by the California Energy Commission.

California PEV Infrastructure Projections 2017-2025: Analysis & Results

Kadir Bedir, PhD.

Zero-Emission Vehicle Infrastructure Office

California Energy Commission

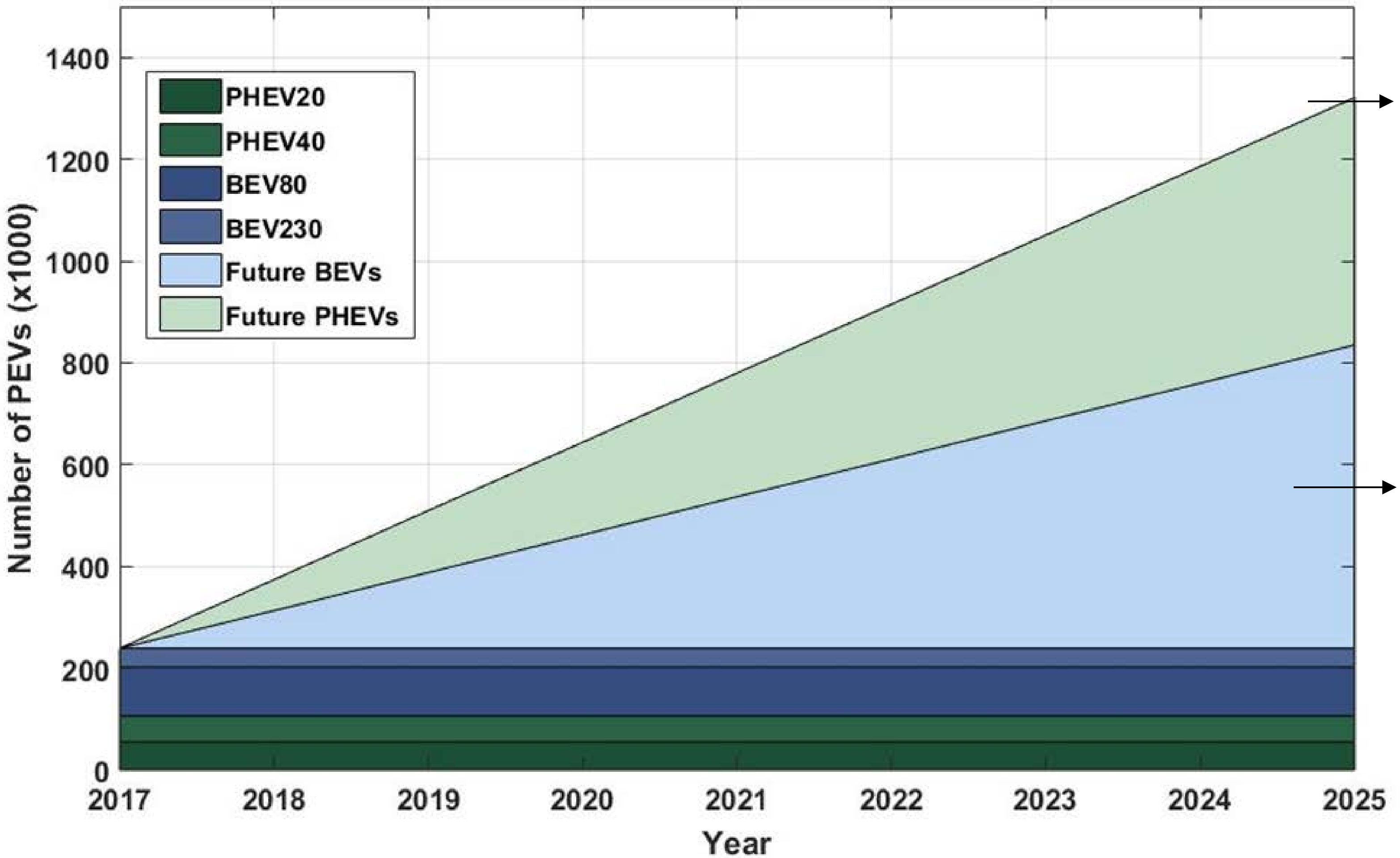
CEC Staff Workshop

5/23/2018

Outline - Analysis & Results

- **CEC Default Scenario Formulation**
  1. Statewide PEV fleet input
  2. County-level distribution of PEVs
  3. Electric range & charging power projections
  4. Fuel pricing assumptions
- **Results**
  1. Total PEV charging loads
  2. Charger count estimates
  3. Residential charging
  4. Regional analysis

1. Statewide PEV Fleet Input (Annual BEV and PHEV Adoption)



~1.3M PEVs
(per EO B-16-2012 and CARB's 2025 Clean Technologies and Fuels Scenario)

45%:55%
Today's PHEV:BEV fleet split stays same

Statewide and County-Level PEV Fleet Inputs 2017-2025

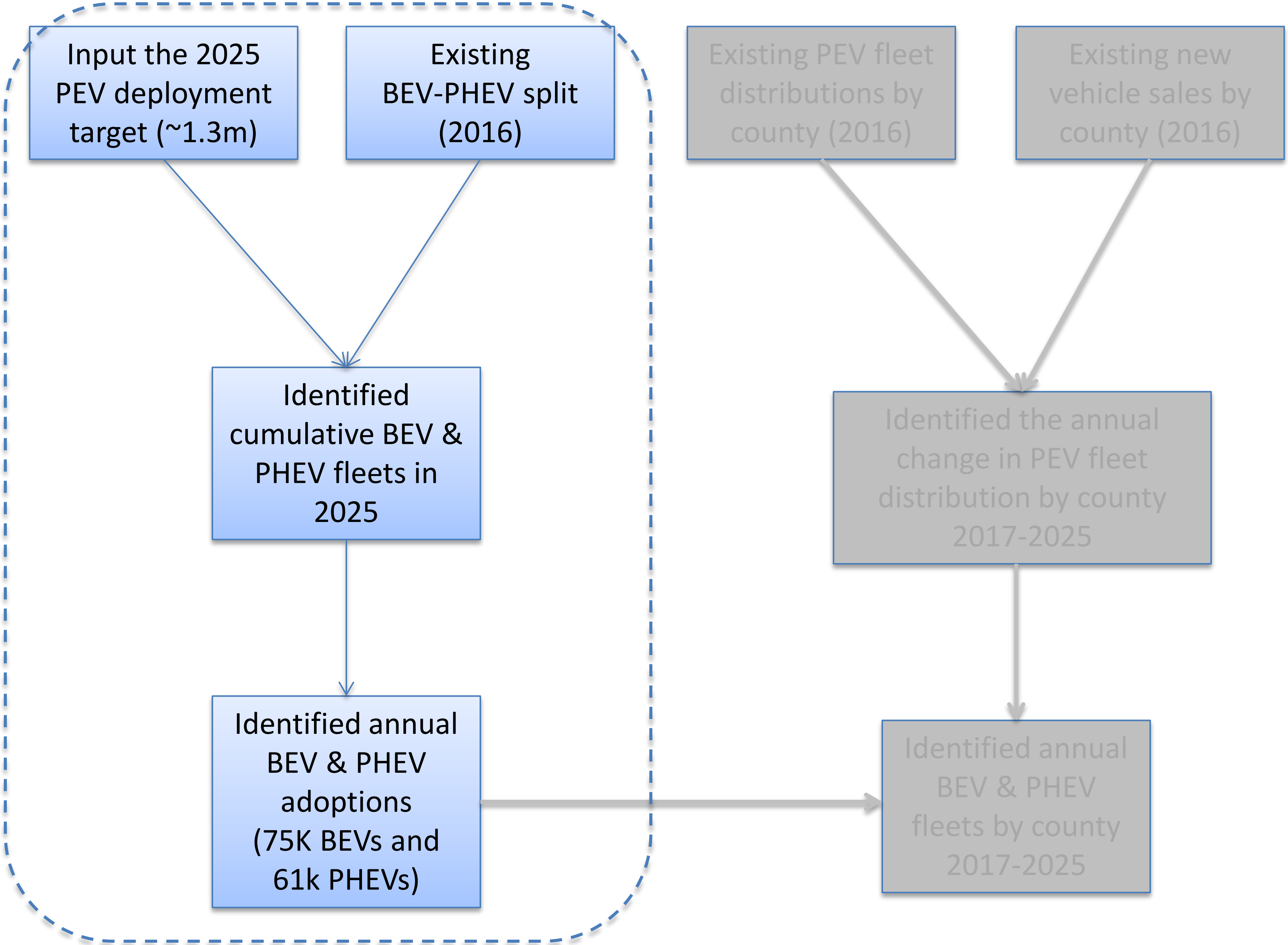
Resources used:

