Medium- and Heavy-Duty Electric Vehicle Forecasting & Load Growth

Final Deliverable

October 29, 2021

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Project Overview

Project scope and output

Project Scope

2020 CalETC Scope (EV Adoption, EV Charging Needs)

- Assess the probable **adoption of non-LD EVs in California** on the 2030, 2040, and 2050 timeframe – leveraging any existing non-LD EV projections, information related to current California non-LD regulatory rulemakings, and market intelligence
- Assess the expected **need and site configurations for private and public EV charging infrastructure** to accommodate non-light-duty EV adoption – including laying out a set of probable charging site configurations (power level and number of chargers per site)

2021 CA LSE Scope (EV Load Growth)

- **Statewide MD/HD Approach**. Methodological continuity across CA load serving entities (LSE) for recurring electric vehicle (EV) load growth forecasting
- **Statewide MD/HD Narrative**. Support consistent narrative in regulatory and legislative policy arenas by providing top-down results to support policy decision-making
- **Statewide MD/HD Results**. Build upon CalETC statewide EV adoption & charging forecast while focusing on the Planned Incentives modeling scenario
- **Map results by census tract** to each CA LSE jurisdictions and display by service-level territory
- Perform MD/HD system **load growth (kWh) and system peak (kW) impact** forecasts by LSE based on projected EV adoption through 2040

Project Outputs

2020 CalETC Scope (EV Adoption, EV Charging Needs)

- Develop a 2020-2050 EV **adoption forecast** in California, at the census tract level, for non-light-duty vehicles, including medium- and heavy-duty on-road vehicles as well as medium- and heavy-duty off-road vehicles
- Perform **EV charging needs** forecasting to provide CalETC with an understanding of approximate locations for EV charging infrastructure development based on projected adoption of EVs through 2050, along with typical **site configurations**

2021 CA LSE Scope (EV Load Growth)

- **Perform EV load growth** forecast to provide CA LSE's with an understanding of MD/HD system load growth (kWh) and system peak (kW) impacts by LSE based on projected EV adoption through 2040

*(**Out Of Scope for 2020 and 2021**) Light-duty vehicles; to be addressed in 2022*

Project schedule: 2020 CalETC Study

Month	March 2020			April 2020					May 2020		
Week of	Mar 9	Mar 16	Mar 23	Mar 30	Apr 6	Apr 13	Apr 20	Apr 27	May 4	May 11	May 18

Medium- and Heavy-Duty Electric Vehicle Forecasting

Tasks and Activities

1 Project Initiation (Mar 9 – Mar 16)

- Confirm methodology for EV Adoption and EV Charging Needs
- Identify any relevant data to leverage from existing studies
- Align on vehicle segmentation

2 EV Adoption Forecasting (Mar 23 – Apr 27)

- Develop 2020-2050 EV adoption forecast, at census tract level, for both on-road and off-road non-light-duty vehicles
- Develop 3 scenarios (Base, High, Low) with associated assumptions
- Provide Excel workbook with output data tables and summarize key results in PowerPoint presentation

3 EV Charging Needs and Site Configuration (Apr 27 – May 18)

- Develop EV charging needs to serve expected EV adoption, at census tract level
- Develop 3 scenarios (Base, High, Low) with associated assumptions
- Formulate EV charging site configurations (small, medium, large) for public and private sites
- Provide Excel workbook with output data tables and summarize key results in PowerPoint presentation

Meetings

- Annual All Member Meeting (Mar 16)
- Kickoff Meeting (Mar 16)
- Check-In Meeting #1 (Mar 30)
- Interim Presentation (Apr 6)
- Check-In Meeting #2 (Apr 20)
- Check-In Meeting #3 (May 4)
- Final Presentation (May 18)

Deliverables

- 1 Workplan and Schedule (Mar 16)
- 2 EV Adoption Forecasting (May 4)
- 3 EV Charging Needs and Site Configuration (May 18)

Project schedule: 2021 CA LSE Study

Month	September 2021			October 2021			
Week of	Sept 13	Sept 20	Sept 27	Oct 4	Oct 11	Oct 18	Oct 25
	Medium- and Heavy-Duty Electric Vehicle Load Growth Forecasting						
	1 Project Initiation	2 Office Hour	3 VAST™ EV Adoption, Infrastructure, System Impacts Forecast Statewide and by LSE			4 Final Report and Workshop	
Tasks and Activities	• Project kickoff, review expected outcomes for MD/HD EV Load Growth Forecasting	• Q&A on MD/HD forecast methodology (MS Teams, 1 hr)	• Leverage results from previous CalETC study on MD/HD adoption and charging infrastructure needs, including mapping results by CA LSE • MD/HD EV adoption forecast by CA LSE* (Excel) • MD/HD EV infrastructure forecast by CA LSE* (Excel) • MD/HD system load growth (kWh) and system peak (kW) impacts by LSE based on projected EV adoption through 2040 (Excel) • MD/HD forecast review workshop (MS Teams, 1 hr) * Cross-walking existing CalETC results from census tract to each CA LSE jurisdictions.			• Final summary report and forecasts data tables (PDF, Excel) • Final report workshop (MS Teams, 1 hr)	
Meetings	◇ Kickoff Meeting & Method Workshop	◇ Optional Office Hour meeting			◇ Results Workshop 1		◇ Results Workshop 2
Deliverables	1 MD/HD forecast methodology summary (PPT)				2 Draft Forecast Data Tables (Excel)		3 Final Summary Report and Forecast Data Tables (PDF, Excel)

Guidehouse

Project organizational chart: 2020 CalETC Study

Steering Committee

Scott Briasco, Yamen Nanne, LADWP
David Sawaya, Will Quinn, PG&E
Jered Lindsay, SCE
Bryan Cope, SCPPA
Jaron Weston, SDG&E
Bill Boyce, Eric Cahill, SMUD
Jillian Solomon, Motiv

Project Oversight
Derek Jones

Core Team

Co-Project Managers

Eileen Wenger Tutt
Kristian Corby

Project Manager
Alex Metz

Modeling Lead
Becca Kuss

Modeling Support
Jared Stanley

Research Lead
Raquel Soat

Subject-Matter Experts

Ajay Chawan (Automaker Industry)
Scott Robinson (Modeling Methodology)
Vivek Nath (Modeling Quality Assurance)

We leveraged a project team structure ensuring strong collaboration between CalETC and Guidehouse:

- A **Steering Committee** comprised of CalETC utility members who provided guidance alongside Guidehouse's global Mobility lead
- A **Core Team** organized as a working group with dedicated focus on this effort, driving the project from start from finish, comprised of a project manager, a modeling team, and a research lead
- Select **Subject-Matter Experts** offering Guidehouse's latest thought leadership on EV forecasting, whom the Core Team tapped as appropriate

Project organizational chart: 2021 CA LSE Study

Steering Committee

CalETC | CMUA | Guidehouse

- **Contract Oversight** – Eileen Wenger Tutt
- **Contract Oversight** – Frank Harris
- **Project Oversight** – Derek Jones

Core Team

- **CalETC Participants** – SCE
- **CMUA Participants** – SCPPA (6 LSEs), NCPA (15 LSEs), Other/CMUA-only (10 LSEs)
- **Project Manager** – Tiina Aardemae
- **Modelling Advisors** – Vivek Nath, Scott Robinson
- **Modelling Lead** – Kajal Gaur

Subject-Matter Experts

Alex Metz (Strategic Planning)
Greg Mandelman (Utility Integration)
Ajay Chawan (Automaker Industry)

We suggest a project team structure ensuring strong collaboration between CalETC, CMUA and Guidehouse:

- A **Steering Committee** comprised of CalETC and CMUA senior leadership who will provide guidance alongside Guidehouse's global mobility lead
- A **Core Team** organized as a working group with dedicated focus on this effort, driving the project from start from finish, comprised of a project manager and modeling team
- Select **Subject-Matter Experts** offering Guidehouse's latest thought leadership on EV forecasting, whom the Core Team will tap as appropriate

Project meetings: 2020 CalETC Study

Meeting	Objectives	CalETC	Guidehouse	Logistics
Annual All Member Meeting	• Present modeling methodology overview	• Core Team • CalETC Members	• Steering Committee • Core Team	• Mar 19, 2:20 – 2:40 pm PDT, via teleconference
Check-In Meetings	• Review deliverable in progress • Discuss any outstanding item(s)	• Steering Committee • Core Team	• Core Team • Subject-Matter Experts as appropriate	• Mar 31, 1:00 – 2:00 pm PDT, via Skype • Apr 22, 2:00 – 3:00 pm PDT, via Skype • May 6, 10:00 – 11:30 am PDT, via Skype
Interim Presentation	• Review EV Adoption Forecasting deliverable (Task 2)	• Steering Committee • Core Team	• Steering Committee • Core Team • Subject-Matter Experts as appropriate	• Apr 8, 10:00 – 11:30 am PDT, via Skype
Final Presentation	• Review EV Charging Needs and Site Configuration deliverable (Task 3)	• Steering Committee • Core Team	• Steering Committee • Core Team • Subject-Matter Experts as appropriate	• May 21, 9:30 – 11:00 am PDT, via Skype

Project meetings: 2021 CA LSE Study

Meeting	Objectives	CalETC / CMUA	Guidehouse	Logistics
Project Kickoff	• Review expected outcomes for MD/HD EV Load Growth Forecasting • Present modeling methodology overview	• Steering Committee • Core Team	• Steering Committee • Core Team	• Sept 15, 2:00 – 2:45 pm PDT, via MS Teams
Optional Office Hour	• Q&A on MD/HD forecast methodology	• Steering Committee • Core Team	• Steering Committee • Core Team	• Sept 22, 2:00 – 3:00 pm PDT, via MS Teams
Results Workshop #1	• Review EV Load Growth statewide results	• Steering Committee • Core Team	• Steering Committee • Core Team	• Oct 13, 2:00 – 3:00 pm PDT, via MS Teams
Results Workshop #2	• Q&A on LSE-specific data tables (adoption, infrastructure, load growth)	• Steering Committee • Core Team	• Steering Committee • Core Team	• Oct 27, 2:00 – 3:00 pm PDT, via MS Teams

EV Adoption Output (2020 CalETC Study Results)

Market was split into 13 vehicle segments spanning across on-road and off-road use

Road Usage	Vehicle Duty	Vehicle Segment	Example Vehicle
On-Road	Light Duty	Class 1 Vehicles	• Sedan, small sport utility vehicle, small crossover, small pickup truck — *Out Of Scope*
		Class 2a-2b Vehicles	• Sport utility vehicle, pickup truck, small delivery van
	Medium and Heavy Duty	Class 3 Trucks	• Walk-in van, city delivery van
		Class 4-5 Trucks	• Box truck, city delivery van, step van
		Class 6 Trucks	• Beverage truck, rack truck
		Class 7-8 Trucks	• Short-haul truck, long-haul truck
		School Buses	• School bus
		Transit Buses	• Transit bus
		On-Road Specialty Vehicles	• Fire truck, ambulance, recreational vehicle, refuse truck, drayage truck
		Transport Refrigeration Units	• Refrigeration unit (excluding tractor trailer) for warehouses, distribution centers, grocery stores
Off-Road		Airport Ground Support Equipment	• Aircraft refueler, aircraft pushback tractor
		Seaport Cargo Handling Equipment	• Hostler truck, rubber-tired gantry crane, container handler (ship at birth out of scope)
		Other Forklifts	• Counterbalance / telescopic handler forklift for warehouses, lumberyards, and construction sites

Modeling scenarios reflect 3 potential futures of EV adoption in California

Drivers	Description	No Incentive Scenario	Planned Incentives Scenario	Regulatory Target Scenario
Incentives	Dollar per EV tax incentive ($)	• Any existing and planned California **incentives discontinued**	• California incentive policies **currently existing and planned** (AFDC, Off-Road Vehicle Industry)	• **Additional** "cash on the hood" **incentive** per vehicle covering 50% of incremental cost of EV over ICEV[1]
Battery Costs	Battery pack costs ($ per kWh)	• Guidehouse Insights **higher-bound battery cost** forecast (leading to increased EV operating costs)	• Guidehouse Insights **base battery cost** forecast	• Guidehouse Insights **lower-bound battery cost** forecast (leading to decreased EV operating costs)
Fuel Prices	Gasoline and diesel prices ($ per gallon)	• 25% **lower gasoline and diesel prices** vs. base (leading to decreased operating ICEV costs)	• AAA California average **base** assumption, adjusted for inflation	• 75% **higher gasoline and diesel prices** vs. base (leading to increased operating ICEV costs)
Consumer Awareness and Acceptance	Marketing and outreach influencing customer familiarity (i.e., public awareness / acceptance), prerequisite for adoption	• One-third **lower consumer awareness and acceptance** vs. base (leading to decreased EV adoption)	• Guidehouse Insights **base** assumption, calibrated to California's historical consumer awareness metrics	• One-third **higher consumer awareness and acceptance** vs. base (leading to increased EV adoption)[1]
Regulations	Policies regulating ICEVs and EVs	• **Penalties** paid **in lieu of adoption** per ZEV, ACT, ACT Fleet, ICT, and TRU rules	• **Penalties** paid **in lieu of adoption** per ZEV, ACT, ACT Fleet, ICT, and TRU rules	• **Adoption** consistent with ZEV, ACT, ACT Fleet, ICT, TRU, and Heavy-Duty Diesel Vehicles rules, and reinstated CAFE standards

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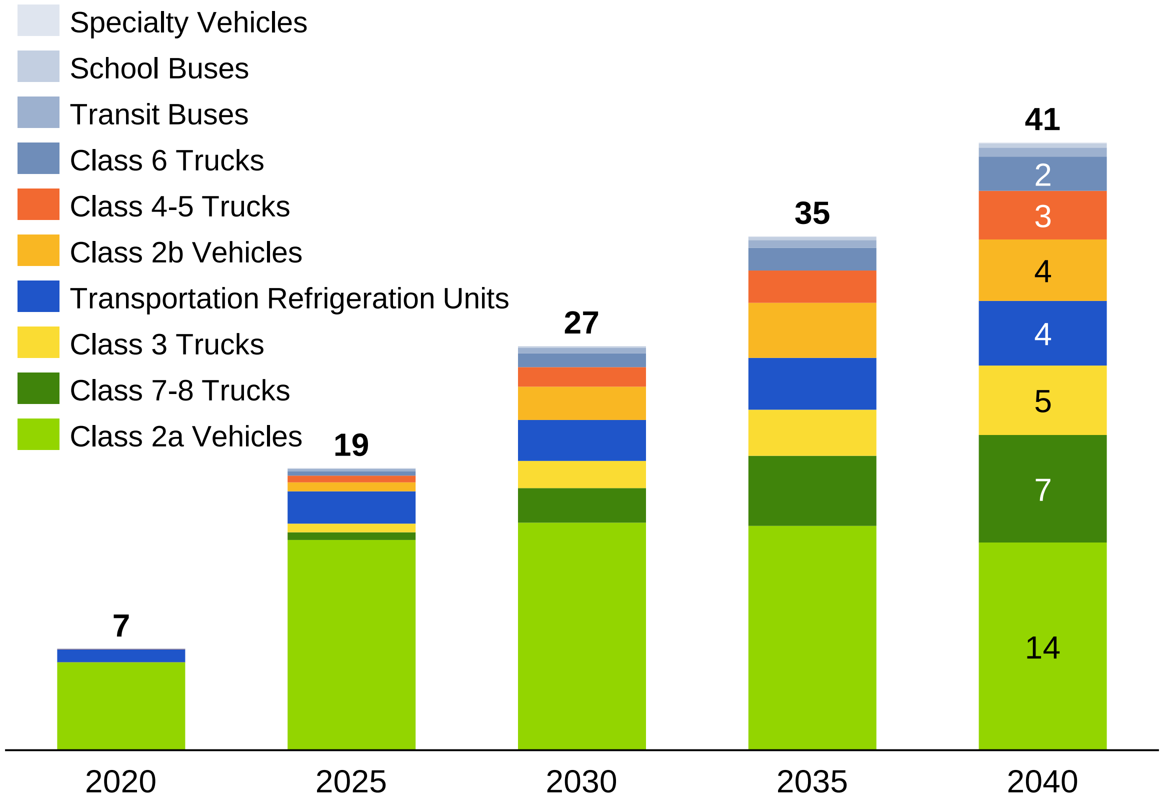
1. Incentives and Consumer Awareness and Acceptance drivers were adjusted to achieve regulatory targets per Regulations driver requirement.

Planned Incentives Scenario: Circa 41,000 non-light duty, on-road EV annual sales in 2040 (12% market share)

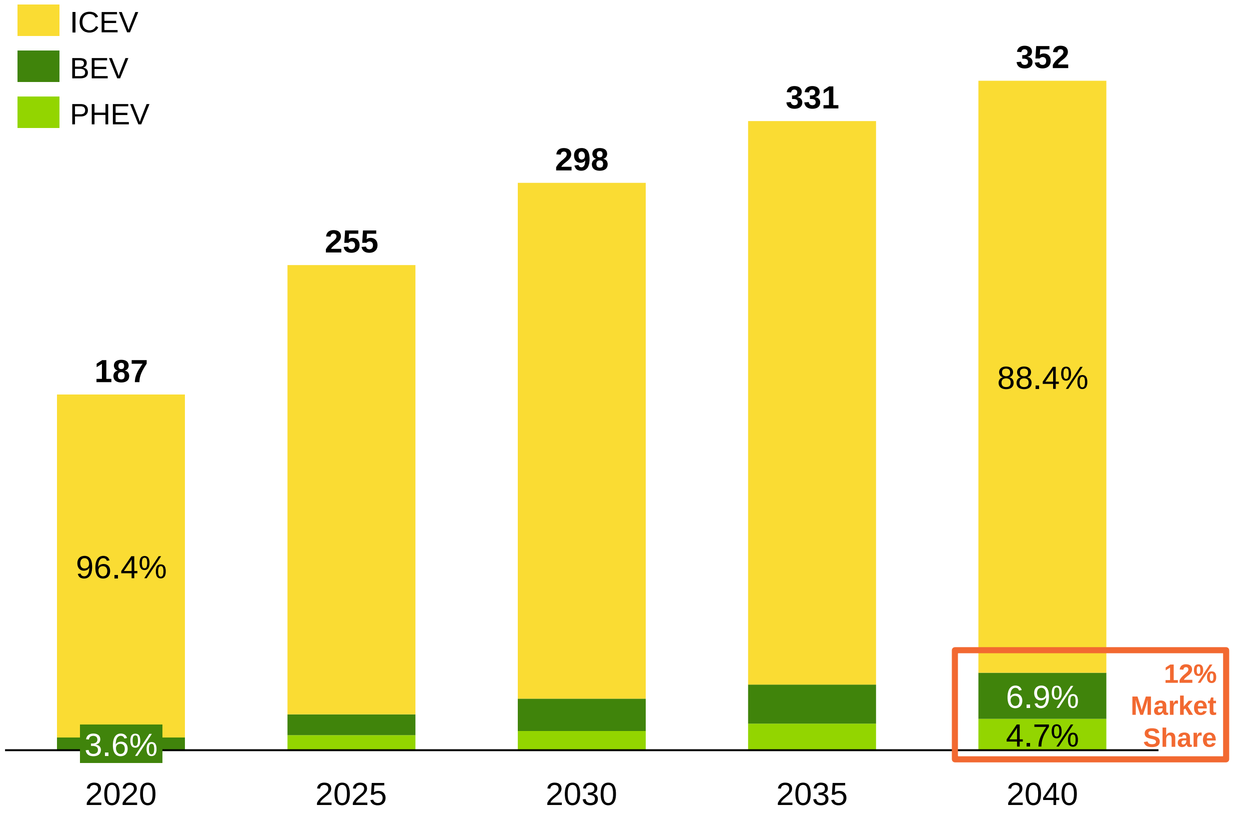
On-Road EV Annual Sales by Vehicle Segment

