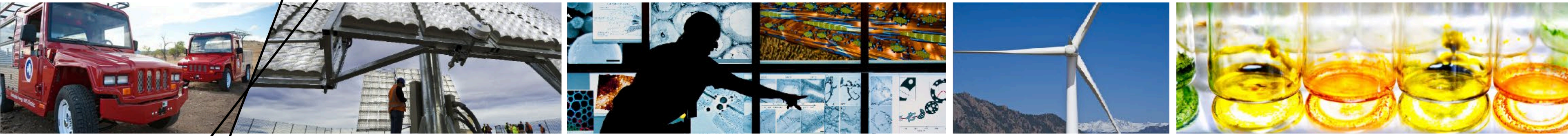
NATIONAL RENEWABLE ENERGY LABORATORY

California Statewide PEV Infrastructure Assessment



Plug-In Electric Vehicle (PEV) Infrastructure Site Selection Workshop
CPUC, San Francisco, CA

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June 10, 2015

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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.

Presentation Overview

- **The Statewide Assessment provides a framework for understanding the potential energy (kWh) and demand (MW) impacts of PEV market growth**
  - Potential peak MW demands have been estimated
  - Historical vehicle sales are a guide to early market growth regions and areas
- **PEV travel simulations can inform the role of public infrastructure in future market growth**
  - The degree to which increased public charging may increase e-miles can be simulated (with assumptions about behavior)
  - The influence on PEV sales is more uncertain
- **Ongoing Assessment updates and AFDC outreach can help coordinate stakeholder planning and decision making**
  - How can these activities reduce stakeholder uncertainties?

The Statewide Assessment

Scenario Methodology

- **We do not yet have sufficient empirical market and consumer behavior data to develop a predictive model of EVSE expansion**
- **Therefore, a scenario approach is warranted**

Some high-level numbers…

- Electricity demand = total miles * Wh/mile = 2,759 million kWh
- This is 900,000 PEVs driving on average ~20 e-miles per day

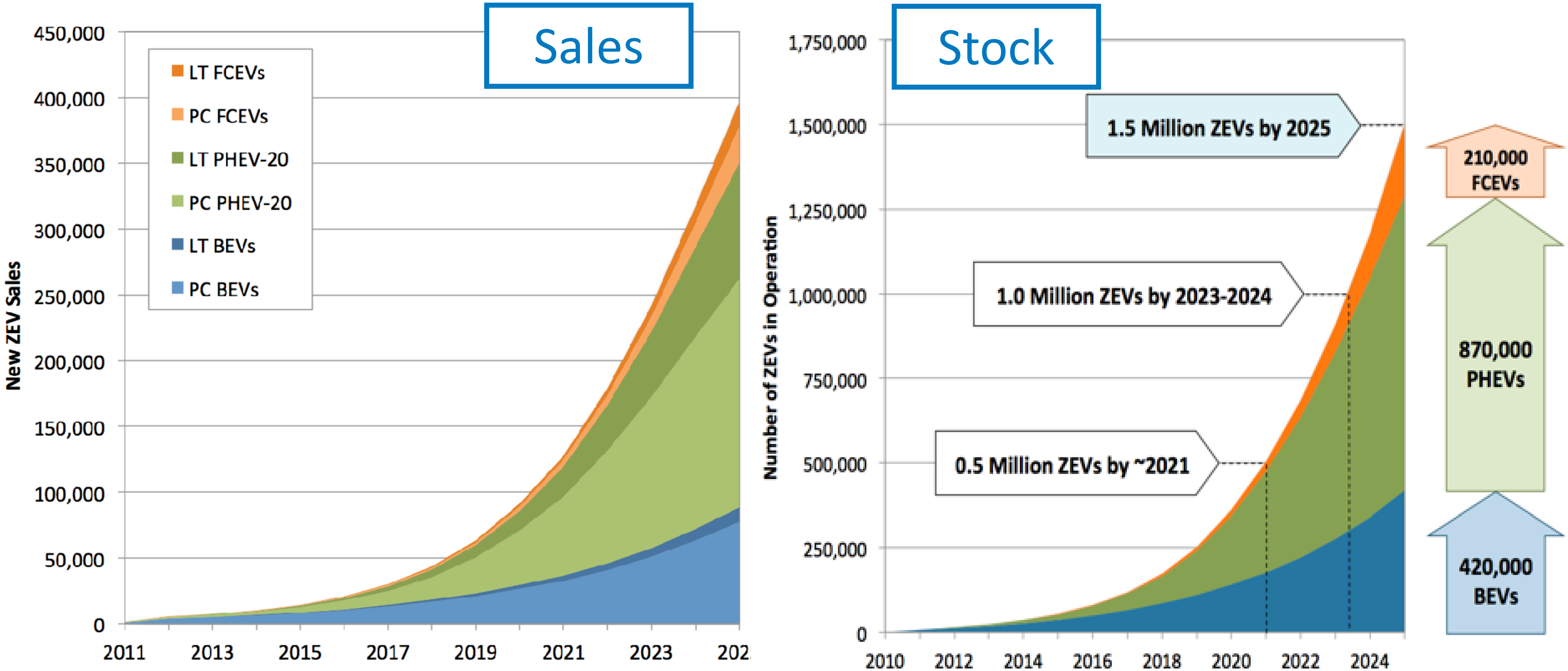
General approach: Allocate kWh by EVSE location and type

- Home, Public, and Workplace EVSE stations
- Three types EVSE: Level 1, Level 2, Fast Charge

The 2020 goal is a snapshot of a rapidly expanding market
This demand would increase rapidly with exponential PEVs sales, reaching 4.0 billion kWh in 2025, and nearly 10 billion kWh by 2030