EO B16-2012, CARB's CTF Scenario (2016), CVRP (2017), IHS Markit (2016)

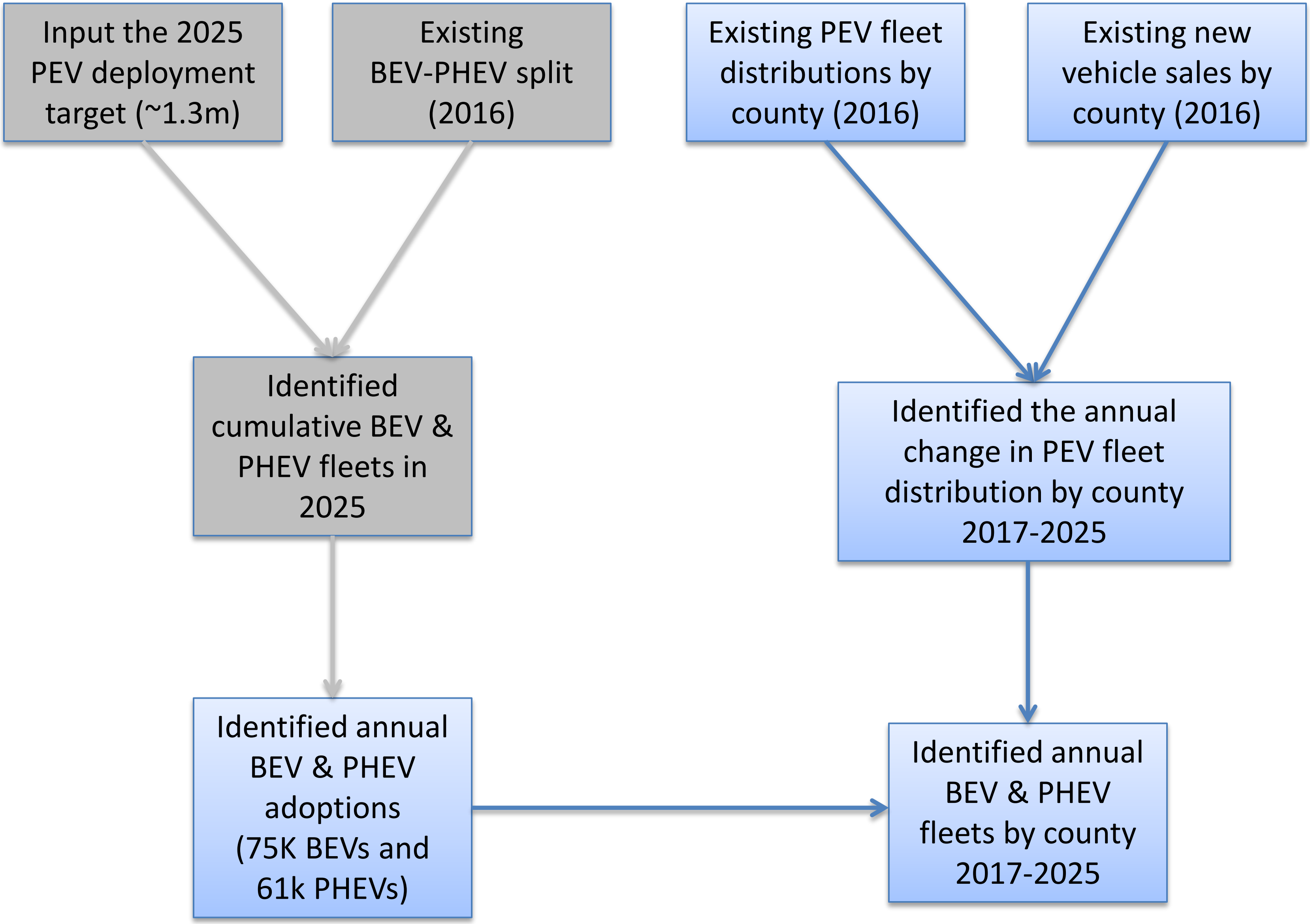
Assumptions made:

1. Todays' statewide PHEV-BEV split (45:55) stays same through 2025
2. BEV and PHEV adoptions will follow a linear growth through 2025,
3. By 2025, today's PEV distribution by county converges to new LDV distribution split.