‘000 Vehicles, Planned Incentives Scenario, 2020-2040



On-Road Vehicle Annual Sales by Powertrain

‘000 Vehicles, Planned Incentives Scenario, 2020-2040



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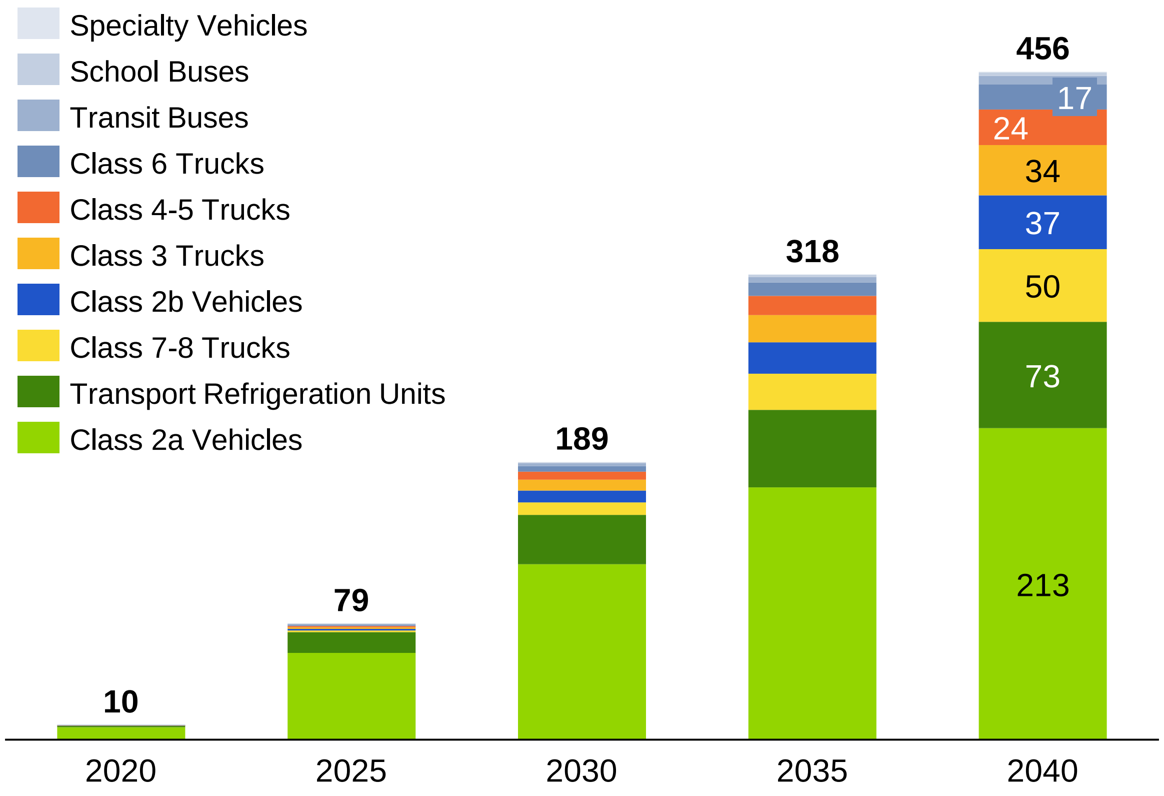
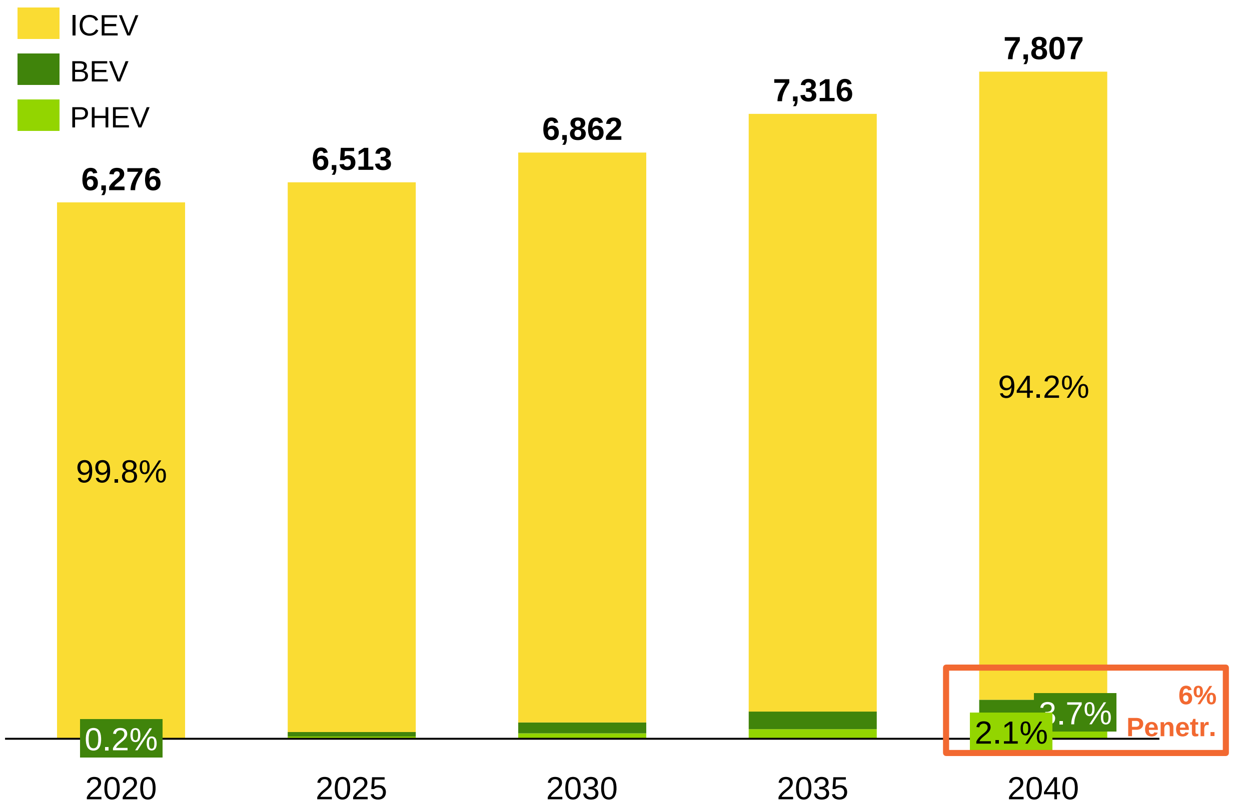
Planned Incentives Scenario: Over 456,000 non-light duty, on-road EVs expected by 2040 (6% penetration)

On-Road EV Population by Vehicle Segment
‘000 Vehicles, Planned Incentives Scenario, 2020-2040

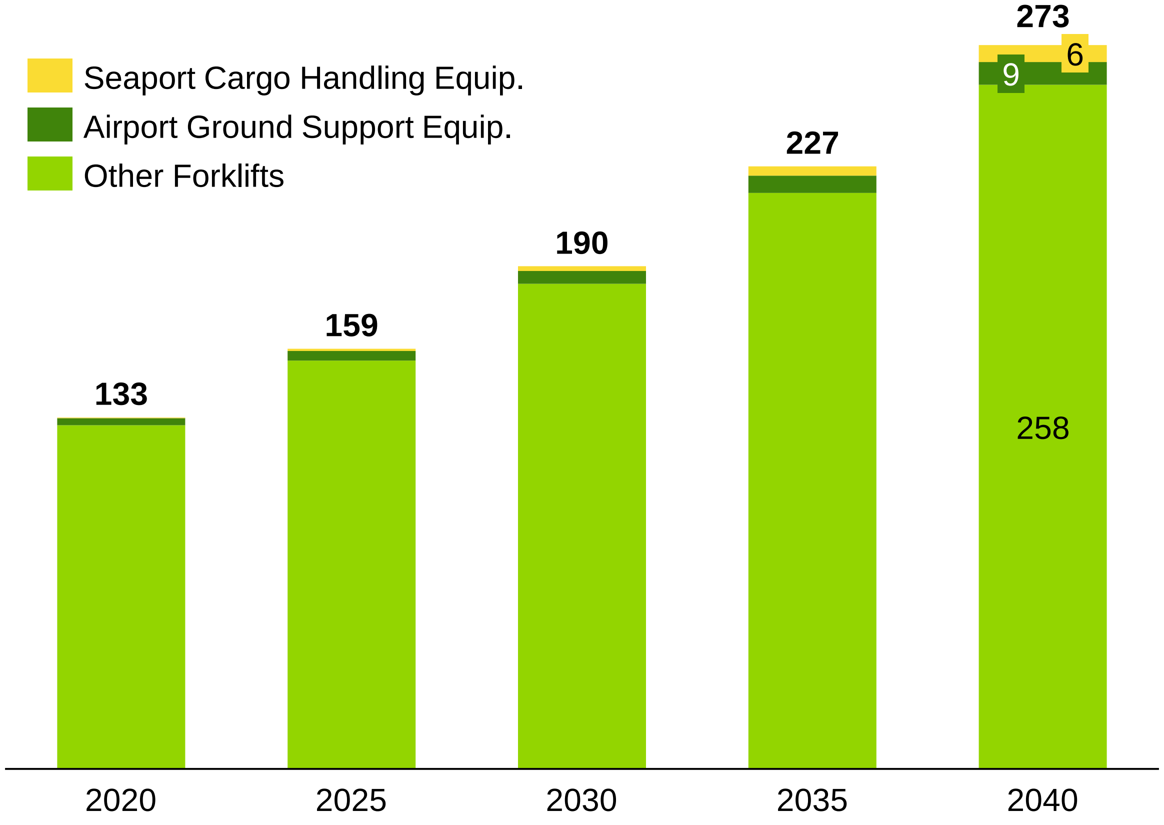


On-Road Vehicle Population by Powertrain
‘000 Vehicles, Planned Incentives Scenario, 2020-2040

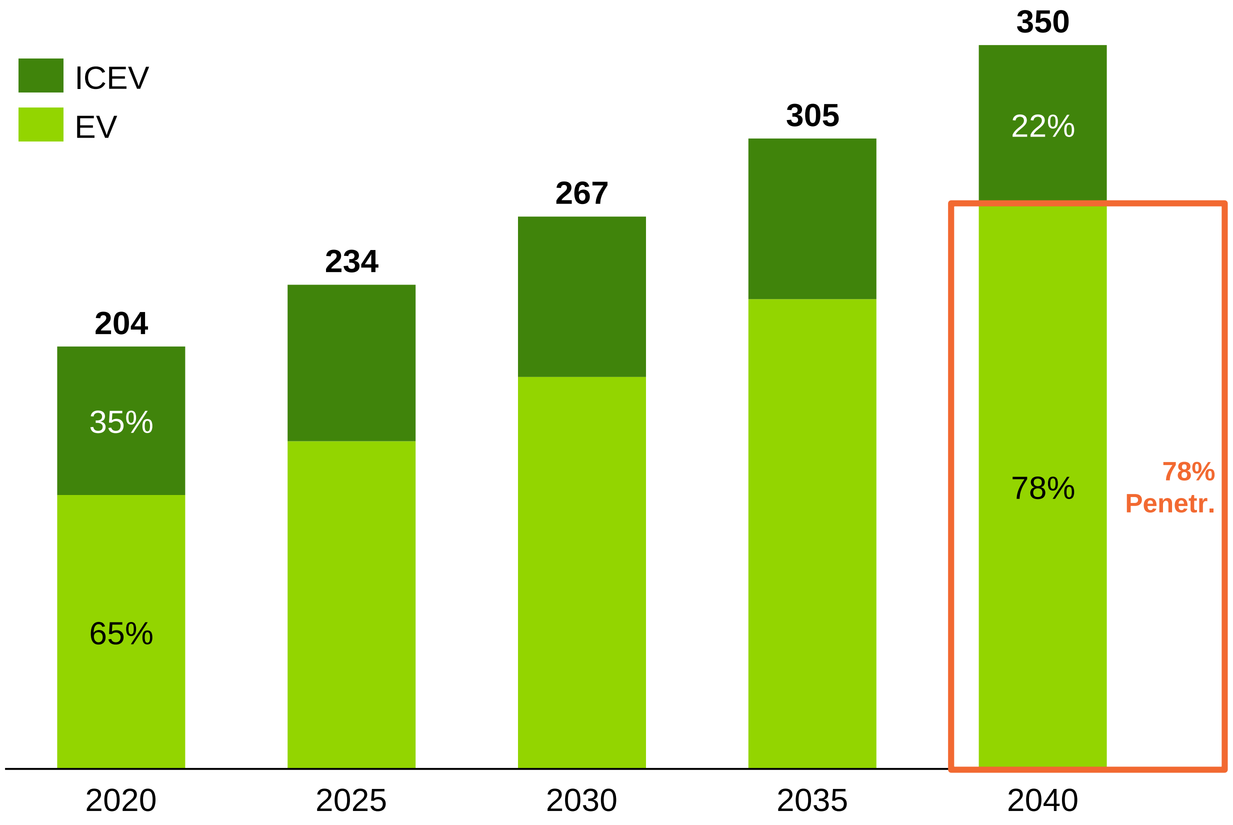


Planned Incentives Scenario: Circa 273,000 off-road EVs expected by 2040 (78% penetration)

Off-Road EV Population by Vehicle Segment
'000 Vehicles, Planned Incentives Scenario, 2020-2040



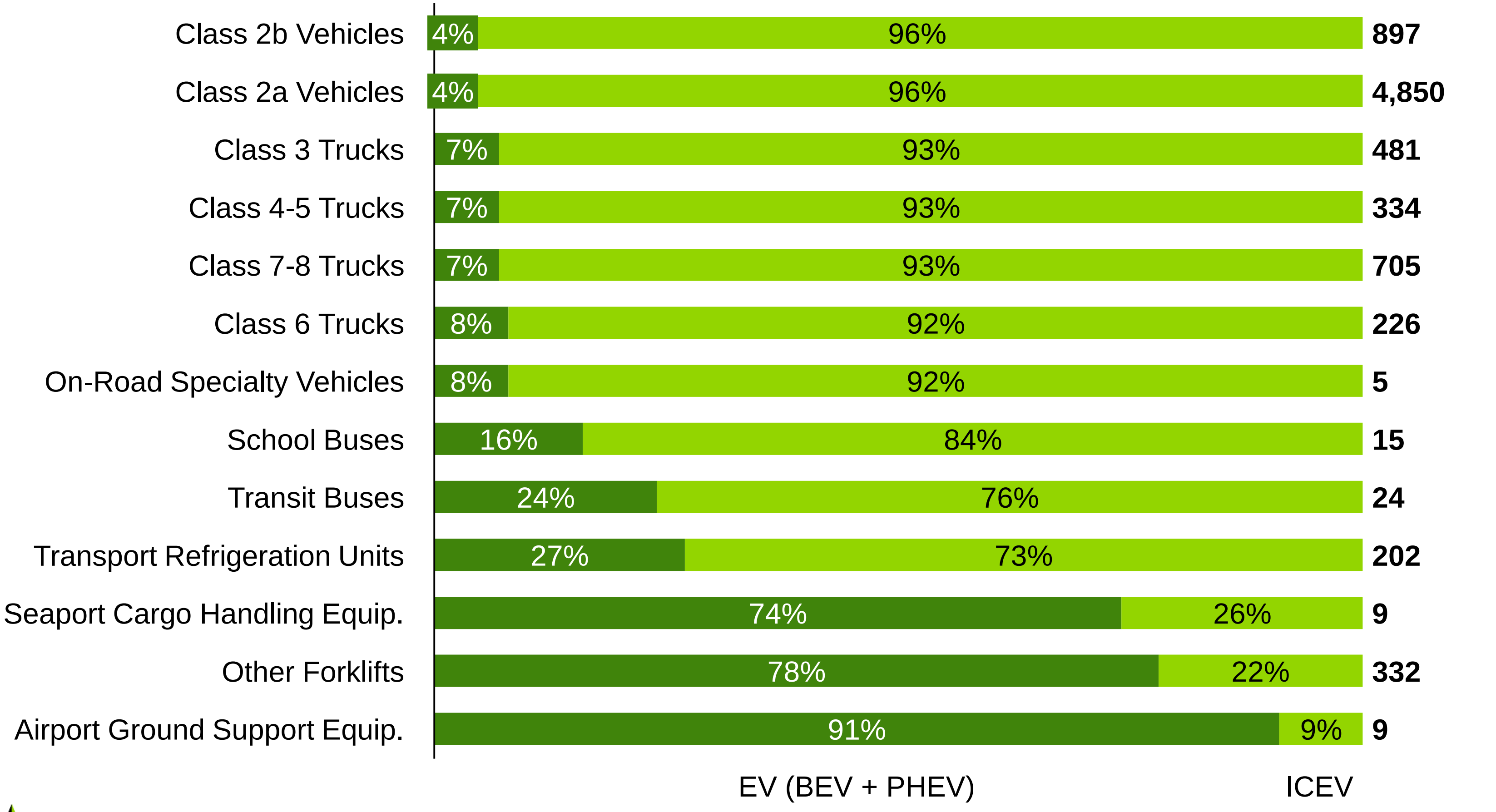
Off-Road Vehicle Population by Powertrain
'000 Vehicles, Planned Incentives Scenario, 2020-2040



Other Forklifts segment is expected to continue electrification replacing ICEV powertrain (driven by market dynamics and conversion limitations expected for heavier-duty use cases), and Seaport / Airport segment is expected to reach 74% / 91% electrification by 2040 respectively.

Planned Incentives Scenario: EV penetration by 2040 ranges by vehicle segment between 4% and 91%

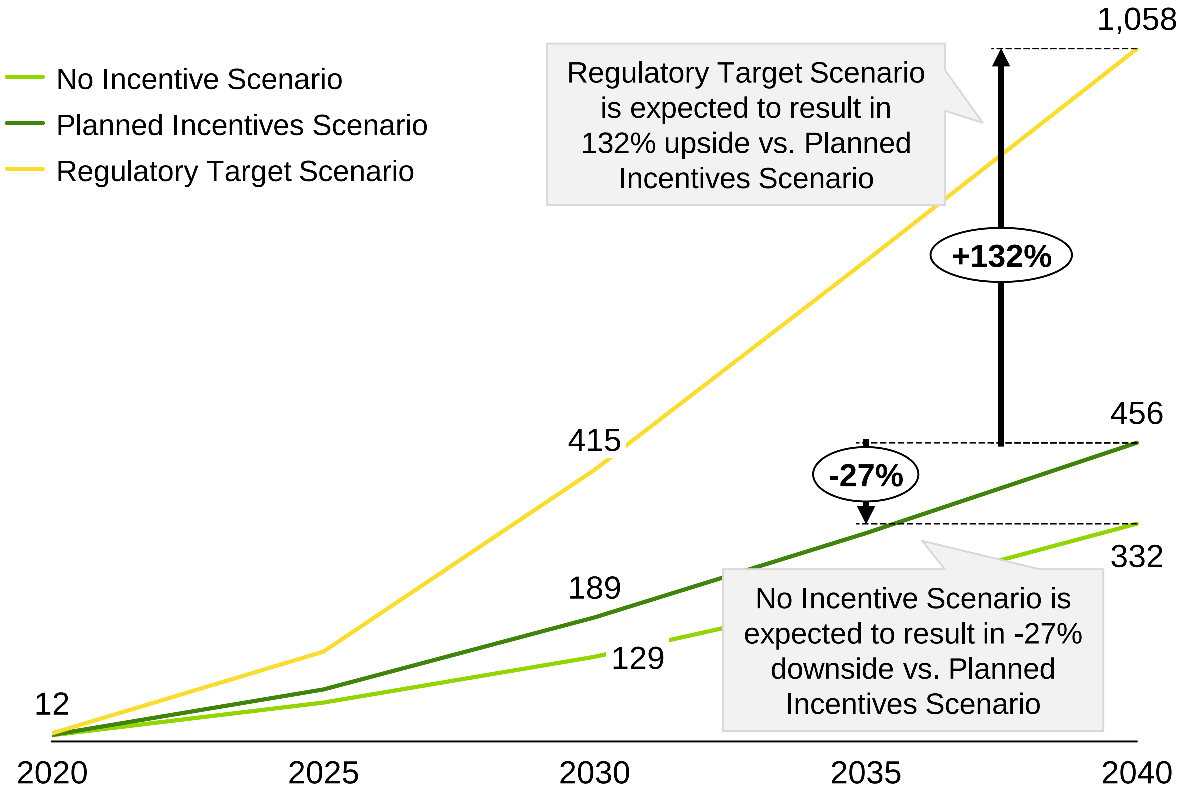
EV Penetration as a Share of Total Population, by Vehicle Segment
%, Planned Incentives Scenario, 2040