ZEV Rollout Scenario and Electricity Demand

- **ZEV Action Plan identifies 2020 and 2025 goals**
  - Sufficient EVSE to support 1.0 million ZEVs by 2020
- **ZEV likely compliance scenario proposes vehicle market share trends**
- **ARB-VISION model used to account for ZEV fleet adoption dynamics**
- **New vehicles introduced to the fleet over time (stock turnover model)**



Two EVSE Scenarios

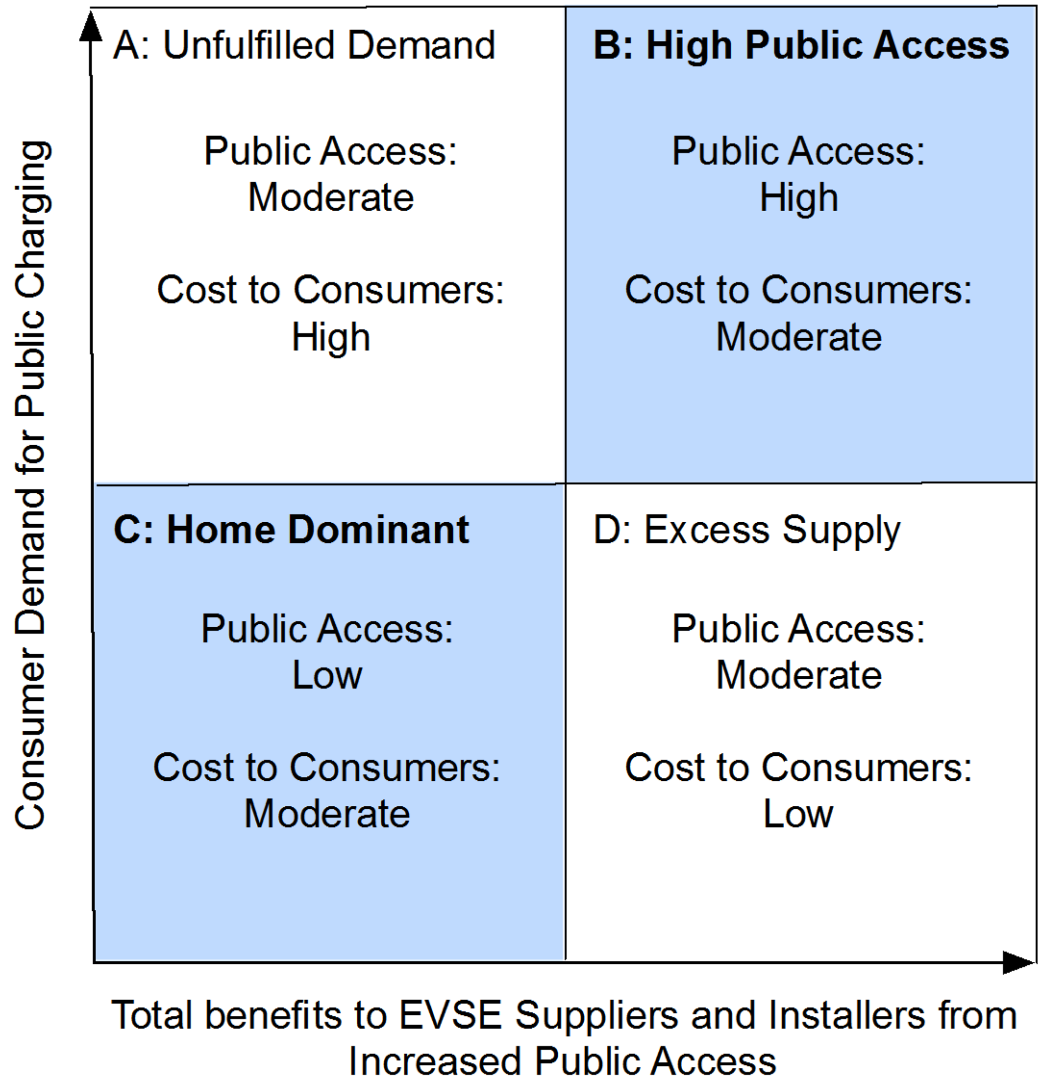
Focus on Two Key Trends

Consumer Demand

Overall consumer demand for workplace and public charging

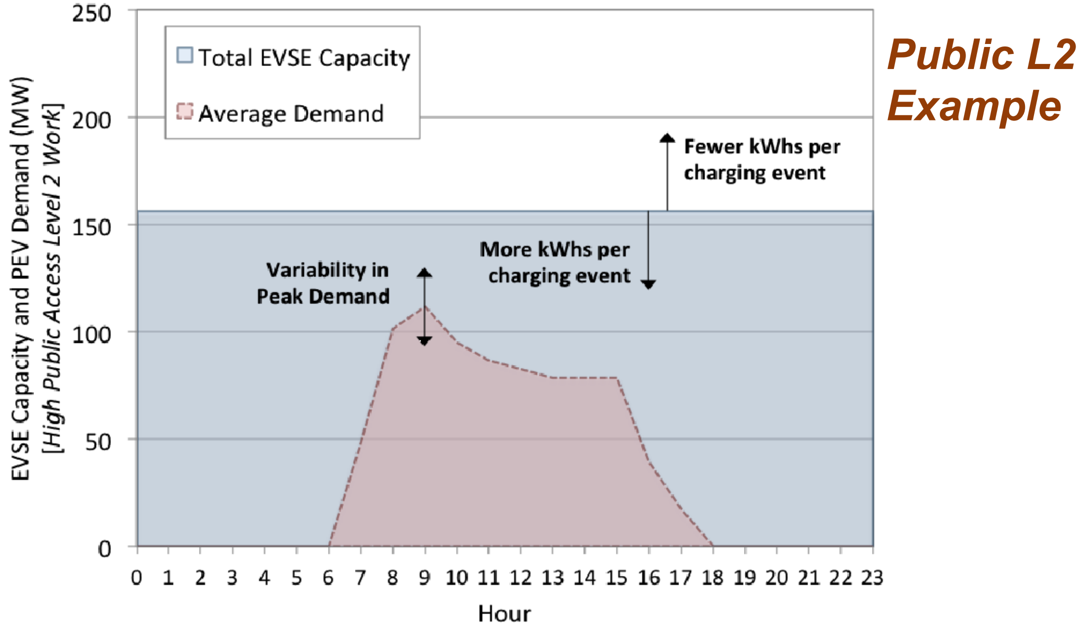
EVSE Supply

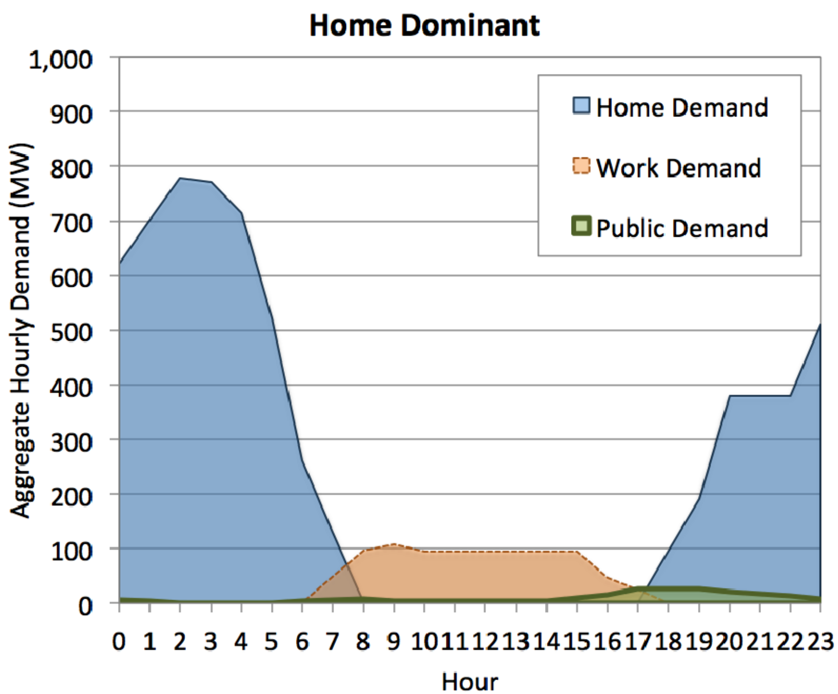
Total benefits to EVSE suppliers from increased workplace and public access