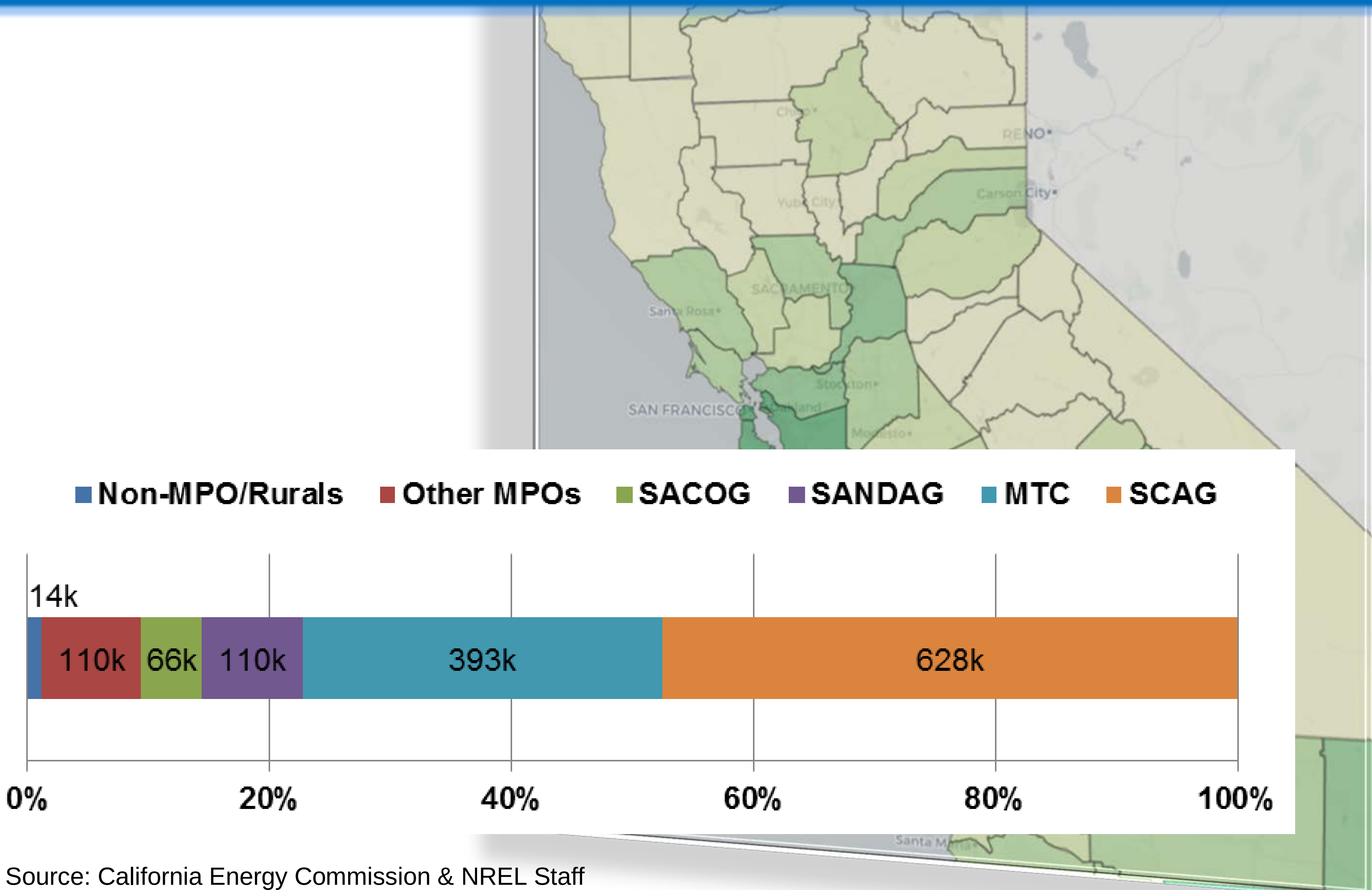
1. Statewide PEV Fleet Input: Steps for Projecting Annual Adoption



2. County Distribution of the PEV Fleet: Steps



2. County Distribution of the PEV Fleet by County: Results Aggregated for Metropolitan Planning Organizations (MPOs)



Source: California Energy Commission & NREL Staff

3. Vehicle & Charger Technology

Electric Range and Charger Power Level Projections			
PHEVs	**(As-of-2017)**		**(By 2025)**
Electric Range (miles):	29.6	→	40.0
Residential L2 (kW):	3.6	→	4.9
Destination L2 (kW):	3.6	→	4.9
BEVs	**(As-of-2017)**		**(By 2025)**
Electric Range (miles)	121.8	→	210.0
Residential L2 (kW)	6.6	→	11.4
Destination L2 (kW)	6.6	→	6.6
Fast Charging (kW)	50.0	→	105.0

The increases in electric range follow California's Advance Clean Cars Midterm Review report (CARB, 2017), while charger power levels increase proportional to the increase in electric range.

4. Fuel Pricing

- Assume mainstream drivers are rational
  - Have range anxiety ($\leq$ 20 miles)
  - Won't change travel schedule/dwell behavior
  - Will minimize cost by choosing where to charge
    - Pricing order corresponds to EVSE capital expenditure