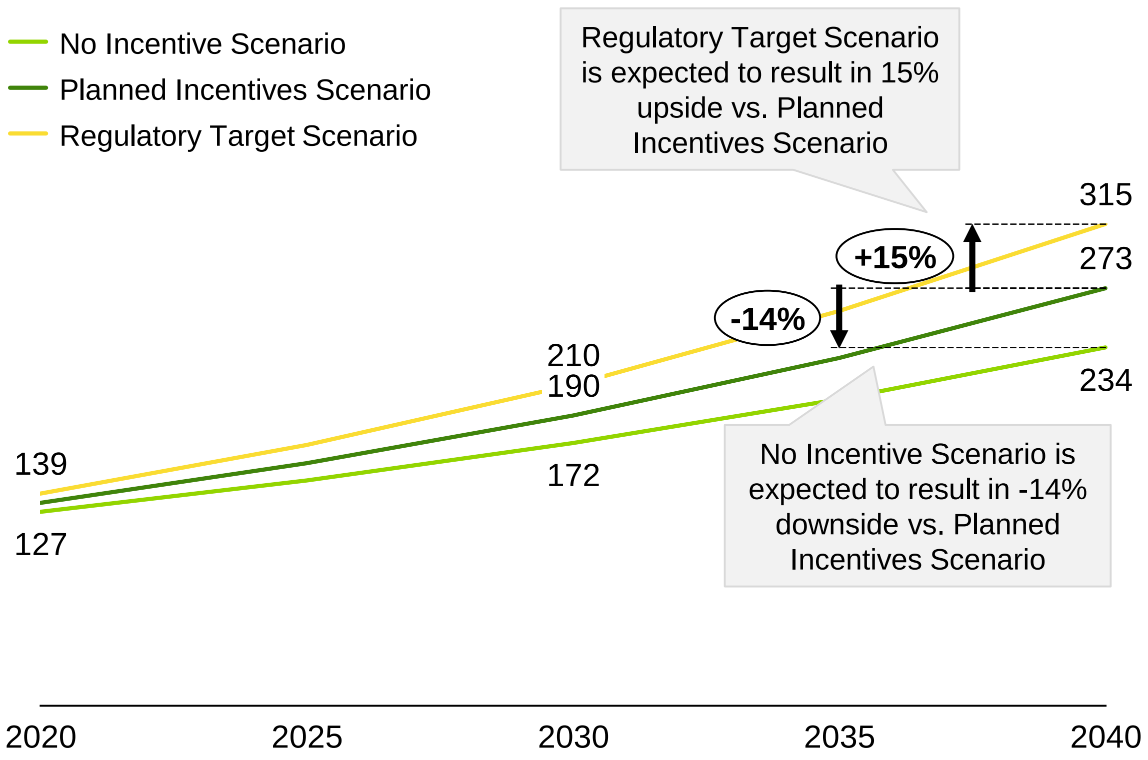
- **Airport Ground Support Equipment** and **Other Forklifts** are vehicle segments with **highest** expected EV penetration by 2040, due to relatively high EV population to date and wider vehicle availability.
- **Class 2a Vehicles** and **Class 2b Vehicles** are vehicle segments with **lowest** expected EV penetration by 2040, based on EMFAC and CARB vehicle forecasts. However, low relative EV penetration still means large absolute numbers given total vehicle segment population.

Regulatory Target Scenario: 132% upside for on-road and 15% for off-road vehicles vs. Planned Incentives Scenario

On-Road EV Population by Scenario
'000 Vehicles, 2020-2040

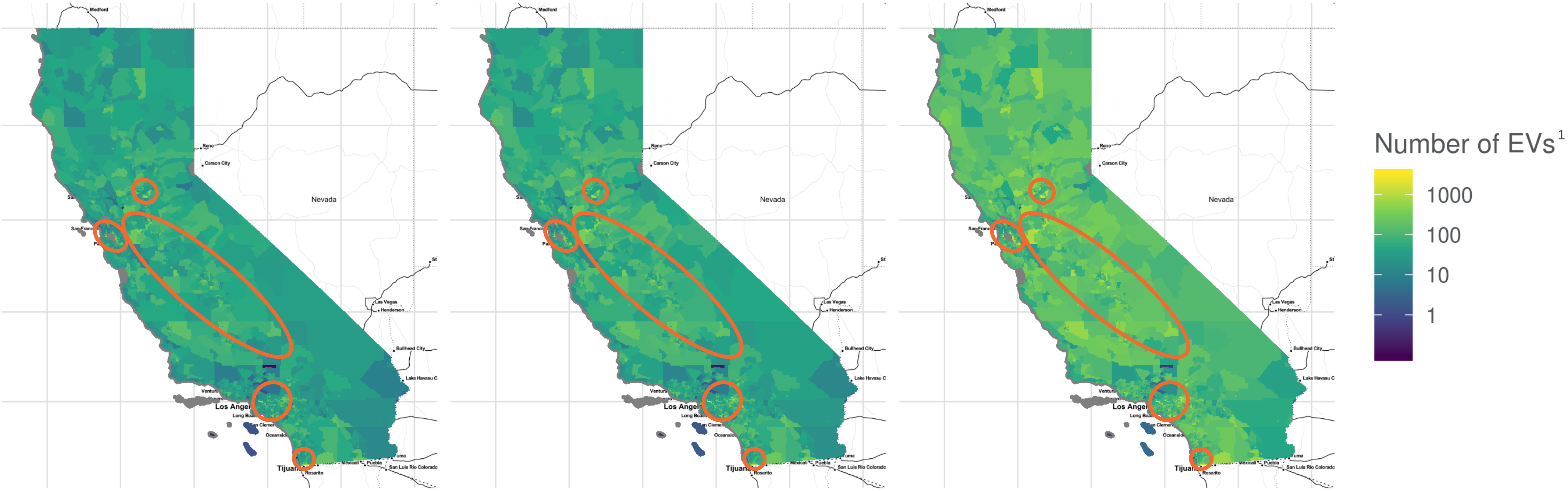


Off-Road EV Population by Scenario
'000 Vehicles, 2020-2040



Non-light duty, on-road EV adoption is expected to be spread across major metro areas, ports and Central Valley

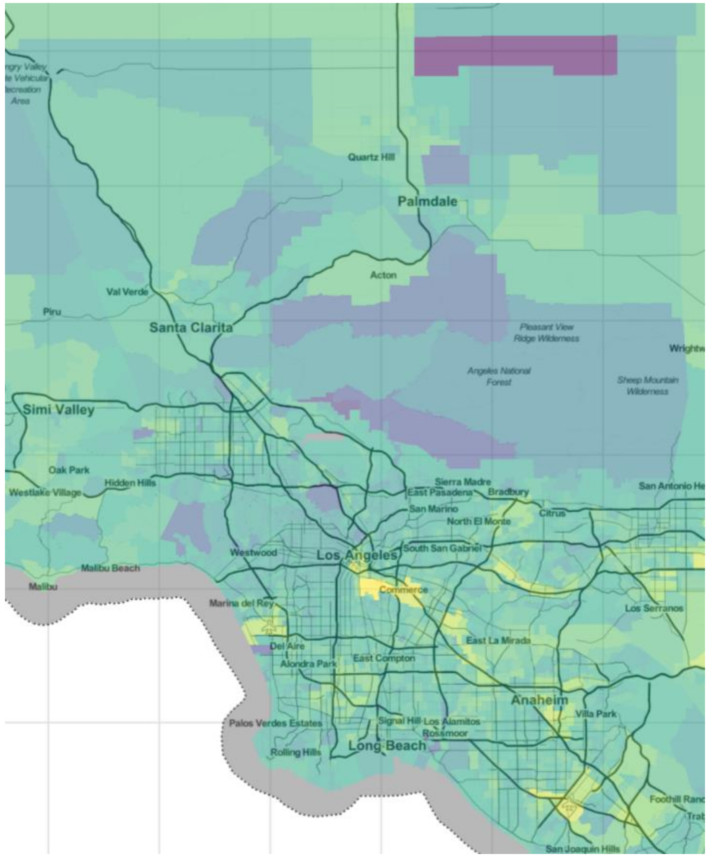
No Incentive Scenario, 2040 | Planned Incentives Scenario, 2040 | Regulatory Target Scenario, 2040



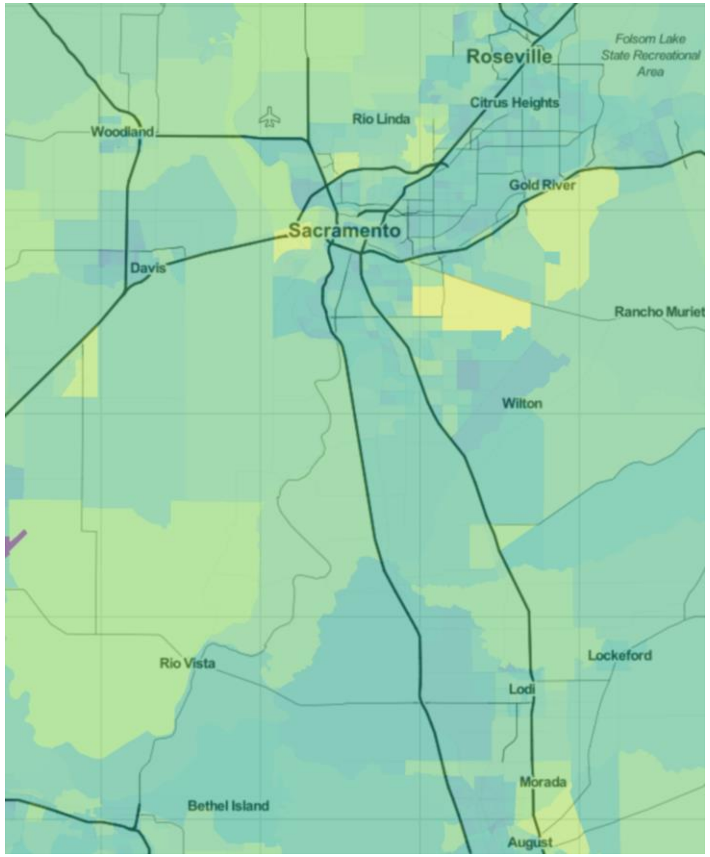
1. Total on-road medium- and heavy-duty EVs of any class in 2040, not adjusted for area or population.

Los Angeles, Sacramento, and San Francisco Bay Area are metro areas expecting higher on-road EV adoption

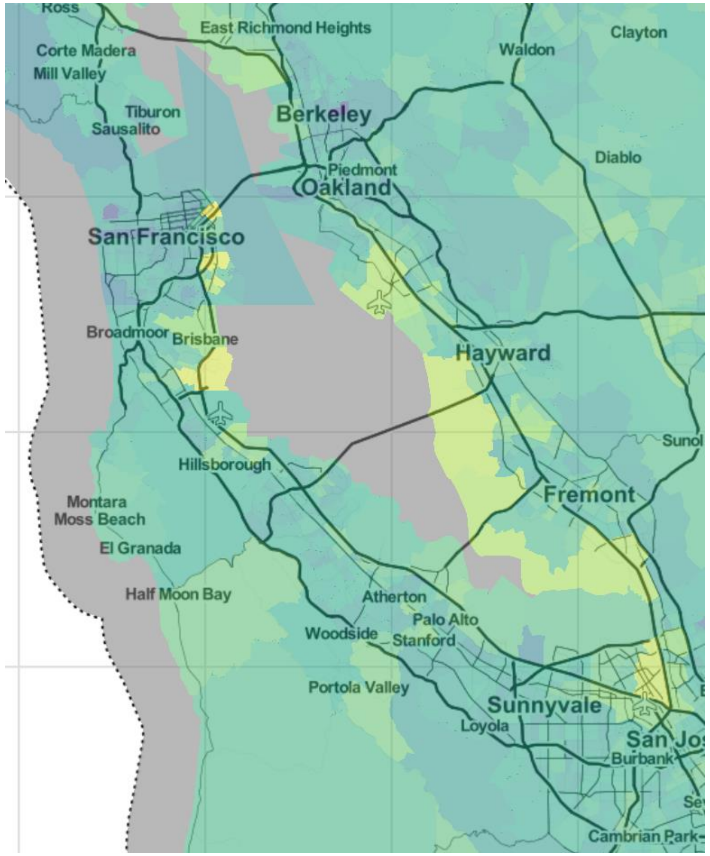
Los Angeles, Planned Incentives Scenario, 2040

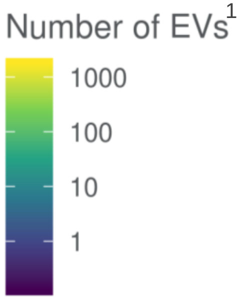


Sacramento, Planned Incentives Scenario, 2040



SF Bay Area, Planned Incentives Scenario, 2040





1. Total on-road medium and heavy duty plug-in electric vehicles of any class in 2040, not adjusted for area or population.

EV Charging Needs and Site Configuration Output (2020 CalETC Study Results)

EV charging site configuration overview

	Public Hub		Private Depot	
Location	Site location was determined based on highway annual average daily traffic (AADT)		Site location was determined based on where vehicle is registered	
Size	**Small**	Site sizes were determined based on highway traffic demand at each site	**Small**	Site sizes were determined based on number of vehicles registered in each tract
	Medium		**Medium**	
	Large		**Large**	

Infrastructure charging needs differ by vehicle segment and site type

Charging Port Ratio Needed per 1,000 Vehicles[1], Planned Incentives Scenario, 2040

Vehicle Segment	DCFC Private Depot	Level 2 Private Depot	DCFC Public Hub	Level 2 Public Hub
Class 2a Vehicles	5	610	3	20
Class 2b Vehicles	5	610	3	20
Class 3 Trucks	270	250	60	30
Class 4-5 Trucks	270	250	60	30
Class 6 Trucks	280	250	60	30
Class 7-8 Trucks	870	0	110	30
School Buses	120	650	0	0
Transit Buses	730	15	0	0
On-Road Specialty Vehicles	560	130	80	30
In-State TRUs	0	870	110	30
Airport Ground Support Equipment	500	270	0	0
Seaport Cargo Handling Equipment	500	270	0	0
Other Forklifts	0	770	0	0

- **Private charging** is expected to fulfil the majority of charging needs for all use cases, driven by convenience and customer preference.
- **Level 2 charging** is expected to continue to play a key role for Class 2 Vehicles, however, **DCFC** will be key for Class 3 Trucks and above, as well as for off-road segments.
- **Heavier-duty** vehicle segments such as Class 7-8 Trucks are expected to rely primarily on **DCFC**.

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1. Charging Port Count is stacking across site type, e.g., 1,000 Class 2a Vehicles require 5 DCFC Private Depot + 610 Level 2 Private Depot + 3 DCFC Public Hub + 20 Level 2 Public Hub sites in total.

Site configurations for Class 2a-2b Vehicles

Planned Incentives Scenario, 2040

Site Type[4]	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	1	172	588	77.3
	Medium	Public hub station with 5-15 chargers along public corridor	<1	170	955	24.3
	Small	Public hub station with <5 chargers on rural highway	<0.1	169	1,416	14.3
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	5	13	588	38.9
	Medium	Public hub station with 5-15 chargers along public corridor	1	12	955	11.7
	Small	Public hub station with <5 chargers on rural highway	<1	12	1,416	6.3
DCFC Private Depot	Large	50+ rental car fleet	1	161	550	93.2
	Medium	5-10 unit multifamily complex with shared chargers	<1	161	2,546	59.9
	Small	3-truck fleet owned by small contractor	<0.1	161	19,999	50.2
Level 2 Private Depot	Large	50+ delivery van fleet	3	11	1,394	49.4
	Medium	5-10 unit workplace charging for mid-sized employer	1	11	8,311	46.9
	Small	Single truck owned by individual contractor	1	11	284,386	1,584.0

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 3.6 kW to 19.2 kW for Level 2 and from 50 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.
4. Class 2a-2b Vehicles are expected to use some Level 1 charging, which would come in addition to the charging needs displayed here.

Site configurations for Class 2a Vehicles

This table is a breakout of the Class 2a-2b Vehicles table.

Planned Incentives Scenario, 2040

Site Type[4]	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	1	173	588	72.2
	Medium	Public hub station with 5-15 chargers along public corridor	<1	173	955	18.8
	Small	Public hub station with <5 chargers on rural highway	<1	173	1,416	8.4
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	5	13	588	36.3
	Medium	Public hub station with 5-15 chargers along public corridor	1	13	955	8.8
	Small	Public hub station with <5 chargers on rural highway	<1	13	1,416	3.5
DCFC Private Depot	Large	50+ rental car fleet	1	159	375	78.4
	Medium	5-10 unit multifamily complex with shared chargers	<1	159	1,736	50.4
	Small	3-truck fleet owned by small contractor	<1	159	13,638	42.3
Level 2 Private Depot	Large	50+ delivery van fleet	4	11	952	41.6
	Medium	5-10 unit workplace charging for mid-sized employer	1	11	5,668	39.5
	Small	Single truck owned by individual contractor	<1	11	244,872	1,336.0

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 3.6 kW to 19.2 kW for Level 2 and from 50 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.
4. Class 2a-2b Vehicles are expected to use some Level 1 charging, which would come in addition to the charging needs displayed here.

Site configurations for Class 2b Vehicles

This table is a breakout of the Class 2a-2b Vehicles table.

Planned Incentives Scenario, 2040

Site Type[4]	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	<1	164	588	5.0
	Medium	Public hub station with 5-15 chargers along public corridor	<1	164	955	5.4
	Small	Public hub station with <5 chargers on rural highway	<1	164	1,416	5.8
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	<1	12	588	2.6
	Medium	Public hub station with 5-15 chargers along public corridor	<1	12	955	2.8
	Small	Public hub station with <5 chargers on rural highway	<1	12	1,416	2.8
DCFC Private Depot	Large	50+ rental car fleet	<1	174	349	14.9
	Medium	5-10 unit multifamily complex with shared chargers	<1	174	1,619	9.5
	Small	3-truck fleet owned by small contractor	<1	173	12,723	8.0
Level 2 Private Depot	Large	50+ delivery van fleet	1	12	885	7.8
	Medium	5-10 unit workplace charging for mid-sized employer	<1	12	5,285	7.4
	Small	Single truck owned by individual contractor	<1	12	79,028	248.0

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 3.6 kW to 19.2 kW for Level 2 and from 50 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.
4. Class 2a-2b Vehicles are expected to use some Level 1 charging, which would come in addition to the charging needs displayed here.