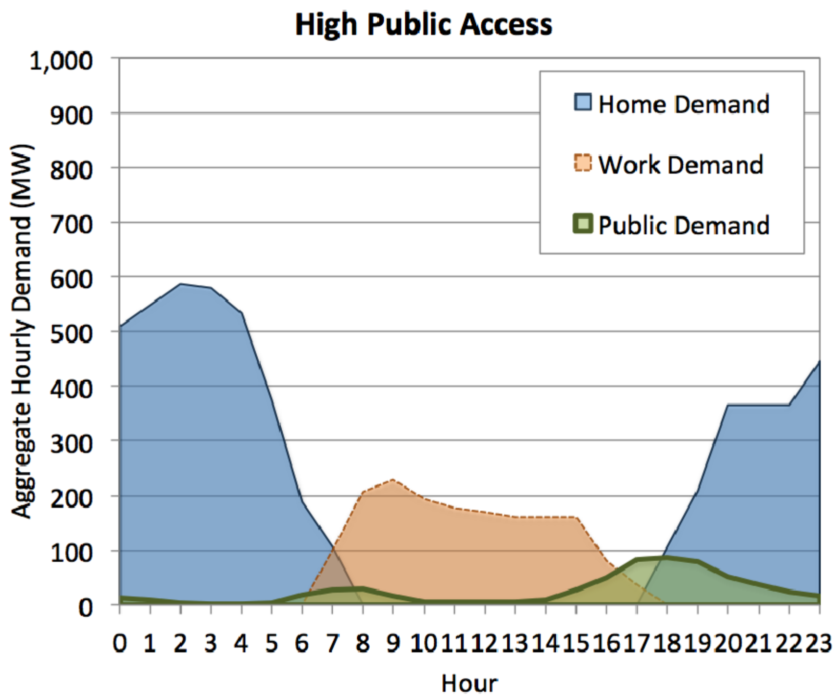


Demand Profiles

Broken out by EVSE location and type

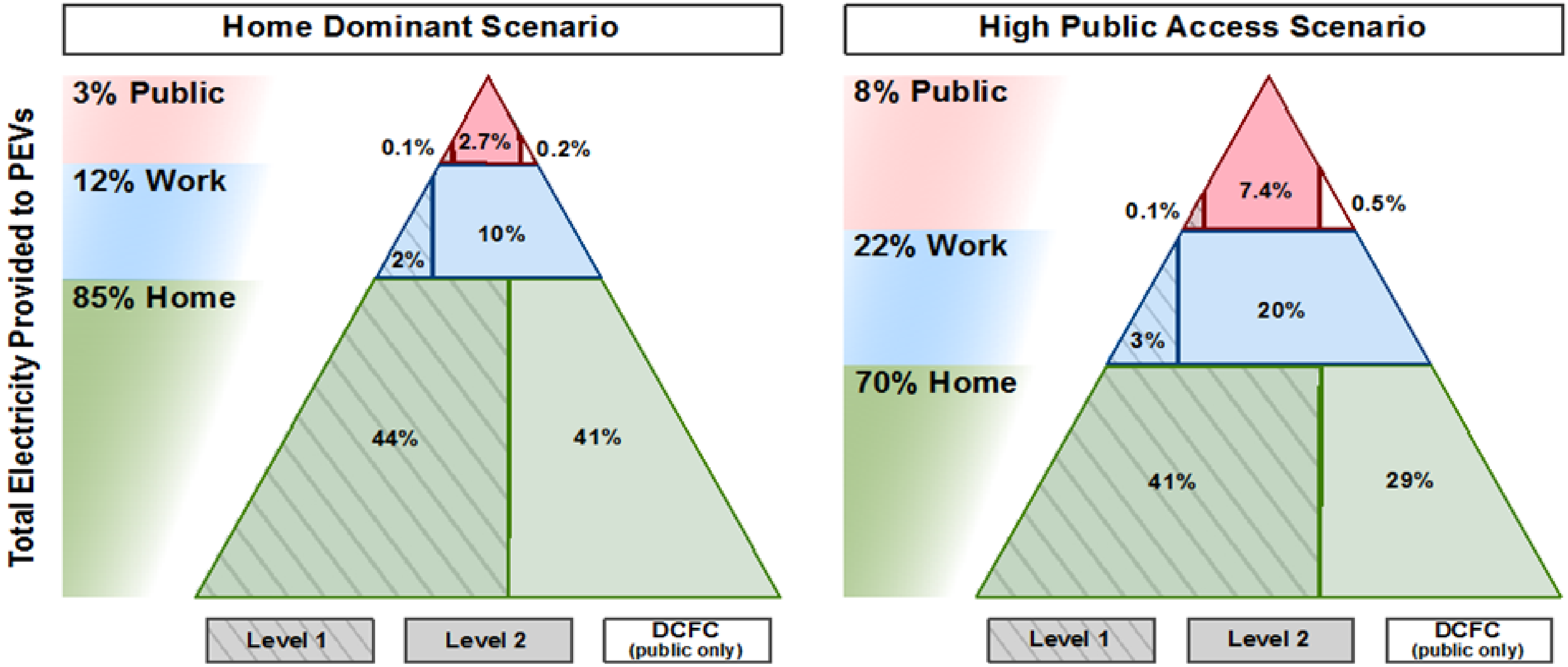




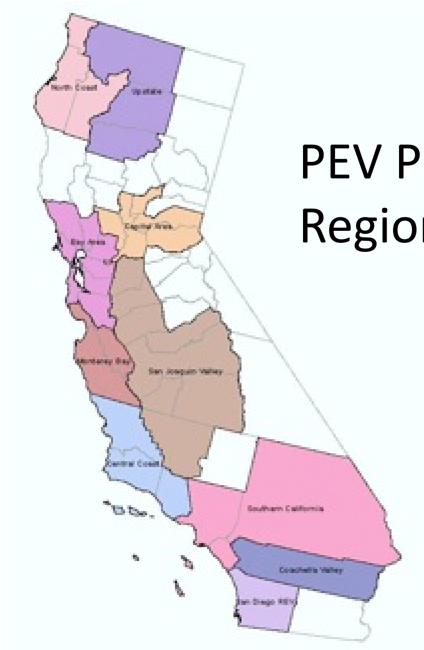


Distribution of kWh by EVSE Type

- These high-level input assumptions are balanced against a variety of EVSE supply metrics
- Most charging is still done at home in both scenarios