$$Price_{Residential} < Price_{Workplace} < Price_{Public}$$

For BEVs

Default Scenario

$$Price_{Public\ DCFC} < Price_{Public\ Level\ 2}$$

Provides weight to driver preference for DCFCs

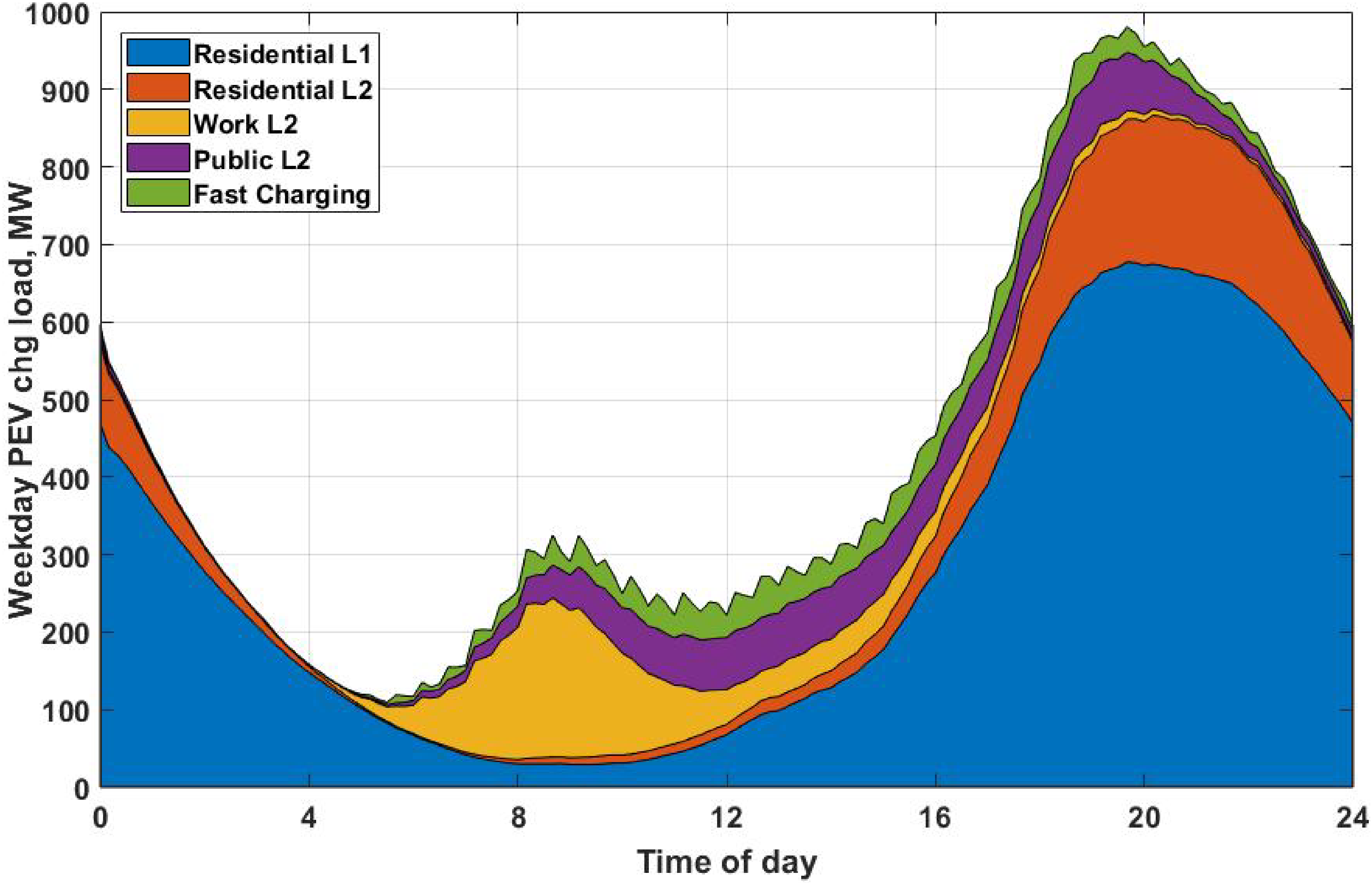
Alternative Pricing Scenario

$$Price_{Public\ Level\ 2} < Price_{Public\ DCFC}$$

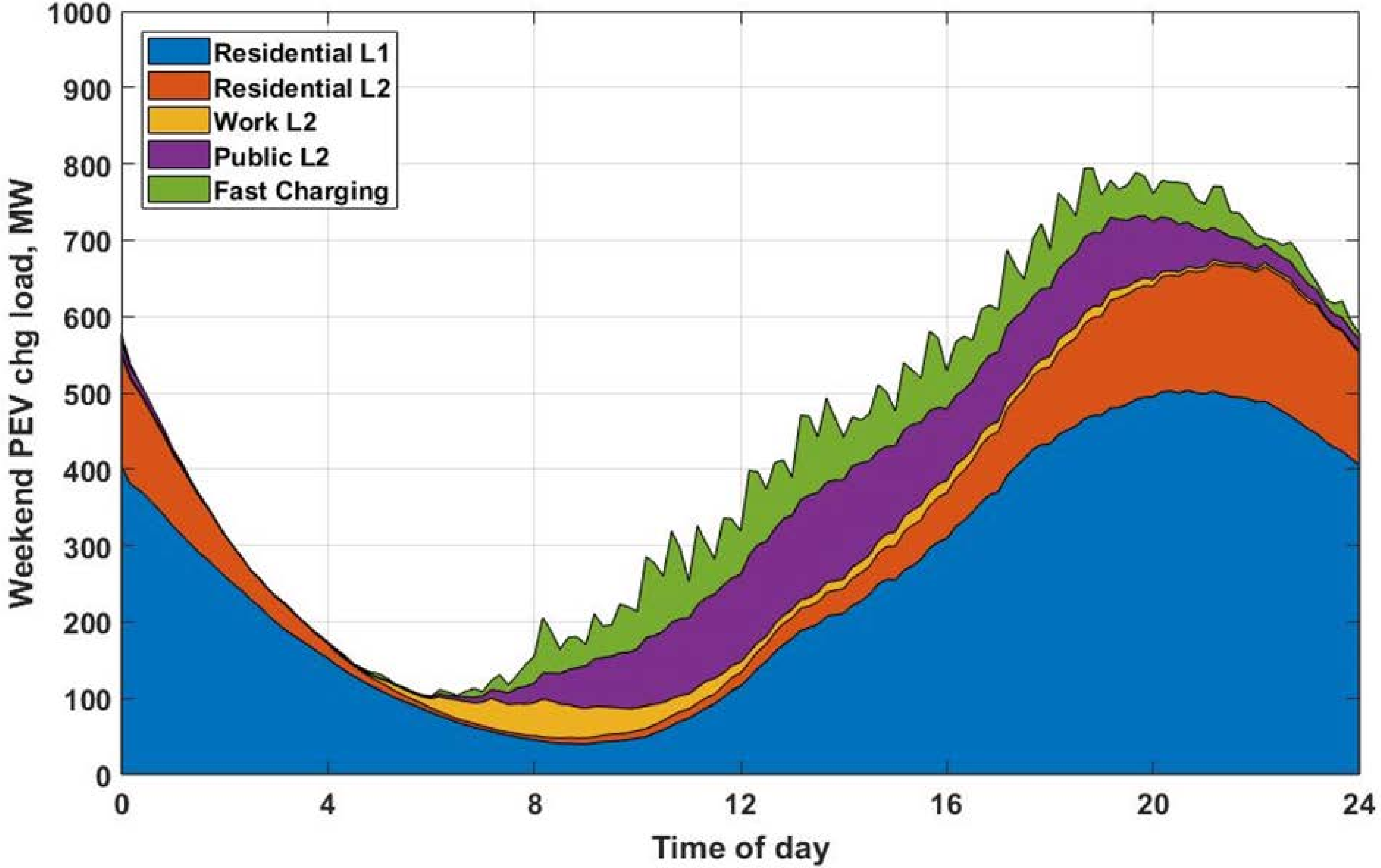
Unrealistic DCFC demand:
2018 deployment $\approx$ 2025 deployment

Results: Total PEV Charging Load

1 GW System Load- Weekday Peak



A.M. DCFC crowds impact distribution



Load Profiling

- Plug-in upon arrival at home
  - 500 MW ramp in 3 hours, peaking at 8-9pm
- Non-residential segments have large variations in use patterns:
  - Workplaces 4x difference in load WD vs WE
  - DCFC: +70 MW within 1 hour to hit peak
- A baseline: assumes no TOU rates or VGI tech

Location	Weekday		Weekend	
	Demand (MW)	Time	Demand (MW)	Time
Residential Total (L1&L2)	867	8:10 pm	669	9:10 pm
Work L2	205	8:40 am	50	8:10 am
Public L2	80	7:20 pm	134	1:20 pm
Fast Charging	55	5:10 pm	120	10:40 am
Total PEV Charging Load	981	7:40 pm	794	6:50 pm

Residential Charging Demand

- **83% charge at single-family units**
  - At least 66k PEVs could not complete travel with L1 (L2 needed)
  - Remainder (1.1 M PEVs) could technically meet need with L1
- **9% charge at multi-family units** (121k chargers)
  - At least 6.9k PEVs could not complete travel with L1 (L2 needed)
  - Remainder (114k PEVs) could technically meet need with L1
- **8% charge elsewhere** (at non-residential locations only).