Site configurations for Class 3-6 Trucks + On-Road Specialty Vehicles

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	33	207	107	734.2
	Medium	Public hub station with 5-15 chargers along public corridor	4	207	174	156.2
	Small	Public hub station with <5 chargers on rural highway	1	207	258	27.6
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	18	15	107	27. 8
	Medium	Public hub station with 5-15 chargers along public corridor	2	15	174	5.9
	Small	Public hub station with <5 chargers on rural highway	<1	15	258	1.0
DCFC Private Depot	Large	10+ delivery van / rack truck fleet	11	214	79	178.9
	Medium	5-10 delivery van / rack truck fleet owned by local contractor	10	214	406	823.5
	Small	3-truck fleet owned by small contractor	3	214	5,453	3479.2
Level 2 Private Depot	Large	10+ delivery van / rack truck fleet	5	15	140	11.3
	Medium	5-10 delivery van / rack truck fleet owned by local contractor	5	15	725	52.4
	Small	Single truck owned by individual contractor	2	15	9,706	220.4

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Class 3 Trucks

This table is a breakout of the Class 3-6 Trucks + On-Road Specialty Vehicles table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	15	208	107	330.6
	Medium	Public hub station with 5-15 chargers along public corridor	2	208	174	70.3
	Small	Public hub station with <5 chargers on rural highway	<1	208	258	12.4
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	8	15	107	12.5
	Medium	Public hub station with 5-15 chargers along public corridor	1	15	174	2.7
	Small	Public hub station with <5 chargers on rural highway	<1	15	258	0.5
DCFC Private Depot	Large	10+ delivery van fleet	8	213	46	75.9
	Medium	5-10 delivery van fleet owned by local contractor	7	213	205	318.5
	Small	3-truck fleet owned by small contractor	3	213	2,638	1,609.0
Level 2 Private Depot	Large	10+ delivery van fleet	4	15	84	4.9
	Medium	5-10 delivery van fleet owned by local contractor	4	15	369	20.4
	Small	Single truck owned by individual contractor	1	15	4,773	103.3

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Class 4-5 Trucks

This table is a breakout of the Class 3-6 Trucks + On-Road Specialty Vehicles table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	**Large**	Public hub station with 15+ chargers at high-traffic suburban highway exit	11	207	107	233.5
	Medium	Public hub station with 5-15 chargers along public corridor	1	207	174	49.7
	Small	Public hub station with <5 chargers on rural highway	<1	207	258	8.8
Level 2 Public Hub	**Large**	Public hub station with 15+ chargers at high-traffic suburban highway exit	6	15	107	8.8
	Medium	Public hub station with 5-15 chargers along public corridor	1	15	174	1.9
	Small	Public hub station with <5 chargers on rural highway	<1	15	258	0.3
DCFC Private Depot	**Large**	10+ delivery van fleet	8	213	32	58.1
	Medium	5-10 delivery van fleet owned by local contractor	7	213	191	288.4
	Small	3-truck fleet owned by small contractor	2	213	2,556	1,069.1
Level 2 Private Depot	**Large**	10+ delivery van fleet	4	15	58	3.7
	Medium	5-10 delivery van fleet owned by local contractor	4	15	344	18.5
	Small	Single truck owned by individual contractor	1	15	4,626	68.6

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Class 6 Trucks

This table is a breakout of the Class 3-6 Trucks + On-Road Specialty Vehicles table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	7	207	107	164.9
	Medium	Public hub station with 5-15 chargers along public corridor	1	207	174	35.1
	Small	Public hub station with <5 chargers on rural highway	<1	207	258	6.2
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	4	15	107	6.2
	Medium	Public hub station with 5-15 chargers along public corridor	1	15	174	1.3
	Small	Public hub station with <5 chargers on rural highway	<1	15	258	0.2
DCFC Private Depot	Large	10+ rack truck fleet	8	213	24	41.2
	Medium	5-10 rack truck fleet owned by local contractor	5	213	188	209.8
	Small	3-truck fleet owned by small contracting business	1	213	2,600	749.3
Level 2 Private Depot	Large	10+ rack truck fleet	4	15	44	2.6
	Medium	5-10 rack truck fleet owned by local contractor	3	15	337	13.4
	Small	Single truck owned by individual contractor	1	15	4,676	47.8

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Class 7-8 Trucks + Transport Refrigeration Units

This table is a breakout of the Class 7-8 Trucks + Transport Refrigeration Units table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	109	203	79	1742.5
	Medium	Public hub station with 5-15 chargers along public corridor	14	203	128	370.7
	Small	Public hub station with <5 chargers on rural highway	2	203	190	65.4
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	32	14	79	36.6
	Medium	Public hub station with 5-15 chargers along public corridor	4	14	128	7.8
	Small	Public hub station with <5 chargers on rural highway	1	14	190	1.4
DCFC Private Depot	Large	50+ freight truck fleet	50	214	29	306.2
	Medium	20-50 freight truck fleet	47	214	178	1791.7
	Small	<20 freight truck fleet	12	214	2,715	7134. 8
Level 2 Private Depot	Large	10+ transport refrigeration unit fleet	15	14	2,282	491.6
	Medium	2-10 transport refrigeration unit fleet	2	14	3,892	98.1
	Small	1-2 transport refrigeration unit fleet	1	14	5,175	65.7

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Class 7-8 Trucks

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	53	210	79	878.3
	Medium	Public hub station with 5-15 chargers along public corridor	7	210	128	186.8
	Small	Public hub station with <5 chargers on rural highway	1	210	190	33.0
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	16	15	79	18.3
	Medium	Public hub station with 5-15 chargers along public corridor	2	15	128	3.9
	Small	Public hub station with <5 chargers on rural highway	<1	15	190	0.7
DCFC Private Depot	Large	50+ freight truck fleet	50	214	29	306.2
	Medium	20-50 freight truck fleet	47	214	178	1,791.7
	Small	<20 freight truck fleet	12	214	2,715	7,134.8
Level 2 Private Depot	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for School Buses

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
DCFC Private Depot	Large	10+ school bus fleet owned by large school district	13	50	1	0.7
	Medium	5-10 school bus fleet owned by mid-size school district	1	50	117	6.3
	Small	1-2 school bus fleet owned by small school district	<1	50	6,403	7.6
Level 2 Private Depot	Large	10+ school bus fleet owned by large school district	69	15	1	1.0
	Medium	5-10 school bus fleet owned by mid-size school district	6	15	117	9.9
	Small	1-2 school bus fleet owned by small school district	<1	15	6,403	12.1

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and 50 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Transit Buses

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
DCFC Private Depot	Large	10+ transit bus fleet owned by large public transit agency	121	207	17	423.9
	Medium	5-10 transit bus fleet owned by mid-size public transit agency	9	207	184	325.8
	Small	1-2 transit bus fleet owned by small public transit agency	<1	207	6,891	137.3
Level 2 Private Depot	Large	10+ transit bus fleet owned by large public transit agency	2	14	17	0.5
	Medium	5-10 transit bus fleet owned by mid-size public transit agency	<1	14	184	0.4
	Small	1-2 transit bus fleet owned by small public transit agency	<1	14	6,891	0.2

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for On-Road Specialty Vehicles

This table is a breakout of the Class 3-6 Trucks + On-Road Specialty Vehicles table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	**Large**	Public hub station with 15+ chargers co-located at high-traffic suburban highway exit	<1	208	107	5.1
	Medium	Public hub station with 5-15 chargers along public corridor	<1	208	174	1.1
	Small	Public hub station with <5 chargers specifically for specialty use case	<1	208	258	0.2
Level 2 Public Hub	**Large**	Public hub station with 15+ chargers co-located at high-traffic suburban highway exit	<1	15	107	0.1
	Medium	Public hub station with 5-15 chargers along public corridor	<1	15	174	<0.1
	Small	Public hub station with <5 chargers specifically for specialty use case	<1	15	258	<0.1
DCFC Private Depot	**Large**	City fleet of 10 refuse trucks	2	259	8	3.6
	Medium	Mid-size hospital with two electric ambulances and few ICEVs	1	281	24	6.8
	Small	Single rental RV charged at fleet depot site	<1	296	473	51.9
Level 2 Private Depot	**Large**	City fleet of 10 refuse trucks	<1	17	11	0.1
	Medium	Mid-size hospital with two electric ambulances which serve in conjunction with ICEVs	<1	18	30	0.1
	Small	Individually-owned RV charged at residential site	<1	19	563	0.7

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for In-State TRUs

This table is a breakout of the Class 7-8 Trucks + Transport Refrigeration Units table.

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	56	196	79	864.3
	Medium	Public hub station with 5-15 chargers along public corridor	7	196	128	183.9
	Small	Public hub station with <5 chargers on rural highway	1	196	190	32.4
Level 2 Public Hub	Large	Public hub station with 15+ chargers at high-traffic suburban highway exit	17	14	79	18.3
	Medium	Public hub station with 5-15 chargers along public corridor	2	14	128	3.9
	Small	Public hub station with <5 chargers on rural highway	<1	14	190	0.7
DCFC Private Depot	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Private Depot	Large	10+ transport refrigeration unit fleet	15	14	2,282	491.6
	Medium	2-10 transport refrigeration unit fleet	2	14	3,892	98.1
	Small	1-2 transport refrigeration unit fleet	1	14	5,175	65.7

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 300 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Airport Ground Support Equipment

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
DCFC Private Depot	Large	Primary commercial service airport, e.g., Los Angeles International Airport	1,011	126	3	383.5
	Medium	Non-primary commercial service airport, e.g., Del Norte County Airport	155	126	7	136.9
	Small	General aviation airport, e.g., Imperial County Airport	2	126	61	15.5
Level 2 Private Depot	Large	Primary commercial service airport, e.g., Los Angeles International Airport	560	14	3	22.8
	Medium	Non-primary commercial service airport, e.g., Del Norte County Airport	86	14	7	8.1
	Small	General aviation airport, e.g., Imperial County Airport	1	14	61	0.9

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 150 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Seaport Cargo Handling Equipment

Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
DCFC Private Depot	Large	Port of Los Angeles	145	128	12	231.6
	Medium	Humboldt Bay Harbor	64	128	19	154.4
	Small	Port of San Luis Harbor	6	128	30	22.0
Level 2 Private Depot	Large	Port of Los Angeles	80	14	12	14.4
	Medium	Humboldt Bay Harbor	36	14	19	9.6
	Small	Port of San Luis Harbor	3	14	30	1.4

1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 150 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Site configurations for Other Forklifts

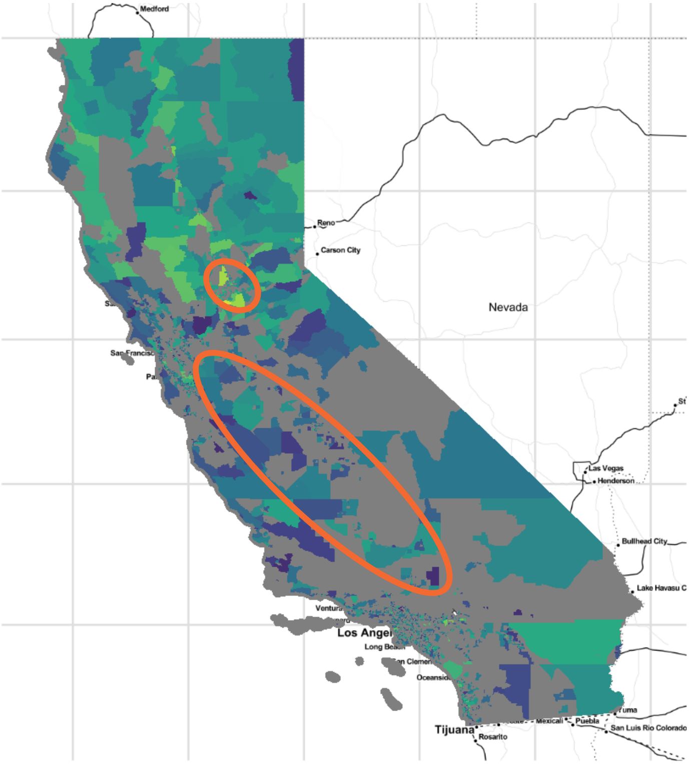
Planned Incentives Scenario, 2040

Site Type	Site Size	Illustrative Use Case	Average Port Count[1]	Average Rated kW[2]	Total Site Count	Total Rated MW[3]
DCFC Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Public Hub	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
DCFC Private Depot	Large	-	-	-	-	-
	Medium	-	-	-	-	-
	Small	-	-	-	-	-
Level 2 Private Depot	Large	Warehouse with 100+ forklifts	1,068	14	36	540.5
	Medium	Warehouse with 10-100 forklifts	53	14	1,410	1,042.0
	Small	Warehouse with less than 10 forklifts	3	14	26,379	1,183.6

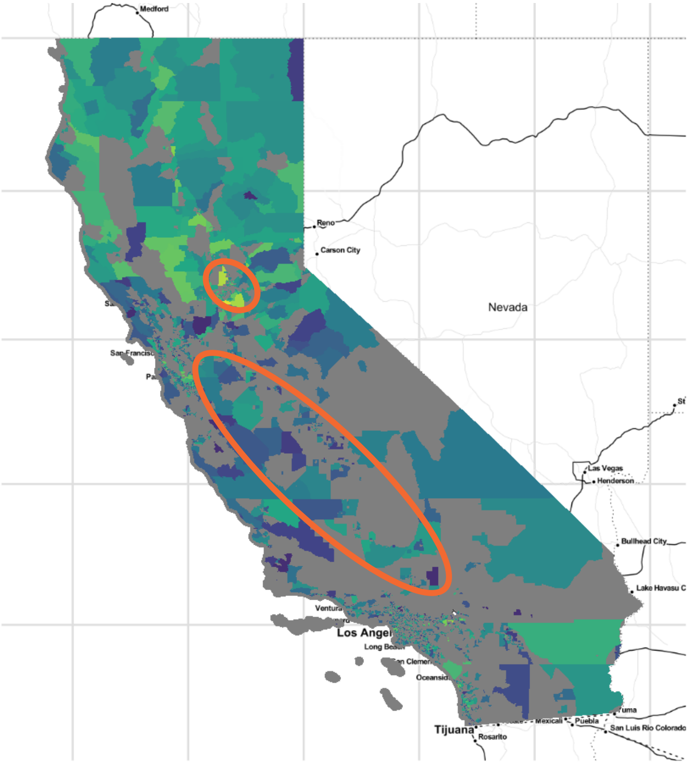
1. Average Port Count is stacking across vehicle segments and technologies, i.e., ports for multiple vehicle segments are expected to be co-located, resulting in an actual site having a summed up port count from all segments served.
2. Average Rated kW is the average charger rated capacity accounting for charger levels ranging from 9.3 kW to 19.2 kW for Level 2 and from 100 kW to 150 kW for DCFC.
3. Total Rated MW is the result of Average Port Count x Average Rated kW x Total Site Count, not discounted for any load management, and is therefore different from any grid systemwide coincident / noncoincident peak calculation. See modeling assumptions for further detail.

Public charging infrastructure is expected to follow traffic patterns along highway corridors outside of metro areas

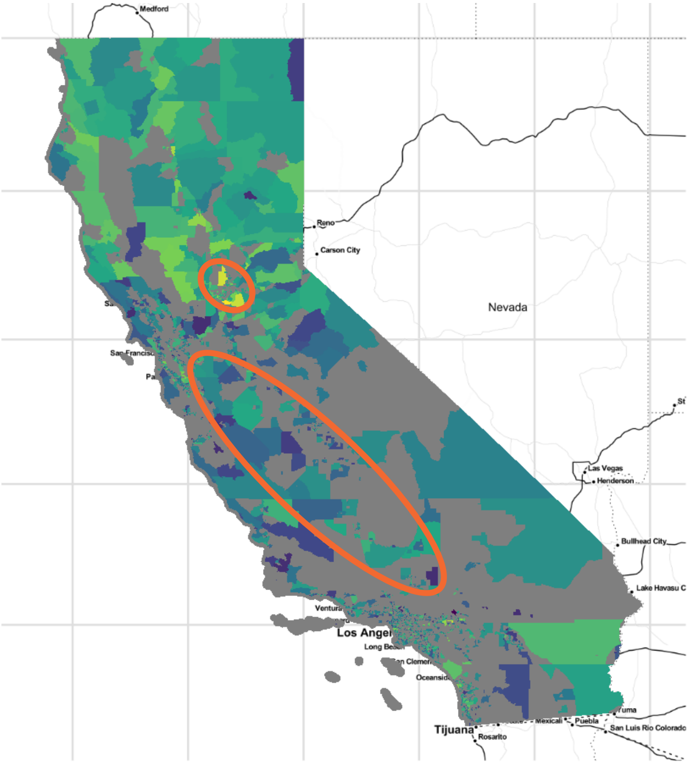
No Incentive Scenario, 2040

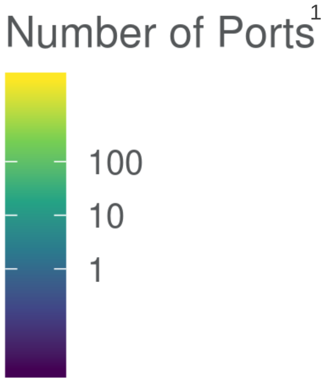


Planned Incentives Scenario, 2040



Regulatory Target Scenario, 2040



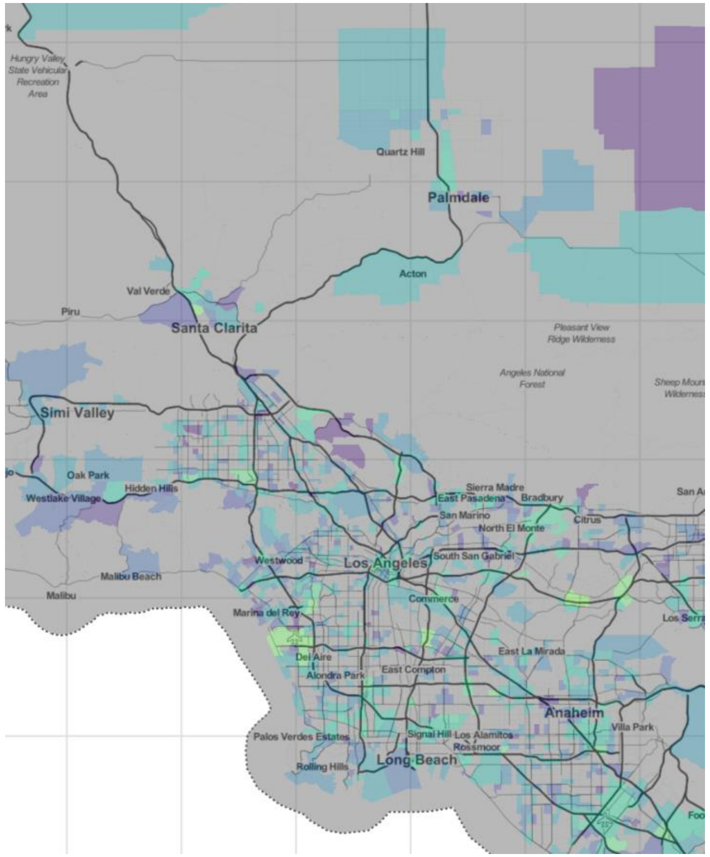


Guidehouse

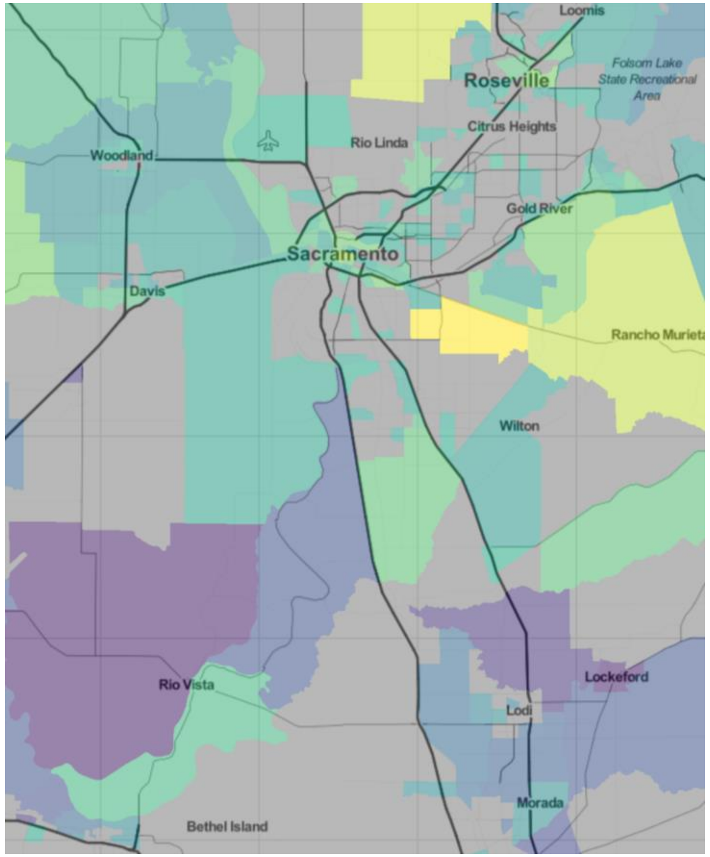
1. Total Public Hub charging ports (therefore excluding Private Depot charging) of any class in 2040, not adjusted for area or population.