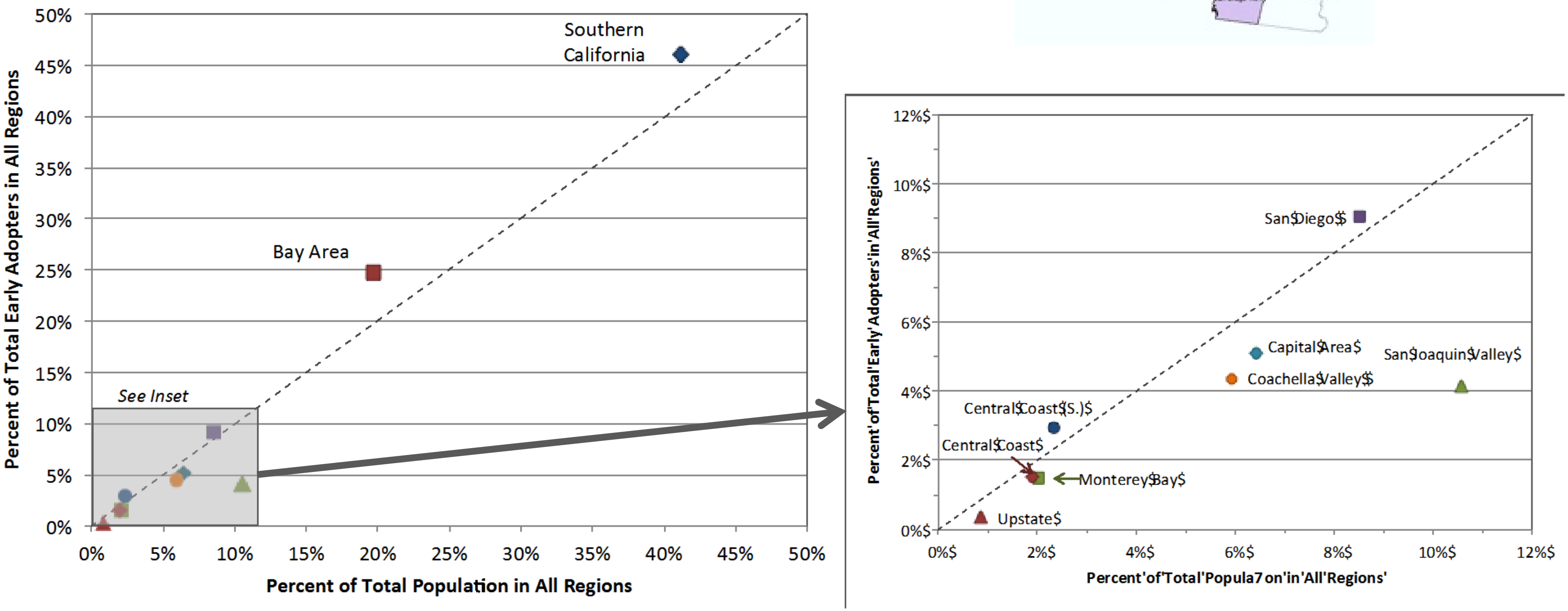


EAM Distribution Differs from General Population Distribution

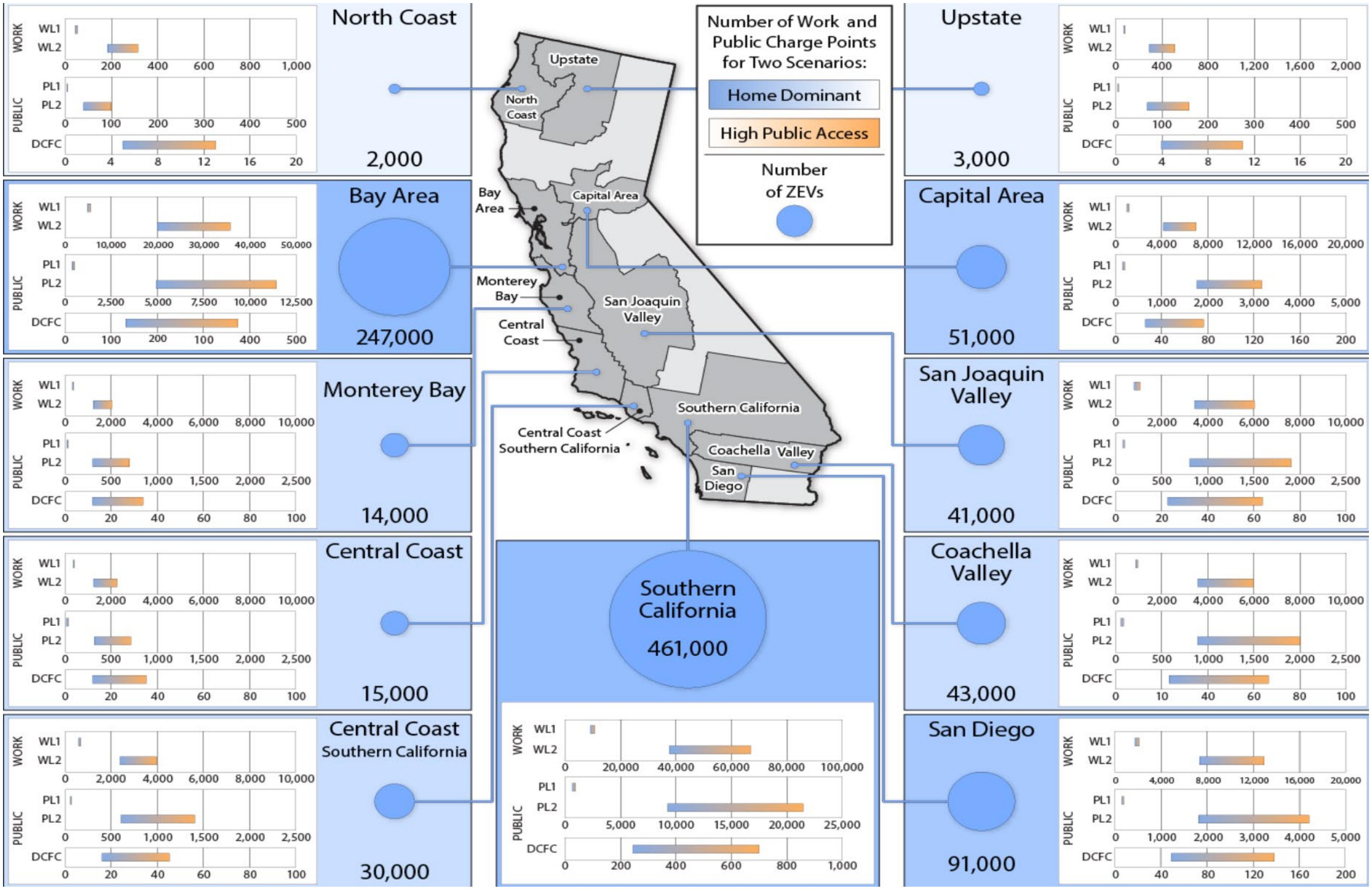


PEV Planning Regions

- Some regions have more early adopters than others
- The percent of Early Adopters (y axis) in each region is compared to the percent of total population (x axis) in the figures below



Comparisons across Planning Regions



PEV Travel Simulations

How Will CEC Use These Scenarios?

Adaptive management strategy. Need more data on market trends.