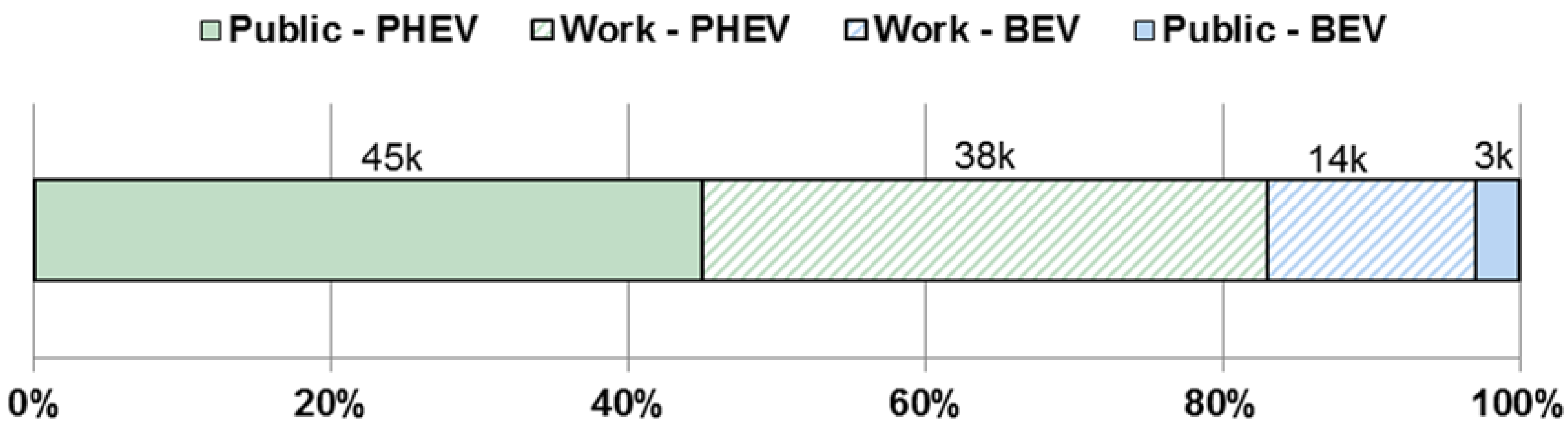
Non-Residential Charger Demand

Projections for Statewide PEV Charger Demand

Demand for L2 Destination (Workplace and Public) Chargers (The Default Scenario)			
	Total PEVs	**Lower Estimate (Chargers)**	**Higher Estimate (Chargers)**
As-of-2017	239,207	21,502	28,701
By-2020	645,017	53,173	70,368
By-2025	1,321,361	99,333	133,270
Demand for DC Fast Chargers (The Default Scenario)			
	Total BEVs	**Lower Estimate (Chargers)**	**Higher Estimate (Chargers)**
As-of-2017	133,386	2,005	5,877
By-2020	359,169	4,881	13,752
By-2025	729,097	9,064	24,967

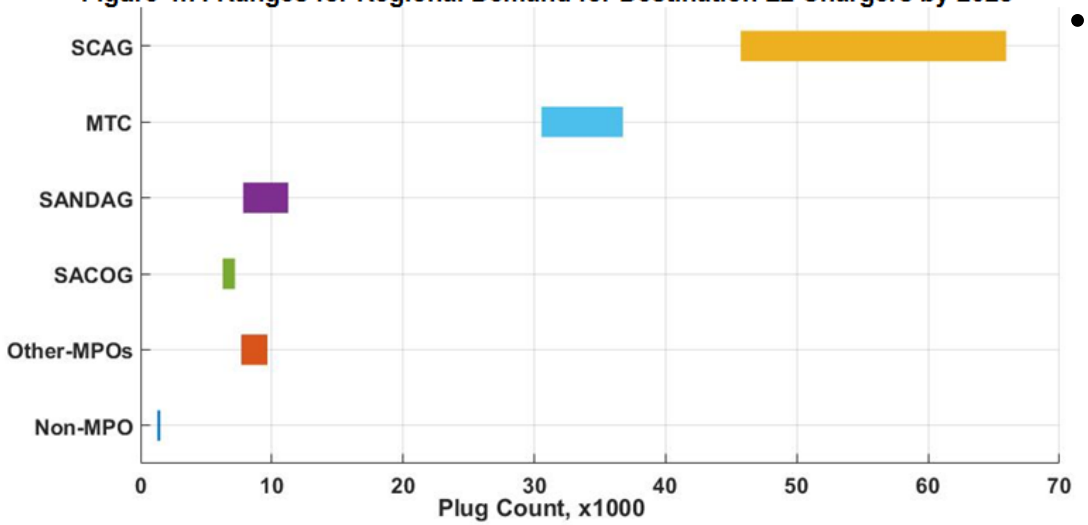
Effect of PHEV eVMT Objective

- PHEVs account for 80%+ of Destination Level 2 charging sessions.
- Minimizing petroleum use substantially increases network size.
- PHEV driver use of L2 is optional and behavior is still being characterized.