Los Angeles, Sacramento, and San Francisco Bay Area are expecting moderate infrastructure in surrounding areas

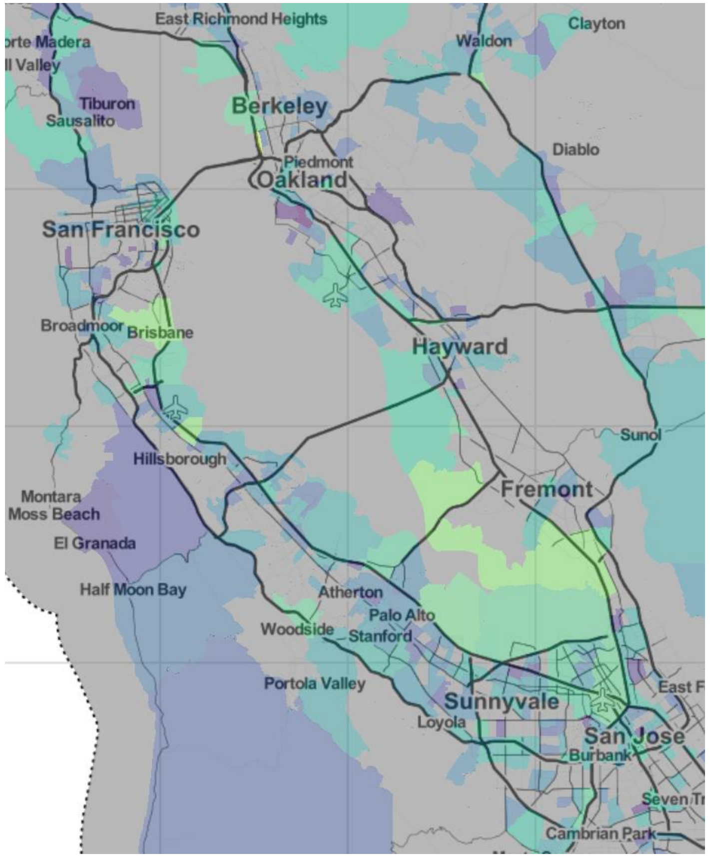
Los Angeles, Planned Incentives Scenario, 2040

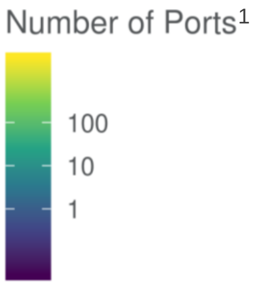


Sacramento, Planned Incentives Scenario, 2040



SF Bay Area, Planned Incentives Scenario, 2040





1. Total Public Hub charging ports (therefore excluding Private Depot charging) of any class in 2040, not adjusted for area or population.

EV Load Growth (2021 CA LSE Study Results)

2021 Load Growth Approach: Modeling scenarios reflect Planned Incentive Scenario for EV adoption in California

Drivers	Description	No Incentive Scenario	This Scope Planned Incentives Scenario	Regulatory Target Scenario
Incentives	Dollar per EV tax incentive ($)	• Any existing and planned California **incentives discontinued**	• California incentive policies **currently existing and planned** (AFDC, Off-Road Vehicle Industry)	• **Additional** “cash on the hood” **incentive** per vehicle covering 50% of incremental cost of EV over ICEV[1]
Battery Costs	Battery pack costs ($ per kWh)	• Guidehouse Insights **higher-bound battery cost** forecast (leading to increased EV operating costs)	• Guidehouse Insights **base battery cost** forecast	• Guidehouse Insights **lower-bound battery cost** forecast (leading to decreased EV operating costs)
Fuel Prices	Gasoline and diesel prices ($ per gallon)	• 25% **lower gasoline and diesel prices** vs. base (leading to decreased operating ICEV costs)	• AAA California average **base** assumption, adjusted for inflation	• 75% **higher gasoline and diesel prices** vs. base (leading to increased operating ICEV costs)
Consumer Awareness and Acceptance	Marketing and outreach influencing customer familiarity (i.e., public awareness / acceptance), prerequisite for adoption	• One-third **lower consumer awareness and acceptance** vs. base (leading to decreased EV adoption)	• Guidehouse Insights **base** assumption, calibrated to California’s historical consumer awareness metrics	• One-third **higher consumer awareness and acceptance** vs. base (leading to increased EV adoption)[1]
Regulations	Policies regulating ICEVs and EVs	• **Penalties** paid **in lieu of adoption** per ZEV, ACT, ACT Fleet, ICT and TRU rules	• **Penalties** paid **in lieu of adoption** per ZEV, ACT, ACT Fleet, ICT, and TRU rules	• **Adoption** consistent with ZEV, ACT, ACT Fleet, ICT, TRU, and Heavy-Duty Diesel Vehicles rules, and reinstated CAFE standards

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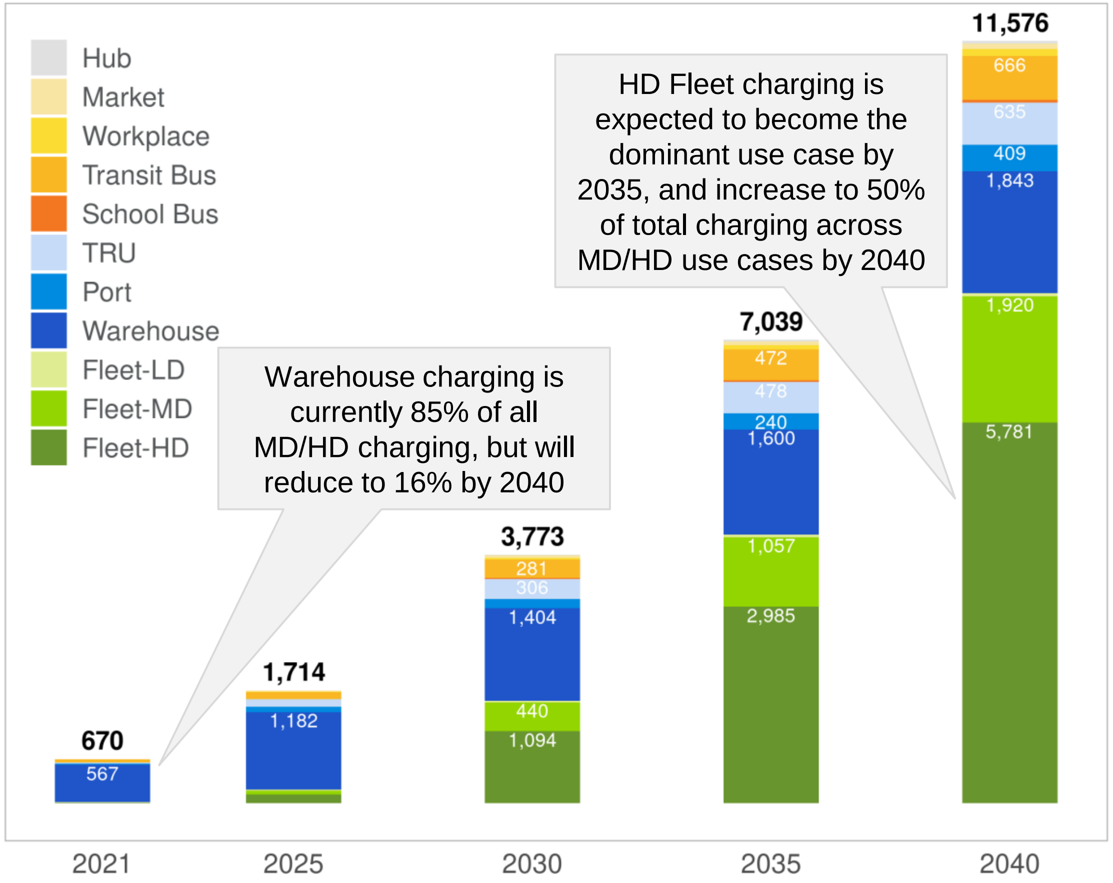
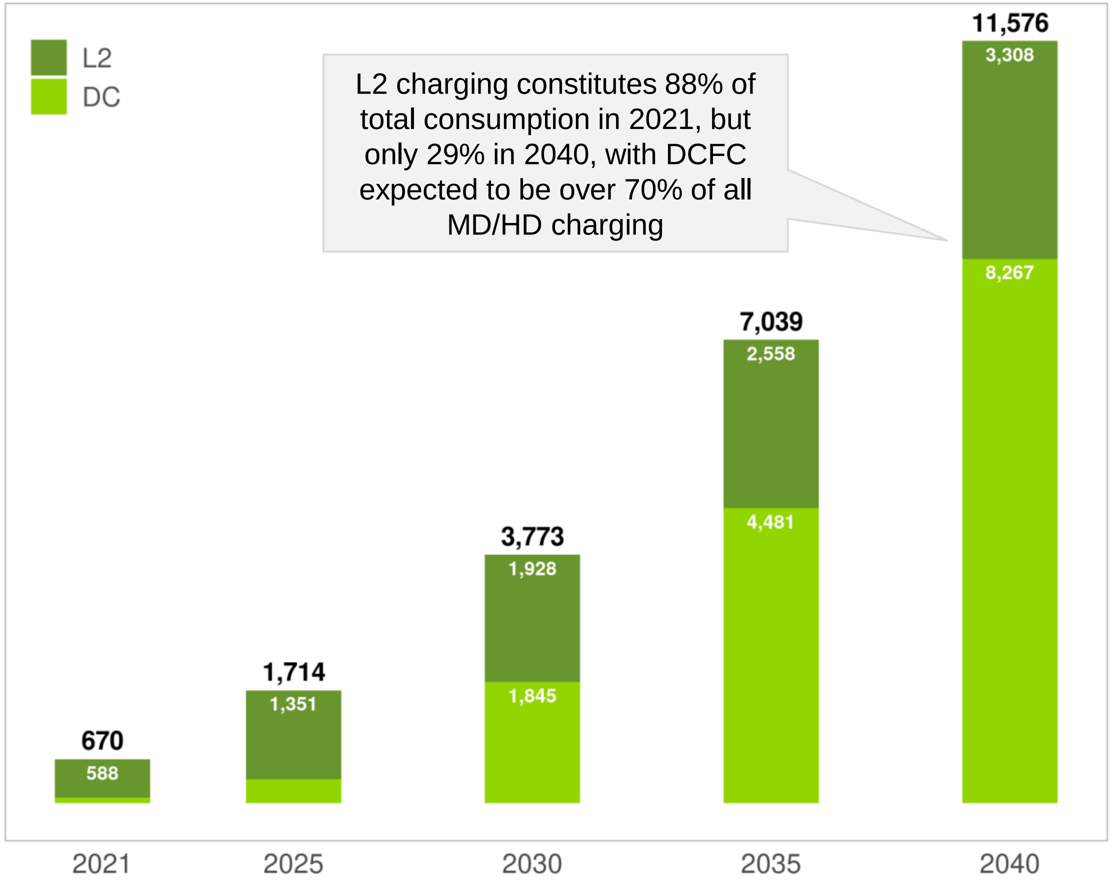
1. Incentives and Consumer Awareness and Acceptance drivers were adjusted to achieve regulatory targets per Regulations driver requirement.

Planned Support Scenario: Over 11,000 GWh of annual energy consumption by non-light duty EVs by 2040

Annual Energy Consumption By Use Case
Impacts (GWh), 2021-2040

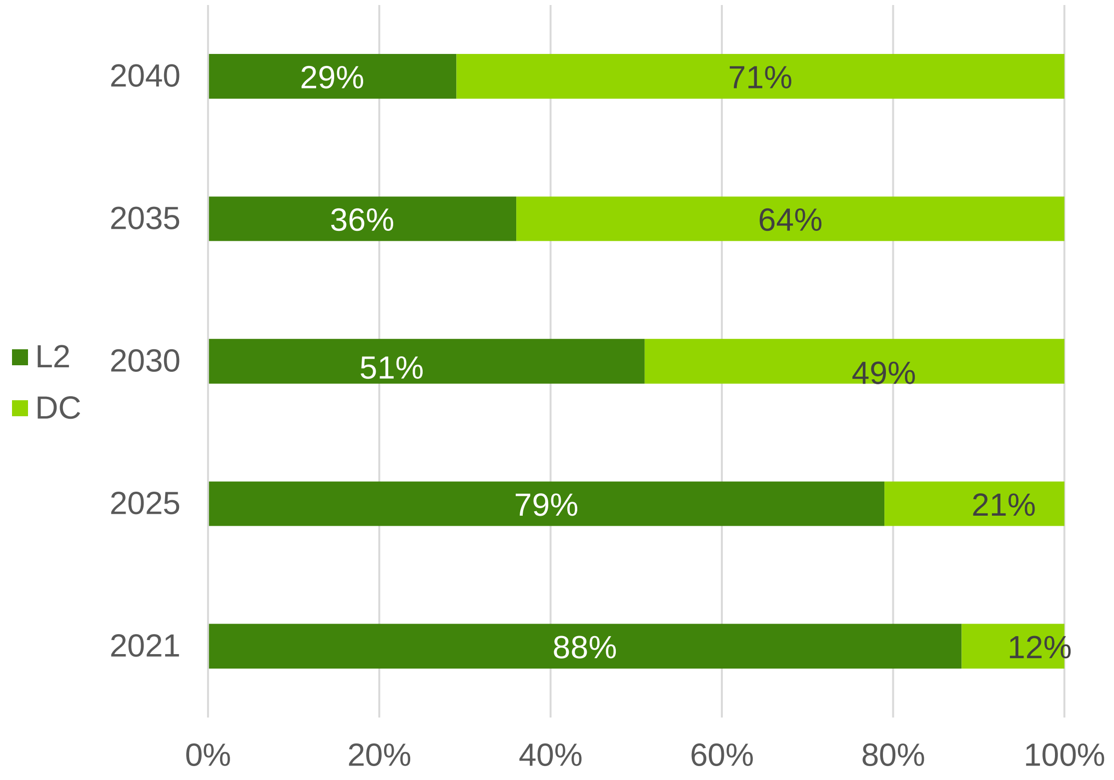


Annual Energy Consumption By Technology
Impacts (GWh), 2021-2040



Planned Support Scenario: 71% of MD/HD annual energy consumption will be from DCFC by 2040

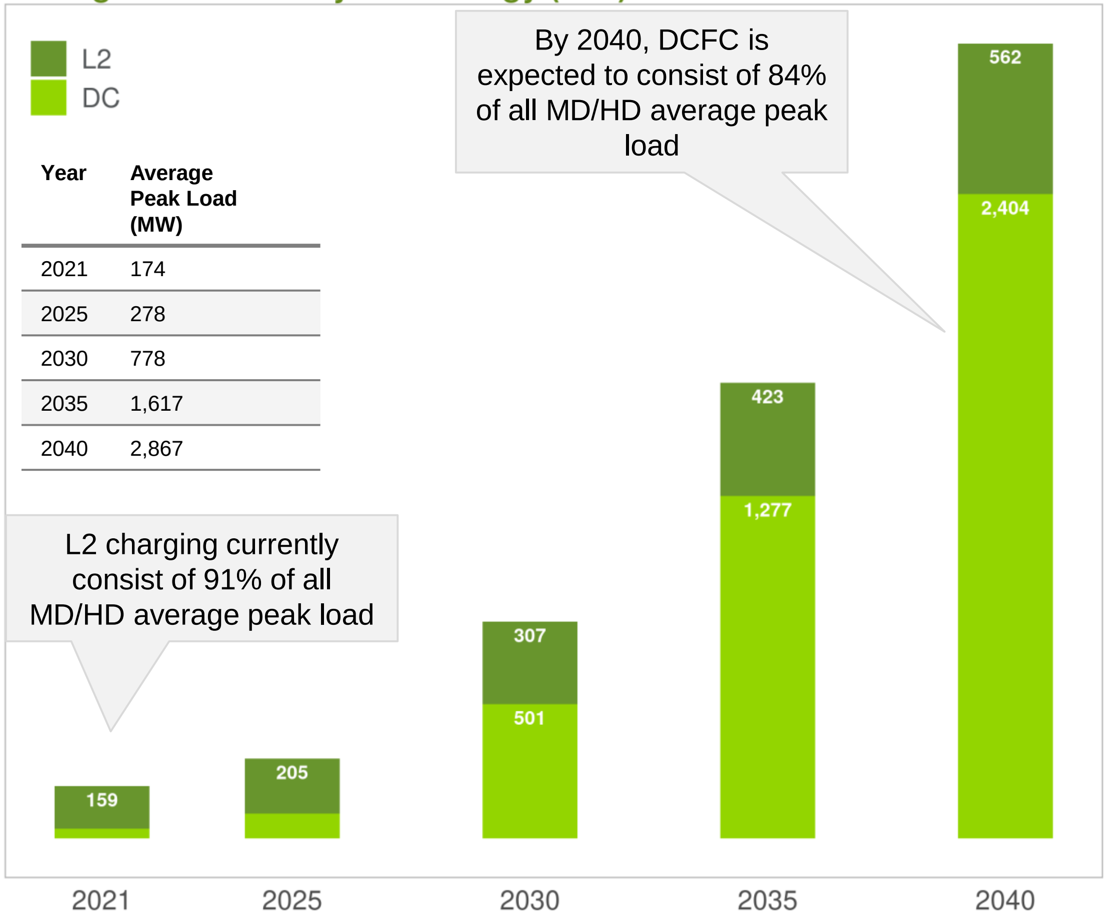
Energy Consumption by Technology (L2, DCFC)
(%, Planned Incentives Scenario for MD/HD)



- DCFC will begin to **overtake L2 charging after 2030** for MD/HD
- DCFC charging for MD/HD is forecasted to **increase by approximately 100-fold**, rising from 82 GWh in 2021 to 8267 GWh in 2040.
- L2 charging for MD/HD is forecasted to **only increase five-fold**, rising from 588 GWh in 2021 to 3308 GWh in 2040.

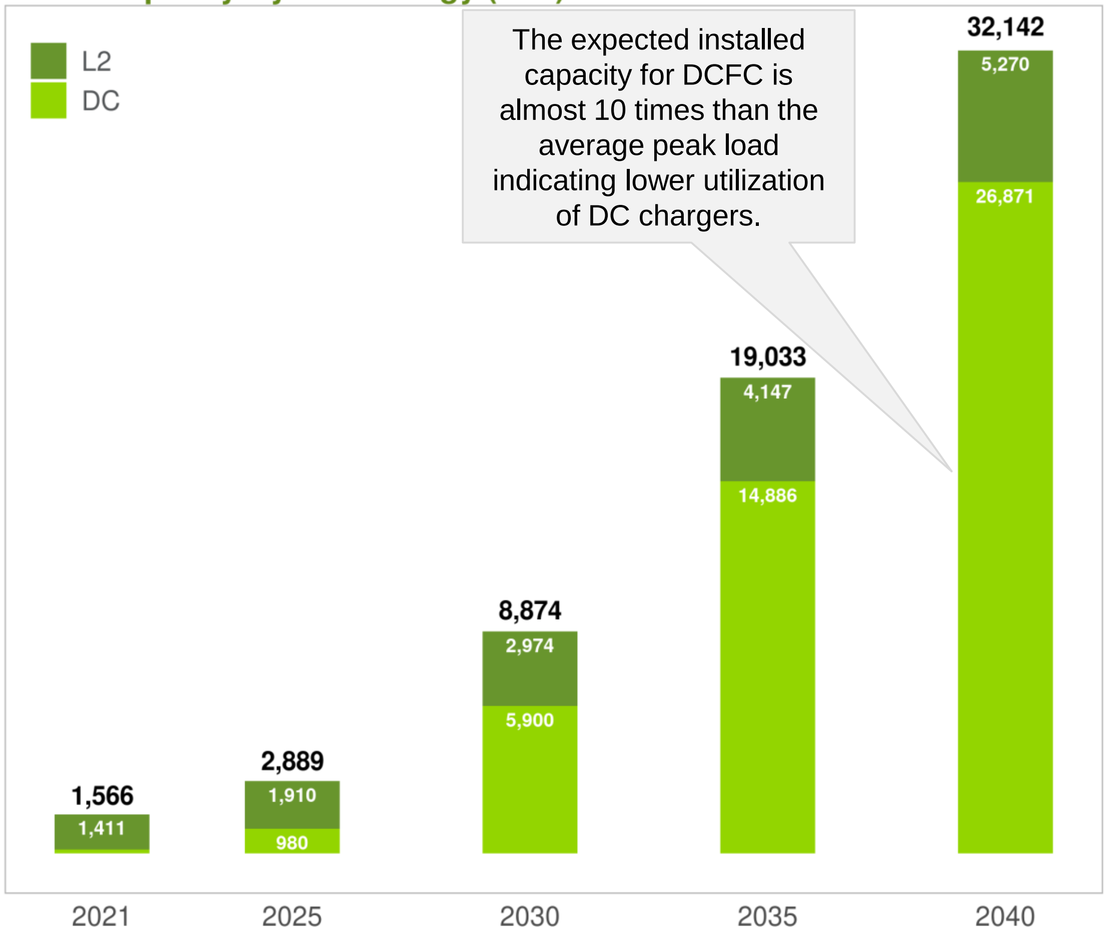
Planned Support Scenario: >2.5 GW avg hourly peak load[1] and 32 GW rated capacity with non-LDV charging by 2040