Two of the investment strategy responses the Energy Commission may consider as additional data are collected and trends are characterized include the following:

- **Apparent deficiency in EVSE availability.** If PEV sales or e-miles driven in a given locality or region appear to be dampened due to a lack of EVSE availability, the Energy Commission may consider increasing efforts to support focused EVSE deployment.
- **Apparent lack of PEV market support.** If conditions for PEV adoption appear to be favorable in a given locality or region, including sufficient EVSE availability and favorable early adopter demographics, the Energy Commission may consider increasing efforts to support focused PEV market adoption.

NREL PEV Simulations in BLAST-V

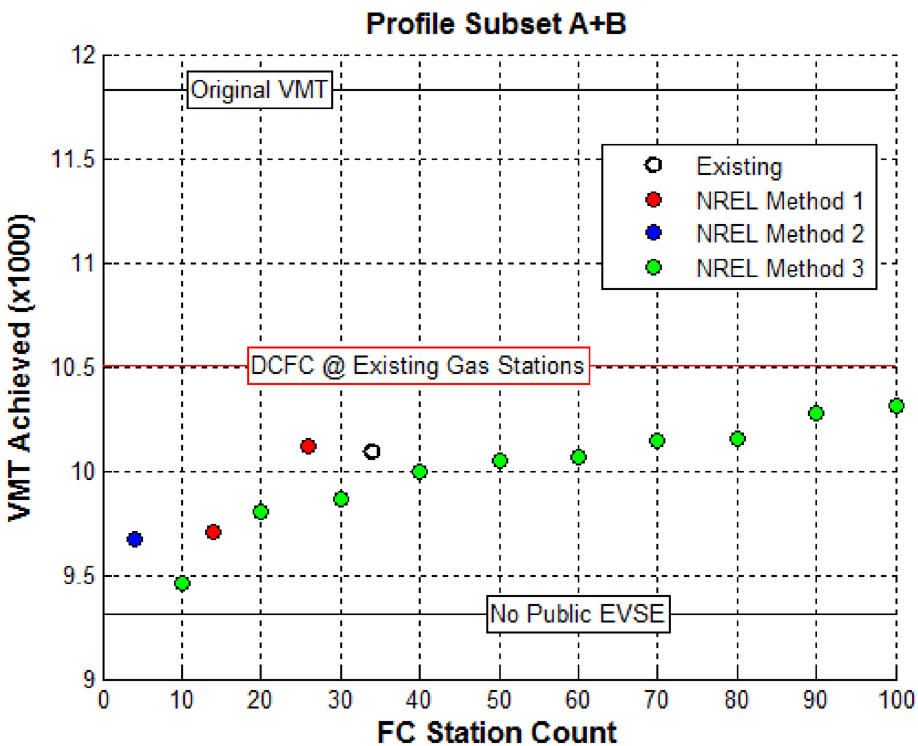
Battery Lifetime Analysis and Simulation Tool for Vehicles

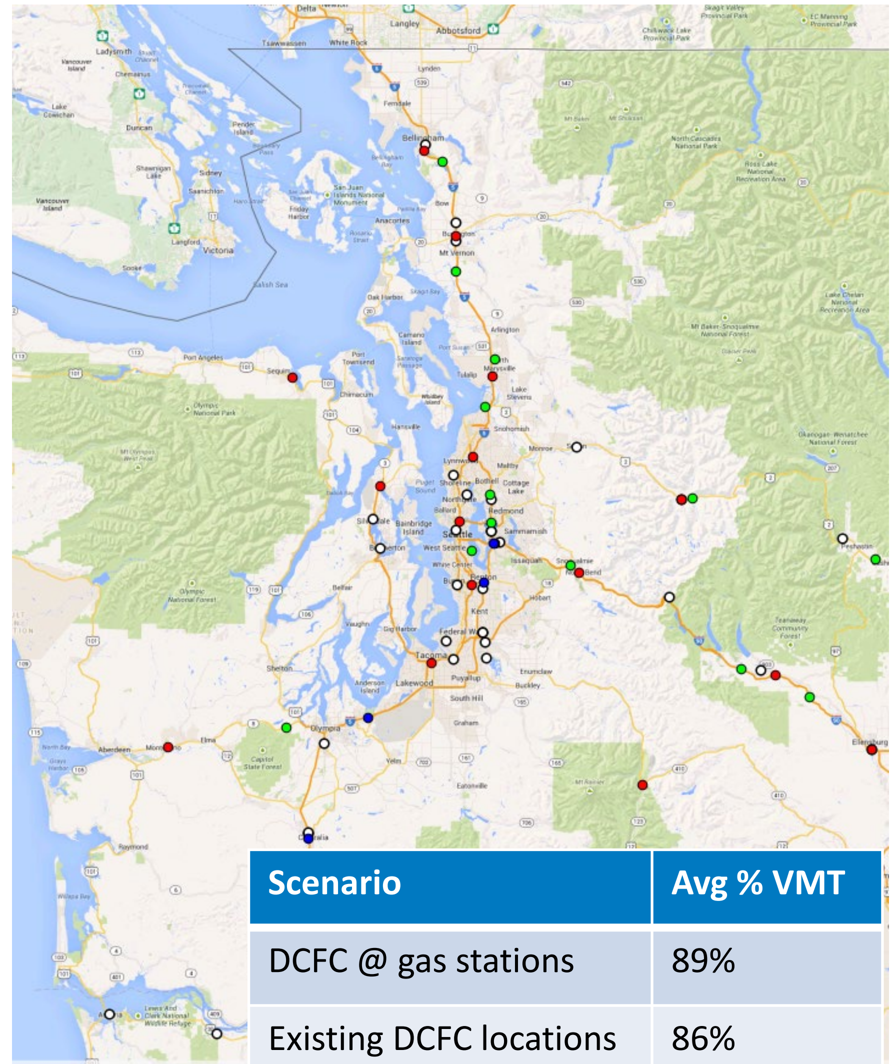
- **PHEV/BEV multi-day, time series simulations based on empirical travel data**
  - Travel data generally sourced from personally-owned, light-duty, conventional vehicles (mass market travel requirements)
- **Modular programming enables analysis of:**
  - EVSE spatial/temporal availability (home/work/public)
  - Battery/cabin HVAC loads across real-world climate data
  - Battery degradation relative to thermal/electrical cycling and calendar fade