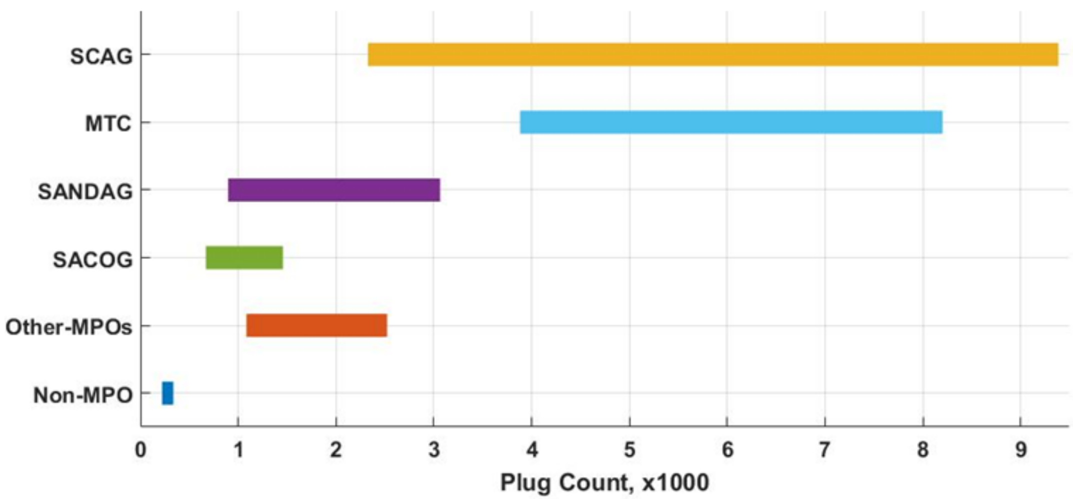
Regional Travel Effect on Demand

Figure 4.7: Ranges for Regional Demand for Destination L2 Chargers by 2025



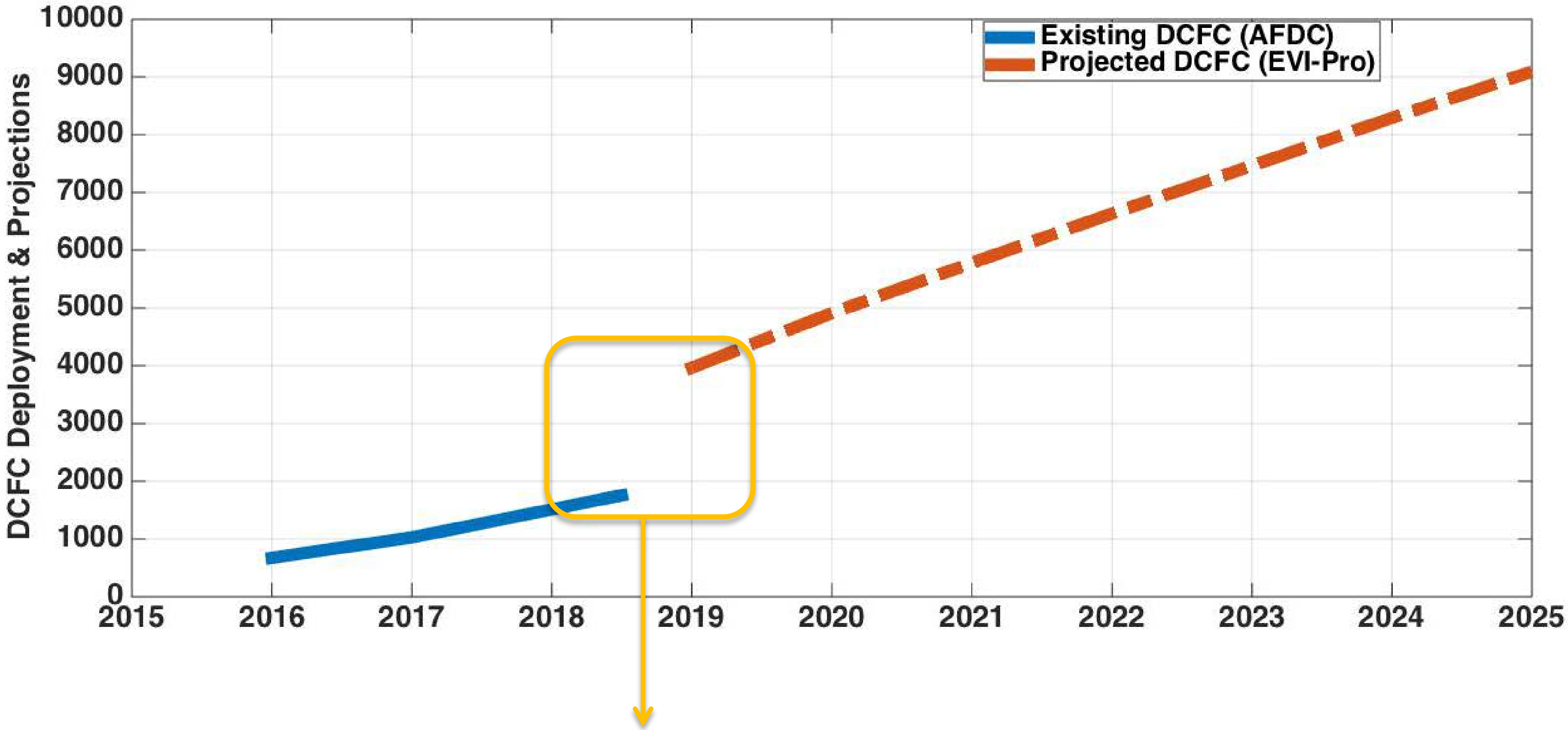
Source: California Energy Commission & NREL Staff

Figure 4.8: Ranges for Regional Demand for Fast Chargers by 2025



- Charger sharing potentials are regionally specific.
  - *Work-intensive* counties have high peak demand
  - i.e. a small difference between the high and low counts thus limits sharing potential
- Unknown interaction(s) between factors:
  - Regional & Interregional Travel of BEVs
  - Prevalence of housing type affect charging
  - Geographic areas

Regional Travel Effect on Demand



California has an immediate gap of 2200 DCFCs that must be addressed by the end of 2018!

Conclusions and Next Steps

Noel Crisostomo

Air Pollution Specialist, Fuels & Transportation Division

California Energy Commission

EVI-Pro quantifies chargers needed to serve mainstream PEV travel

California EV charging network needed in 2025 (thousands)

	EVI-Pro Default	Order B-48-18
DC Fast Chargers	9-25	10
Destination	99-133	Unspecified
Multi-Unit Dwellings	121	Unspecified
Total	**229-278**	**250**

The Energy Commission must immediately invest in charging to close service gaps throughout the state.

Agencies should establish stable policy frameworks that are consistent statewide to encourage incremental and steady installation.