Average Peak Load By Technology (MW)



Year	Average Peak Load (MW)
2021	174
2025	278
2030	778
2035	1,617
2040	2,867

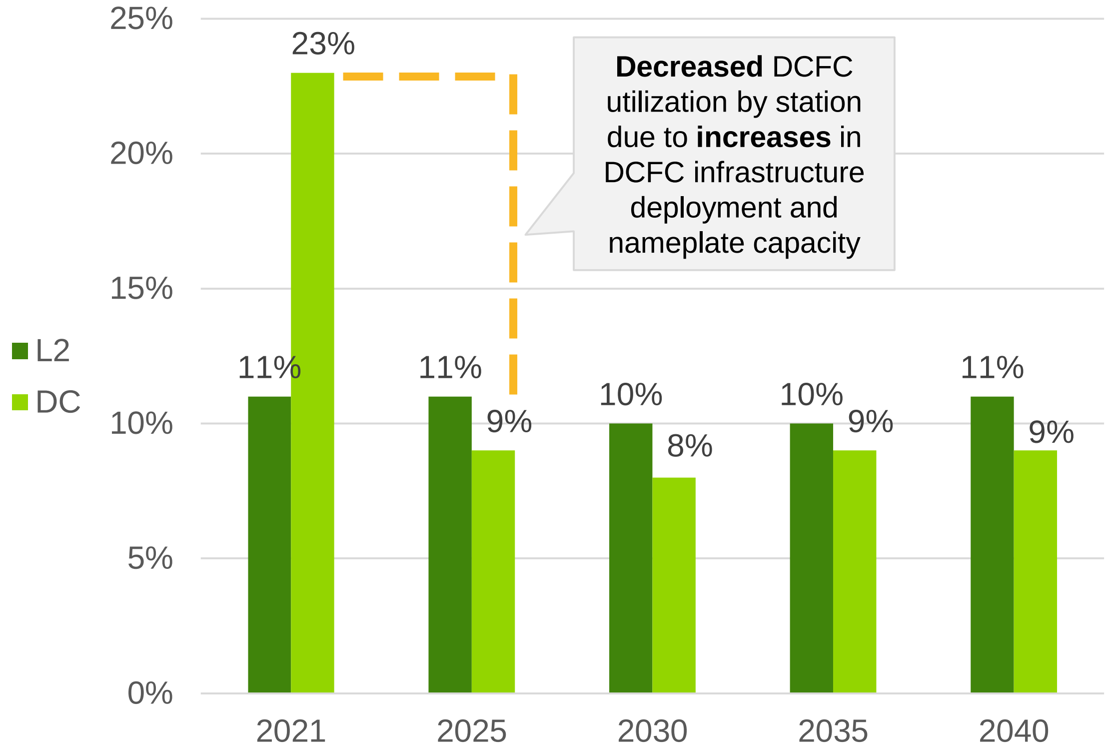
Rated Capacity By Technology (MW)



1 The average hourly peak load is the maximum of the average energy consumption in an hour for that year and **not the instantaneous peak.** Also, the hourly peak loads shown in the plot are non coincident peaks, i.e., occur at different times for different technology based on the typical technology load shape.

Planned Support Scenario: DCFC utilization expected to initially decrease from 2021 to 2025

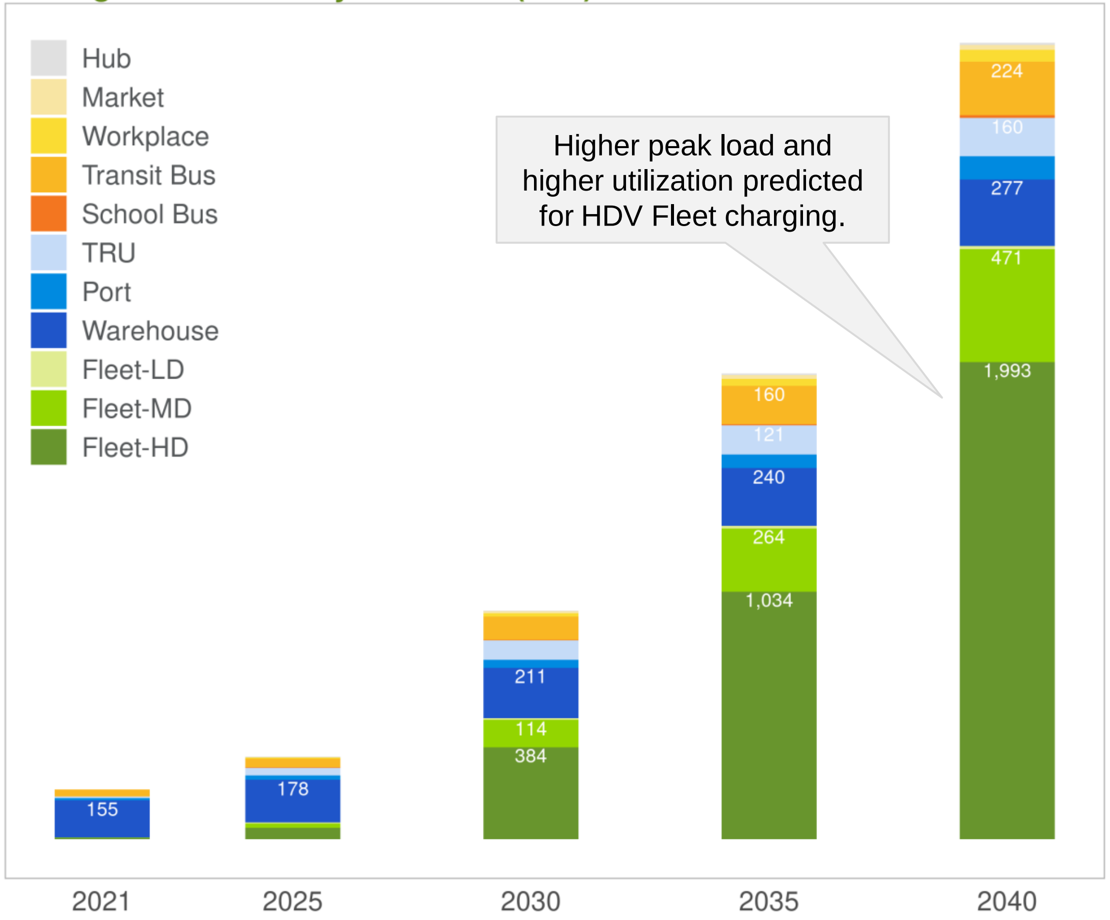
Energy Utilization by Technology (L2/DCFC)
(Peak Load / Rated Capacity, Planned Incentives Scenario for MD/HD)



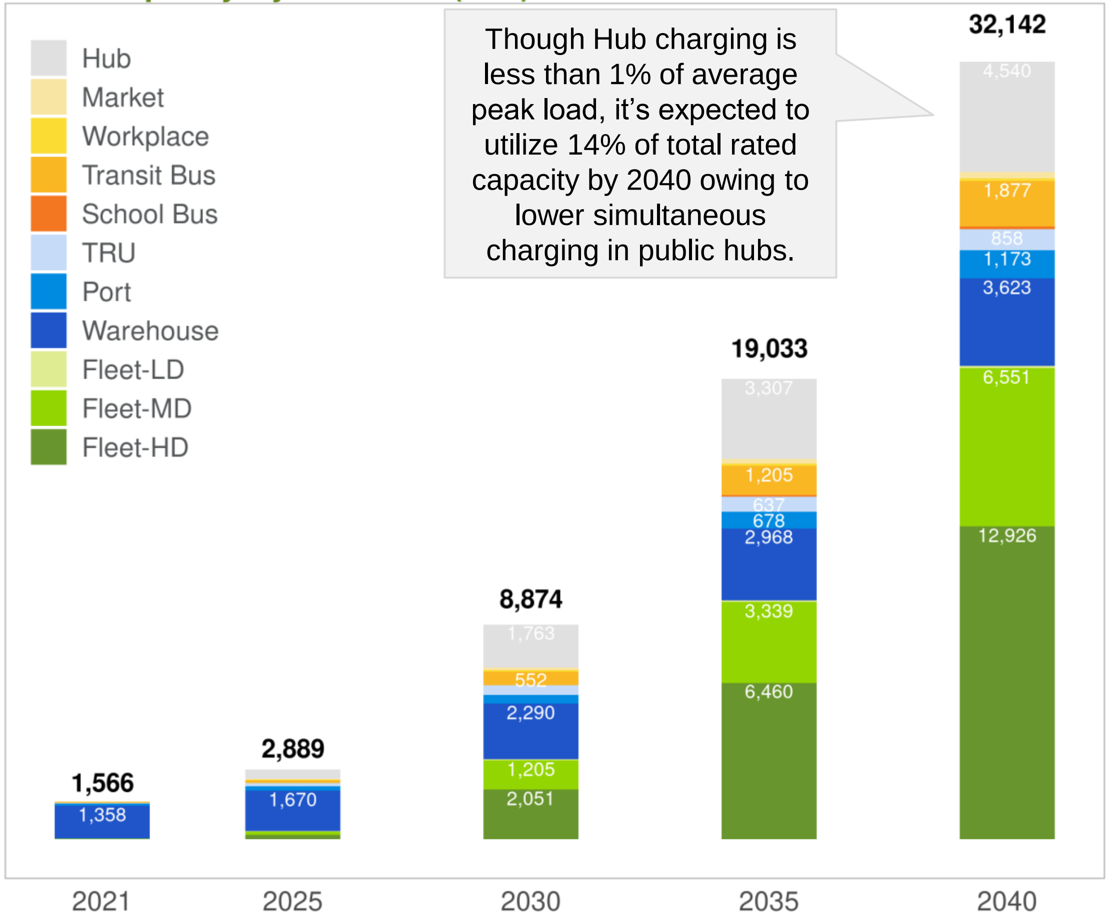
- While L2 utilization remains consistent across time, the **average DCFC utilization is expected to significantly decrease** from 23% in 2021 to 9% in 2025, and then levelized thereafter. This effect is due to two increases:
  - **DCFC Deployment.** Sharp increase in charger deployment across California as DCFC installations catch up to meet charging needs of newly deployed EVs
  - **DCFC Capacity.** Increased rated nameplate capacity of chargers (50kW to 150kW) to meet customer need for shorter charging sessions
- Average utilization of DCFC stations is **lower in comparison to L2 stations** due to the shorter charging sessions provided by DCFC technology.

Planned Support Scenario: Hub charging will be <1% average peak load, but utilize 14% of total rated capacity

Average Peak Load By Use Case (MW)



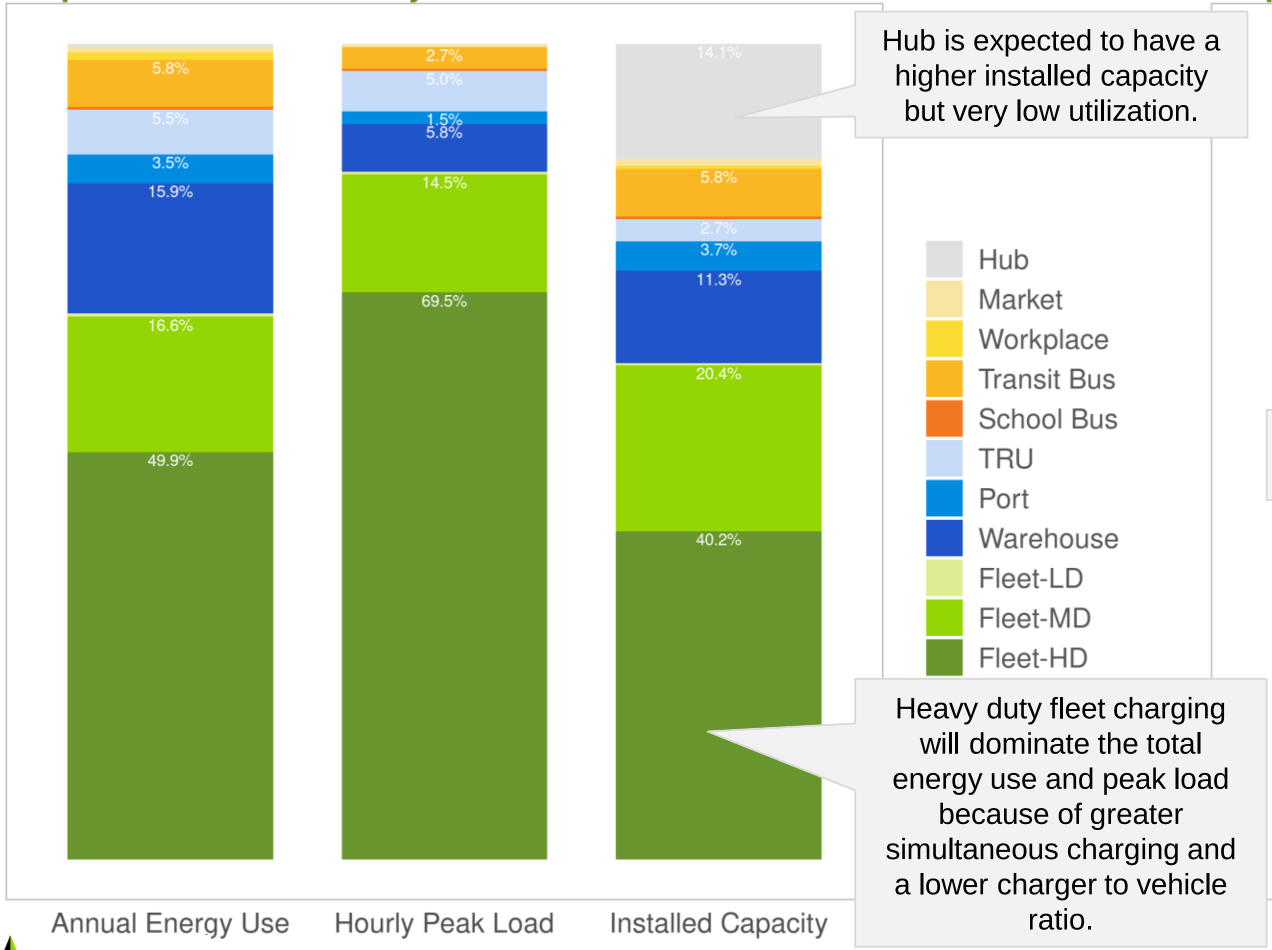
Rated Capacity By Use Case (MW)



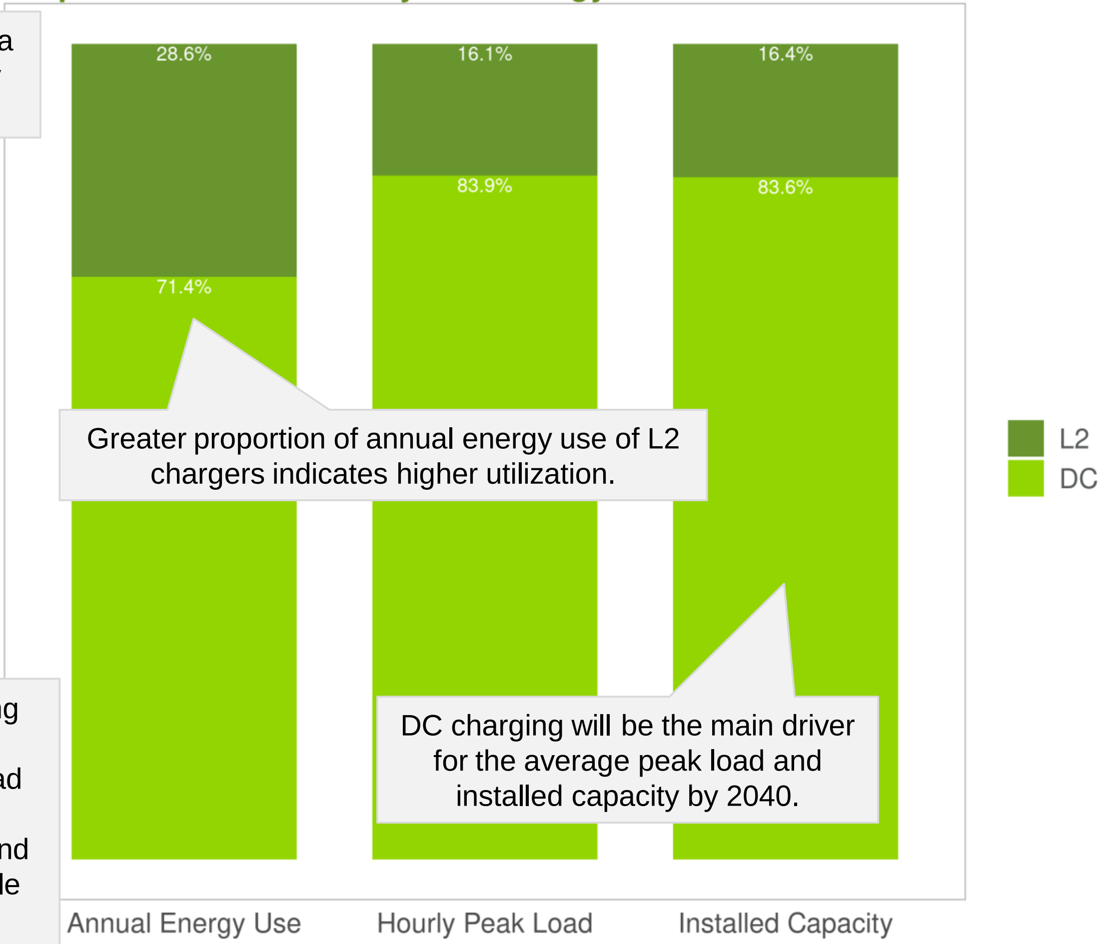
Note: The average hourly peak load is the maximum of the average energy consumption in an hour for that year and **not the instantaneous peak.** Also, the hourly peak loads shown in the plot are non coincident peaks, i.e., occur at different times for different use cases based on the typical use case load shape.