BEV75 Simulated Utility Results

Incremental utility afforded by existing FC stations was compared to a number of artificial rollouts in Seattle metropolitan area

Found existing infrastructure scenario to be sufficient at improving BEV utility with a relatively small number of stations





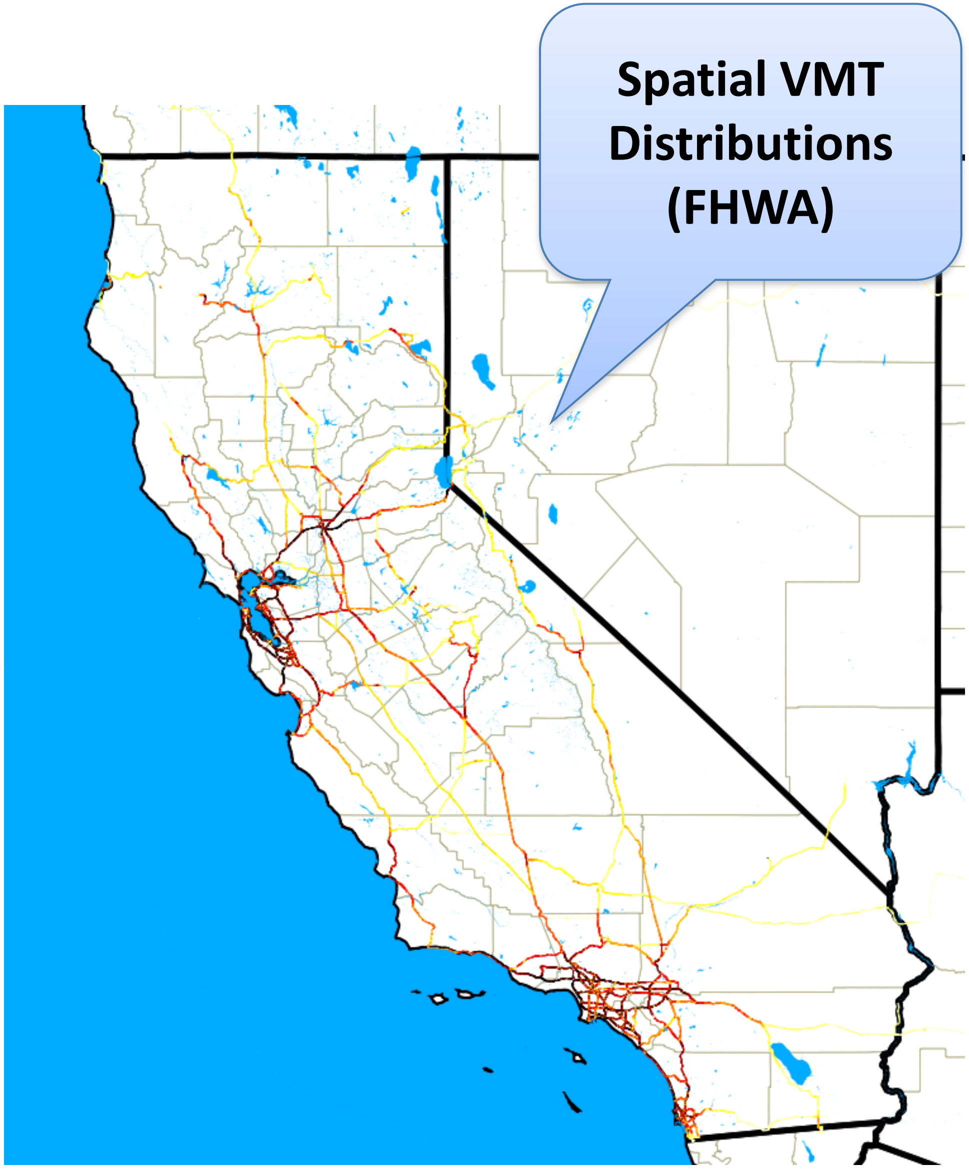
Scenario	Avg % VMT
DCFC @ gas stations	89%
Existing DCFC locations	86%
No DCFC	79%

Travel Pattern Simulation Insights

How important are actual or conception infrequent, long-distance trips to vehicle purchasers?

Based upon LDV travel patterns, it seems that some investments, such as DCFC or L2 along corridors, are likely to:

- Increase PEV sales
- Have relatively poor rates of return
- Increase e-miles and rates of return for urban infrastructure investments
- Be small in number compared to urban areas (over time)



Market Adoption Insights from Future Analysis Work?

<u>As more representative market data become available</u>:

1. **Statistical analysis of relationship between (local) public charging availability and PEVs sales**
   - Analysis would need to account for all other influential factors – PEV type, housing prevalence, neighbor effect, etc.
   - Implies use of a more systemic vehicle purchase decision choice model (ADOPT, etc.)
2. **Extend this analysis from local charging availability to include long-distance trip coverage, along corridors, etc.**
   - Trip simulations would need to be taken into account
3. **Can evaluation metrics for site selection be applied to specific projects or portfolios of investments?**
   - Are the first two efforts prerequisites to the third?