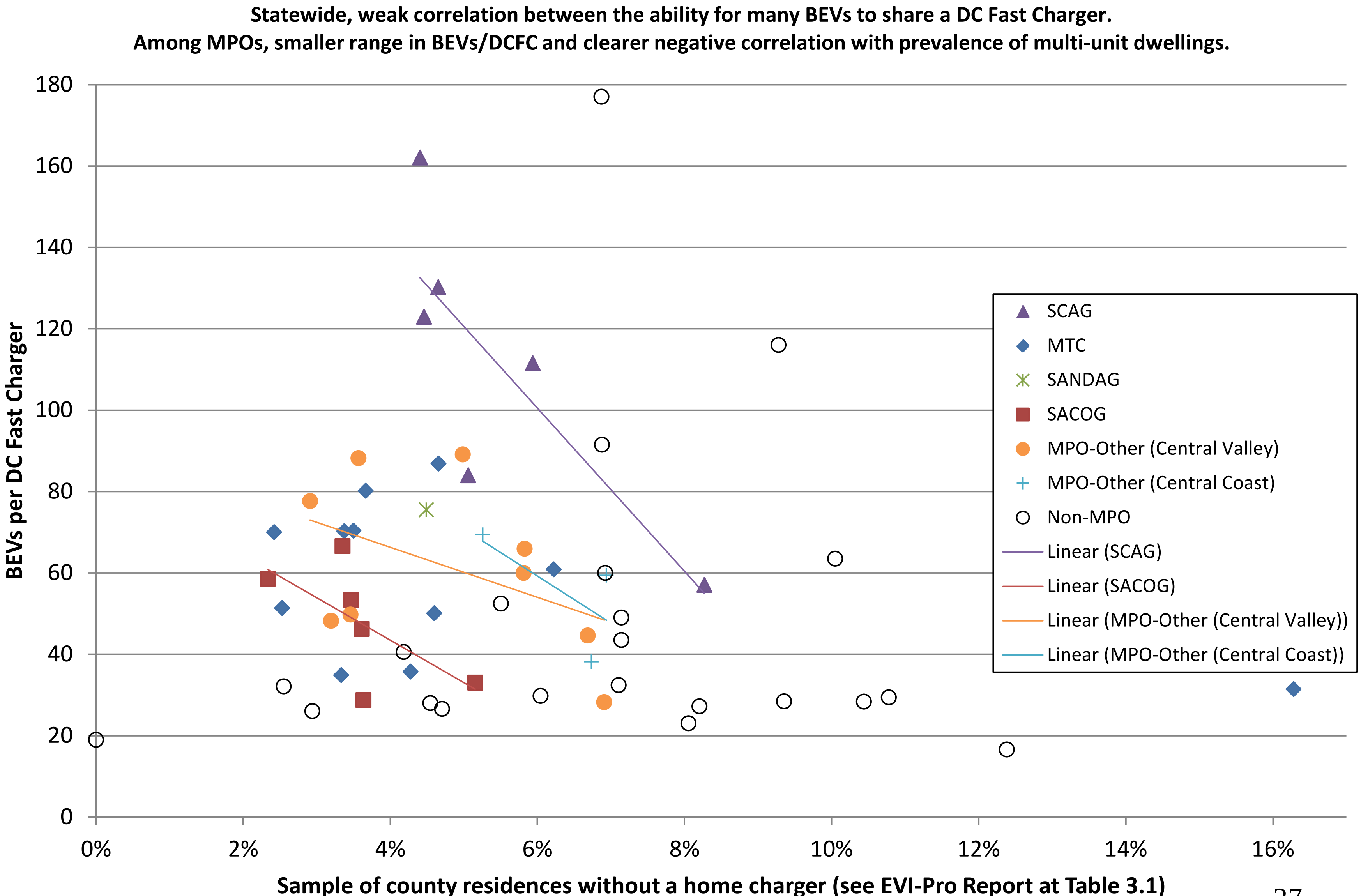
Deployments share chargers to reduce network size and costs

The EVI-Pro methodology contributes to charging infrastructure demand modeling by quantifying the potential to share chargers across time and among PEV types.

Quantities of chargers demanded represent significant variance in the size of the charging network (e.g. for DCFC, 25,000 EVSE used twice daily vs. 9,000 coincidently demanded).

Improving driver access to installations and maintaining high reliability is essential to reduce network size and cost. Real-time networking technologies enable oversight to monitor use.

Local travel and housing significantly affect vehicle to charger ratios



Charging must be efficiently integrated with the electric system

By 2025, unmanaged charging may create a 500 MW ramp from 4-7pm, demanding an additional 1 GW of peak load. ¾ of the ramp results from Level 1 initiated upon arrival home.

EVSE power and location diversity enables load shifting (e.g. Level 2s at home and work may better stagger early morning and daytime sessions, respectively). Shared use networking technologies can automate demand responsive charging.

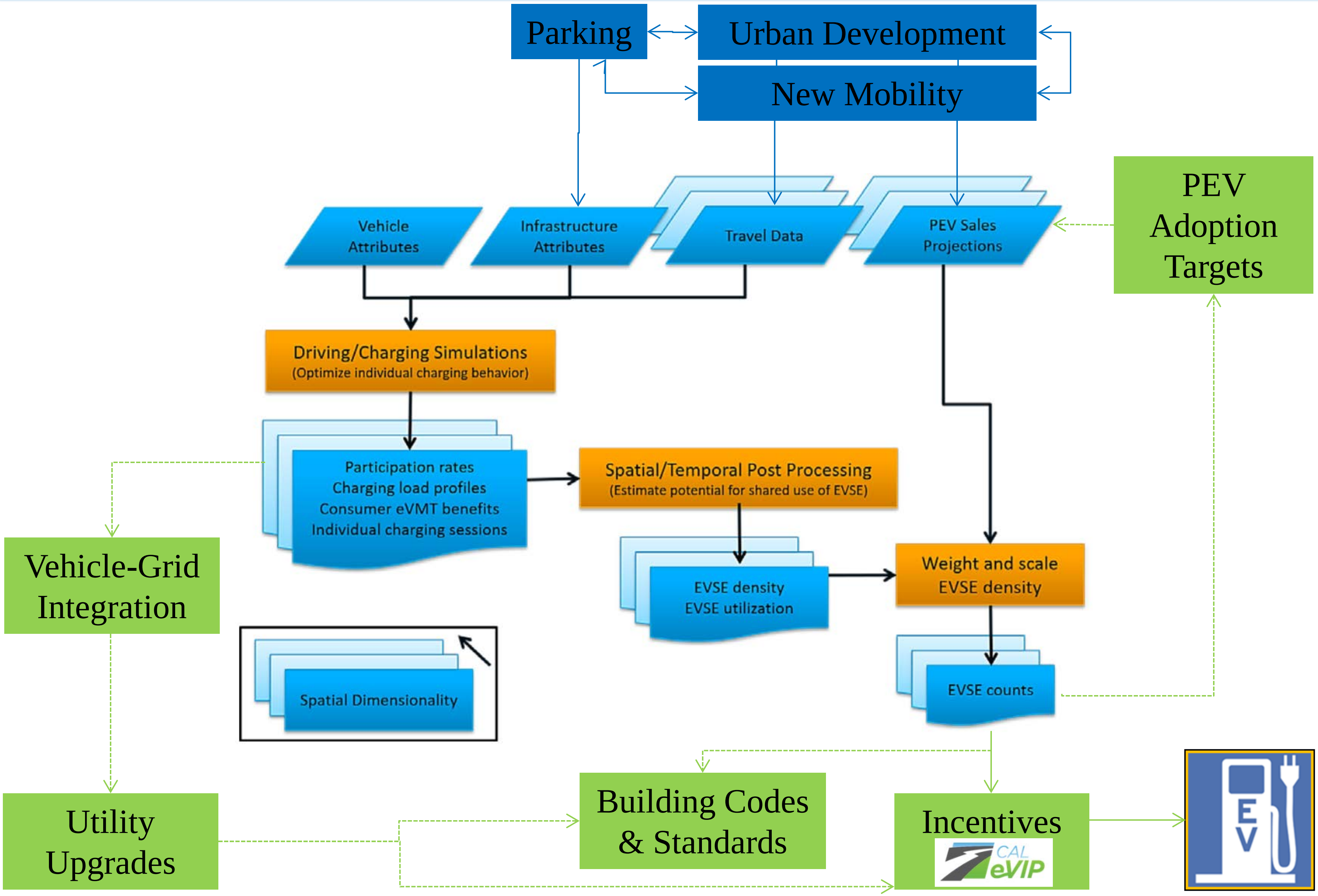
Periodic surges of statewide DC Fast Charging demand may cause distribution grid level impacts, which could be managed with providing sufficient service in combination with storage and distributed generation to reduce demand charges.