Planned Support Scenario: HD fleets and DC charging will dominate peak and avg charging load by 2040

Proportional Allocation By UseCase



Proportional Allocation By Technology



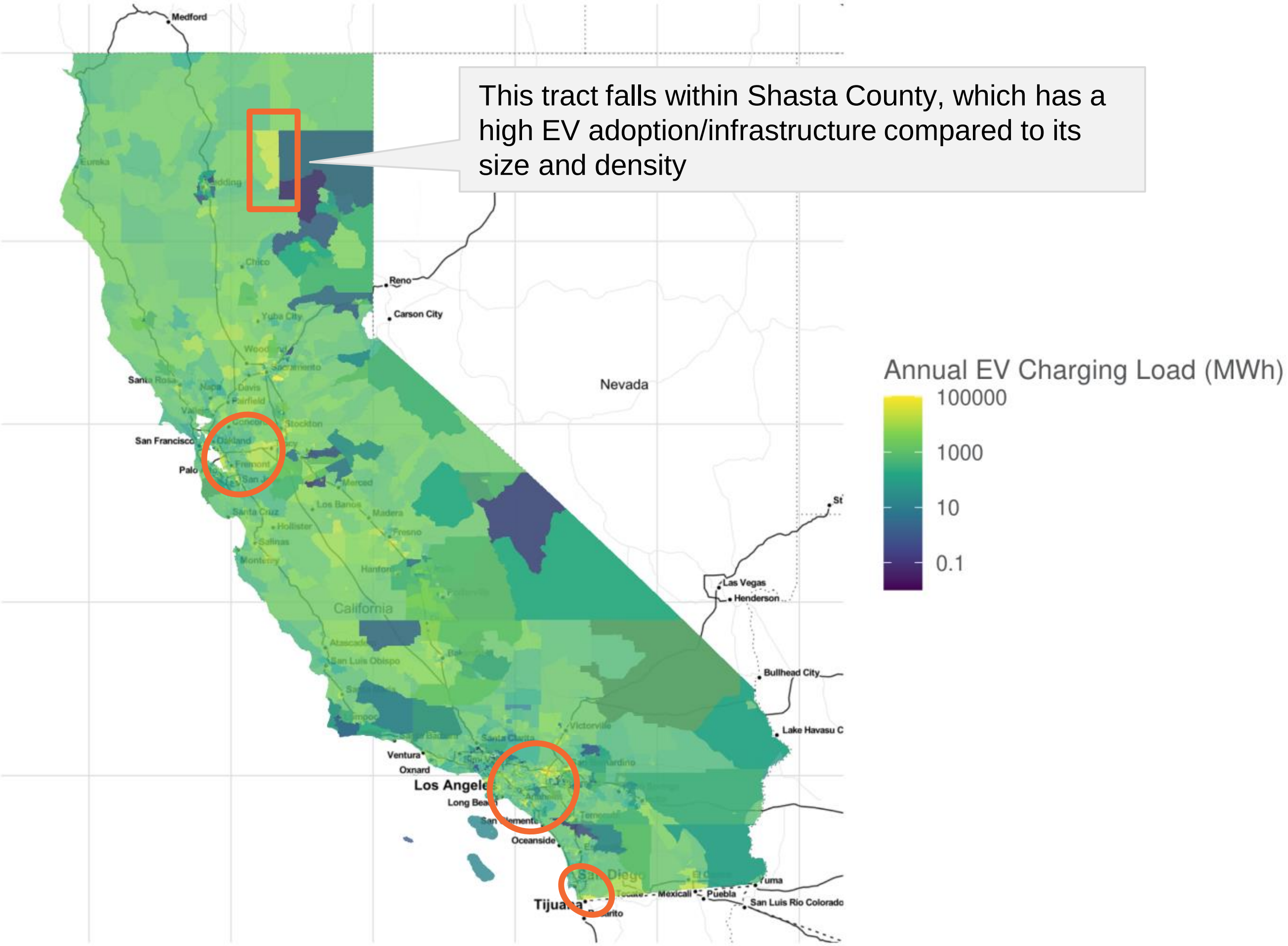
MD/HD Load Forecast Summary Table

Planned Incentives Scenario, 2040

Site Type	Illustrative Use Cases (examples)	Charger Counts	Annual Energy Use (GWh)	Hourly Peak (MW)	Rated Capacity (MW)
DCFC Public Hub	Public hub station on rural highway Public hub station for specialty use case Public hub station high-traffic suburban highway exit Public hub station along public corridor	15,846	92	24	4,621
Level 2 Public Hub	Public hub station on rural highway Public hub station for specialty use case Public hub station high-traffic suburban highway exit Public hub station along public corridor	10,139	25	6	187
DCFC Private Depot	Freight truck/delivery van/rack truck fleet School/transit bus fleet City fleet of refuse trucks General aviation airport Mid-size hospital with electric ambulances	76,480	8,175	2,395	22,250
Level 2 Private Depot	Delivery van/rack truck fleet Transport refrigeration unit fleet Warehouse Workplace charging for mid-sized employer General aviation airport Port	277,010	3,283	557	5,083

Major metro areas, ports industrial complexes are expected to have higher tract-level EV charging load

Planned Incentives Scenario, 2040



- **Heat map notes:**
  - Map only includes MD/HD.
  - Map shows tract level results for annual EV charging load.
  - Charging load is **not normalized** at tract-level (e.g., Shasta County).
- **Key takeaway:**
  - While public charging infrastructure is expected to follow patterns along highway corridors outside of metro areas, **load growth follows private infrastructure** that is located at commercial / industrial centers.

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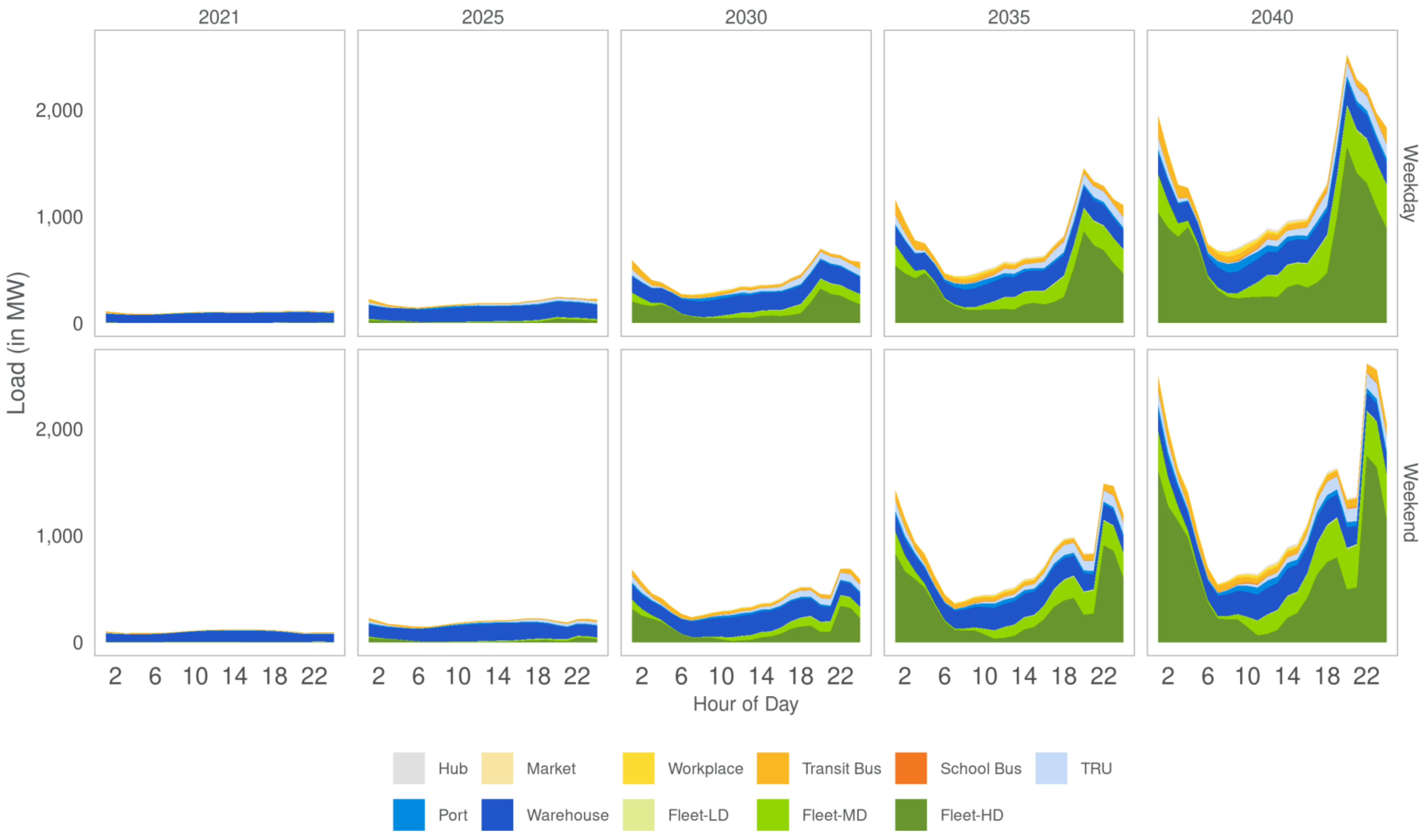
Load Shapes: Totaled by use case



- **Hourly demand:** Warehouse charging will be a majority contributor of hourly EV charging demand until 2030.
- **Fleet-HD impact:** expected to dominate average hourly load starting 2030 when Fleet-HD adoption becomes more substantial.
- **Evening peak:** Due to a “peakier” nature of Fleet-HD charging profile, utilities may see a significant evening peak.
- **Peak management:** These peaks can be managed by utility-driven smart charging programs or EV specific time-of-use energy and demand charges.

Note: Load shapes based on currently available EV charging data and ICEV driving behavior data with limited assumptions about changes over time. Uncertainty in load shapes is greater for years further in the future and is expected to be refined over time.

Annual Energy Consumption By Use Case (GWh)

	2021	2025	2030	2035	2040
Hub	0.1	1.6	9.2	22.7	41.9
Market	2.8	14.9	34.0	55.2	75.7
Workplace	0.5	7.6	30.0	66.8	113.6
Transit Bus	46.4	106.2	281.1	472.3	666.2
School Bus	0.5	2.4	10.0	25.1	41.7
TRU	13.5	117.9	306.5	477.8	634.9
Port	23.5	77.4	141.1	240.4	408.7
Warehouse	566.7	1,181.8	1,403.6	1,599.9	1,842.7
Fleet-LD	2.1	10.8	23.8	37.4	49.9
Fleet-MD	4.2	63.8	439.7	1,056.6	1,919.7
Fleet-HD	9.1	130.0	1,093.8	2,984.7	5,780.6
TOTAL	**670**	**1,714**	**3,773**	**7,039**	**11,576**

Annual Energy Consumption By Technology (GWh)

	2021	2025	2030	2035	2040
DC	81	363	1,845	4,481	8,267
L2	588	1,351	1,928	2,558	3,308
TOTAL	**670**	**1,714**	**3,773**	**7,039**	**11,576**

Average Peak Load By Use Case (MW)

	2021	2025	2030	2035	2040
Hub	4.8	47.2	384.1	1,034.2	1,992.6
Market	1.1	3.3	7.0	10.8	14.2
Workplace	1.8	19.0	114.0	263.6	471.4
Transit Bus	0.1	0.5	2.6	6.0	10.8
School Bus	1.2	3.8	8.8	14.5	20.1
TRU	9.7	18.5	33.7	57.5	96.5
Port	0.2	0.7	2.6	6.3	11.0
Warehouse	27.9	37.2	98.1	160.3	223.7
Fleet-LD	6.1	32.9	79.7	120.9	160.0
Fleet-MD	154.8	177.6	210.9	240.4	276.9
Fleet-HD	0.4	3.5	13.4	29.3	49.4

Note: The average peak load is the maximum of the average energy consumption in an hour for that year and **not the instantaneous peak.** Also, the peak loads shown in the table are non coincident peaks, i.e., occur at different times for different use cases based on the typical use case load shape. Therefore, the results in this table are not additive.

Average Peak Load By Technology (MW)

	2021	2025	2030	2035	2040
DC	36	92	501	1,277	2,404
L2	159	205	307	423	562

Note: The average peak load is the maximum of the average energy consumption in an hour for that year and **not the instantaneous peak.** Also, the peak loads shown in the table are non coincident peaks, i.e., occur at different times for different use cases based on the typical use case load shape. Therefore, the results in this table are not additive.

Rated Capacity By Use Case (MW)

	2021	2025	2030	2035	2040
Hub	10.1	183.6	2,051.5	6,460.2	12,926.3
Market	4.0	19.3	58.5	85.3	84.5
Workplace	8.8	137.4	1,204.6	3,339.4	6,551.0
Transit Bus	8.4	379.1	1,763.4	3,306.9	4,540.2
School Bus	13.5	64.6	129.5	205.3	267.4
TRU	96.8	179.6	366.3	678.0	1,173.3
Port	0.4	2.1	14.8	56.2	116.9
Warehouse	43.4	100.8	552.5	1,204.7	1,877.2
Fleet-LD	21.9	139.3	391.2	637.0	857.8
Fleet-MD	1,357.9	1,670.3	2,289.9	2,967.5	3,622.9
Fleet-HD	0.8	13.4	52.2	92.8	124.1
TOTAL	**1,566**	**2,889**	**8,874**	**19,033**	**32,142**

Rated Capacity By Technology (MW)

	2021	2025	2030	2035	2040
DC	155	980	5,900	14,886	26,871
L2	1,411	1,910	2,974	4,147	5,270
TOTAL	**1,566**	**2,889**	**8,874**	**19,033**	**32,142**

Modeling Methodology Overview – EV Adoption

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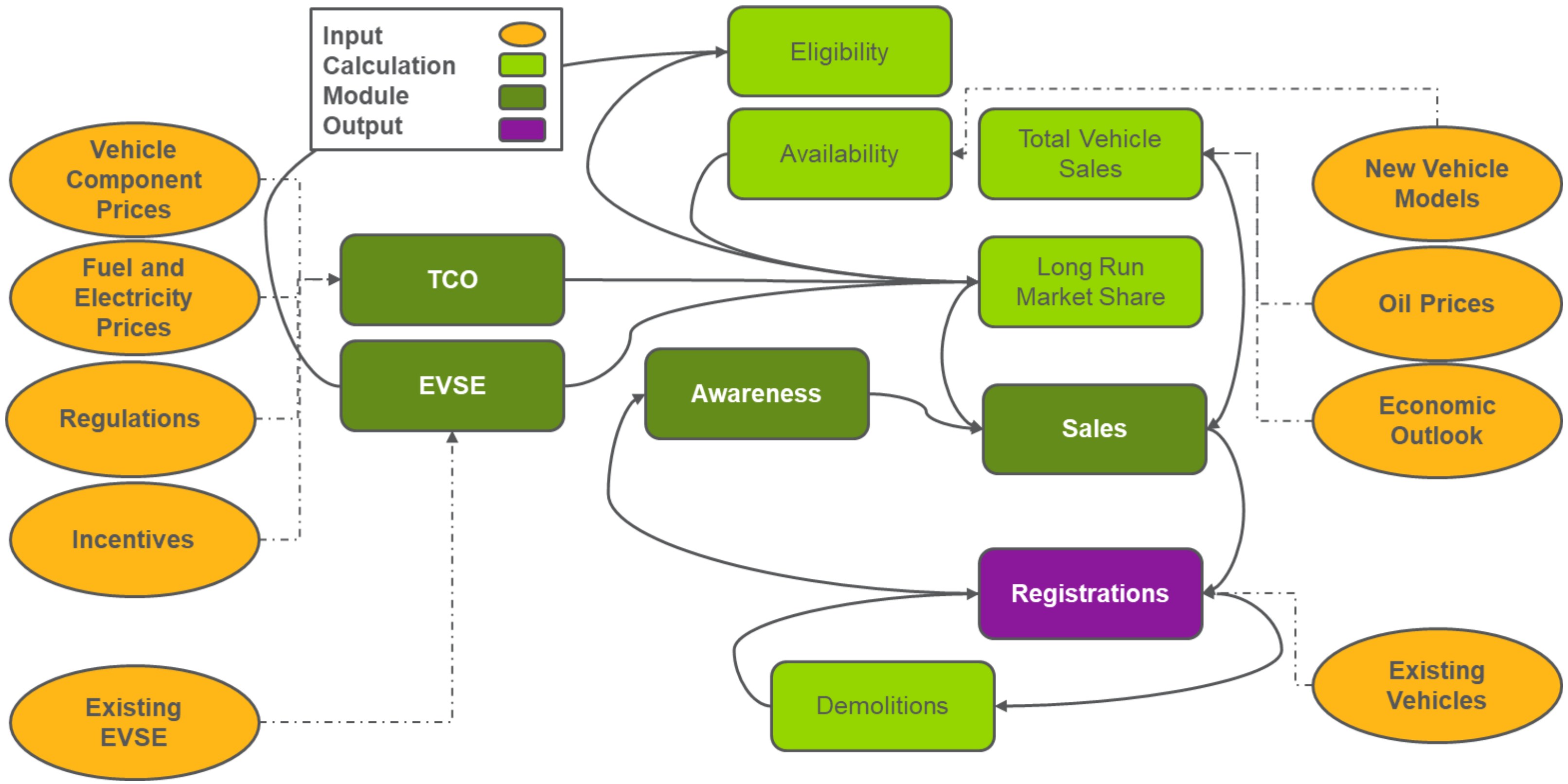
Market was split into 13 vehicle segments spanning across on-road and off-road use

Road Usage	Vehicle Duty	Vehicle Segment	Example Vehicle
On-Road	Light Duty	Class 1 Vehicles	• Sedan, small sport utility vehicle, small crossover, small pickup truck — *Out Of Scope*
		Class 2a-2b Vehicles	• Sport utility vehicle, pickup truck, small delivery van
	Medium and Heavy Duty	Class 3 Trucks	• Walk-in van, city delivery van
		Class 4-5 Trucks	• Box truck, city delivery van, step van
		Class 6 Trucks	• Beverage truck, rack truck
		Class 7-8 Trucks	• Short-haul truck, long-haul truck
		School Buses	• School bus
		Transit Buses	• Transit bus
		On-Road Specialty Vehicles	• Fire truck, ambulance, recreational vehicle, refuse truck, drayage truck
		Transport Refrigeration Units	• Refrigeration unit (excluding tractor trailer) for warehouses, distribution centers, grocery stores
Off-Road		Airport Ground Support Equipment	• Aircraft refueler, aircraft pushback tractor
		Seaport Cargo Handling Equipment	• Hostler truck, rubber-tired gantry crane, container handler (ship at birth out of scope)
		Other Forklifts	• Counterbalance / telescopic handler forklift for warehouses, lumberyards, and construction sites

Guidehouse's EV adoption model is based on multi-dimensional inputs to forecast vehicle penetration



Scope

- Within California
- Including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs)
- Including medium- and heavy-duty (MHD) vehicles
- Including individually- and fleet-owned vehicles

Methodology

- Leveraging VAST™ Suite[1], a proprietary model developed by Guidehouse to forecast geographic penetration and dispersion of electric vehicles
- Taking inputs at the census tract level, including:
  - Vehicle registrations by make and model
  - Expected gasoline and battery prices
  - Vehicle lifetime
  - Incentives
  - Annually collected survey data on vehicle owners
  - Demographic data, e.g., population, income, units in housing structure, vehicle ownership, household counts, educational attainment

1. Guidehouse's **Vehicle Analytics Simulation Tool™ (VAST) Suite** uses in-house datasets to provide market transparency that informs client lifecycle consulting needs, such as electric vehicle (EV) charger location optimization analysis to develop an EV charging infrastructure plan.

EV adoption modeling inputs and outputs

Key Inputs

Input	Description	Source
Registration Data	California vehicle registration by fuel type and zip	IHS Markit
Fuel Costs[1]	Electricity rates ($/kwh) and gasoline and diesel prices ($/gal)	Energy Information Administration (electricity) AAA (gasoline and diesel)
Vehicle Availability	Guidehouse research on future availability of EVs, including MHD vehicles in California	Guidehouse Insights
VMT	Forecasted annual vehicle miles traveled, California	Federal Highway Administration
Vehicle Efficiency	kWh/mile forecast	Argonne National Lab
PHEV e-Utilization	Proportion of PHEV miles using battery	Argonne National Lab
BEV Range	Total miles increase forecast	Guidehouse Insights
Education and Income	Educational attainment and income levels, California, by census tract	US Census Bureau
Battery Cost	$/kWh cost decline forecast	Guidehouse Insights

Key Outputs

Output	Description
EV Sales	Number of units per year
EV Population	Total units in operation in a given year, accounting for cumulative sales and scrappage
Year	2020-2050
Location	Census Tract
Duty	Medium and Heavy
Class	See slide 11
Owner	Individual, Fleet
Powertrain[2]	BEV, PHEV

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1. Fuel mix for MHD vehicles is 78.3% diesel, 18.0% gasoline, 1.6% compressed natural gas, and 2.1% other fuel types as of year-end 2019.
2. BEV = battery electric vehicle. PHEV = plug-in hybrid electric vehicle.

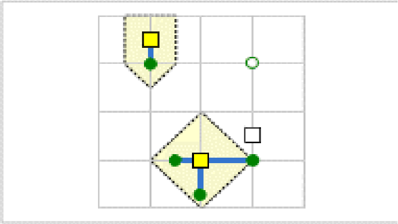
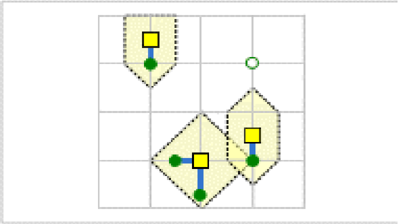
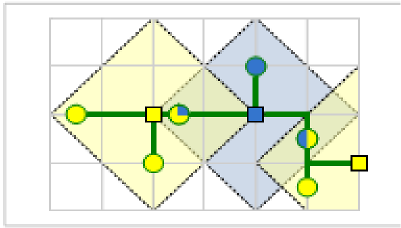
Modeling Methodology Overview – EV Charging Needs

Vehicle take-rates by site type and use case

Site Type	Specific Use Case	Vehicle Segments Served
Public Hub	Market	Class 2a Vehicles, Class 2b Vehicles
	Hub	Class 3 Trucks, Class 4-5 Trucks, Class 6 Trucks, Class 7-8 Trucks, TRUs, On-Road Specialty Vehicles
Private Depot	Residential (Single-Family, Multi-Family)	Class 2a Vehicles, Class 2b Vehicles
	Workplace	Class 2a Vehicles, Class 2b Vehicles
	Fleet Depot	Class 2a Vehicles, Class 2b Vehicles, Class 3 Trucks, Class 4-5 Trucks, Class 6 Trucks, Class 7-8 Trucks, On-Road Specialty Vehicles
	Bus Depot	School Buses Transit Buses
	TRU Facility	TRUs
	Airport, Seaport	Airport Ground Support Equipment, Seaport Cargo Handling Equipment
	Warehouse	Forklifts

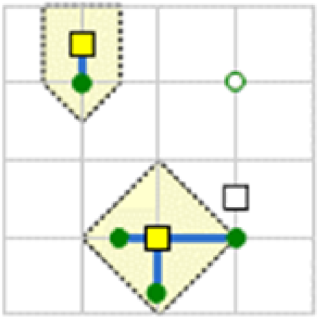
- **Vehicle take-rates** consider the variety of vehicle use cases listed in the table to the left.
- Observed or simulated **load profiles** were modeled for each specific use case to verify the take-rate is sufficient to meet charging demand based on the vehicle **duty cycle**.
- The take-rates for each use case were rolled up to provide take-rates by **site type** for Public Hub and Private Depot charging.