Ongoing Assessment Updates and AFDC Outreach

Assessment Updates to be Conveyed to Target Audiences through a Web Portal

- Portal updates will include integration of regional plans and AFDC station updates
- More accessible interface than an annual report
- Can include extensions or data useful to specific types of planning or coordination activities
- Opportunity to integrate collection of real-world data with updated analysis results based upon those data
- Increase accessibility to updated metrics for:
    - Station availability
    - PEV market progress
    - Sufficiency of planning outlook
    - Corridor gaps, etc.

AFDC Stakeholder Coordination

- Significant progress has been made to collect the most recent, verifiable, and extensive data on stations
- Integration of planned stations would add significant value, reducing uncertainties for planning organizations
- **Example: Clean Cities National Parks Initiative**
  - Coordination to work across multiple jurisdictions: San Joaquin Clean Cities Coalition, National Park Service, Yosemite National Park, and supporting stakeholders
  - Future potential: Sharing information, aligning planning activities, improving decisions and/or joint decisions

Questions

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Questions?

Backup Slides

Additional Assumptions and Metrics

Scenario Assumption or Metric	Home Dominant	High Public Access
Percent of PEVs without home charging (assumption)		
BEVs	0.9%	6.5%
PHEVs	3.9%	12.4%
Public Commercial EVSE: Average miles traveled (and percent of average daily e-miles) provided per charging event (assumption)		
BEVs		
DC Fast Charging Stations	20.9 mi (60%)	22.6 mi (65%)
Level 2 Public	15.6 mi (45%)	19.2 mi (55%)
Level 1 Public	7.0 mi (20%)	8.7 (25%)
PHEVs		
Level 2 Public	11.7 mi (75%)	12.5 mi (80%)
Level 1 Public	8.6 mi (55%)	9.4 mi (60%)
Workplace EVSE: Average miles traveled (and percent of average daily e-miles) provided per charging event (assumption)		
BEVs		
Level 2 Work	12.2 mi (35%)	14.0 mi (40%)
Level 1 Work	10.5 mi (30%)	12.2 mi (35%)
PHEVs		
Level 2 Work	11.7 mi (75%)	13.3 mi (85%)
Level 1 Work	9.4 mi (60%)	10.2 mi (65%)
Average number of EVSE stations per 100 square miles in urban areas (metric)		
Level 2 Public	127	294
Level 1 Public	20	26
FC Stations	3.5	9.8
FC stations in reference to urban interstate miles (metric)		
Average nominal distance between FCs along urban interstates[a]	8.2 miles	2.9 miles

a Length of interstate miles within each planning region is used as a proxy for the density of high-volume travel. It is not assumed that all FC stations would actually be located along interstates.

Resulting EVSE Stations by Type and Region

Region & Scenario

00 144,000

Note: L1: Level 1 charger; L2: Level 2 charger; FC: fast charger

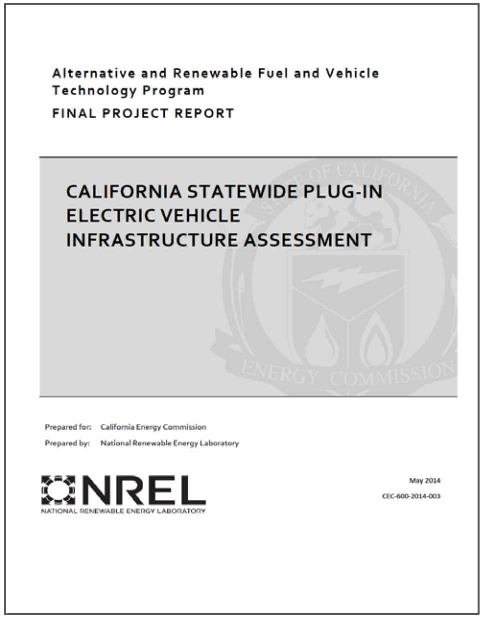
Summary of Quantitative Results

The EVSE charge point results below summarize key quantitative results from the statewide assessment

	Total Statewide EVSE Charge Points by Location and Type (2020)						
Scenario	***L1 Home***	***L2 Home***	***L1 Work***	***L2 Work***	***L1 Public***	***L2 Public***	***DCFC***
Home Dominant	511,000	365,000	20,100	82,000	1,620	20,100	551
High Public Access	517,000	289,000	22,900	144,000	2,100	46,500	1,550

Purpose of the Assessment

- ***This is the first statewide analytical framework for EVSE infrastructure***
- ***The Assessment establishes a framework for how to achieve the ZEV Action Plan goal of EVSE deployment sufficient to support 1.0 million ZEVs by 2020***


Alternative and Renewable Fuel and Vehicle Technology Program
FINAL PROJECT REPORT

CALIFORNIA STATEWIDE PLUG-IN ELECTRIC VEHICLE INFRASTRUCTURE ASSESSMENT

Prepared for: California Energy Commission
Prepared by: National Renewable Energy Laboratory

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NATIONAL RENEWABLE ENERGY LABORATORY

May 2014
CEC-600-2014-003

The assessment achieves the following:

- Articulates the Energy Commission's conclusions and recommendations regarding PEV infrastructure planning
- Conveys stakeholder feedback collected from the PEV Infrastructure Plan Stakeholder Workshop, review comments on earlier draft versions, and results from discussions with key stakeholders