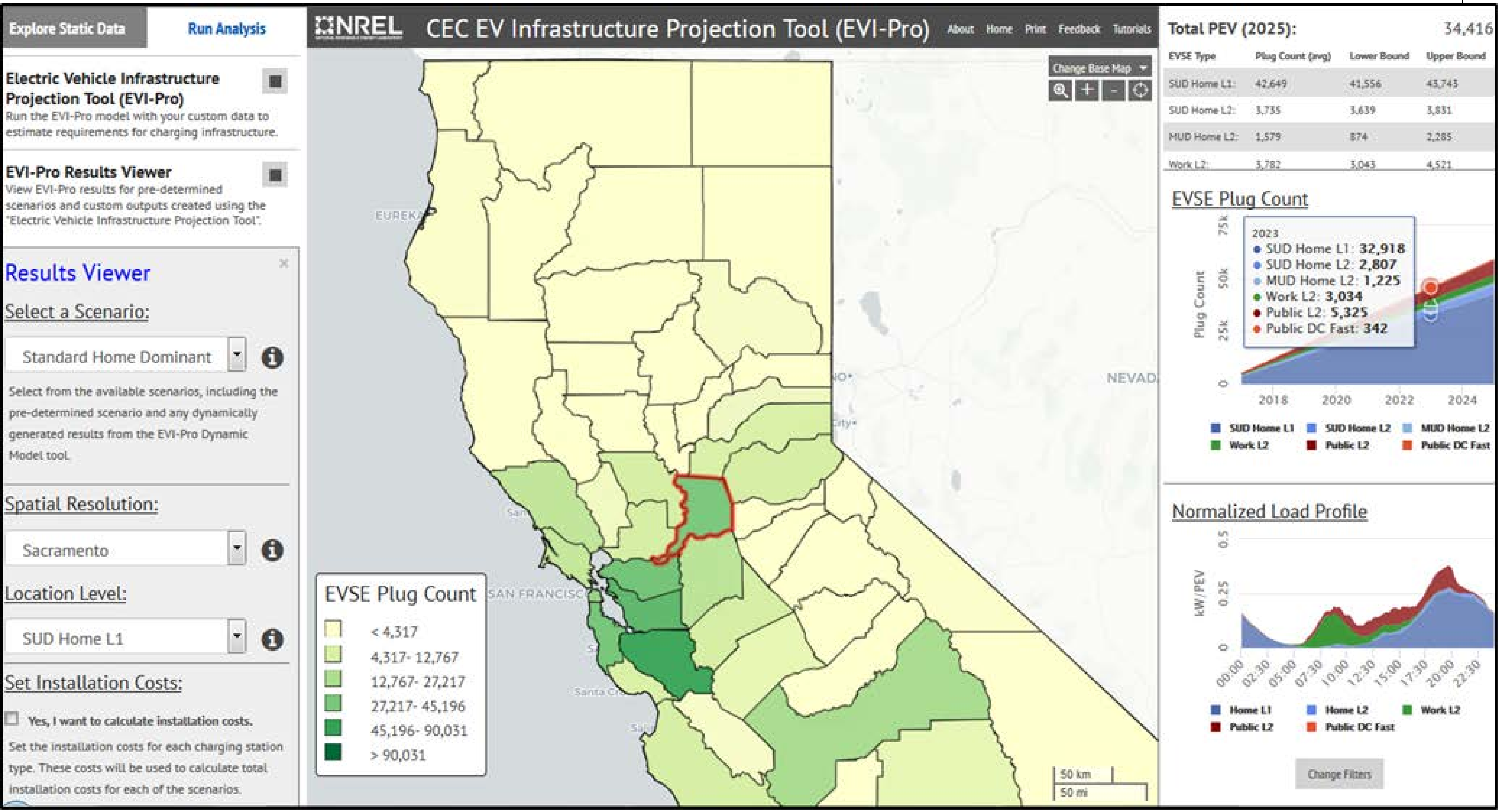
Characterizing infrastructure demand requires ongoing analysis

New data and scenarios will improve infrastructure quantification and investment strategy. Using the EVI-Pro Tool and EVI-Pro Lite Calculator as a 2-way platform that guides public planning and engages with industry stakeholders can improve characterization of market trends:

- Local residential parking configurations
- Residential and commercial vehicle travel
- Vehicle and charging equipment technology improvement
- Utility tariff and resulting EVSP pricing structures
- Driver preferences for range and time
- New mobility: automated, shared, and ride-hailing vehicles
- Non-light duty transportation segments
- Greenhouse gas reduction policy interactions

Modeling market trends to inform policy and charging investments





Explore Static Data
Run Analysis
Electric Vehicle Infrastructure Projection Tool (EVI-Pro)
Run the EVI-Pro model with your custom data to estimate requirements for charging infrastructure.
EVI-Pro Results Viewer
View EVI-Pro results for pre-determined scenarios and custom outputs created using the "Electric Vehicle Infrastructure Projection Tool".
Results Viewer
Select a Scenario:
Standard Home Dominant
Select from the available scenarios, including the pre-determined scenario and any dynamically generated results from the EVI-Pro Dynamic Model tool.
Spatial Resolution:
Sacramento
Location Level:
SUD Home L1
Set Installation Costs:
Yes, I want to calculate installation costs.
Set the installation costs for each charging station type. These costs will be used to calculate total installation costs for each of the scenarios.
NREL
CEC EV Infrastructure Projection Tool (EVI-Pro)
About
Home
Print
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Tutorials
Change Base Map
EUREKA
SAN FRANCISCO
NEVADA
EVSE Plug Count
< 4,317
4,317- 12,767
12,767- 27,217
27,217- 45,196
45,196- 90,031
> 90,031
50 km
50 mi
Total PEV (2025): 34,416
EVSE Type | Plug Count (avg) | Lower Bound | Upper Bound
SUD Home L1: | 42,649 | 41,556 | 43,743
SUD Home L2: | 3,735 | 3,639 | 3,831
MUD Home L2: | 1,579 | 874 | 2,285
Work L2: | 3,782 | 3,043 | 4,521
EVSE Plug Count
2023
SUD Home L1: 32,918
SUD Home L2: 2,807
MUD Home L2: 1,225
Work L2: 3,034
Public L2: 5,325
Public DC Fast: 342
Plug Count
75k
50k
25k
0
2018
2020
2022
2024
SUD Home L1
SUD Home L2
MUD Home L2
Work L2
Public L2
Public DC Fast
Normalized Load Profile
kW/PEV
0.5
0.25
0
00:00
02:30
05:00
07:30
10:00
12:30
15:00
17:30
20:00
22:30
Home L1
Home L2
Work L2
Public L2
Public DC Fast
Change Filters