EV charging site location allocation options

Objective Function	Concept	Goal	Key Application
Minimize Facilities Full coverage with minimum sites		Access to all	Meet all demand, corridor sites
Maximize Coverage Maximum coverage with a specific number of sites		Access to as much as possible	Meet as much demand as possible with limited number of sites
Target Market Share Meet target market share		Highest utilization	Efficiently allocate sites to meet points of highest demand

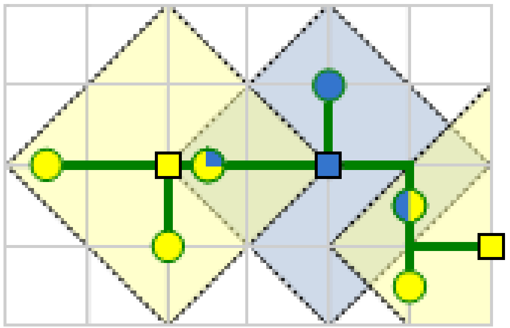
Source: http://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/location-allocation.htm

Guidehouse model used a Minimize Facilities + Target Market Share hybrid approach



Minimize Facilities with a specific distance between sites

Minimize Facilities flags optimal sites for ensuring complete coverage in areas with low availability of charging infrastructure, such as rural areas



Target Market Share

Target Market Share best simulates the behavior of all agents in the market, so it's the best for forecasting future load

Modeling approach for transport refrigeration units

State-Level Adoption Forecast

- Leverage state-wide TRU population and TCO data from CARB report[1] to forecast adoption of electric TRUs[2]

Census-Tract-Level Adoption Forecast

- Use County Business Patterns (CBP) dataset from US Census Bureau to disaggregate statewide forecast to census tract level by number of employees per tract

EVSE Annual Energy and Site Configurations

- Leverage current energy consumption data from CARB report[1] along with census-tract-level adoption forecast to project annual energy consumption for electrified TRUs

1. CARB Technology Assessment: Transport Refrigerators, page II-9.
2. This segment includes only electric refrigeration units. Electric trucks are included in other on-road truck segments. See slide 11 for vehicle segmentation.

EV charging needs inputs and outputs

Key Inputs

Input	Description	Source
Siting Objective Function	Desired objective function for EVSE siting process	Guidehouse / CalETC
Charging Site Distance Threshold	The network distance defining the radius around each site serviced by that site	Guidehouse
Charger-to-Vehicle Ratios[1]	Current, long-run, and interpolated ratios of chargers needed to support number of EVs, by Tech, EVSE Owner (Public/Private), Use Case	Alternative Fuel Data Center (current) NREL's EVI-Pro (long-run)
VMT	VMT by segment provides calibration point for charger-to-vehicle ratios based on expected utilization	Federal Highway Administration
Existing Charging Infrastructure	Locations of existing chargers by tech, owner and use case	Alternative Fuels Data Center
Annual Average Daily Traffic	Annual average daily traffic for roads in service area	Federal Highway Administration

Key Outputs

Output	Description
Site Location	Census tract
Use Case	Charging use case, examples include Public Market and Private Depot
Technology	L2, DC
Rated kW	Average rated kW by use case, technology, and year
Year	2020-2050
Number of Ports	Number of ports forecasted for each site

1. Vehicle-per-charger ratio assumptions will be co-developed with CalETC and based on the best publicly-available data (even if LD only) along with substantiated refinements calibrated to Guidehouse synthetic vehicle load shapes by use case. Charging duty cycles will then be backchecked to ensure assumptions are operationally realistic.

Modeling Methodology Overview – EV Load Growth

Vehicle classes served by charger site types

Site Ownership	Example Use Cases	Vehicle Classes Served
Private	Residential (Out Of Scope) • *Single-Family (SUD)* • *Multi-Family (MUD)*	• Light Trucks
	Workplace	• Light Trucks
	Fleet Depot • *Fleet-LD* • *Fleet-MD* • *Fleet-HD*	• Light Trucks • Delivery Trucks • Semi Trucks
	Bus Depot • *School Bus* • *Transit Bus*	• School Buses • Transit Buses
	Off-Road • *Ports* • *Warehouse* • *TRU*	• Airport Ground Support Equipment • Seaport Cargo Handling Equipment • Forklifts • Transport Refrigeration Units (TRU)
Public	Curbside Residential (Out Of Scope) • *Single-Family Shared (SUD-Shared)*	• Light Trucks
	Market	• Light Trucks
	Hub	• Delivery Trucks • Semi Trucks

- Charger **use cases** are specific to the needs of different **vehicle classes**, as listed in the table to the left.
- **Private charging** is expected to fulfill most of the charging needs for all use cases, driven by convenience and customer preference.
- **Public charging** is expected to serve some demand from the lighter duty vehicles (Class 2) and long-haul trucks.
- **Level 2 charging** is expected to continue to play a key role for Class 2 Vehicles.
- **DCFC** will be key for the heavier vehicle segments, as well as for off-road segments. This includes pantograph charging for buses.

See EV Load Growth (2021 CA LSE Study Results) Section for load growth and impact results by color-coded use case

Vehicle classes by ownership model and use cases

Road Usage	Vehicle Duty	Vehicle Segment	Energy Allocation by Site Ownership[1] Public	Private	Load Profile Use Cases
On-Road	Light Duty	Class 1 Vehicles	Low	High	Market, Workplace, Fleet-LD, SUD, MUD, SUD-shared *Out Of Scope*
		Class 2a-2b Vehicles	Low	High	Market, Workplace, Fleet-LD
	Medium and Heavy Duty	Class 3 Trucks	Low	High	Fleet-MD, Hub
		Class 4-5 Trucks	Low	High	Fleet-MD, Hub
		Class 6 Trucks	Low	High	Fleet-MD, Hub
		Class 7-8 Trucks	Low	High	Fleet-MD, Hub
		School Buses	None	High	School Bus
		Transit Buses	None	High	Transit Bus
		Transport Refrigeration Units	Low	High	Hub, TRU
Off-Road		Airport Ground Support Equipment	None	High	Port
		Seaport Cargo Handling Equipment	None	High	Port
		Other Forklifts	None	High	Warehouse

1: Low = ≤20%; Medium = 21-79%; High = ≥80%

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See EV Load Growth (2021 CA LSE Study Results) Section for load growth and impact results by color-coded use case

EV load forecasting modeling inputs and outputs

Key Inputs

Input	Description	Source
EV Adoption Forecast	Number of BEVs and PHEVs by census tract by year	Guidehouse
EVSE Forecast	Number of chargers needed to support EV adoption	Guidehouse
VMT	VMT by segment, along with vehicle efficiency, determines total energy needs	Federal Highway Administration[1]
Vehicle Efficiency	kWh/mile forecast	Argonne National Lab
PHEV e-Utilization	Proportion of PHEV miles using battery	Argonne National Lab
Stock Vehicle Charging Profile	Typical hourly charging behavior by vehicle type and use case	Guidehouse

1 For Use Cases like Forklifts, Airport GHEs, Seaport CHEs typical hours of operation were used instead.
Source: Commercial and Industrial Guide to Electric Transportation by EPRI

Key Outputs

Output	Description
Site Location	Service Territory
Use Case	Charging use case, examples include Public Hub and Private Depot
Technology	L2, DC
Rated kW	Average rated kW by use case, technology, and year
Year	2021-2040
GWh	Annual energy consumption
MW	Peak annual demand

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Modeling Assumptions

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Modeling assumptions (1/5)

Class 2a / 2b Vehicles

- IHS Markit registration input data does not differentiate between Class 2a and Class 2b vehicles, making it difficult to segment both vehicle subclasses for each other.
- However, CARB maintains an inventory of Class 2a and Class 2b vehicles, accessible on the EMFAC website, and provided Guidehouse with ACT forecast inventory by vehicle segment.
- Therefore, Guidehouse leveraged CARB's EMFAC data and ACT forecast data for the Class 2a / 2b forecast.

On-Route Ultra-High-Power Private Charging

- On-route charging, which places ultra-high-power chargers along transit / off-road routes, is a niche use case to accommodate transportation systems where between-route charging is not possible.
- These private charging use cases are included in the Private Depot use case.
- Guidehouse recognizes that on-route chargers may be located in neighboring census tracts, rather than the tract where the vehicle is registered; however, Guidehouse notes the lack of locational data and estimates that the number of such charging use cases is limited.

Modeling assumptions (2/5)

LCFS Credits

- Low Carbon Fuel Standard (LCFS) credits were excluded from the scope.
- Guidehouse recognizes that LCFS credits can be significant for specific vehicle segments, e.g., circa $10,000 credit value per transit bus per year.

Sub-State Incentives

- The Heavy Duty Truck Emission Reduction Grants from the San Joaquin Valley Air Pollution Control District was identified to be the most impactful sub-state incentive, and was included in the analysis. Any other explicit sub-state (e.g., utility-level) incentive programs were excluded from the scope.
- Guidehouse recognizes that utility-level incentive programs may further drive EV adoption in specific census tracts. The historical impact of local incentive programs on EV adoption is implicitly accounted for when calibrating the model against census tract level registration data.

Modeling assumptions (3/5)

Level 1 Charging

- Level 1 charging was not included in the EV Charging Needs and Site Configuration output, however, it was included in the underlying analysis.
- More specifically, individually-owned Class 2a-2b Vehicles were expected to use some 1.4 kW Level 1 charging, which would come in addition to the Level 2 and DCFC charging needs.

Total Rated kW

- Total rated kW provided in the EV Charging Needs and Site Configuration output is the result of average port count x average rated kW x total site count, not discounted for any load management.
- Total rated kW is therefore different from any grid systemwide coincident / noncoincident peak calculation.

Modeling assumptions (4/5)

General

- 2020 CalETC vehicle sales and population projections were not revised
- Analysis uses CalETC 2020 study vehicle counts
- Since MD/HD market is nascent, there is additional uncertainty in how quickly the markets will grow, and how these vehicles will distribute their charging

LSE Service Territory

- No variation between territory driving patterns other than vehicle distribution between territories (no territory-specific VMTs used)
- Service territories are defined based on each LSE's unique shapefiles. For partially covered tracts, vehicles are proportionally allocated based on population density
- Long-haul trucks registered within LSE territory are assumed to conduct charging at their registered location (both hub and depot chargers). No truck flow analysis was done in this project to account for out-of-territory vehicles using charging assets en route

Modeling assumptions (5/5)

Electric Vehicle Supply Equipment (EVSE)

- Total charger rated capacity represents the instantaneous demand drawn if all chargers were utilized simultaneously
- Charger rated capacity assumed to increase over time
- Because chargers are shared assets (vehicles across multiple classes utilizing the same chargers), load growth results are not broken down by vehicle class

Load Profile

- Average kW represents the average peak, not the instantaneous peak (e.g. kWh/hr)
- Load profiles are derived from a combination of publicly available sources and anonymized data from other utility partners, and are not LSE-specific
- Load profile assumptions does not include any TOU or managed charging rates and assumes flat volumetric rates

Key Modeling Inputs

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ICEV fuel prices

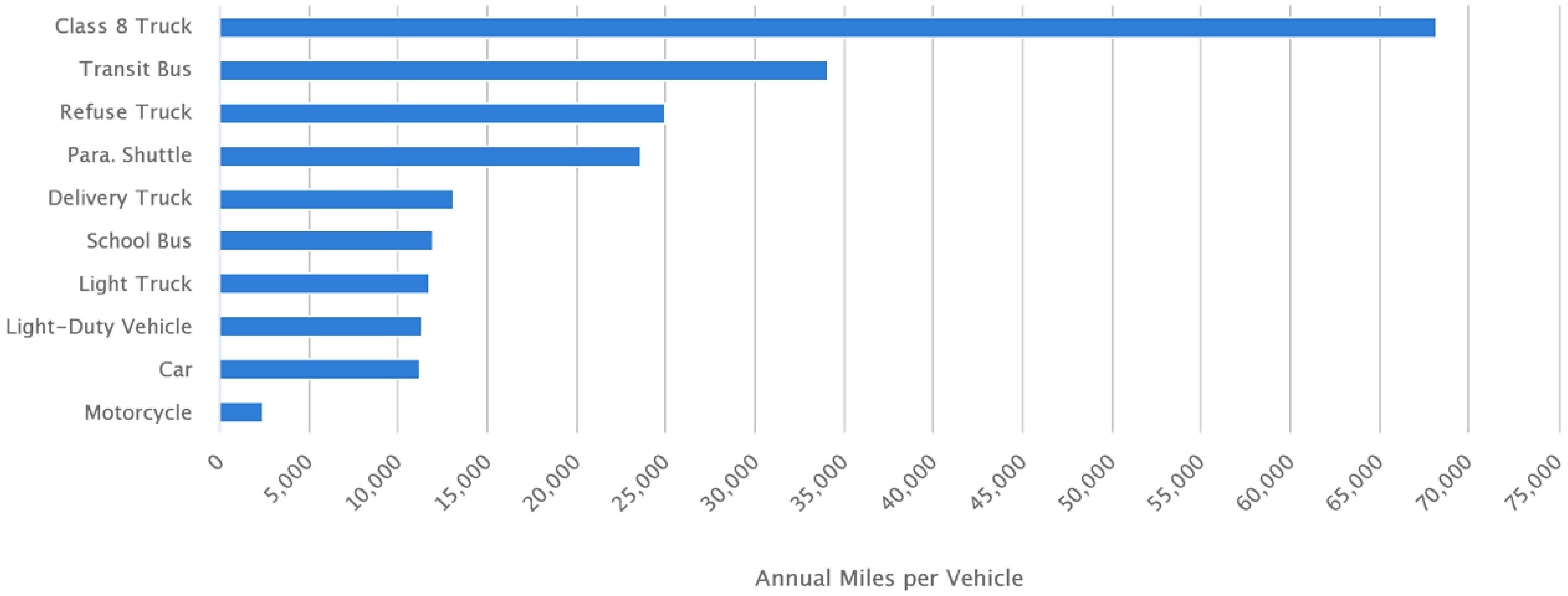
Fuel prices for ICEVs are a blended average of gas and diesel prices

- The fraction of Gas and Diesel vehicles is calculated from IHS Markit registration data for California
- The table to the right demonstrates how the blended average fuel price is computed

Duty	Fuel Type	Fraction of Total Vehicles by Duty[1]	Fuel Price[2]	Blended Price
HDV	Diesel	0.982	$4.28	$4.27
	Gas	0.018	$3.82	
MDV	Diesel	0.693	$4.28	$4.14
	Gas	0.307	$3.82	

1. Fraction remains constant year to year
2. Source: EIA, AAA (example for year 2020)

Average annual vehicle miles traveled



Source: Federal Highway Administration, Highway Statistics 2016, Table VM-1, updated December 2018
VMT inputs for Guidehouse's analysis were derived from Federal Highway Administration data

ACT regulation inputs

ACT and ACT Fleet regulations are modeled using a long-term target sales percentage for a given year consistent with the ACT 15-day regulation

- The **Long-Term ACT Target** represents the percentage of sales that must be zero-emission (ZE)
- The **ACT Target Year** represents the year at which manufacturers must achieve the sales target. Requirements continue after the target year.

Vehicle Class	Long-Term ACT Target[1]	ACT Target Year[2]
Class 2b-3	15%	2030
Class 4-8	50%	2030
Class 7-8 Tractors	15%	2030

1. Target for percentage of vehicle sales that must be ZE
2. ACT requirements continues after Target Year

TRU forecasting inputs

Input	Truck TRUs	Trailer TRUs	Railcar TRUs	TRU Gen Sets	Guidehouse Input
Daily California-based Population Operating in California	7,100	20,400	1,300	4,800	Adoption Forecasting
Daily Out-of-State-Based Population Operating in California	-	12,500	-	3,000	
Annual Engine Activity in California (hp-hrs/year)	75,228,000	872,106,00	34,255,000	80,989,000	Annual Energy Forecasting

Source: CARB Technology Assessment: Transport Refrigerators, page II-9

Glossary

Glossary

Acronym	Definition
AADT	Annual Average Daily Traffic
ACT	Advanced Clean Truck
AFDC	Alternative Fuels Data Center
BEV	Battery Electric Vehicle
CAFE	Corporate Average Fuel Economy
CalETC	California Electric Transportation Coalition
CARB	California Air Resources Board
CBP	County Business Patterns
Charger	Refers to a single electrical port on a charging station
CMUA	California Municipal Utilities Association
DCFC	Direct Current Fast Charge
EMFAC	Refers to EMission FACtor (EMFAC), a model that estimates the official emissions inventories of on-road mobile sources in California
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
HDV	Heavy-duty vehicle (also 'HD')
IHS	Interstate Highway System
ICEV	Internal Combustion Engine Vehicle
ICT	Innovative Clean Transit; CARB regulation replacing Fleet Rule for Transit Agencies

Acronym	Definition
L1	Level 1 Charging
L2	Level 2 Charging
LCFS	Low Carbon Fuel Standard
LD	Light Duty
LDV	Light-duty vehicle (also 'LD')
LSE	Load Serving Entity (utility, electric company)
MDV	Medium-duty vehicle (also 'MD')
MHD	Medium and Heavy Duty
PHEV	Plug-in Hybrid Electric Vehicle
PEV	Plug-in Electric Vehicle (includes PHEVs and BEVs)
Port	Refers to seaport, airport, etc., in context of use cases (ex, warehouse, school bus, etc.)
TCO	Total Cost of Ownership
TRU	Transport Refrigeration Units
VAST™	Vehicle Analytics & Simulation Tool (Guidehouse proprietary software)
VMT	Vehicle Miles Traveled
ZCTA	Zip Code Tabulation Area
ZEV	Zero emission vehicle

Illustrative Class 2a Vehicles

Battery Electric Vehicles

Tesla Model X

Audi e-tron

Plug-In Hybrid Electric Vehicles

Chrysler Pacifica PHEV

BMW X5 PHEV

Porsche Cayenne PHEV

Mercedes GLE PHEV

Range Rover PHEV

Lincoln Aviator PHEV

Illustrative Off-Road Vehicles

Airport Ground Support Equipment	
Vehicle Type	**Use Case**
Aircraft Refueler	Truck used as a mobile refueling station
Aircraft Pushback Tractor	Low-profile pushback tractor that moves aircraft away from airport gates
Cargo / Luggage Loader	Equipment used for loading / unloading luggage, containers, and pallets into the aircraft hold

Seaport Cargo Handling Equipment	
Vehicle Type	**Use Case**
Hostler Truck	Moving cargo containers over short distances
Rubber-Tired Gantry Crane	Grounds or stacks shipping containers, typically in large-sized ports
Container Handler	Stacking cargo containers, typically in small- and medium-sized ports

Other Forklifts	
Vehicle Type	**Use Case**
Class 1 Forklift	Indoor warehouse use
Class 2 Forklift	Indoor warehouse narrow aisle use
Class 3 Forklift	Pallet stacking indoor and outdoor uses
Class 4 Forklift	Indoor warehouse and distribution uses
Class 5 Forklift	Outdoor lumberyard or construction use
Class 6 Forklift	Assembly line use
Class 7 Forklift	Outdoor lumberyard or construction use

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